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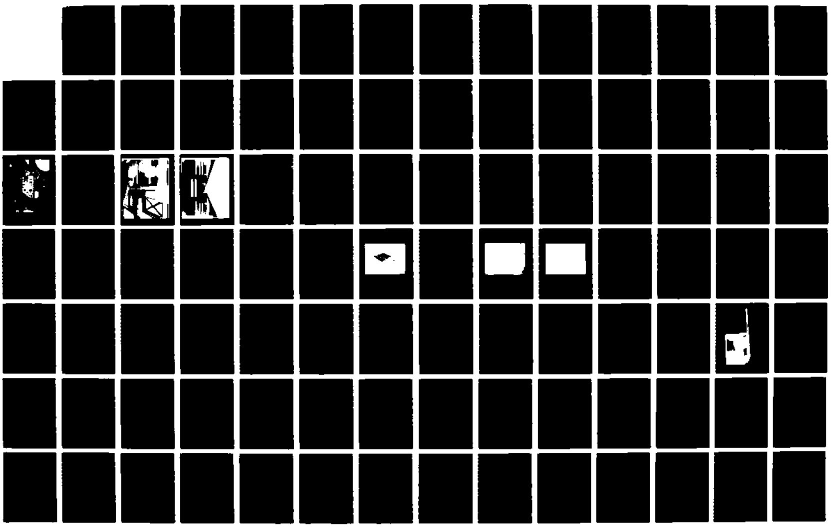

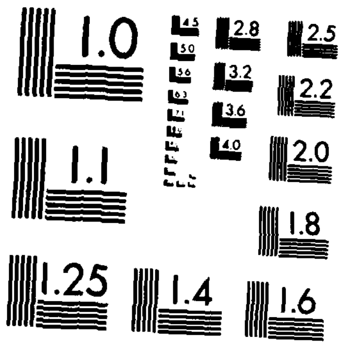


MICROCOPY RESOLUTION TEST CHART
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Final Technical Report PFTR-1033-80-1
Contract No: MDA903-76-C-0241
January 1981

# AUTOMATED TACTICAL COMPUTER MAPPING SYSTEMS

JAN SMOOT
GERSHON WELTMAN
AZAD MADNI

Prepared For:
DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
Systems Sciences Office
1400 Wilson Boulevard
Arlington, VA 22209



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| Flat Keyboard | Movie Map | Talking Map |
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| Interaction | Speech Synthesis | |

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This report presents the results of a two year research and development program aimed at exploring the use of computer-generated pictorial maps. The work reported on is designed to explore problems and techniques associated with the automatic production, storage, and display of three-dimensional color views of a locale. To produce large quantities of visual representations an appropriate digital data base of cultural and terrain information is first transformed into a useable description of the area of interest, desired viewpoints are defined, images are generated, transferred to videodisc, and

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finally displayed under user control using either the Map Store or the Talking Map display system.

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# 1. INTRODUCTION

## 1.1 Summary

This report presents the results of a two year research and development program aimed at exploring the tactical use of computer-generated pictorial maps. The work reported on is designed to explore problems and techniques associated with the automatic production, storage, and display of three-dimensional color views of a locale. To produce large quantities of visual representations an appropriate digital data base of cultural and terrain information is first transformed into a useable description of the area of interest, desired viewpoints are defined, images are generated, transferred to videodisc, and finally displayed under user control using a specially-engineered map delivery system.

Section 2 outlines background information on past studies, and software development and selection. Various problem solving approaches were taken in the subtasks of the problem and are described in detail in section 3. Section 4 provides some conclusions of the research study.

## 1.2 Problem Statement

Accurate and efficient map interpretation is essential in nearly all phases of military planning and operations. Much of the research into map design and training procedures is intended to overcome the fundamental problem of visualization, that is, seeing the abstract display and forming a useful mind-picture of the situation. Studies have shown that more information can be learned and retained about a geographic area from simulated three-dimensional representations than from conventional flat maps (Ciccone 1978).

Computer-based display systems are a natural and effective method of presenting computer-generated, three-dimensional, full-color visualizations of a locale. In addition to the traditional static overview, sequences of images can be linked to provide a user-controlled dynamic view of an area. The viewer is free to acquaint himself with the spatial layout of the terrain and its accompanying cultural features via ground or aerial pathways.

The following blend of mapping data is collected and provided to assist the user:

(1) Orientation cues.
(2) Distance measures.
(3) Three dimensional representations.
(4) Conventional map displays.

These components are integrated to allow the user to:

(1) Control movement in a dynamic environment.
(2) Relocate quickly by street name, intersection, or distance.
(3) Have constant access to location information.

Additional interesting enhancements to such a mapping system would include:

(1) Voice feedback to aid in user location and orientation.
(2) Touch sensitive interaction to the system.
(3) Access to landsat, aerial photography, and specialized displays.

## 1.3 System Overview.

The exploration of alternate mapping strategies involving the production, storage and display of three-dimensional computer-generated mapping information has required both software and hardware development. To produce the end display system which would provide alternatives to conventional map usage, a series of processes was required. As outlined in Figure 1.1, a data base of locale information is fed through the picture production process which produces digital descriptions of video images. These images are then processed and transferred onto videodisc for display on a display system.

Two major data bases were utilized in our mapping explorations. One, a data base of the fictitious town of Dar-El-Mara, was custom designed, and then digitized. The other set of data was drawn randomly from an existing data base of Richmond, VA. These two data sets have various qualities which will help illustrate the use of this type of tactical mapping system. The area of Dar-El-Mara is a small, confined town with a broad range of features, such as an apartment building, a government complex, an airport, a train station with accompanying paraphernalia, a residential section, and market area. This type of data source can provide greater flexibility for illustrating different surrogate travel techniques due to the limited size of the digital descriptions and subsequently short picture production times. A realistic place, on the other hand, offers additional opportunities. Since any type of video image may be stored on a videodisc, additional road maps, and filmed ground views were added to the store of computer-generated pictures to provide a multidimensional representation. Scenes which were to be computer-generated were defined and produced for both areas.

A collection of mapping images was assembled; computer-generated ground and aerial views, accompanying street maps, and color film sequences were taken

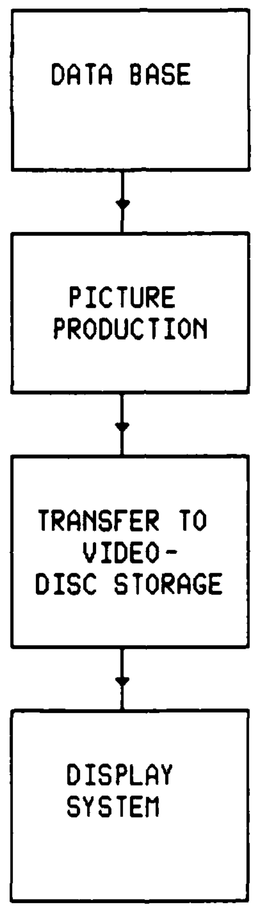



FIGURE 1-1.
SYSTEM OVERVIEW

at ground level along streets. All of these images were edited onto film and delivered to a mastering facility for transfer to videodisc.

Once the desired images were stored on disc, they were then available for display on a map display system. Two display systems were developed. One display system, the Map Store Unit, was designed and engineered to be a self-contained desk-top display device. Its primary design goals were compactness and simplicity within a typical military field package. A videodisc-based computer controlled mapping system provides a flexible presentation vehicle for a wide range of materials.

The main components of the Map Store display unit are:

(1) Color TV Monitor.
(2) Mini-Floppy Disk Drive.
(3) Microcomputer System
(4) Control Interface
    (a) Joystick
    (b) Keyboard
    (c) Special Purpose Buttons

Additional interests were generated concerning a display system so a totally separate second display system was developed. A mesh of ideas was incorporated and resulted in a system which allows the user to interact with the system through a hand held touch panel, and provides computer-generated narration along with the video images. This system is supported by a time-shared minicomputer, and no component integration was attempted; rather, efforts were concentrated towards the voice and touch interactions.

# 2. BACKGROUND

## 2.1 Map Performance Improvement with Computer Generated Movie Maps.

2.1.1 Overview. Perceptronics conducted an experimental study which examined the use of computer generated movie maps as a substitute for conventional maps in basic map performance tasks. To conduct the experiment a prototype movie map, a sequence of computer generated views linked to form a tour, of the fictitious desert town of Dar-El-Mara was produced. Forty-five participants were tested for (1) the comparative effectiveness of the computer movie map versus a conventional map in teaching the map user about Dar-El-Mara; and (2) the effect of movie map display size on performance effectiveness. The study showed that the computer movie map significantly improved map performance, and display size was relatively unimportant.

2.1.2. Prototype Movie Map. Rather than find a real place with all the desired attributes, a fictitious town, Dar-El-Mara, was designed and modeled. The display generation of the tour through Dar-El-Mara was conducted by the Mathematics Applications Group Inc. (MAGI) using their Synthavision system. This system allows creation of realistic color imagery of scenes consisting of user defined objects. These objects are composed from a selection of standard geometrical shapes. A seven minute movie sequence was produced with narration and landmark identification enhancements to increase user comprehension. The tour was structured to include overviews, freeze frames, and alternate ground-level "driving" and aerial "flying" which obeyed logical restrictions.

2.1.3 Testing, Results, and Comments. Utility of the movie map was tested against a conventional map to measure two navigational skills, self localization, and spatial relations, and topographical knowledge.

Three groups of subjects; map-only, map-movie, and movie-only, were evaluated over three study sessions.

Overall comparisons indicate that computer movie maps are clearly superior to conventional hardcopy displays. Movie map subjects performed significantly better on every test measure. The difference was particularly striking with regard to spatial relations. Display size appeared to have only a marginal effect on movie map effectiveness.

The test highlights the potential of using realistic portrayals of an area to convey mapping information. In addition, by allowing the user to preview an unfamiliar destination in a natural way, no special skills are required. Once the concept of the computer movie map had been established, questions were raised about their utility in real situations. Where would the data come from? Through what mechanism would imagery be produced? How would the user access the scenes? How would the information be displayed? These are the types of questions which were tackled during this project.

## 2.2 Picture Production Systems.

2.2.1 Overview. Developments in computer graphics systems have made it possible to synthesize full color, shaded, hidden-line and hidden-surface removed pictures. Two ARPA contracts, one with Evans and Sutherland Corporation (E&S), and the other with Mathematical Applications Group, Inc. (MAGI) have produced software systems which can be used to generate such visualizations from digital representations of geographic information. The end results of the two systems are similar, but the methodologies and data requirements are quite different.

2.2.2 Evans and Sutherland (E&S) System. The E&S system may be viewed as a set of interactive software tools and associated hardware with which an experimenter can manipulate and control a digital data base. Two forms of visual display and several types of interaction are available to the user, as shown in Figure 2-1. With the E&S system, the user can see the data base displayed calligraphically, in a color-shaded or line representation with hidden-surfaces or lines removed. The difference is a function of generation time. The calligraphic displays are generated on an Evans and Sutherland Picture System II, a vector graphics terminal with its own display processor which has special hardware for rotating, translating, scrolling, and transforming images in real time.

Full color "photographic" views of the data base can be generated, but not in real-time. These pictures can be created in two ways. Single full color hidden-line removed pictures can be requested by the user at any time during their real-time flight through the PS II wire-frame world. Real-time travel is interrupted while the system generates the picture. Depending on the complexity of the scene (i.e., a direct function of the number of points and line segments) this process may take from 2 to 30 minutes. An entire movie can be created by recording a scenario of the user's interaction with the data base while using the calligraphic system. The scenario, a set of movements through the data base describing object and eyepoint motion, can be converted one frame at a time into a full color movie for the purposes of filmmaking or verification.

