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4907 FILE MANAGER IS A POWERFUL GRAPHICS AID

By Les Brabetz and Gary P. Laroff

The last issue of TEKniques (Vol. 1 No. 9) introduced the 4907 intelligent flexible disc mass storage unit for the 4051. A SORTing program was also included in that issue. This month begins a series of articles on powerful graphics handling routines made possible by the large direct access storage capability and multiple-level file-by-name library structure supported by the 4907. Just as numerical records can be accessed in any order on the disc, so can graphic entities be stored and retrieved.

Consider a large data base, perhaps the high resolution map of the United States in Fig. 1. It might be desirable to plot the entire map. In this case all of the coordinates in the data base are required and can be read sequentially. This is as easy and convenient to do with data stored on magnetic tape as it is with disc storage methods. But what if only a subset of the map is desired? How is it possible to quickly locate those coordinates that will be plotted in the desired map area, and discard those that fall outside the boundaries? The file library system available on the 4907 is designed to offer solutions to such graphic applications.

The data base consists of about 3000 X,Y pairs and takes about four minutes to display. The objective is to store the data so that any map area can be chosen and quickly displayed. The data base designs are described in this article. Succeeding articles will present a program to construct a segmented data base from an existing sequential data base and another program that selects the segments to display.

The map as originally digitized can be displayed with a number of DRAW commands and MOVE commands. The data is stored as a series of coordinates that can be displayed with a MOVE to the first coordinate pair and an array DRAW to the remaining coordinates. Because each of these data sections consists of a different number of coordinates, the number of coordinate pairs is also stored. The data format is:

$$N, X_1, X_2, \ldots, X_n, Y_1, Y_2, \ldots, Y_n$$

where N is the number of coordinate pairs. The data base could be read and displayed from either tape or disc with
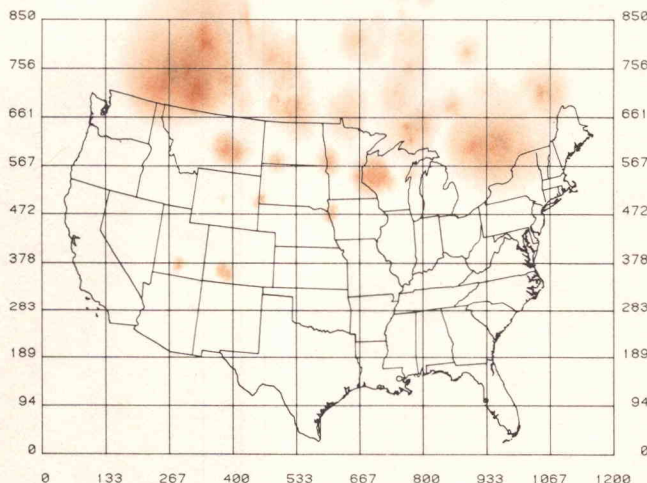

Fig. 1. Master file of digitized map with arbitrary grid values.
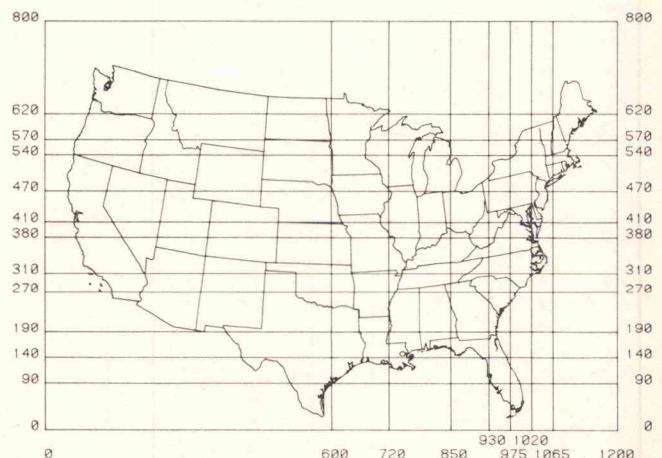

Fig. 2. Map data base illustrating segment division lines to produce 96 map segments.

similar programming:

```
FROM TAPE              FROM 4907

100 READ @33:N         100 READ #1:N
110 DELETE X,Y         110 DELETE X,Y
120 DIM X(N),Y(N)      120 DIM X(N),Y(N)
130 READ @33:X,Y       130 READ #1:X,Y
```

These arrays can then be displayed by a MOVE to the first point and a DRAW for the entire array:

```
140 MOVE X(1),Y(1)
150 DRAW X,Y
```

All of the arrays are READ and displayed in this manner. The data base consists of 30 arrays containing about 3000 coordinate pairs.

This data base is not optimized for displaying subsections of the map. With this filing method, four minutes are required to display any map section because the 4051 must READ every data pair and "clip" all graphics that would appear outside the designated window.

A far superior technique would be to divide the map into many smaller sections. The program could then look at the desired plot boundaries and choose those map sections required for the display. The random file access feature of the 4907 makes this quite practical. For the purposes of this description, 96 segments created a data base that could quickly display any section of the original map. Fig. 2 shows the map as segmented into eight divisions horizontally and twelve vertically. An attempt was made to select a segment definition which would create an equal distribution of coordinates between the file segments. The fine detail required by the eastern coastline and minimum detail required for western state boundaries caused the density of graphic coordinates to be far greater toward the eastern part of the map. Smaller segment definition was required in some areas in order to attain reasonably equal vector densities in each segment.

Each segment is a rectangle and must contain the coordinates of intersection of any map lines with its borders. This is a substantial task; the program that builds this segmented data base will be discussed in the next issue.

Once the segmented data base is completed (as 4907 files USMAP/SEG1 through USMAP/SEG96), a simple program can be used to access the files, then quickly display any segment of the map. In this manner, one can rapidly access and display any section of a large data base (such as a map) and then use custom routines to add such information as county boundaries, major highways or weather information.

4051 Plots Roads in Australia

by E.S. Webber
Sydney, Australia

(At the request of TEKniques, Laurie, Montgomery and Pettit Pty. Ltd., consulting engineers and Tektronix Australia customers, obligingly subitted the following article through Tektronix Australia.)

Our most ambitious graphics effort so far is the perspective plotting of a road. Our client had questioned the sight lines and aesthetics of a section of a country road, straight in plan, where the vertical curves in our design were not continuous. They thought the effect might be a "kink" at the junction of the straights and the curves. The object of plotting the perspective of the road, therefore, was to investigate this possibility, and demonstrate if possible that the sight lines would have a smooth transition.

About two kilometres of road were critical, and cross sections were available every 25 metres. Fourteen points were used to fully define each cross section, including the standard template defining embankment and cutting slopes. Since not all the points appeared on every section, some were doubled up in order to keep the sequence the same. (See Fig. 1.)
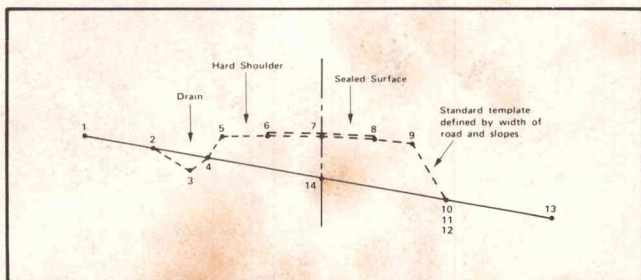

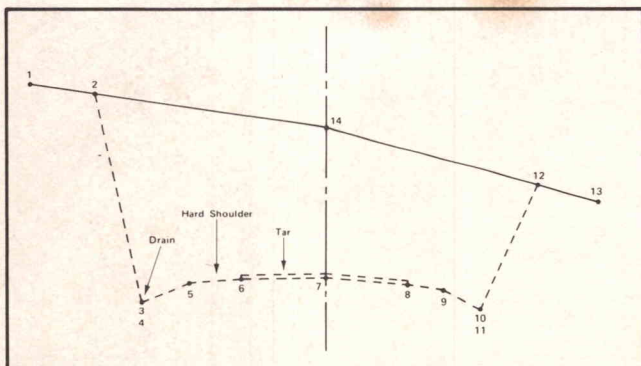Fig. 1.a. Cross section—all embankment.
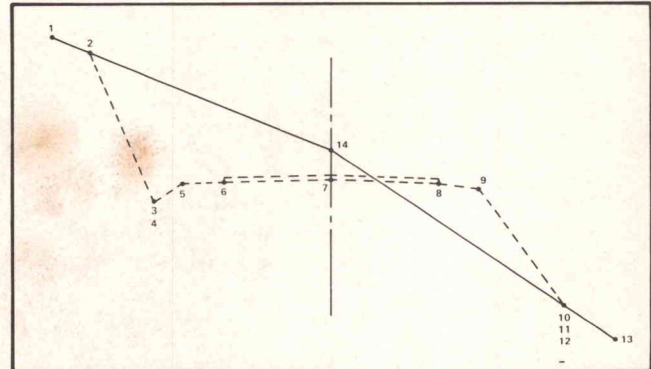

Fig. 1.b. Cross section—all cutting.

Fig. 1.c. Cross section—half-and-half cutting and embankment.

3D-Data for the perspective plot was generated by an initial program (ROADSECT) which stores the standard cutting and embankment templates. For each cross section, it is then necessary only to enter four elevations:

1. Ground level a standard distance, say 15 metres left of centreline (point 1)

2. Ground level at centreline (point 14)

3. Ground level 15 metres right of centreline (point 13)

4. Road formation level at centreline (point 7)

ROADSECT then checks at each cross section whether the road is all in cutting, all in embankment, or one side in and one side out; and then generates the 2-D data for all the other points, and stores it in a tape file. Sections were at regular intervals, so the Y dimension was not stored. There was no requirement for horizontal curves, road junctions, or other complications, but a little further effort in programming could accommodate these.

The second program is an adaptation of the perspective plotting routine given in the "PLOT 50 Introduction to Graphics Programming in BASIC" manual. The "draws" were set to connect points on consecutive cross sections having the same array number i.e., all point sevens were connected, all point eights, etc. Finally, the cross section was drawn for the end closest to the "camera."

Once the data was prepared by ROADSECT, the ROADPERSPECT program allowed input prompts to select at will:

The number of cross sections plotted

The number of repeat plots, and the distance increment between each repeat

The eye location (3 coordinates)

The perspective centre (3 coordinates)

Forward or backward view along the road.

When the most effective viewpoint etc., had been determined after several screen displays (some recorded on the hard-copy unit), the program was amended to create a plot on a Hewlett Packard 7202 plotter (bought previously, not in preference to the Tektronix plotter) using the Datacom interface. Removal of some hidden lines was achieved by watching the screen display and switching the plotter on and off at appropriate times. (The plotting speed was rather slow: about 10 minutes for each example shown.) Also, the program was modified so that the point-plot feature of the plotter was activated for the road centreline, and 50 m marker posts were drawn on
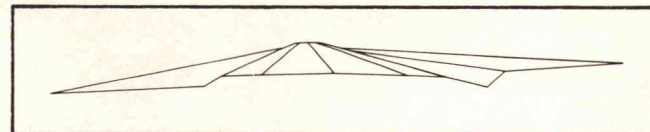

Fig. 2. Simulated view from driver's eye at 1.5 (x), 3395 (y), 892.97 (z) looking to −1.5, 3325 and 391.5.

the hard shoulder, each one metre high, thus giving a better feeling of scale (Fig. 3).

Views were produced from many different viewpoints. Initially, the eyeline of a driver of a car was simulated as he drove down the road in each direction. The results of this were a little disappointing (Fig. 2) because points more than a hundred metres away merged to a single blob on the screen. A much more explicit effect was obtained by moving the eye point (in response to an input prompt) about 10 metres up and 30 m to one side of the road, even though it is unlikely anyone would see the view from such a position.

Finally, stereo pairs were made by means of a 1 metre eye-shift. When viewed through a stereoscope, the landscape
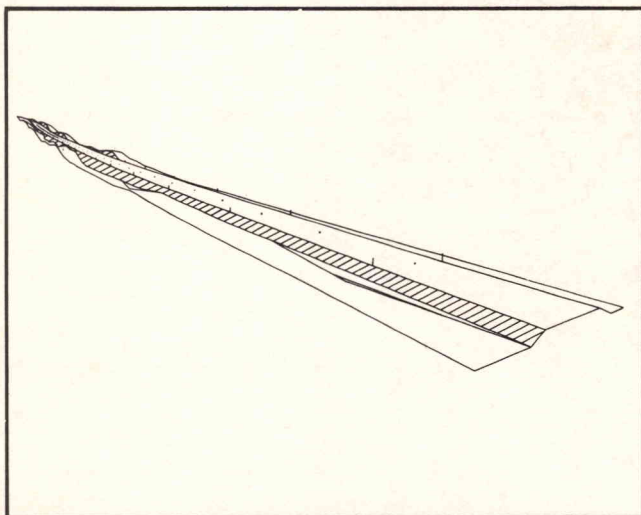

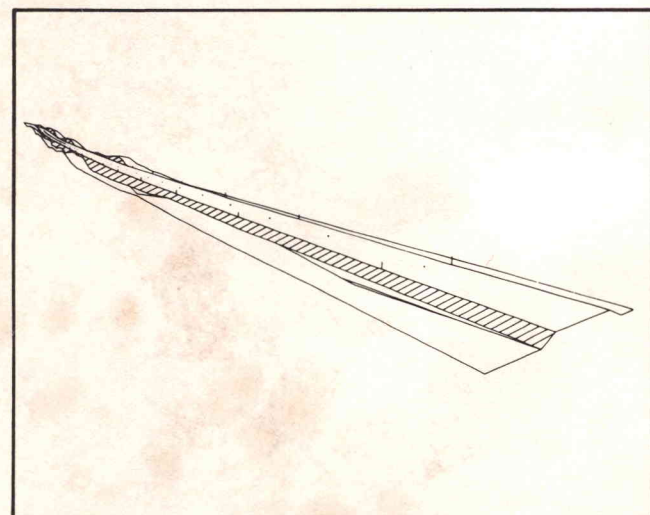Fig. 3.a. Stereo left view—eye at −30 (x), 4090 (y), 900 (z) metres.

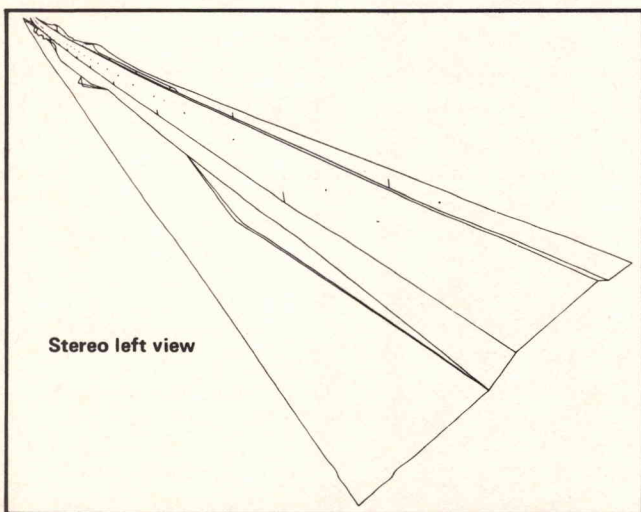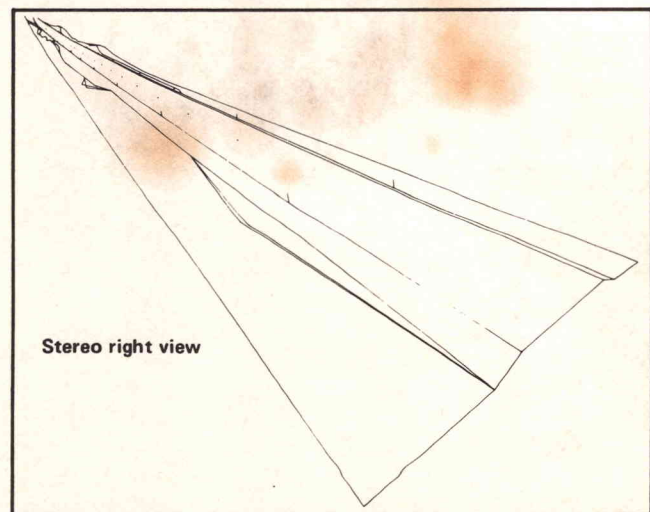Fig. 3.b. Stereo right view—eye at −29 (x), 4090 (y), 900 (z) metres.

Stereo left view

Fig. 4. Goulbourn to Pejar Dam Road—eye at 10 metres above and to left of centreline.

Stereo right view

popped into view very effectively, with the road superimposed.

Another program developed for the 4051 is RESLAG, a Reservoir Flood Routing Program. This program is capable of routing a flood through a storage area, with the

outflow initially controlled by pipe capacity and later by spillway capacity if the water level rises above the spillway crest. Any form of outflow is accepted; variable water surface area is assumed.

The program optionally supports a printer and/or a hard-copy unit. It will output time, infow, outflow, depth, area, and volume, along with maximum depth and outflow. The program will also plot input and output hydrographs.

In its present form, the Road Plotting Program is most useful for straight roads, but can be modified. Both will be upgraded for prospective customers. Both the Road Plotting Programs and the Reservoit Flood Routing Program may be purchased from Laurie, Montgomery, and Pettit Pty, Ltd. Their address is K.M.S. Building, 8-24 Kippax St., Sydney, N.S.W. 2010, Australia.