Three modes of operation are possible with the E&S system. In the first mode, the user can specify how and at what time objects in the data base begin motion. This permits the creation and control of dynamic objects. For example, a user could define the time, position, and movement of a tank independent of the user's own viewpoint and motion. Another mode of operation allows the user to "fly" interactively through the data base. In this mode, the user's motions can be recorded for playback at another time. An interactive graphics tablet is used to control object of eye-point motion. A third option open to the user consists of a combination

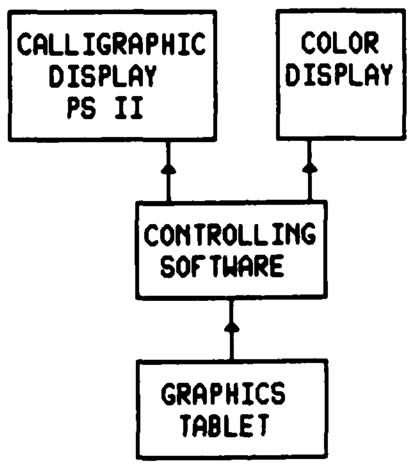



FIGURE 2-1.
EVANS AND SUTHERLAND SYSTEM OVERVIEW

of the first two modes. Under this mode of operation, a background scenario plays while the user controls his eyepoint position or some other system parameters.

2.2.3 Mathematical Applications Group, Inc. Like the E&S system, the MAGI Terrestrial Visualization System (TV System) is designed to generate realistic color images of scenes containing natural and man-made features against a natural background. Shadows produced by color illumination may be included in the scene. The TV System in its present configuration is a series of interrelated operations, but it is not interactive.

The system is designed around a data base with five libraries which can contain terrain, tree, forest, camouflage, and object data. For each type of data a separate preprocessor manages the creation, modification, and deletion of its library elements. To create a picture with the TV System the user then selects the desired components from the libraries, scales, orients and positions them in the scene. After the scene is assembled, the user then enters a series of commands in a director's language to control the movement of a simulated camera through the scene. Parameters for camera position, focal length, and movement sequences are also user specified. Figure 2-2 gives an overview of the TV System.

The primary technique used to generate images is ray tracing. Specifically, straight lines in space are traced from the simulated camera position through assigned directions in space. When a ray encounters an object, its identity, distance, and surface normal are recorded. Because of the program size, ray tracing is carried out separately for each of the scene components; that is, the image processor generates the completed image by scanning the scene for each scene component. Each scan generates a contribution to the full image, and merges it with previously produced image information. During this phase of the operation, the distance to the object surface is retained as part of the image

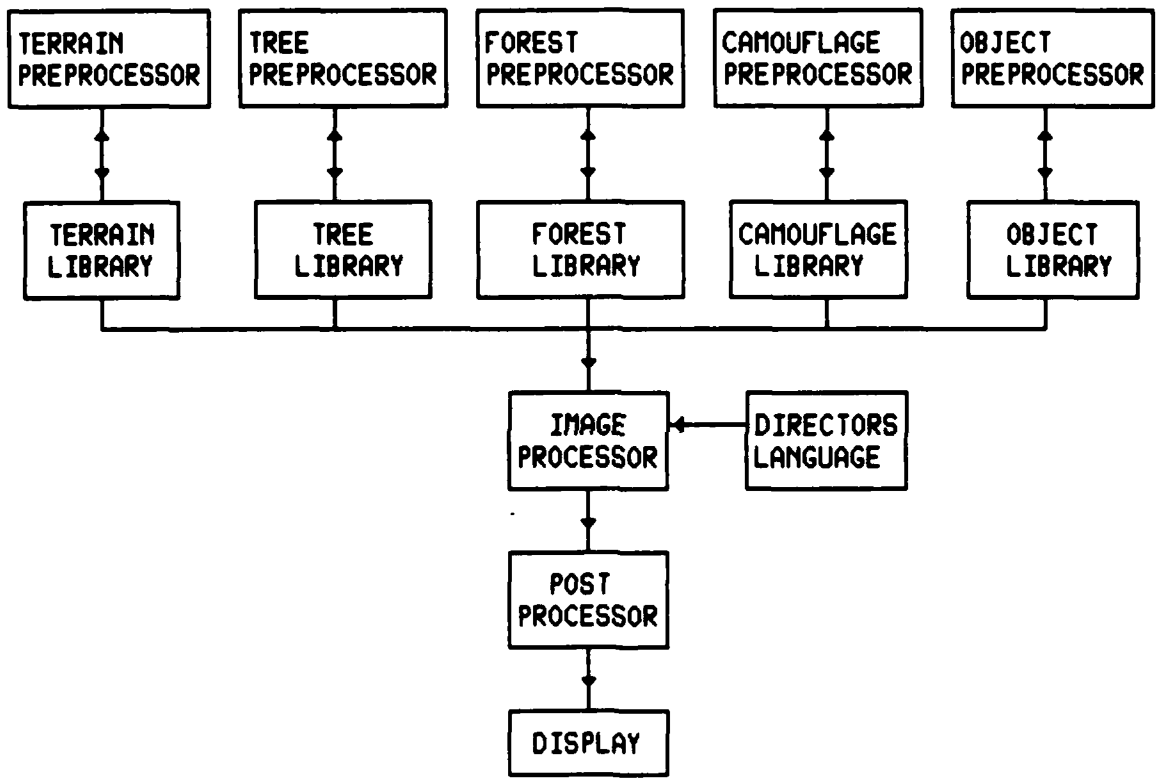



FIGURE 2-2.
TV SYSTEM OVERVIEW

information for determining which object is seen from the simulated camera. Each new object is merged into the previously defined image until the scene is complete. Once the image is complete, a post processor converts it into a form acceptable to the analog output display device.

2.2.4 Selection of a Picture Production System. The two picture production systems described above provide similar visual output, but they are different in many respects. Major variations lie in:

(1) Operational configurations.
(2) Data requirements.
(3) Modeling capabil.ties.
(4) User interface.

Both picture generation systems have good and bad qualities. Each system was delivered and evaluated for future incorporation into the TACMAP project.

The TV System was originally developed to run on IBM equipment in FORTRAN IV. It was later expanded and restructured to operate under the UNIX operating system on a PDP 11/70. The UNIX system under which it will execute was modified by Bolt Beranek and Newman to allow the TV System to access large data arrays. During the first year of the project a properly configured system was operational and available. The E&S system is also written in FORTRAN, but it runs only under an RSX-11 operating system which has user-maintained virtual memory capabilities. Such a system was not available until the second year of the project.

Even though the visual results of the systems are quite similar, the data requirements and modeling capabilities are quite different. The TV System allows extremely fine levels of detail to be specified. Trees are an obvious example. Leaves are modeled as inherent parts of a tree so that when a tree becomes more visible leaves become discernable. Groups of trees may easily be specified as a line or scattered throughout an area at a user specified density and normally distributed heights. Any level of detail may be specified when a user defines an object using combinatorial geometry objects as building blocks. Man-made objects, such as houses, buildings, or vehicles, can be constructed from these building blocks. Once defined, multiple copies may be scaled and placed anywhere on or above the terrain. Terrain patches are modeled by simply listing the longitude, latitude, and elevation. Roads may also be specified by longitude, latitude designation, with any desired width and color.

The E&S system requires that all objects be modeled using closed n-sided polygons. This restriction puts a great deal of burden on the user to properly define the world which is to be modeled. Coloring of planes requires that each plane be "marked" as either visible or not visible. The test data base provided with the E&S system was a model of the New York Harbor. Color representations for many of the perspectives contained "black holes" which in reality were either invisible planes or non-defined planes. This test highlighted the fact that defining a real-world environment with these strict data requirements would be a diffcult task.

After inspecting the documentation of both systems the user interfaces were evaluated. The user level of interaction differs markedly. The E&S system provides a natural, easy mechanism to preview the data base and define pathways, while the TV System is a batch oriented non-interactive system. The TV System's only mechanism to preview a scene is through a crude printer plot. A printer plot is only useful for extremely simple scenes, but the resolution is too poor for a high utility.

Evaluations indicated that the TV System would provide the most viable, flexible picture generation system available due to its convenient modeling schemes, minimal data requirements, and current operational status. With this decision made, all subsequent efforts toward the design of the interface programs were tailored to best utilize the TV system.

## 2.3 Mapping Data Bases

2.3.1 Overview. Two primary data bases were chosen for inclusion in this mapping effort. One is the previously mentioned town of Dar-El-Mara. It provided a readily available, simplified "cartoonish" version of a small town. To illustrate the other extreme, a small portion of a generalized digital data base was randomly windowed out for automatic feature and terrain modeling.

2.3.2 Defense Mapping Agency Digital Land Mass System (DLMS) Data Base. The DMA is currently amassing fairly complete worldwide terrain and cultural digital data bases, referred to as the Digital Land Mass System (DLMS) Data Base. The data base is a collection of magnetic tapes containing information in digital form including geographic coordinates and descriptive information for planimetric features. The intent of the production and use of these data bases was oriented toward use for:

(1) Sensor Simulation Displays.
(2) Sensor Prediction Displays.
(3) Obscuration Plots.
(4) Navigational Aids for Advanced Weapons Systems.

The data base may be broken into two main components, terrain and cultural data. Two levels of detail are planned for collection and are defined as (taken from Product Specifications for Digital Land Mass System (DLMS) Data Base July 1977):

(1) Level 1

(a) Terrain: Relief information in DMA standards digital format on a three seconds of latitude arc (approximately 100 meters (300 feet)) matrix.

(b) Culture: A generalized description and portrayal, in DMA standard digital format, of planimetric features. The Level 1 data base is intended to cover large expanses of the earth's surface and has relatively large minimum size requirements for protrayal of planimetric features.

(2) Level 2

(a) Terrain: Relief information in DMA standard digital format on a one second of latitude arc (approximately 30 meters (100 feet)) matirx.

(b) Culture: A highly detailed description and portrayal, in DMA standard digital format, of planimetric features. The Level 2 data base is intended to cover small areas of interest and has small minimum size requirements for portrayal of planimetric features.

Level 2 is the most detailed terrain data available. Terrain elevations are digitized in a 1x1 degree square matrix with data points in 30 meter intervals. Offsets from a base line latitude reference point in the lower Southwest corner are primarily sequenced in ascending latitude bands (south to north), and secondarily by ascending longitude bands (west to east), as illustrated below.

| | | | |
|---|---|---|---|
| 1,N | 2,N | | N,N |
| . | . | | . |
| . | . | | . |
| . | . | | . |
| 1,3 | 2,3 | | N,3 |
| 1,2 | 2,2 | | N,2 |
| 1,1 | 2,1 | ... | N,1 |

A one data point overlap is provided between adjacent squares. For more information on precise file formats see Chapter 4 of the Product Specifications for Digital Landmass System (DLMS) Data Base.

Information concerning cultural features is gathered and formatted in a less rigorous manner. Areas called feature analysis manuscripts are evaluated and digitized by machine and then hand checked against addi tional material such as aerial and ground photography, map source, textual materials and intelligence reports. DMA has defined a taxonomy for cultural features. Features may be described as either a point, a linear or an aerial feature. Feature analysis is designed to determine what the physical characteristics of a feature are and which features will be selected for portrayal on the feature manuscript. The selection of features to be portrayed is based upon size, surface material makeup and predominant height.

A minimum size of 2 meters is required for any feature, and all subsequent sizes will be rounded to the nearest 2 meter increment. Surface material information is also included. The predominant surface is analyzed and classified as one of the following 13 categories:

TABLE 2-1.
SURFACE MATERIAL CATEGORIES

1. Metal
2. Part Metal
3. Stone/Brick
4. Composition
5. Earthen Works
6. Water
7. Desert/Sand
8. Rock
9. Asphalt/Concrete
10. Soil
11. Marsh
12. Trees
13. Snow/Ice

Within each homogeneous surface material area a predominant, not an average height is determined. A predominant height is the height of 51% or more of the structures within the area as featured to the apex. Again, a 2 meter increment and minimum measure is used. See Appendix A for more details on height requirements and rules. Natural landmarks are also included in the surface material categories. Trees are of particular interest due to their masking affects on cultural features beneath or beyond the trees.

To prepare a feature manuscript, a unique feature analysis code number is assigned for all items portrayed. Each feature is classified as either a point, a linear, or an aerial feature type. Additional feature information is dependent upon the feature type specified. Table 2-2 outlines the feature information specified by feature type.

TABLE 2-2

FEATURE DATA BY FEATURE TYPE

| Feature Type | Point | Linear | Aerial |
|---|---|---|---|
| Surface Material Category Code | x | x | x |
| Predominant Height | x | x | x |
| Number of Structures | x | | x |
| Percentage of Tree Coverage | | | x |
| Percentage of Roof Coverage | | | x |
| Feature Identifications | x | x | x |
| Orientation | x | | |
| Directivity | | x | |
| Width | x | | |
| Length | x | x | |

A complete list of feature identifications is given in Appendix B. Feature identifiers are a numeric code which represents a description of the feature such as; a refinery, bridge, commercial building, single family dwelling, pylon, school, airport, silo, as well as landforms and vegetation indicators.

2.3.3 Dar-El-Mara. The fictitious town of Dar-El-Mara was modeled and designed for the creation of a prototype movie map used in previous mapping experiments. To arrive at the basic layout of Dar-El-Mara, project personnel gave a list of basic specifications (terrain features, built-up areas, number of identifiable landmarks, etc.) to an industrial designer, who returned a preliminary sketch of the locale. Several reiterations of the initial design produced the layout shown in Figure 2-3: a seaside town, located on a cliff overlooking a bay, containing the combination of military and civilian landmarks listed in Table 2-3. The final design was constructed as an actual physical model, about four feet square, made of foam-core material. The model was used to check proportions, to specify color combinations, and to evaluate issues associated with candidate tours. This handmade model was then measured for numerical representations for the picture generation system. Figures 2-4 and 2-5 illustrate typical scenes of the Dar-El-Mara area.

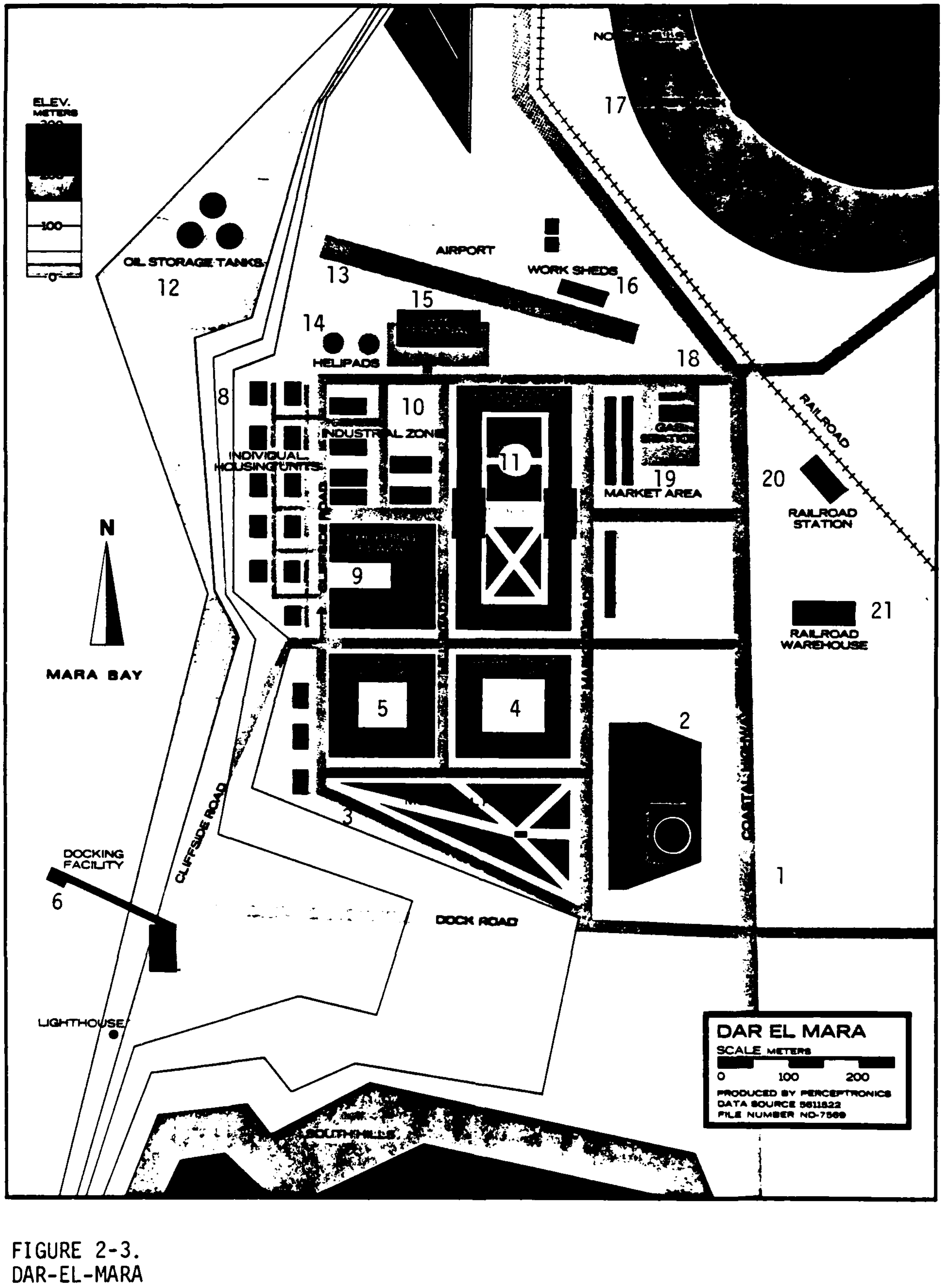
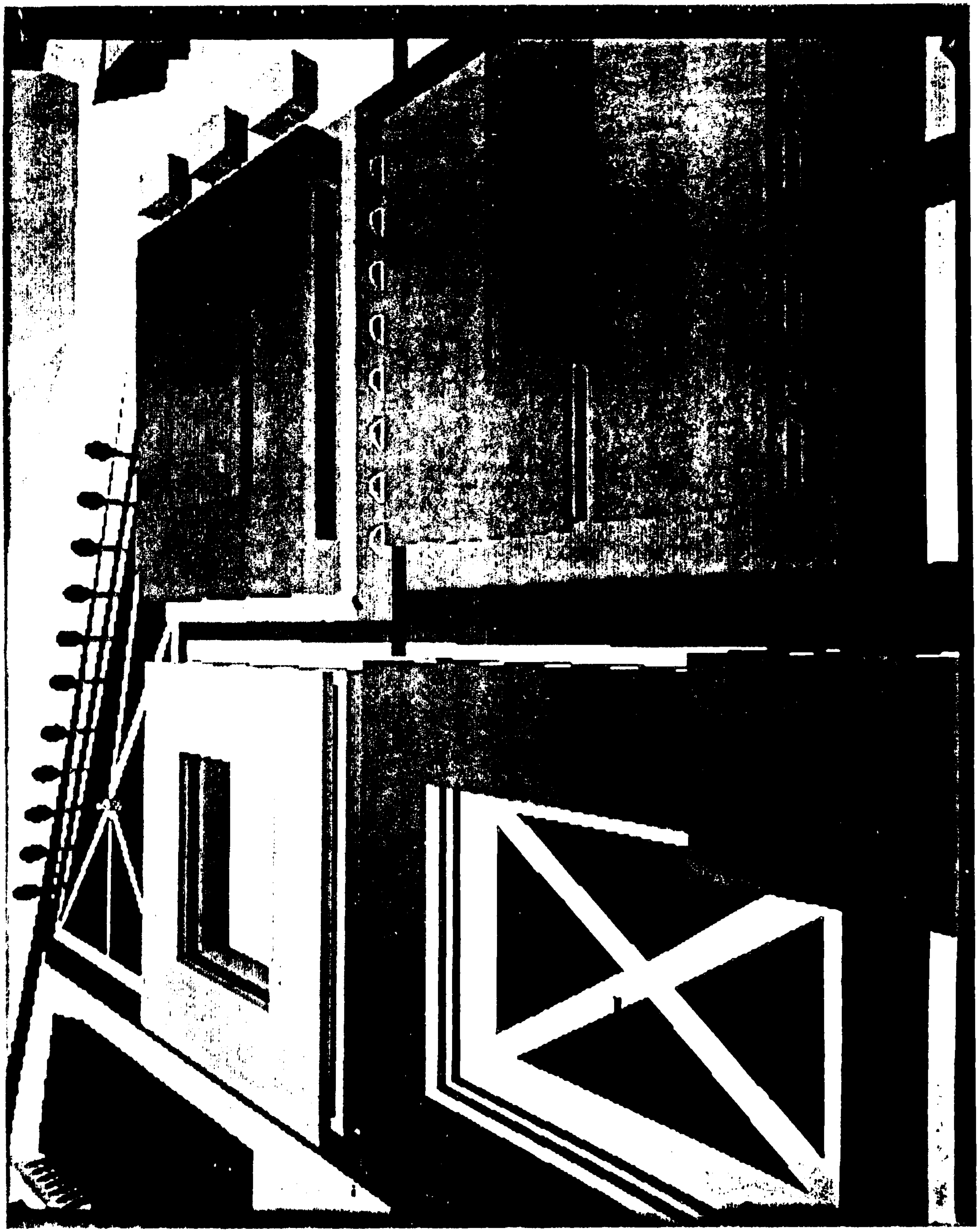


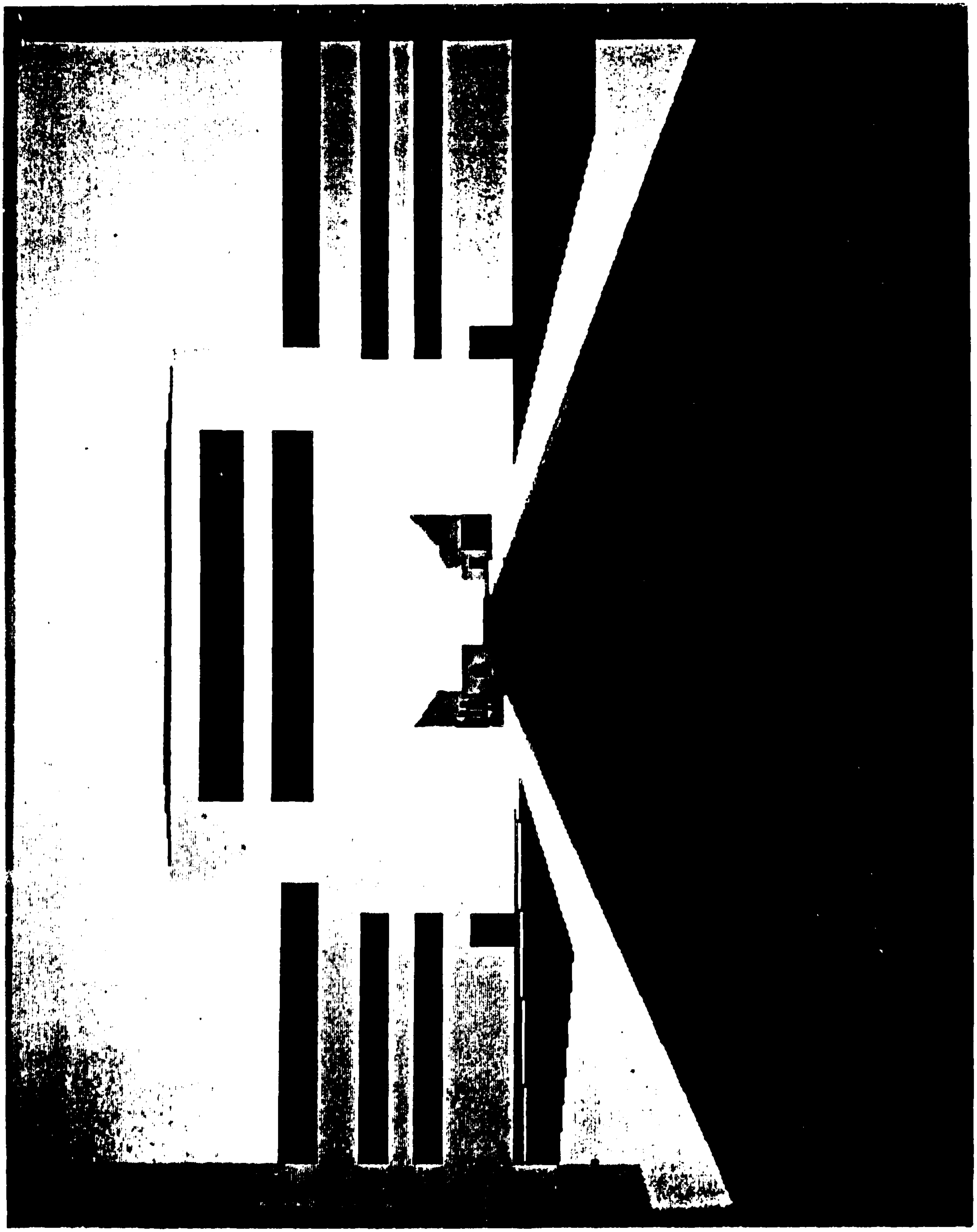

FIGURE 2-3.
DAR-EL-MARA

TABLE 2-3.