4907: Segmented Data Base Provides Fast Graphics Access

By Les Brabetz

(This is the second of three articles on using the new 4907 FILE MANAGER flexible disc mass storage unit as a powerful graphics aid.)
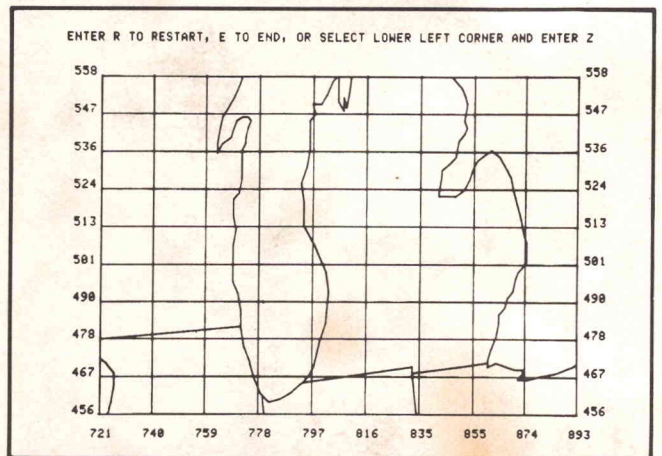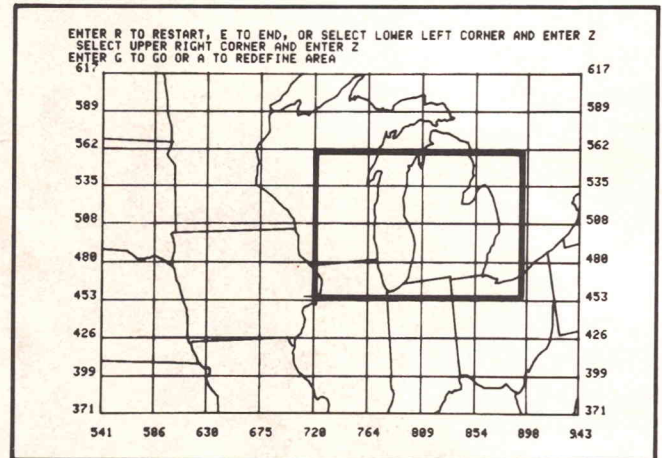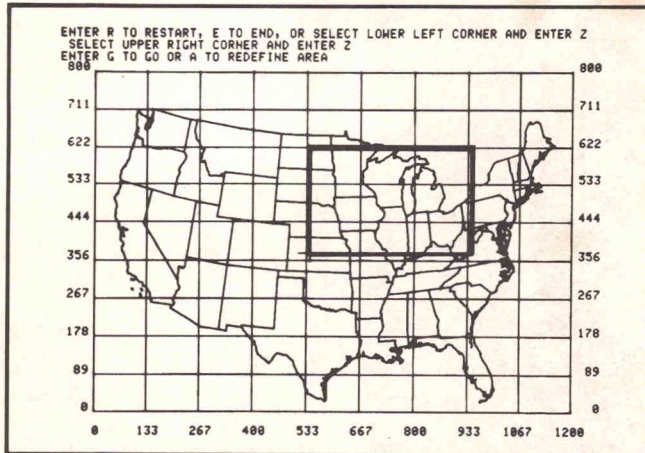
The article on segmented data bases in the previous issue of TEKniques (Vol 1 No. 10), described the use of a segmented graphics data base. The techniques discussed permit rapid display of portions of the data base rather than displaying the entire data base to view a smaller portion. Only those files (or segments of the data base) that are required to complete the display are read into memory and displayed on the screen. The ability of the 4907 FILE MANAGER to randomly access files allows the effective use of this data base technique. A file is created for each segment of a coordinate grid that overlays the entire data base. A rectangular grid was defined which varied in segment size to provide a reasonably equal density of vectors per segment. The segments generated with this grid defined some empty files, but was a much better distribution of vectors than a uniform grid.

This article describes construction of the segment files from the master data base file. Once the grid coordinates are defined, there are two possible ways of building the segment files. The first method is to digitize a portion of

Fig. 1. Default map of the United States with area selected for "zooming" (heavy rectangle).

Fig. 2. Map segment selected in Fig. 1 as displayed from segmented data base. Second "zoom" requested of Lake Michigan (heavy rectangle).

Fig. 3. Lake Michigan area as requested in Fig. 2 and displayed from segmented data base.

the data base into each segment file. Any vector which crosses the segment boundaries must end exactly on the boundary, and must end at the correct angle to intercept the vector approaching from the adjacent segment; this is quite difficult. The main requirement of the segmented data base is to provide vector continuity across segment boundaries. The second method, which was used to build the demonstration data base of the U.S. Map, is to take a large data base and select vectors to transfer to separate files. The problem of boundary vector continuity is overcome by calculating an intercept point on the boundary, and adding this point to the segment file.

The original data base of the U.S. Map consists of approximately 3000 X-Y coordinate pairs. Building a

segment file requires examining each point and determining which one of the following four conditions fits that point:

1. The new point and the last point are within the defined area.

2. The new point and the last point are outside the defined area.

3. The point is entering or exiting the area relative to the last point.

4. The last point was outside and the new point is outside, but the vector drawn between the points passes through the segment area.

Conditions one and two are the simplest case as the point is either stored in the segment file or discarded. Condition three requires the slope and direction of the vector to be calculated. Once these are known, the boundary intercept point may be determined. Condition four is the most elaborate solution as it requires determining the points of boundary intersection for both entrance and exit.

A rectangular definition of the segment was chosen to ease the calculation of the boundary intercept point. Once direction and slope of the vector is determined, one boundary coordinate is calculated and stored.

Determining the Boundary Intersection

Refer to the example in Fig. 4. Point P2 exceeds Y3, the maximum value of the Y range of the segment definition. A set of coordinate axes are placed on the point P1 and the quadrant of operation determined by the point relationship of P1 and P2. For this example, quadrant 1 is defined. The slope of the vector connecting P1 and P2 is used to determine which boundary will be intercepted.

If the slope of the vector connecting P1 and P2 is greater than the slope of the vector connecting P1 and P4, Y3 is used for a known boundary value. If the P1 to P2 slope were less than the P1 to P4 slope, then X4 would be used for the boundary calculation. X3 is calculated from the slope and the Y3 intercept value:

$$X3 = slope * distance + origin$$
$$= ((Y2 - Y1)/(X2 - X1) * (Y3 - Y1)) + X1$$

The boundary point P3 is added to the array and output to the segment file. Once the slope of the vector is determined and the boundary value known, the intercept coorinates are easily determined.

The coordinate pairs are read from the master data base file in the form of an array, and are output to the segment file in the same fashion. The output array is stored in memory until the segment boundary is crossed or until reading of the input array has been completed. If the entry array of vectors is outside of the defined area, no transfer occurs between the input and output files. The coordinate

transfer begins when a point is inside the area and ends when the array point crosses the boundary.

After the first attempts were made at using this file transfer technique, two enhancements were formulated. The first was to generate four quadrant files from the main data base and then to use them for the segment file creation. This reduced the amount of time to create the segments by reducing the amount of data to scan and test against the segment area. The second enhancement was to attempt an equal distribution of vectors among many small segments. Careful definition of the grid for the
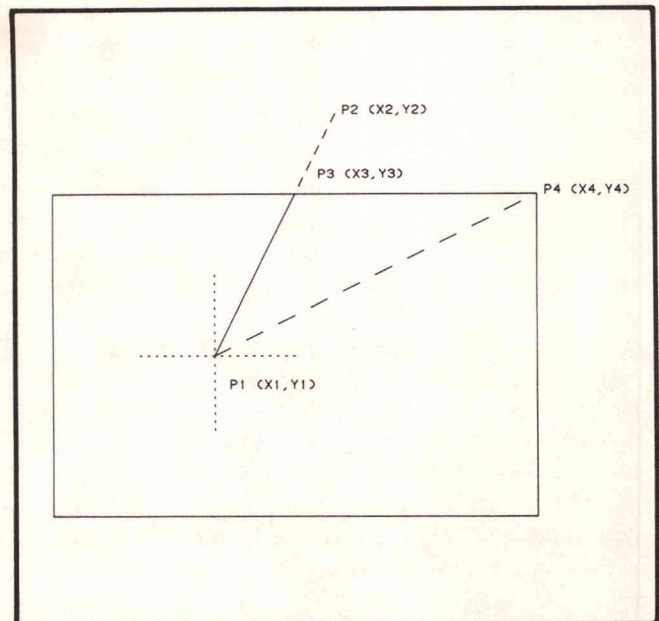
Fig. 4. Example of boundary intercept calculation for condition 3, vector exiting boundary area.

segments is important in both creation time and display time.

Approximately four hours were required to generate the segmented data base. No operator intervention is required as input files are selected and output files defined by the segment definition program. Once created, segments can be chosen and displayed in seconds. The program used for windowing will be documented and placed in the 4051 Applications Library.

The next article regarding the segmented data base will describe the selection of the segment files for building displays.

4907: Graphic Displays from Segmented Data Base

by Les Brabetz & Gary P. Laroff

(This is the third of a three-part article on the new 4907 FILE MANAGER intelligent flexible disc mass storage unit as a powerful graphics aid. The first two articles, in TEKniques Vol. 1 No. 10 and Vol 2 No. 1, described the concept and creation of a segmented data base using the 4907 FILE MANAGER. This article will complete the series by providing background summaries from the first two articles, then will describe segment file selection for creation of a display.)

A segmented data base stores a large, highly detailed graphics display in the form of X-Y coordinate arrays. The storage format is the number of coordinate pairs in an array followed by the coordinate pairs.