DAR-EL-MARA SITE GUIDE

1. Coastal Highway
2. Golden Mosque
3. Municipal Park
4. Apartment Block
5. Office Block
6. Docking Facility
7. Lighthouse
8. Individual Housing Units
9. Shopping Plaza
10. Industrial Zone
11. Government Center
12. Oil Storage Tanks
13. Airport
14. Helipads
15. Air Terminal
16. Work Sheds
17. Water Tank
18. Gas Station
19. Market Area
20. Railroad Station
21. Railroad Warehouse





# 3. TECHNICAL APPROACH

## 3.1 System Concept

Many components: data bases, software systems and hardware devices contribute to the culmination of an integrated mapping system. Ultimately, dynamic and static map products are merged to provide a means of aiding map performance in locale familiarization, field maneuvering, and command coordination.

To illustrate this mapping concept two diversely different data sources were taped; one a fictitious hand-designed town, Dar-El-Mara, the other a generalized digital world data base, DLMS. To automatically produce computer-generated three-dimensional images of a real locale, a test area was randomly choosen from the DLMS data base. Production rules were applied in the interface process and appropriate data generated for input into a picture production system. Conventional maps were specially photographed and combined with real ground-level film footage of the locale to produce a comprehensive videodisc-based overview of the area. All visual data was then compiled and transferred onto videodisc for display on a map display system. Two video disc-based systems were designed to illustrate different strategies for access and display of the visual materials. One system, the MPSTR-1 unit,[1] is a self-contained desk-top unit which was specially engineered and configured by Perceptronics as a simple but powerful map access mechanism. The Talking Maps system is slanted toward providing computer-generated speech for system orientation, and surrogate travel narration. Figure 3-1 outlines the system concept.

Major efforts during the course of the contract period were concentrated around:

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[1]Mass Picture Storage and Retrieval System.

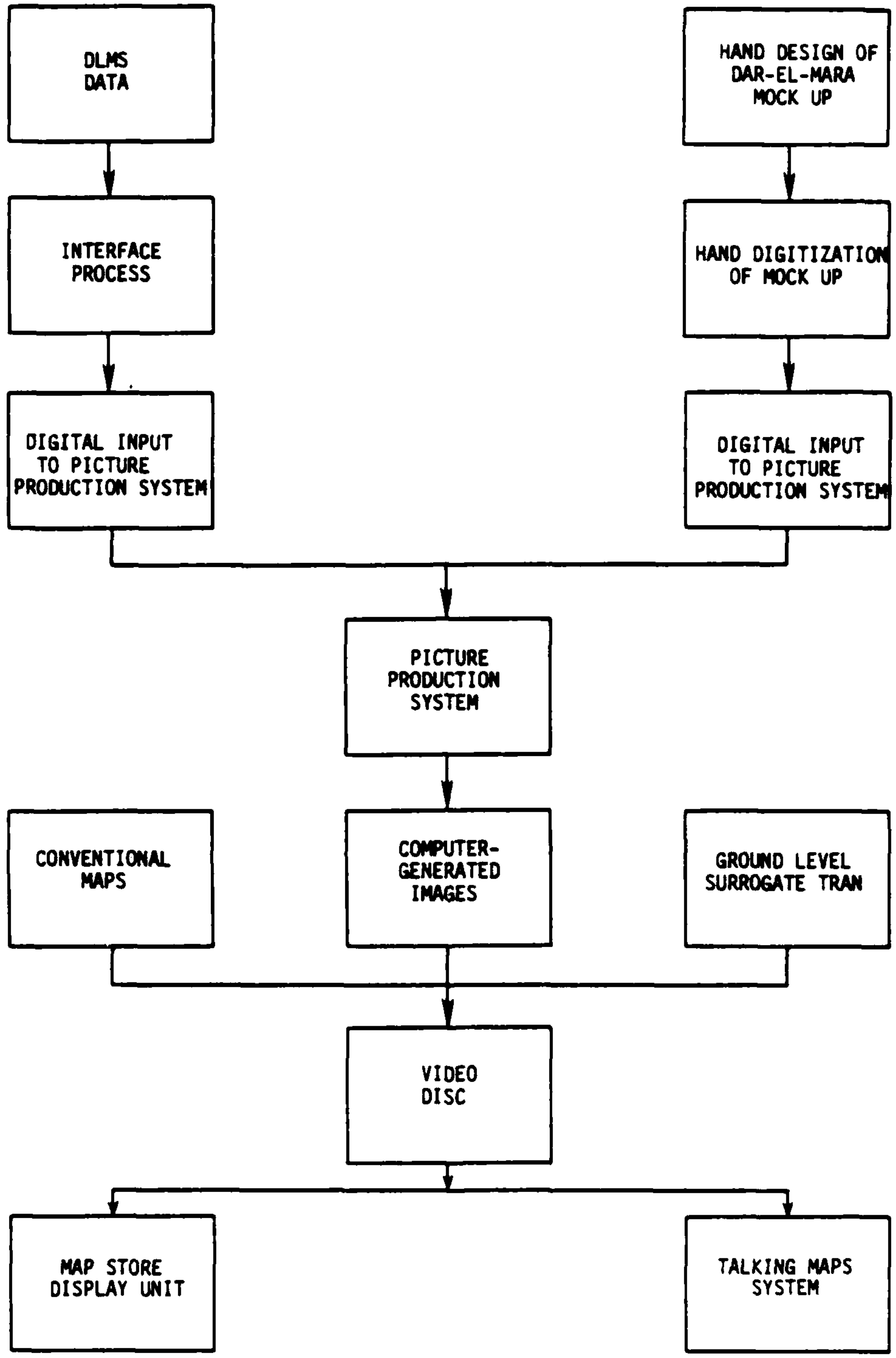



FIGURE 3-1.
SYSTEM CONCEPT

(1) Processing the DLMS data.
(2) Picture generation software validation and enhancements.
(3) Visual verification of video images.
(4) Management and consolidation of all video source material.
(5) Design and construction of the MPSTR-1 display unit.
(6) Development of the Talking Maps system.

These and other efforts are outlined and expanded in greater detail throughout the following section.

## 3.2 Mapping Data Bases

3.2.1 DLMS Data Base. Once the concept of the movie map was proven to be effective, concerns were raised about the problems of expanding the technology to automatically produce pictures from some existing readily available data source. After all, what good is a system without data to drive it? To explore these problems unclassified portions of the Defense Mapping Agency Digital Landmass System (DLMS) data base around the Richmond, Virginia area were obtained. The more detailed level 2 data was available for this area.

The data is distributed on magnetic tape in an encoded form. Data for a random area was extracted and previewed by a team of selected personnel from Perceptronics, members of a related map project from the University of California, Santa Cruz, and a graphic artist. The visually oriented faction of the meeting insisted upon hand-plotting the mile square area to get a feel for the feature content and density. This proved to be an invaluable exercise since several major questions arose:

- Roads were unexpectedly omitted from the data base. How should they be incorporated?

- How should objects be placed on an uneven terrain?
- How should linear features be modeled, i.e., a bridge versus a line of buildings?
- How should houses be distributed within an areal boundary?
- How should buildings be automatically modeled to reflect their size and height, i.e., should they be stretched or modular?
- How should natural features such as rivers be modeled?

Several suggestions were contributed by the more experienced Santa Cruz members.

- Use the picture generation system as a verification tool for object modeling.
- Do not litter the scene with distracting clutter.
- Cartooning is often sufficient for object recognition.

A degree square area, which is equivalent to about one square mile, was selected. A matrix of 21 by 21 terrain elevation points provides the contour description of the theatre floor. Figure 3-2 is a two-dimensional representation of the terrain. The area to be modeled contains a selection of features varying from water and trees to buildings and a smokestack. The list of features is compiled in Table 3-1.

Having identified many of the problems to be overcome, a plan of action was formulated and the interfacing of the DLMS data with the picture generation system was begun.

3.2.2 Dar-El-Mara. The production of the prototype movie map of Dar-El-Mara necessitated the creation of a digital description of the town. This data base was preserved by MAGI for subsequent use during this project period. The original Dar-El-Mara data base was created for MAGI's

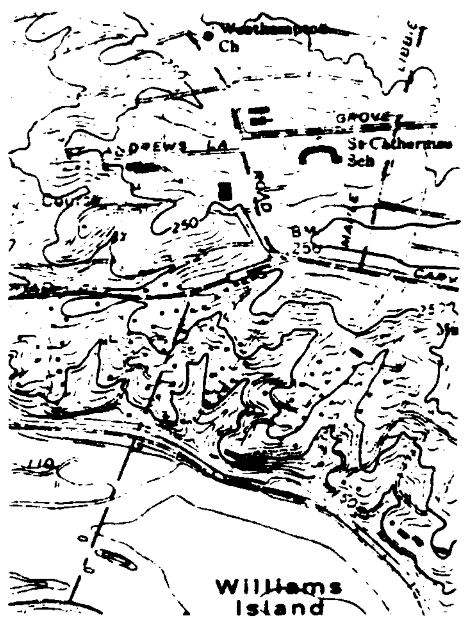



FIGURE 3-2.
CONTOUR OF RICHMOND AREA TERRAIN

TABLE 3-1

LIST OF FEATURES

| NUMBER | FEATURE NAME | FEATURE TYPE POINT | LINEAR | AERIAL |
|---|---|---|---|---|
| 15 | Mixed Trees | 0 | 8 | 7 |
| 4 | Single Family Dwellings | 0 | 1 | 3 |
| 11 | Soil Patch | 1 | 0 | 10 |
| 3 | Apartment/Hotel with a flat roof | 2 | 0 | 1 |
| 4 | Apartment/Hotel with a gabled roof | 2 | 0 | 2 |
| 5 | Commercial Building with a flat roof | 2 | 0 | 3 |
| 7 | Commercial Building with a gabled roof | 5 | 0 | 2 |
| 1 | Vehicle Parking Area | 0 | 0 | 1 |
| 2 | Recreational Activities building | 0 | 0 | 2 |
| 1 | School with a flat roof | 0 | 0 | 1 |
| 1 | School with a gabled roof | 0 | 1 | 0 |
| 1 | House of Religious Worship | 0 | 1 | 0 |
| 1 | Industry Smokestack | 1 | 0 | 0 |
| 1 | Fresh Water subject to ice | 0 | 0 | 1 |

Synthavision System, the precursor to the TV system. The Synthavision code is only capable of producing images of objects constructed from combinatorial geometry building blocks. The data base is upward compatible, however, so there were no restrictions connected with using the previously defined Dar-El-Mara data base with the newly developed TV System. The limited size of the data base allowed for a more extensive collection of views to be generated for experimental ground-to-aerial transition sequences, and walkabout coverage.

## 3.3 Map Production System

3.3.1 Automatic Interface. The automatic interface which provides the link between the DLMS digital data and the picture generation system in the system configuration, as depicted in Figure 3-3, is a complex network of subprograms. More specifically, as outlined in Figure 3-4, the interface performs the functions of:

- Extracting and decoding the DLMS data into useable numeric form.
- Structuring the data for verification.
- Refining the data where applicable.
- Transforming the data into acceptable object and scene definition by automated modeling and production rules.
- Formatting the inputs to the picture production system for component processing and scene generation.

The DLMS data is broken into two parts; terrain and cultural data. The interface processing is conducted as a parallel, but separate series of actions for each data set.

The terrain interface component of the automatic interface is a fairly straightforward process, as illustrated in Figure 3-5. An area of interest

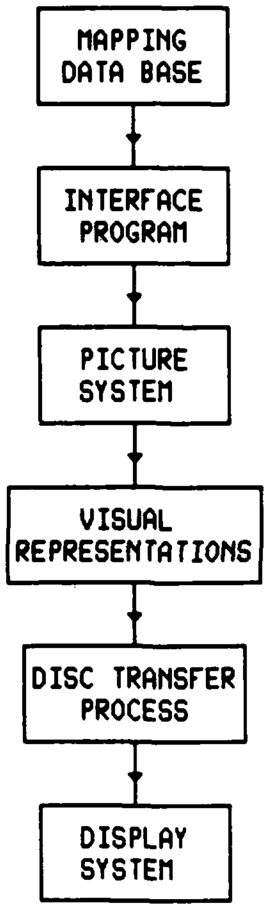



FIGURE 3-3.
SYSTEM CONFIGURATION

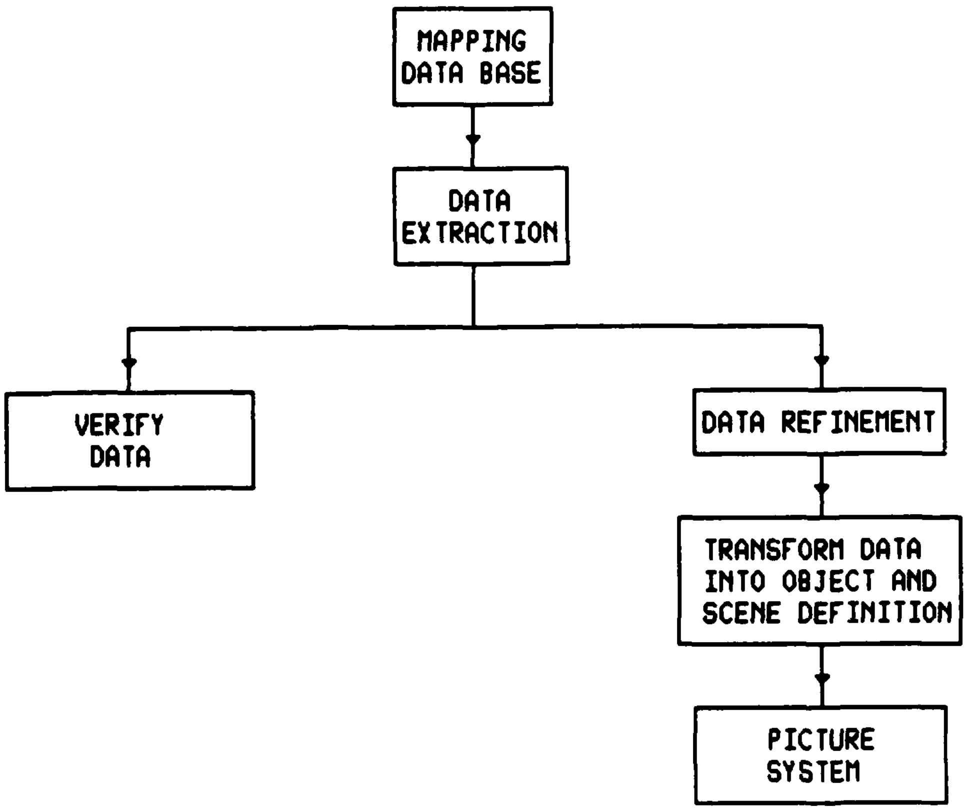



FIGURE 3-4.
GENERAL DESCRIPTION OF INTERFACE PROGRAM

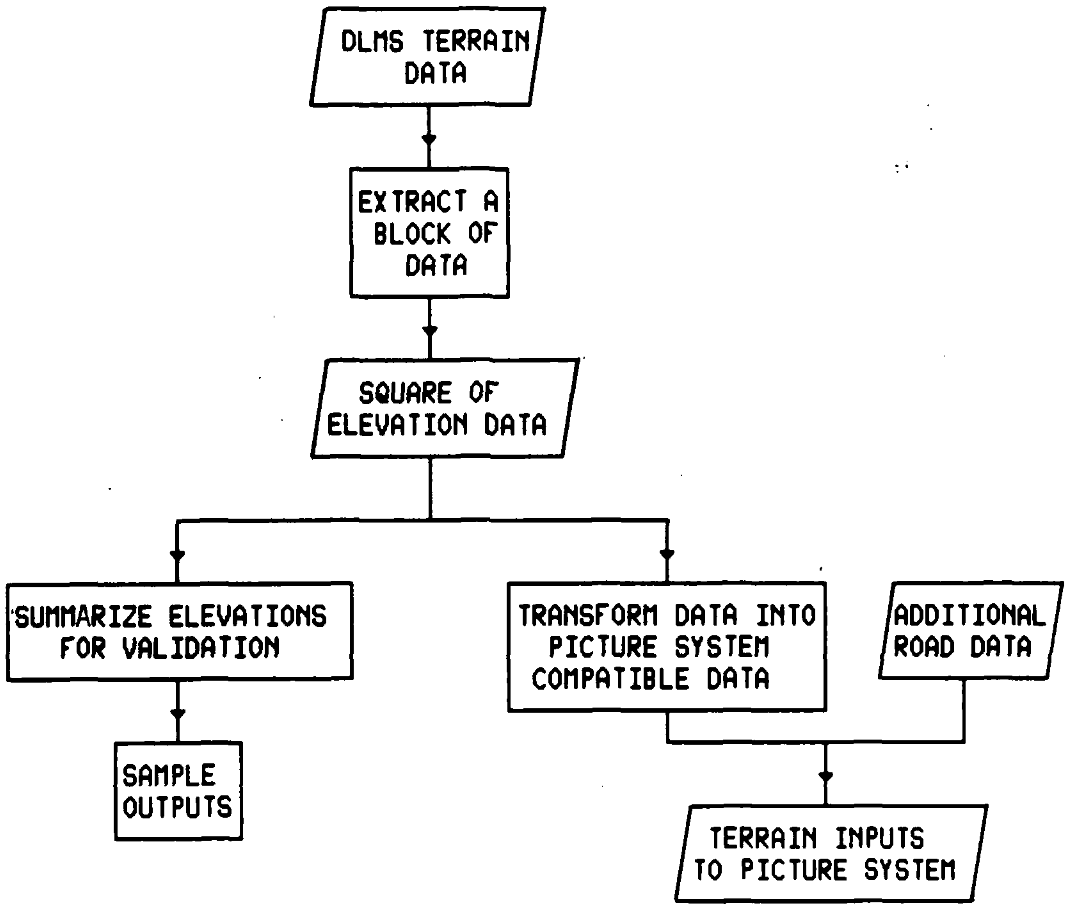



FIGURE 3-5.
TERRAIN INTERFACE COMPONENT

is specified by a longitude, latitude pair which defines the lower left and upper right corners of a rectangle. For developmental purposes, the extracted elevation data was manually verified using topographical maps. Through a simple reformatting process the data was scaled and prepared for use by the TV System. Due to the unforseen omission of road data for this area, roads were digitized by hand and included in the scene descriptions. The TV System provides the capability of placing color patches on the terrain. This allows the modeling of water, roads, soil patches, and sand traps, which may appear in the DLMS cultural data.

Once again, the cultural data is extracted, verified, refined and transformed into compatible TV System inputs. This process is outlined in detail in Figure 3-6. The integration of the cultural information by necessity is a much lengthier complex process. Initially blocks of data called feature manuscripts are decoded and archived. Manuscript coverage of the terrain is not mutually exclusive; one may overlap another, as in Figure 3-7. A manuscript is a collection of point, linear and aerial feature descriptions. Once the user has specified a windowed area of interest, features from the pertinent manuscripts are isolated. Any feature which wholly or partially lies within the window is marked for later processing. At this juncture different feature types; point, linear and areal, are treated differently.

Defense Mapping Agency manuscript analysis requirements dictate rules for feature type definition. According to those requirements the most precise location, orientation, and scaling information is specified for point features. Intuitively point features will, therefore, be the most realistically and accurately modeled. Few assumptions need to be made during the modeling process other than style and color assignments.

A linear feature is specified as a sequence of longitude, latitude locations. Similarly the boundaries of areal features are described by