Initially, a data base exists. It is either computed and stored or digitized and stored. Such a data base consists of some number of arrays of DRAW commands. These could be continuous sections of a map. Islands off the coast would be separate arrays because a MOVE is required to get across the water. A good example of a typical data base is the map of the United States discussed in the first article in this series (TEKniques Vol. 1 No. 10) and reproduced here as Fig. 1. The disadvantage of such a typical data base is that it can only be accessed serially; that is, to see the information stored at the end of the data base, one needs to READ all of the earlier information.

In order to access the graphic data quickly, the data base is segmented into a number of rectangular sections, each of which is stored on the 4907 disc as a separate file. The program that does this was discussed in the last issue of TEKniques (Vol. 2 No. 1). The trick is to compute and store all points where the map crosses one of the straight "segment boundaries.". Any segment may now be called and the data read as quickly as any other.

In summary, each segment or portion of the display consists of a file containing, in theory, an equal number of coordinate pairs. Actually the number of pairs in an array may vary widely. Display or vector generation from the array is performed by MOVing to the first coordinate pair and DRAwing through the remainder of the array. Creation of these segment files is performed by scanning the master data base and selecting those vectors that lie within the defined portion of the display.

Once the segment files have been generated, a means of selecting and displaying the necessary files to build up a display is required. Each segment file is considered a separate entity, independent of the other files in the data base. These building blocks are selected and fit together to fill a defined area. The division of the map of the United States into 96 segments is shown in Fig. 2.

So now that we know how to create a segmented data base, how do we pick the data segments? Being numerical data, the segments have X and Y coordinates associated with each corner. If we then number the segments, we will be able to write a program that will convert minimum and maximum values of X and Y into segment numbers. More precisely, if we DRAW a grid with coordinates over our master data display, we can then enter minimum and maximum values for X and Y (defining the lower left and upper right corners of the rectangular segment, respectively) and have our program look up all of the graphic segments that make up the rectangle. Our looked-up segments will usually form a slightly larger section of the data base than requested.

Our program would then set the graphic WINDOW to the requested rectangle, READ the appropriate numbered segments and display them. Easier said than done? Not really. Let's go a little deeper.

Selecting the Display Area

The 4907 FILE MANAGER demonstration program, which displays the U.S. Map graphics data base, uses the graphics cursor to select the area to display. First the master data base file of the entire map is displayed. The user is requested at this point to select a rectangular area of interest. The graphics cursor is enabled through the POINTER command and the 4952 Option 2 Joystick positions the cursor. When the user positions the graphics cursor to the lower left corner of the desired rectangle, a key is struck on the 4051 keyboard to indicate selection of the location. This returns the X-Y coordinate of the location (in user defined window units) and the character struck. This process is repeated for the upper right corner. The upper and lower limits of the X and Y ranges are now defined. This is only one method of selecting the area. These coordinates could be entered from the keyboard, defined by an operating program, or any other appropriate technique to define the numerical range of interest.

Determining the Segments

The previously defined X and Y coordinates which delineate all the segment boundaries now reside in two
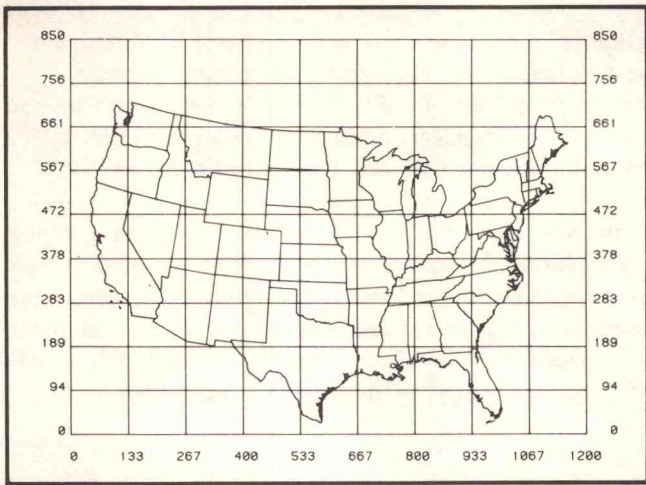
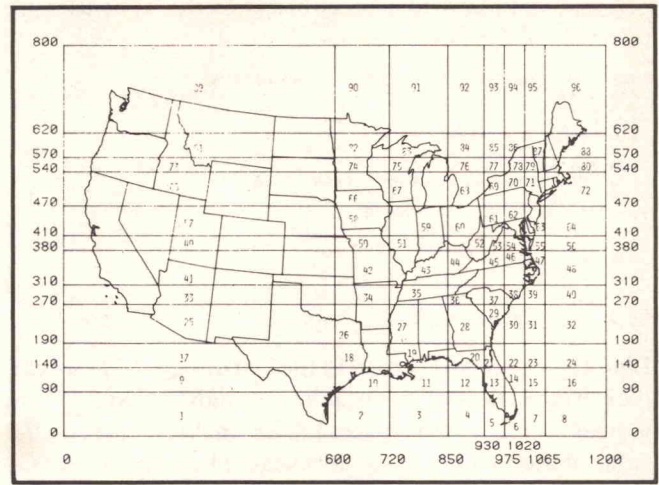Fig. 1.   Master file of digitized map with arbitrary grid values.

Fig. 2.   Map data base illustrating segment division lines and numbering scheme for identification of segments.

Fig. 3.   Example of segment numbering scheme and selection of segments required for a display.

arrays within the 4051 memory. Selecting the segment files is performed by comparing the range of interest with the segment boundary values and choosing the segment boundary values which encompass the range of the desired display. Most of the time the segments to be displayed exceed the defined display area, and the internal clipping features of the 4051 display (WINDOW and VIEWPORT) are used to limit the vectors being displayed.

A simple example will illustrate selection of actual segments. Each segment file is named to correspond with a location in the matrix in Fig. 3, e.g., SEG1 through SEG12. The data range to be displayed will be:

$$X_{min} = 150 \qquad Y_{min} = 50$$
$$X_{max} = 250 \qquad Y_{max} = 250$$

The segment files are chosen from the data base in the following fashion. First the X range is determined by comparing the minimum value with the array values. X(2) is selected as the segment boundary which is less than or equal to the minimum. X(4) is selected as the maximum segment boundary by containing a value greater than or equal to the maximum value. Y(1) and Y(4) are selected in the same fashion. We now know the X range of segments to be 2 to 3 and the Y range as segments 1 through 3.

Calling the Segments

Segments are selected by a row and column method with the row determined by the Y segment range and the column by the X segment range. Since 4907 FILE MANAGER segment files are selected by name, rather than by number, string variables containing the segment numbers will be constructed. First we will generate a master string, A$, which will contain all of our required segment numbers. Segment numbers will be separated
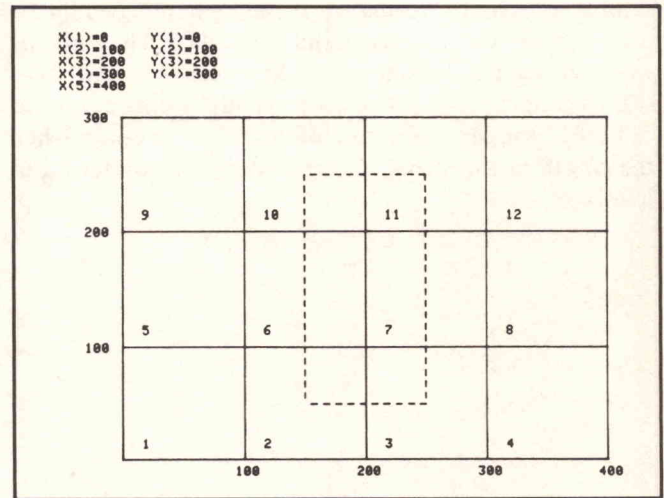
within A$ by a space. SEGMENT FILE NUMBER = (ROW – 1) * 4 + COLUMN.

```
1000 REM SEGMENT FILE SELECTION
1010 A$=""
1020 FOR I=2 TO 3
1030 FOR J=1 TO 3
1040 A=(J-1)*4+I
1050 B$=STR(A)
1060 A$=A$&B$
1070 NEXT J
1080 NEXT I
1090 END

PRINT A$
 2 6 10 3 7 11
```

When the above section of code is executed the string A$ contains the segment file numbers required to complete the display. The string values are separated by spaces which are used as delimiters when selecting the individual files. For the demonstration data base "SEG" was prefixed to the segment numbers. Thus segment 1 is called

11

"SEG1" and segment 12 is called "SEG12." The files are selected by this process:

```
2000 REM  SEGMENT FILE SELECTION AND DISPLAY
2010 C1=2
2020 A$=A$&" "
2030 C=POS(A$," ",C1)
2040 D$=SEG(A$,C1,C-C1)
2050 D$="SEG"&D$
2060 C1=C+1
2070 REM  OPEN AND DISPLAY SEGMENT FILE
2080 GOSUB 3000
2090 IF C1<LEN(A$) THEN 2030
2100 REM END OF DISPLAY
2110 END
3000 PRINT D$;"  ";
3010 RETURN

RUN
SEG2  SEG6  SEG10  SEG3  SEG7  SEG11
```

Line 2020 appends a space to the end of A$ so that we can pick off the last segment number. Variables C and C1 are used as pointers to the spaces present in A$. C takes on the value of the position of the next space in the string with C1 containing the position of the last space plus one position. D$ in line 2040 becomes the segment file number located between spaces. To complete construction of the file-name, "SEG" is appended to the segment number in line 2050. The filenames are printed to the screen in this sample program. Normally, these filenames would be used with an "OPEN" command to the 4907. The contents would be read and displayed to the screen. The end of file (EOF) condition would be used to end the data input and "CLOSE" the file. Operation of this program ceases when the length of the string is exceeded by the pointer C1 in line 2090.