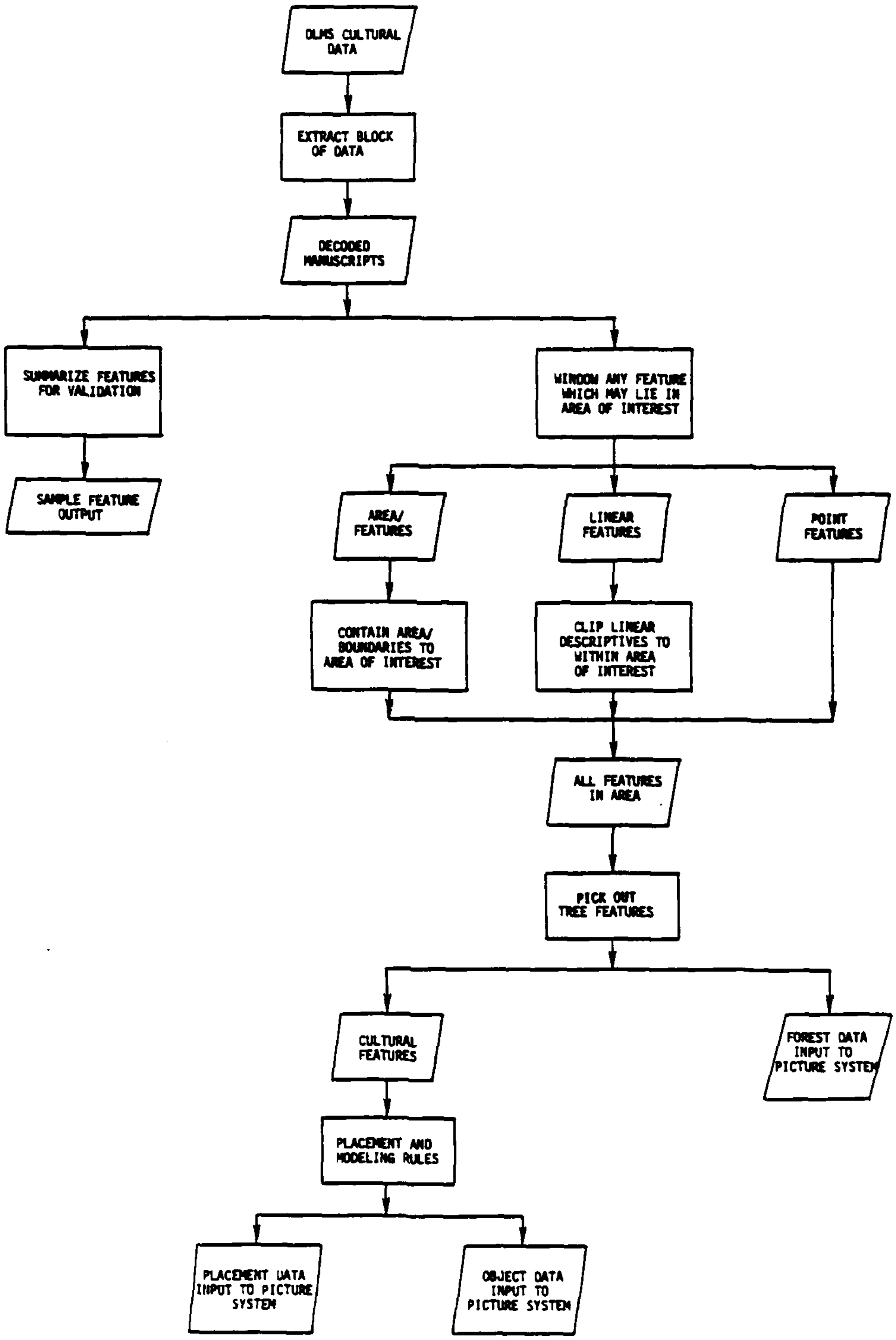



FIGURE 3-6.
CULTURAL INTERFACE

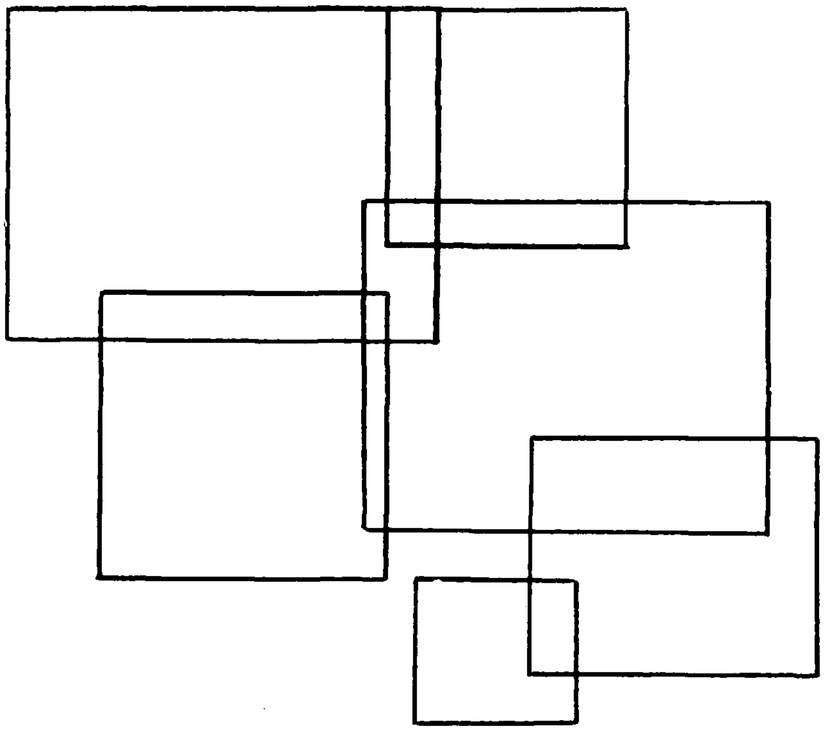


FIGURE 3-7.
AN EXAMPLE OF FEATURE MANUSCRIPT COVERAGE

longitude, latitude coordinates. Both of these features types may lie wholly or partially within the user window. To most realistically model the area any linear or areal feature which falls partially outside the window is "clipped" or redefined to the window's edge so that features do not appear to hang in mid-air. An example of this process is best described visually as in Figure 3-8.

Algorithms for clipping both linear and areal features were developed. Each line segment of a linear feature is checked for intersection with one of the window edges. If the two lines cross, the current line segment of the feature is terminated at the intersecting point. Areal features are a bit more complicated. By definition areal features are defined in a counter-clockwise fashion. That is, the feature lies to the left of the boundary line. With this constraint, once it has been determined that an areal feature passes through a window edge, the appropriate portion of the areal feature is replaced by the bounding window.

After the feature descriptions have been contained to the window boundary, features which contain trees are extracted and formatted for later processing by the TV System forest preprocessor. Once again, input to the forest preprocessor is conveniently oriented toward point, linear and areal definitions of features with trees. The forest preprocessor allows for specification of the tree type, along with height and density parameters.

Placement and modeling rules are then applied to all other cultural features to generate object modeling and scene description inputs. At this point, a review of the possible feature descriptions in Appendix B will help illustrate the nuances of the production modeling rules. A taxonomy of feature modeling techniques was defined given the feature type and description. Complete modeling of all feature descriptions was not

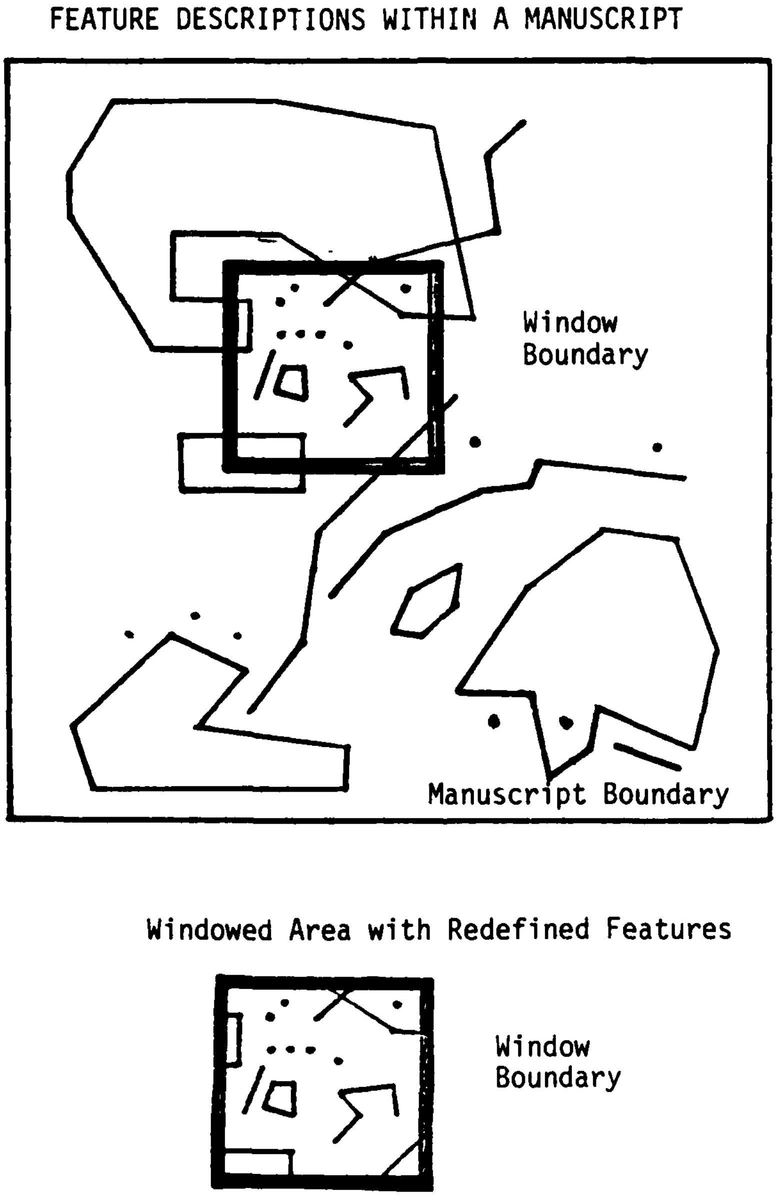



FIGURE 3-8.
FIGURE REDEFINITION

implemented; instead, a representative subset was modeled in detail with special labeling capabilities for those which were not realistically modeled. The gymnasium in Figure 3-9 is a good illustration of a labeled feature.

To understand how the modeling process works lets start with a simple example of the modeling of a point feature. Given the following feature data:

- Unique feature code — 98
- Feature Name — Commercial building with a flat roof
- Height (meters) — 4
- Width (meters) — 10
- Length (meters) — 10
- Orientation (clockwise from north) — 45 degrees
- Surface Material Category Code — Stone/brick

A unique feature name, such as comm98 is formulated from the unique feature code and the feature name is given to the feature for later identification in the TV System object library. Of course if multiple copies of a feature are to be used, the feature will only be modeled one time. This will often occur with features such as power pylons or single family dwellings. Once the feature is identified, modeling is begun. The specifics of the modeling are dependent on the feature name and type. To model a point commercial building with a flat roof, the bulk of the building is defined by a 10x10x3 meter rectangular solid. The TV System provides the following 12 primitive shapes which the user can use to build objects:

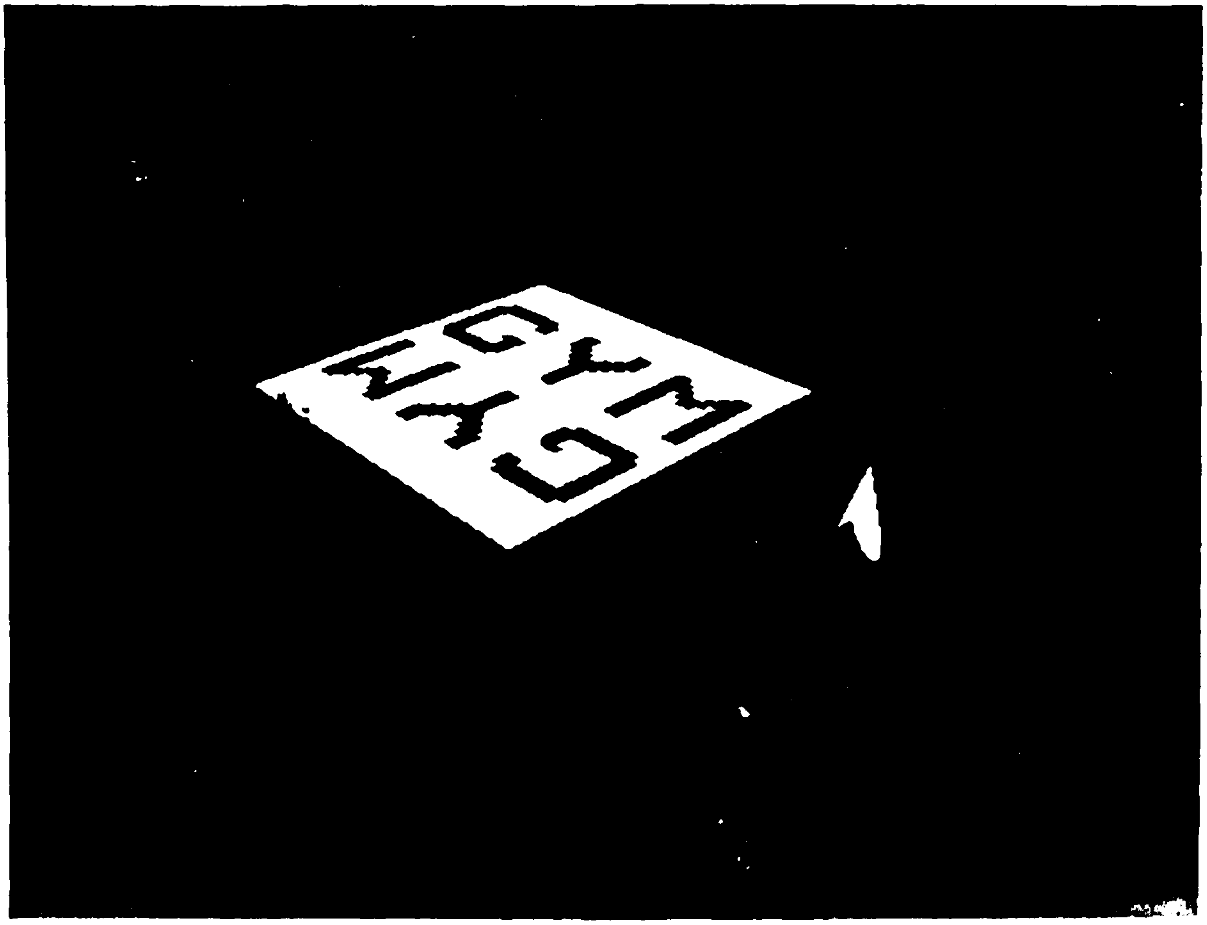



FIGURE 3-9.