The routines developed to perform all of the 4907 graphics data base demonstration will be documented and submitted to the 4051 Applications Library. The master data base of the U.S. Map, the segment files and the program to select and display the segment files will be available for use with the 4907 FILE MANAGER.

Now you have the best of all worlds. With the new applications software program the 4051 will interactively retrieve and display sections of complicated graphics data bases with ease and speed. Interactivity is assured by the 4952 Option 2 Joystick and intelligent flexible disc mass storage is provided by the 4907 FILE MANAGER.
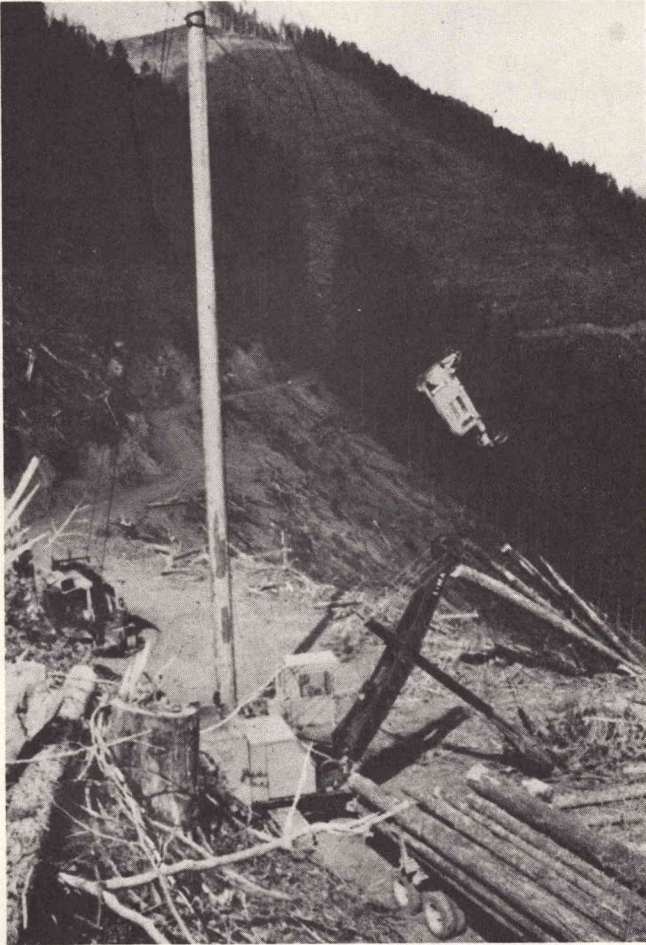
Pictured here is a logging operation going on at the Six Rivers National Forest using a suspended cable system called a Skyline. The location of the head-spar (tall pole) at the yarder machine and the maximum load of logs is computed using the 4051.

4051 Helps Plan Resource Use at Six Rivers

by Thomas C. Bruce
U.S. Forest Service
Six Rivers National Forest
Eureka, CA,
With Terry Davis and Pat Kelley

Demand for all kinds of resources is increasing the world over; forest resources are no exception. And sometimes the only way to manage that demand effectively is to reduce the time necessary to handle requests for those resources and accompanying services. At Six Rivers National Forest, the U.S. Forest Service is using a TEKTRONIX 4051 system to accomplish just such time savings in the management of forest resources.

It's a Big Job

The Forest Service of the U.S. Department of Agriculture manages land parcels across the United States. These lands include both forest and grasslands, and comprise a National Forest System. Forest System lands, in turn, produce a wide array of resources. The primary resources within the National Forest System are timber, water, forage, wildlife, and visual.

Six Rivers National Forest (Fig. 1) contains all of these resources. This area stretches from the Oregon border southward along the Pacific Coast. It's a long but narrow jurisdiction with many wilderness miles in it's boundaries. There are no major airports nearby, few minor ones. Many roads in the Six Rivers National Forest are primitive. Six major rivers within the region give it its name. Mad River, Klamath, Smith, Trinity, Eel, and Van Duzen Rivers. All are known for their excellent fishing, another example of the resources present.

Of course management of such a wide array of natural resources must consider the intensified concern for environmental quality along with the increasing demands for resources. The goal of resources management is to fulfill the needs and desires of the many National Forest users which include skiers, hunters, loggers, fishermen, ranchers, hikers and others. All of these uses must be coordinated with the given land capabilities. Requests for resource use must also be coordinated to long and short range programs that Congress and the Forest Service have agreed to. Such a planning process entails a lot of data handling.

Pressing Considerations

All Forest Service units are directed to develop a general land management program. The Six Rivers National Forest is in a unique position because of the controversies about land and resource use in the region, particularly regarding those giant trees, the redwoods. This has made it necessary to complete the Six Rivers land and resources plan by 1981. The plan must include environmental assessments, reports on physical effects of many possible ground activities, as well as predictions of social and economic impacts.

Formulating an overall direction for future activities requires planning for the future, "as we see the future now!". Public involvement is critical and hundreds of letters of opinion are being reviewed in preparing recommendations to Congress. Concurrently inventory assessments and demand forcasting are part of this planning process. The intent is to provide a long range, forest-wide planning system based on information that can be handled and retrieved in many ways. It is not possible to anticipate all the questions that will ever be asked. Such a system with its inherent public input is consistent with the Forest Service's long-standing
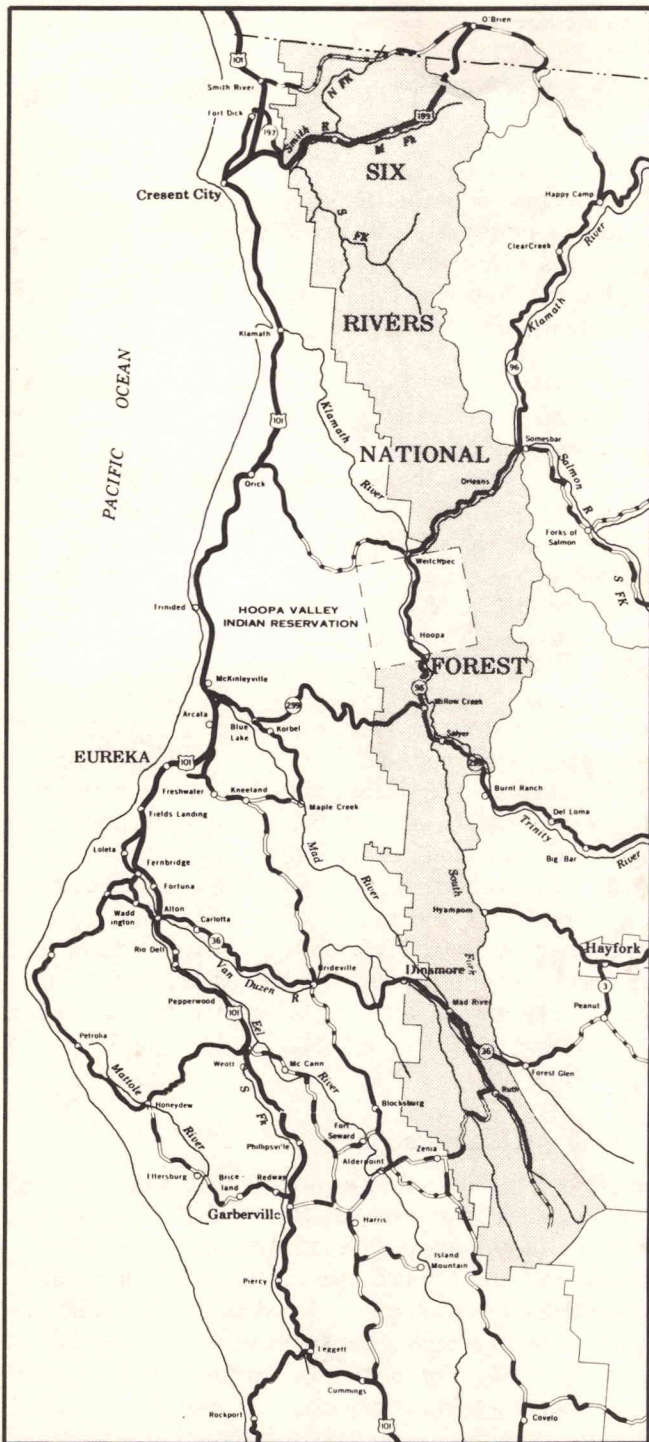
Fig. 1.   The Six Rivers National Forest encompasses 1,120,-657 acres in Northern California.

system based on the 4051 which includes a 4956 Graphic Tablet, a 4662 Plotter and several other peripherals (Fig. 2).

Fig. 2.   Tom Bruce is using a 4051-based system to aid in developing a land management plan for the Six Rivers National Forest.

This system is accessible and set up to operate by forest resource specialists. These people are not necessarily technicians; their expertise is in their unique knowledge of the ground situation, functional skills, and the judgments necessary to analyze problems and develop solutions utilizing an information base that they develop and control. This data is not an end product, but rather the basis for providing visual displays, computer parameters, or simply lists of related resource inventories.

One information base is being assembled by Bruce Marcot, a wildlife biologist with the Fisheries and Wildlife group, and Jim Rogers, who has done the actual programming. They will look at some 400 vertebrate species in the Six Rivers Forest — mammals, amphibians, reptiles and birds. Each animal's response to successional changes in vegetative types from grassland to old growth trees will be examine and correlated with the vegetative data of Northern California. The related effects on breeding, feeding, nesting, season of use, territory size will establish the expected natural life history of each animal. For example, if an animal needs a minimum five acre patch of grassland surrounded by old growth forest for summer forage, we can pretty well infer that the animal will be missing from a two acre patch of grassland surrounded by a young stand of Douglas Fir. Similar files will be set up for fisheries with key stream habitat factors.

This biological information base was originally punched on cards and later transmitted to the 4051 using the new TEKTRONIX 4051C01 high speed interface which is being tested at Six Rivers. All of the data is very soft, and depends on the careful eye of the field biologist who still must authenticate many of the key habitat relationships. The 4051 is used as a tool for aiding, not replacing personnel. Once the data has been verified it will be sent to a remote UNIVAC 1142 computer at Fort Collins, Colo. for general use.

management concept of Multiple Use and Sustained Yield. These Congressional directions are intended to provide the maximum benefits for the greatest number of people, now as well as in the future.

4051 a Useful Tool

As demand for more detailed information continues to increase, the Forest Service has had to find new tools. At the Six Rivers National Forest, one of these new tools is a

With these information bases on hand, inventories will be accessible before ground activity is started. We envision a resource specialist utilizing a broad range of informational elements before going into the field. Environmental analysis reports can be easily generated which determine the impacts on wildlife or timber production, for example. This information will not only assess what adverse impacts a particular land use might have but also what may benefit (Fig. 3). The system will look at all mitigating actions and their trade-offs.

Fig. 3. A trial run from the biology data base shows that thinning a timber stand would benefit the screech owl and saw-whet owl. However, it would destroy the breeding and nesting habitat of the spotted owl which has a legal status.

Field Design Programs

The system is being designed to be user oriented. The ability to display questions and responses in terms that a biologist, logging engineer, or landscape designer understands provides a tool that the field design specialist needs. A package of field design programs is also available including Skyline Analysis (S.A.P.) and the Perspective/Stereo Projection Programs. These two programs were developed from research at Oregon State University and the Regional Forest Service in Portland.

Many forest habitat areas have critical ecological environment, for example, areas with thin soils or near stream sides. This means that logs cannot be harvested by dragging them across the ground. They must be entirely lifted or "flown". In Fig. 4, note the head-spar and tail-hold locations. In logging operations logs are brought up the side of a slope from the tail-hold to the head-spar where the yarding system is located. At the yarder the logs are collected and shipped to the mill. Of critical interest is the positions of the head-spar, tail-hold, road locations, cable size, and allowable cable tensions for a given yarder system. All of these parameters change as each portion of the ground is cut and logged. Besides the ecological impact logging would have, the economical feasibility must be considered. A logging road may have to be built on a ledge to haul out the logs with less environmental impact, for example.

At Six Rivers the logging specialist, Bob McRae, is using the TEKTRONIX 36" X 48" graphic Tablet to measure

hundreds of ground profiles for analysis using the 4051. Previously we had to estimate a particular configuration using a "chain and board" method—and hoped it worked.
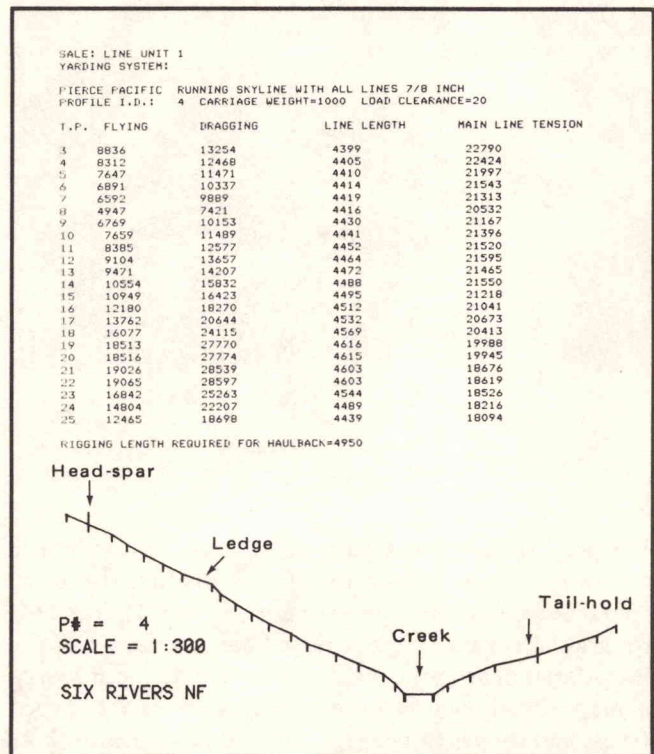
Fig. 4. A profile of a proposed log loading area, with alternative flying and dragging loads.

It usually took 45 minutes for the solution that may have to be re-worked with different factors. It now takes about 30 seconds for a solution on the 4051. Now over 85 profiles, plots and tables, listing allowable load productions can be made in an eight hour day. We are not using district personnel, those closest to the field situations, to run their own analyses with similar equipment.

It is usually very difficult to tell how land will look after it has been cut or treated (not all timber is clear cut, as timber production is usually increased by thining). It is even difficult to tell by just looking at a map or by standing at a site looking at the proposed treatment area. In the past, photographs of the proposed activity were used to develop sketches which would show trees, roads or whatever changes might be planned. Often the photos were difficult to interpret and the sketches were inaccurate.

Ward Blackburn is the landscape architect at the Six Rivers National Forest and the prime mover in getting a 4051 system there. Blackburn cites clear cutting of timber for ski slopes as one example of an extreme visual impact. When clear cut areas are shaped to the natural lines and slopes of the area, their visual impact can become complimentary for recreational users as well as to optimize animal habitat sites.

Fig. 5.   Clearings for ski runs above the parking area follow form, line and texture of the natural landscape. (From "National Forest Landscape Management, Volume 2," Page 30, U.S. Department of Agriculture Handbook Number 462.)

Perspective/Stereo has been developed to provide field design specialists with a tool for evaluating the visual characteristics of a proposed treatment area. They can use the graphic tablet to digitize ridges, contour lines, cut-unit boundaries or any other land feature that can be drawn on a map. Other picture information, such as tree types, poles, and towers can be digitized and plotted along with the terrain data. The program can produce a scaled perspective view or a stereo plot (Fig. 6) from several critical viewing points. Looking through the stereo viewer, its very simple to see if a proposed cut or road lies across a sensitive area. Many actual boundaries have been altered because of this. It is done rapidly, accurately, and doesn't require running out to the site to check.
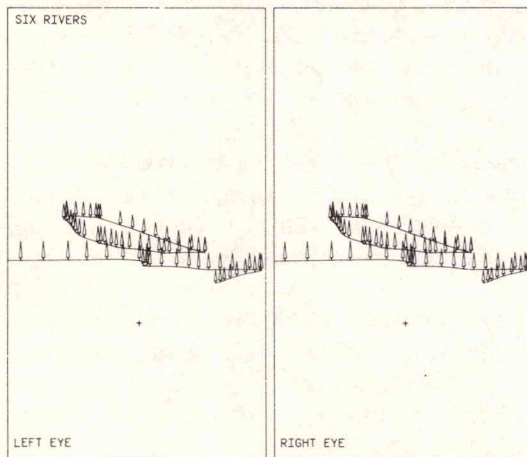

Fig. 6.   Plots for use under the stereo viewer. Note the taller trees on the closer ridges.

Land Mapping Program

The Land Mapping Package is at the heart of the system. It pulls all of the various inventories and applications together by utilizing a common data structure. The Forest is divided into large "management compartments" and each compartment is sub-divided into "land-type polygons". Functional resource specialists then lay out their resources on these compartment maps. Their main concern is to be able to generate a summary of characteristics for various combinations of polygons. The program can selectively plot single or aggregated areas, compute areas, and can plot overlays of various resource layers including linear features such as stream and road networks. Fig. 7 shows a plot from the Land Mapping Package.
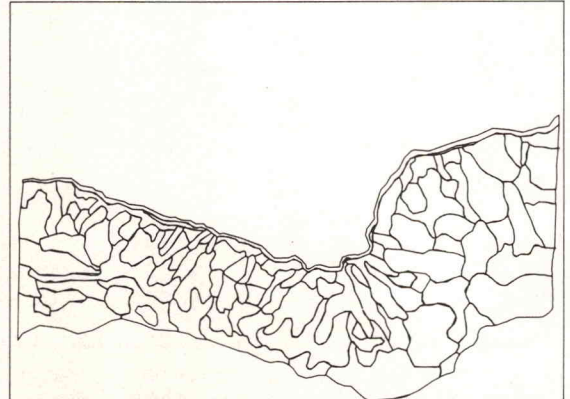

Fig. 7.   Management compartments are broken down into polygons of resources.