TABLE 3-2

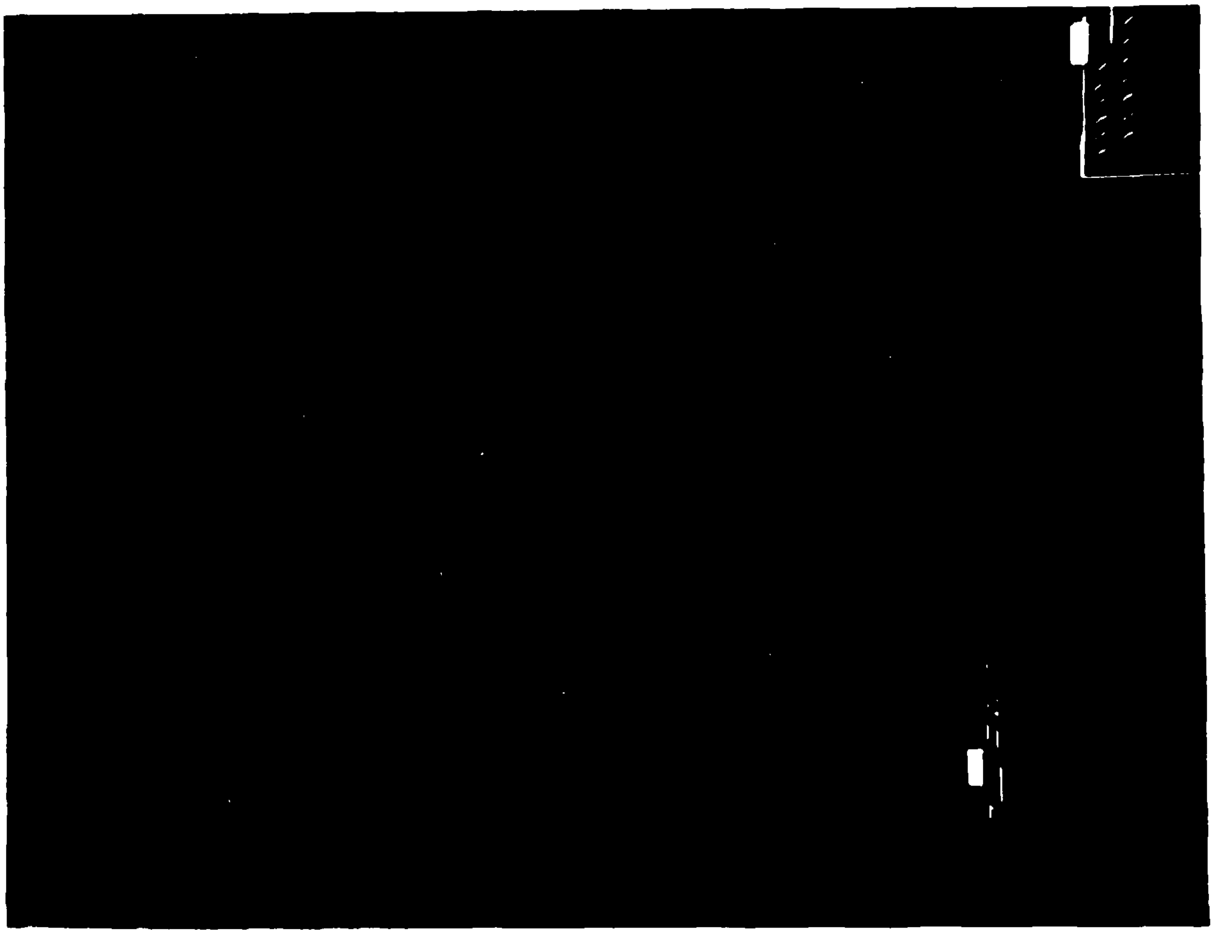
TV SYSTEM COMBINATORIAL GEOMETRY PRIMITIVES

1. Rectangular Parallelepiped
2. Box
3. Sphere
4. Right Circular Cylinder
5. Right Elliptical Cylinder
6. Truncated Right Angle Cone
7. Ellipsoid of Revolution
8. Right Angle Wedge
9. Arbitrary Polyhedron
10. Truncated Elliptical Cone
11. Truncated General Cone
12. Half Space

Scaling parameters are specified and primitives are placed relative to a local origin. After the structure has been defined an appropriate roof type is scaled and located on top of the structure. Windows, doors, steps, and a basement are tacked on the outside walls. Routines were developed to approximate the number of, scale, and placement of various window and door types on a structure. Color values are specified for each part of the structure and will be assigned at a later point. Figures 3-10 and 3-11 illustrate a residential housing area. Notice the finely detailed trees along with the various houses.

Modeling and placement rules for linear and areal features requires estimating the size and location of each structure within the feature description. The kind of feature data which accompanies a particular feature type is outlined in Table 2-2. Notice that the outer surface material and height are indicated for all feature types, and the number of structures is specifically designed for point and areal features, but not for linear features.

FIGURE 3-10.



FIUGRE 3-11.

A scheme was developed to model linear features based upon the feature type, and specific line segment lengths. Features described by a line seem to fall into one of two categories; continuous and discontinuous. Railroads, piers, and bridges would be a continuous strip with no gaps at a bend, such as in Figure 3-12. Special modeling considerations were taken into account to present a continuous, smooth appearance for these types of features. Other types of features, such as an apartment house, would most likely be a line of individual structures, as in Figure 3-13. The number of separate structures for a discontinuous linear feature is estimated by first scaling a structure to the shortest line segment and then placing that structure periodically along the entire length of the feature.

An areal feature may contain zero, one, or more, structures. One structure within an area presents a unique scaling problem. If there is 100% roof coverage, the largest possible structure is squeezed into the feature perimeter. The structure is scaled for any roof coverage less than 100% and placed in the center of the area. A grid placement routine was devised for features with two or more structures within an area. The total area of the feature is estimated and the structure size is then approximated by the percentage of roof coverage parameter. In actuality this was a poor estimate, since the percentage of roof coverage was often unrealistically specified at 20% or 30%. Scaling and placement was performed for all features irregardless of whether the feature was labeled or modeled realistically.

3.2.2 <u>Picture Production System</u>. The picture production system ultimately chosen for use was MAGI's Terrestrial Visualization (TV) System. This system is a "batch" oriented noninteractive set of interlinked processes designed to manage a group of picture component libraries and produce images or sequences of images via a user provided director's language. An overview of the system is shown in Figure 2-2.

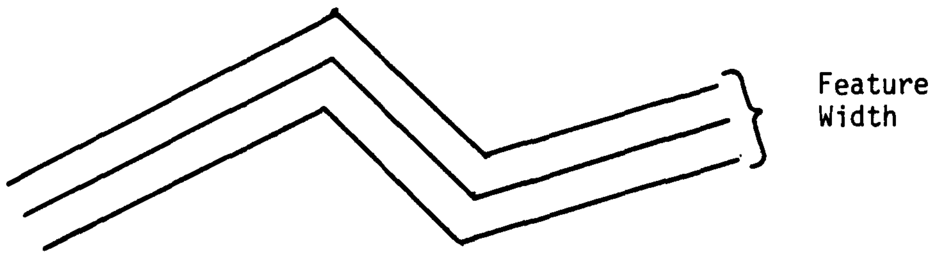



FIGURE 3-12.
A CONTINUOUS LINEAR FEATURE

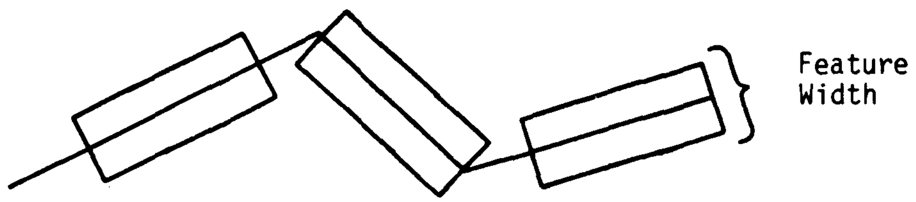



FIGURE 3-13.
A DISCONTINUOUS LINEAR FEATURE

A picture may be composed of objects selected from any of the five data libraries; terrain, tree, forest, combinatorial geometry, and camouflage. The camouflage preprocessor and library were not required by this product and so were not used. The other four libraries were used and their functions are explained below. The preprocessing scheme is shown in Figure 3-14.

The terrain preprocessor accepts inputs in any x, y, z coordinate system which defines a piece or patch of terrain. A terrain patch may be composed of up to 600 x, y, z elevation data points. Terrain modeling is done by a technique called triangulation, that is, given the elevation points, modeling algorithms determine the appropriate triangular planes which will represent the terrain surface. This model does not at present use any smoothing techniques, but rather strives for a fast processing of a large amount of data. Conceptually, the terrain description is used as a floor upon which other components are placed. To allow for modeling of different color planar surfaces on a terrain, such as roads, water, snow, etc., linear segments of any width and color may be specified, as well as areal patches of any shape and color.

An artificial rectangle is placed around the terrain patch elevation points, as in Figure 3-15. The edges of the terrain patch are artificially dropped to a zero elevation as indicated by the shaded portion of the terrain. This aspect of the modeling was visually the most difficult to deal with. Since many terrain patches may be butted up next to each other to form a large expanse, this artificial boundary is often visible. The cross section of two terrain patches in Figure 3-16 shows the improper visible terrain. Several attempts were made to compensate for this problem, but none were successful. This terrain modeling technique proved to be one of the biggest problems with the TV system.