These maps will show where streams and roads are in relation to timber stands, for example. If a main road is being proposed, other specialists must know what's there before a work plan can be developed. Past work is examined to prevent placing one clear cut next to another. The system shows the results of a particular action before it is even put into motion.

Much of the system's local intelligence resides in the graphic tablet itself. The menu-type control pad (Fig. 8) on the tablet is the key to the use of the tablet. This pad can be placed in any position convenient to the user. By digitizing its corner the 4051 "knows" the pad's location and therefore the location of the characters and control functions within the pad. This allows users to digitize, label and control the digitizing process using maps and field notes that they're used to.

Fig. 8.   The control pad for the 4956 allows the user to concentrate on his mapping task.

The specialists attention is on the map. He is thinking about what is in front of him and doesn't want to break his

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train of thought by having to turn his attention back to the computer system. The pad can be used to enter a descriptive label for each feature without having to type it in. Simply hitting the alpha pad spells out the label. In addition, four digitizing functions are included for measuring a contour map: uphill, level, downhill, and change contour interval.

The pad also contains several error correcting functions; you can backspace or delete a series of previous points. Or, if you have digitized 10 points and found that you were going downhill instead of up, you can redo from the beginning of the downhill journey instead of having to backspace those 10 points to wipe them out. Also an automatic labeling and re-draw function have been provided.

The 4051 system is aiding Six Rivers National Forest personnel in a complex and pressing task. Current efforts to build the plan and meet the deadline prevent sparing manpower to help others build a similar system. Like the Forest Service Fire Lab (TEKniques Vol. 2, No. 2) we wanted to share our application in hopes that it may help others define and develop similar plans to solve comparable problems.
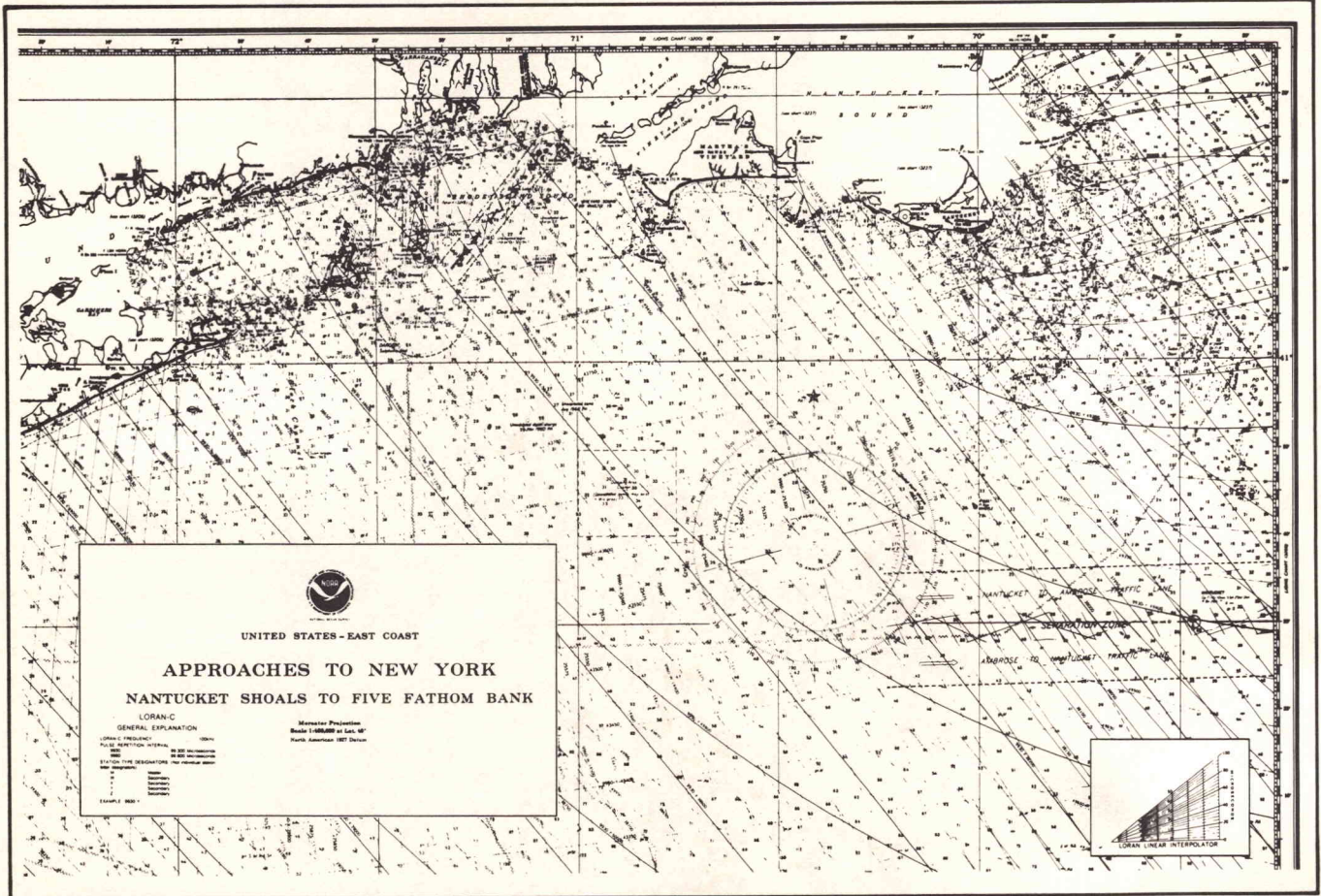
A LORAN-C chart correlates radio signals transmitted from special shore transmitting stations to a ship's position. The DOT Transportation Systems Center in Massachusetts is assessing the usefulness of LORAN-C for on-land site location using the 4051 Graphic System as the experiment controller.

A Recent Development in LORAN-C Data Acquisition, Aided By The 4051

by Peter Mauro
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The use of LORAN-C systems, or LOng RAnge Navigation systems, has grown in the past decade as a valuable aid to maritime navigation. Its users range from supertankers to small fishing craft. Now the Transportation Systems Center of the Department of Transportation (DOT) is evaluating the usefulness of LORAN-C for on-land site location and registration, and for Automatic Vehicle Monitoring (AVM). This research is being sponsored by the DOT's Research and Special Programs Administration, to see if the LORAN-C maritime locator can be used to pinpoint, say, an accident location for emergency vehicles (among many other projected uses).

To perform this experiment, a data acquisition van has been designed using the 4051 Graphic System as the experiment controller (Figure 1).

What is LORAN-C

LORAN-C is a pulsed low-frequency hyperbolic radio-navigation system. It derives its high accuracy from time difference measurements between pulsed signals, and from the inherent stability of low-frequency propagation over seawater. It has developed in recent years as a highly accurate maritime navigational aid.

Hyperbolic navigation systems operate on the principle that the time difference between the arrival of signals from two secondary (slave) stations, observed at any point in their coverage area, is also a measure of the distance to each of the stations. The LORAN-C primary (master) station serves as a master time reference, eliminating the need for an on-board precision clock to

Expanding Onto Land

The expanding LORAN-C grid on both the East and West Coasts, along with the possible addition of a mid-continent chain, has made LORAN-C position location available to a larger user group than the maritime community it was originally designed to serve. In addition, new LORAN-C receivers with advanced microprocessor technology are smaller and lighter, and capable of improved operation in the difficult environments found in large cities, near power lines, etc. These factors have generated interest in a number of potential applications.

One example of a potential use is in state traffic departments. Using LORAN-C, an accident site on a highway could be precisely identified to direct rescue vehicles. The same information could be used to accumulate a data base for future traffic pattern studies. Police units could use LORAN-C coordinates to direct officers in rural areas. Conversely, the system could be used in Automatic Vehicle Monitoring, where an officer's location and status might be transmitted to a dispatch location in a high-crime area. Another example of a unique terrestrial application of LORAN-C is in population location information gathered by the Census Bureau in remote areas where no address is possible.

All of the above examples depend on the reliable and repeatable precision of LORAN-C coordinate data, over both short and long periods of time (minutes or years). The Department of Transportation experiments described here are designed to determine variations in terrestrial LORAN-C data. Long-term seasonal changes due to ground conductivity (fluctuating because of the moisture content) are being checked, along with short-term jitter from man-made and natural interference. The van shown in Figure 1 is a mobile data collection facility that can be driven along a roadway while recording LORAN-C coordinates, odometer-measured distance, and time, all on tape as raw data. The on-board 4051 Graphic System then performs statistical analysis of the data while enroute, enabling a quick look at experimental results before terminating a test run.

The Experiment

The experiment is designed to automatically collect data about the variation of LORAN-C coordinates with time, along a given highway. The route will be traversed many times during the course of the experiments; about 5000 data points are collected during each run. Manual data recording would be tedious and error-prone. Hence, a method of collection, recording, and reduction under computer control was designed, using the 4051 as the controller. And the 4051's graphic display permits easy comparison of data from multiple runs over the same route. Data must be collected over a period of time to verify a predictable drift in coordinates due to seasonal effects. Suitable correction can then be made for the seasonal effects.

Fig. 1 Traversing the highways with their mobile data acquisition van, which includes a 4051 Graphic System, the U.S. Department of Transportation is evaluating the use of LORAN-C signals for on-land site location.

measure time difference. All of the points that have the same observed difference in distance from a pair of stations defines a hyperbola, called a Line of Position (LOP). The intersection of two or more LOPs precisely defines the position of the LORAN-C receiver.

The accuracy of any hyperbolic navigation system depends on the observer's ability to measure the difference between the arrival time of two signals, and the observer's knowledge of the propagation conditions. This latter information allows the measured time differences to be converted to LOPs.

The basic *limitation* on accuracy is knowledge of the velocity of radio wave propagation (about one foot per nanosecond). To achieve accuracies of ten to hundreds of feet, time measurements must be accurate to from ten to hundreds of nanoseconds. Also (and especially important to terrestrial uses), the propagation condition must also be reliably predictable to ten or hundreds of nanoseconds. Since the velocity of progagation will vary with seasonal changes in ground conductivity, considerable investigation will be required before time delays can be reliably predicted for terrestrial use.

The Equipment

Figure 2 is a block diagram of the equipment configuration; the actual equipment is shown within the van in Figure 3. There the 4051 can be seen as the system's automatic controller, operating from a "real-time" BASIC program stored in 30K of RAM. Data sampling occurs at a four-second repetition rate, on command from a LORAN-C receiver. All data is loaded in parallel to a shift register that can accommodate all sources simultaneously, assuring accurate tracking of distance, time, and LORAN-C coordinates.
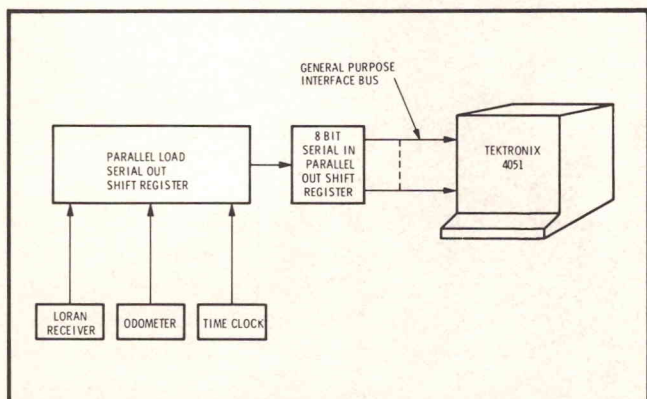
Fig. 2 LORAN-C experiment configuration.

The equipment operates in the following manner: during the four-second interval between sample commands, the data is formatted into eight-bit bytes and transmitted over the GPIB to the 4051. The 4051 then processes and records the data before the next sample command; recording on magnetic tape allows further analysis back in the lab. The software allows the operator to control navigation system mode, data gathering memory, inspection, and other system functions, all through User Definable Keys. This makes the complex, advanced test system simple and easy to use.

Fig. 3 The 4051 Graphic System controls data acquisition in the DOT van. LORAN-C receivers acquire the signals.

Data Reduction and Presentation

The Northeast Coast chain has four operational secondary stations; they're located at Caribou, Maine; Carolina Beach, North Carolina; Dana, Indiana; and Nantucket, Massachusetts. The master station for this chain is located at Seneca, New York. The two secondaries whose LOP's cross the Boston area at nearly right angles are Caribou and Carolina Beach. The Nantucket transmitter provides an exceptionally strong signal, but those with optimum crossing angles are preferred.

The data shown in Figure 4 is displayed in tabular form on the 4051 Graphic System screen. This allows the results to be monitored during the progress of the experiment.

Fig. 4 LORAN Experiment Data.

In the table, the first two columns are the time difference measurements, in microseconds, between the master station and secondary A (TDA) and secondary B (TDB). Column three is the odometer-measured distance to one-hundredth of a mile. (Note that a stationary vehicle produces a reading of zero.) Column four is the odometer readout in feet; it appears on the data printout and on the odometer electronic display simultaneously.

Columns labled Alarm 1 and 2 are status indicators for the LORAN-C receiver. A number is displayed for every possible operating mode of the receiver; Alarm 1 is associated with TDA and Alarm 2 with TDB. The indicator number may range from one to 128 to show the status of the transmitter or receiver equipment. In the example shown, the number 4 indicates that both transmitter and receiver are working correctly.

Preliminary Results

A pilot demonstration was conducted to 1) gain an understanding of the concept of relating accident locations to highway characteristics; 2) verify the procedures for linking accident locations to highway

characteristics using LORAN-C; and 3) demonstrate the usefulness of LORAN-C coordinates for location identification.

This pilot experiment was conducted in Columbia County on Routes 23 and 9 near the town of Hudson, New York, during the fall of 1977. Data was recorded manually and reduced manually at a plotting facility of the Transportation Systems Center. The pseudo road map in Figure 5 was generated there. The map approximates the actual highway along which the data was collected, but the jitter in the lines clearly indicates that some form of smoothing is required. The scale is approximately one nanosecond per foot, which is 50,000 feet (9.4 miles) between Lines of Position.
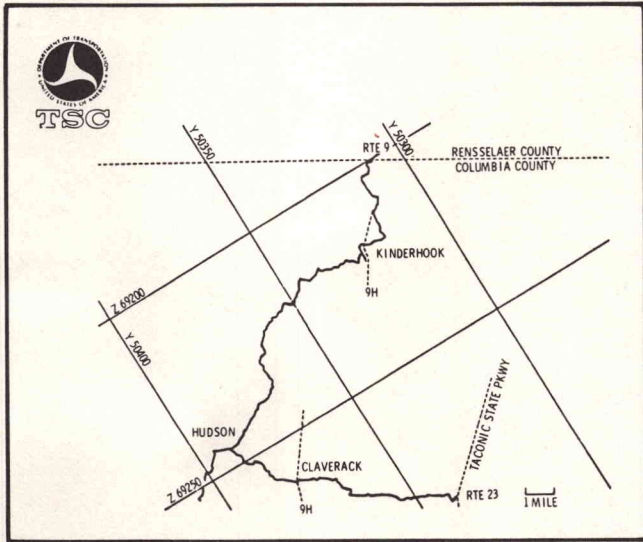

Fig. 6 LORAN Experiment—Boston Area.

Fig. 5 LORAN-C Pilot Experiment—New York

More Plans

The results of the pilot experiment encouraged more-detailed investigation into terrestrial use of LORAN-C. The 4051-based system now in use makes the data gathered more immediately useful through real-time analysis and reduction. Real-time monitoring, along with graphically displaying key variables in navigation data, allows the test procedure to be modified on the spot, depending on the results observed.

Figure 6 is an example of a pseudo map generated on the 4051 while enroute on Highway 93 in the Boston area. For this experiment, the old East Coast LORAN-C stations were chosen (Dana, Indiana, and Nantucket, Massachusetts, with the master station located at North Carolina). These secondaries give a less-than-perfect right angle crossing, but are adequate for the initial trial. As this experiment progressed, it quickly became clear where LORAN-C reception was difficult. Scale on this map is 5 microseconds between grid lines, or approximately 5,000 feet.
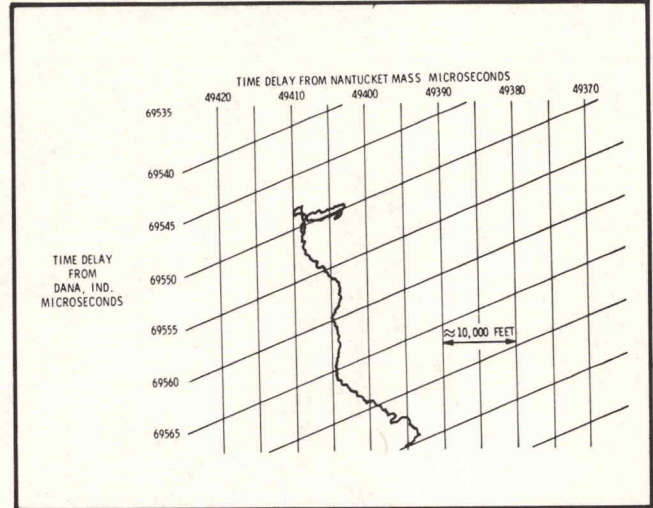
The 4051 software support programs enable complete statistical analysis of the data collected at a fixed location, including mean, variance, standard deviation, skewness, kurtosis, etc. But the data collected in this experiment is deliberately not stationary, and some form of smoothing is required.

Programs are currently being investigated for the mobile data, where samples are averaged and subtracted from a straight line, to display a smoothed curve that approximates the highway as shown on a road map. Hard copies of the pseudo road maps generated for each run will show shifts in the LORAN-C grid when superimposed on a light table. Tabular results will enable a correction factor to be developed for seasonal changes, if necessary.

Many other potential uses for LORAN-C are also being considered for investigation; this research will be the basis for future developments. And at the heart of the data gathering and evaluation process is the 4051 Graphic System, making the system easy to use and, through immediate graphic feedback, quick to evaluate.

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