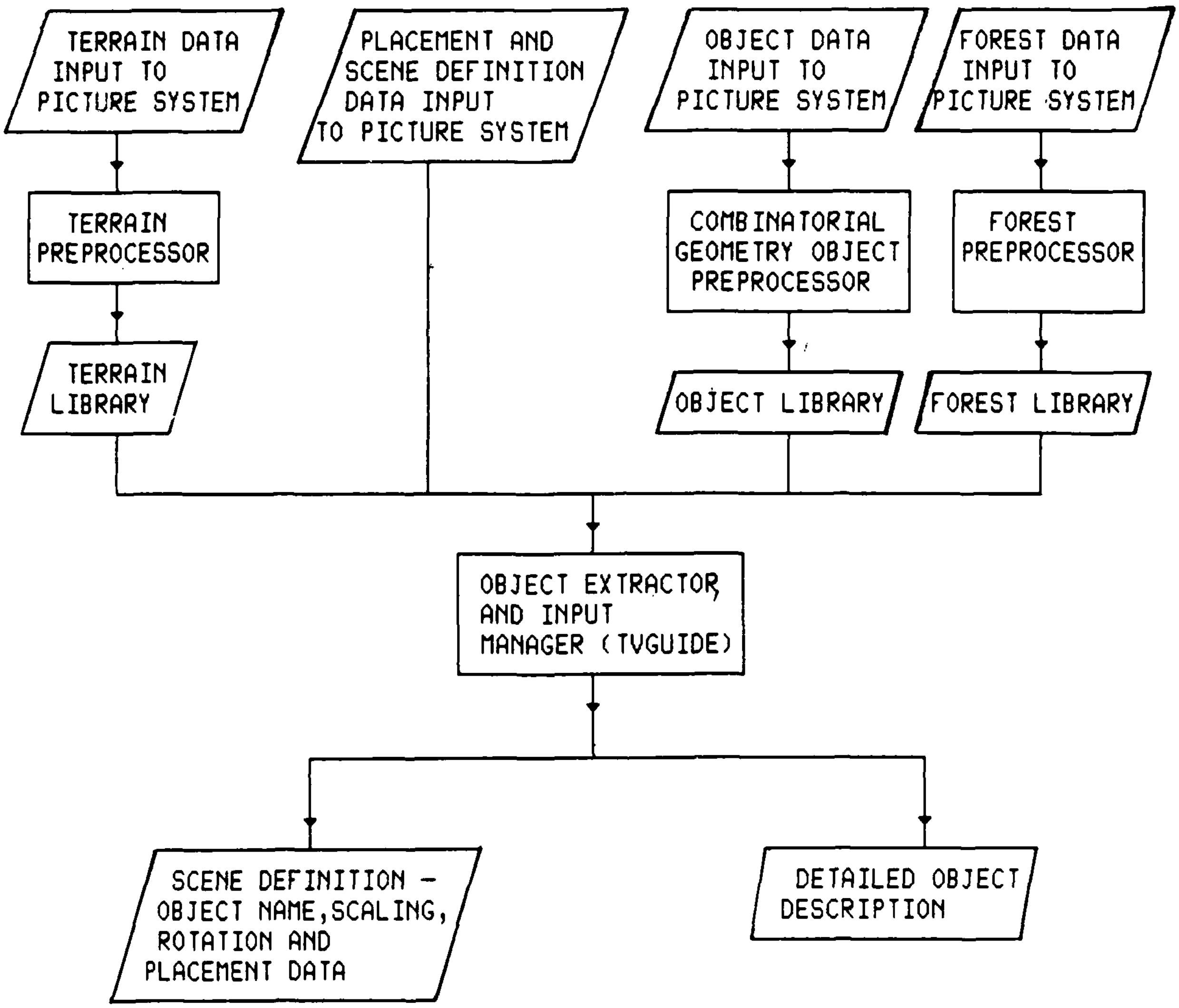



FIGURE 3-14.
PREPROCESSING SCHEME FOR THE TV SYSTEM

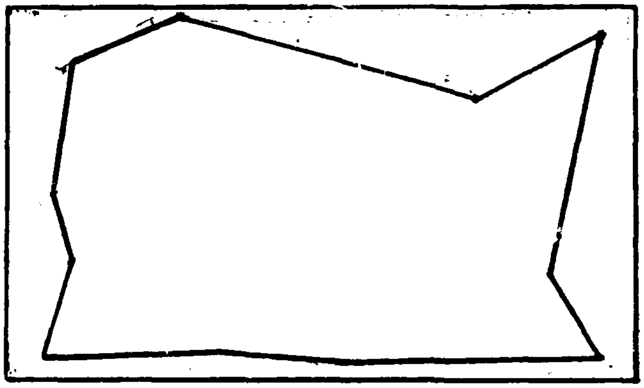


FIGURE 3-15.
PLANAR VIEW OF A TERRAIN PATCH

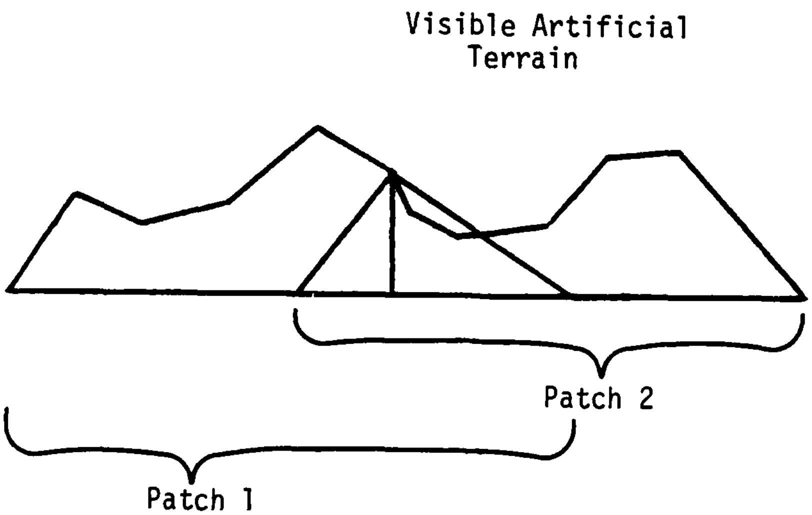
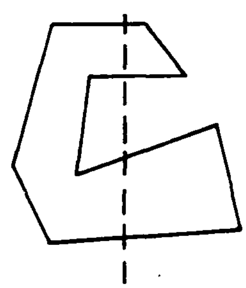



FIGURE 3-16.
CROSS SECTION OF TERRAIN PATCH MATCHING

A tree library of two tree types; Virginia Pine and a Pine Oak were provided by MAGI for our use. The tree preprocessor allows the user to mathematically define a tree type by specifying parameters for shape, density, limb structure, etc. Since the DLMS data base only required the two tree types which were already in the tree library, no further detailed modeling of specific tree types was performed.

Calculations performed by the TV System image processor for tree representations are done in one of three ways depending on the distance of the tree from the eyepoint and user inputs. A tree will be modeled as either a high resolution tree, a low resolution tree, or a "billboard" tree. A high resolution tree is used when the tree is within a close range or when the tree will occupy a large percentage of the final image. This is a very detailed model which simulates a tree by modeling the trunk, the limbs and all the leaves. Thus, as the camera gets close to the tree, more detail is distinguishable. If a tree is farther away from the eyepoint and will take up a smaller percentage of the image a low resolution tree modeling technique is used. If a tree is farther from the eyepoint less detail is required in the model. Leaves, for instance, will be seen as large clumps of foliage, and fewer limbs will be visible. The use of a coarser tree model speeds up processing time by a factor of 2 or 3 times. A third tree model was developed by MAGI during the first year of this project. They developed and implemented the concept of a "billboard" tree. This model simulates a tree by "painting" a tree image on a hexagonal column; six sides and a top. The "billboard" tree is utilized for trees at a long distance, which requires no detailed modeling. The "billboard" model provides an even faster way to model realistic trees with little burden placed on the user.

To include trees within a scene the user specifies individual tree location; lines or areas of trees by using the forest preprocessor. Many user defined parameters are required to define the width, offset, density of tree lines, clustering of trees within an area and average and standard deviation of height and tree type. Two difficult TV System restrictions made forest modeling tedious. Initially there was a restriction of a total of 20 point, line, or areal tree descriptions per terrain patch. This prohibited the proper modeling required to tree the Richmond mile square test area, so the area was broken into five seperate terrain patches. This unfortunately induced mismodeling of the terrain due to improper TV System modeling of terrain borders. The limit of 20 tree descriptions has since been corrected. The second difficulty with the forest pre-processor is a restriction on areal boundary shapes. An areal boundary may not be shaped so that a vertical line passes through the boundary more than twice. A misshaped areal boundary might look like:



This modeling restriction requires breaking the area into three smaller areas along the dotted line.

If a scene component cannot be modeled using the terrain, tree, forest, or camouflage net, it must be modeled using the combinatorial geometry (CG) preprocessor. Twelve primitive shapes as listed earlier in Table 3-2 are referred to as CG bodies and are used as building blocks to create CG regions. A region is a set of one or more bodies which can also be a building block. For example, to simplify modeling the four wheels on a car, one wheel may be defined using several bodies; one for the tire, the rim, the nuts, bolts, etc. This wheel assembly would be a region which would be named and easily placed in several different locations.

Clever use of CG modeling can produce varied results. Hand modeling is a tedious task which requires detailed spatial understanding of the primitives and an artistic approach to using them. Automatic CG modeling may be somewhat less artistic, but much faster and precise. Labeling of nonmodeled features was done using CG objects as letters. These letters were scaled to fit the maximum height or width and placed along all four walls and along the length of the roof in two directions. MAGI has hand modeled an elegant alphabet font, but would not provide it for our use. So an alphabet font routine was developed.

The image processor portion of the TV System consists of three processes. The first, a data management routine called TVGUIDE, see Figure 3-14, transforms the user's placement and scene definition data from a scene description into two data files, one a text file of the scene definition and the other a binary file of object descriptions, required by the second process, TVSHOW, the image generator. TVSHOW, see Figure 3-17, performs ray tracing calculations using all user requested scene components to produce a digital description of the video image. This picture description is referred to as a run length encoded file. It is simply a file which contains the color of each pixel which will appear on the output display device. The third process, TVOUT, provides color assignment capabilities. The colors up until this point have been arbitrarily assigned a value. Once the picture file is complete those arbitrary color values are assigned a real color chosen from the color map, a selection of 30 colors mixed from red, green and blue light sources.

3.3.3 <u>Display Scheme</u>. The purpose of the TV System is to create a three-dimensional color image. In fact a digital description of an image is

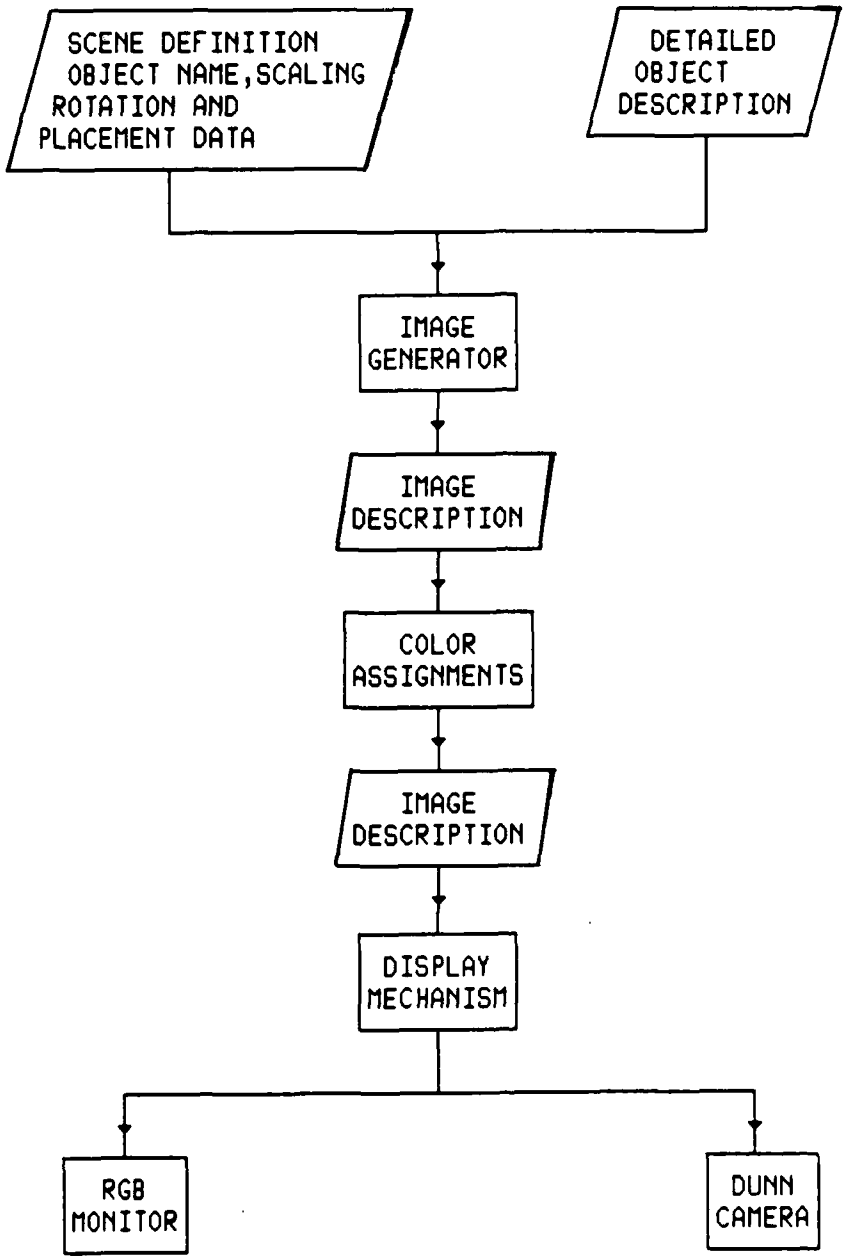



FIGURE 3-17.
TV SYSTEM IMAGE PROCESSING

created, but this digital information must be converted to the proper analog signal for monitor display. To accomplish this, as shown in Figure 3-18, a process was developed during the project period in which a display generation interface transfers the image description in the picture file into a frame buffer for intermediate storage before it is converted to the appropriate analog signals for display.

The final product of the TV System is an image description or a picture file. When the user wishes to view the created image the picture file is directed to the display generation interface. The display generation interface first opens the frame buffer for use. This causes the display device driver to load a prestored file of 480x512 microcode with associated control information into the random access memory of the frame buffer microprocessor. This microcode is a binary file of instructions which will later be executed by the frame buffer on board microprocessor. The display generation interface then loads the picture file, into the frame buffer memory through the system display device driver and initiates the processes which result in the appropriate signals suitable for output to the display devices.

The picture file consists of two portions; pixel information of the 480x512 display, and a 256-color color map. This data is transferred from the user picture file into the pixel plane memory and color map locations within the frame buffer. The pixel information is an 8-bit digital description of each color which will appear on the display. Being an 8-bit quantity the value may range from 0 to 256. The display generation interface then instructs the microprocessor to execute the microcode commands. This initiates the process of scanning each 8-bit pixel location in the pixel plane memory and using it as an index into the color map to access the appropriate 12-bit color value.

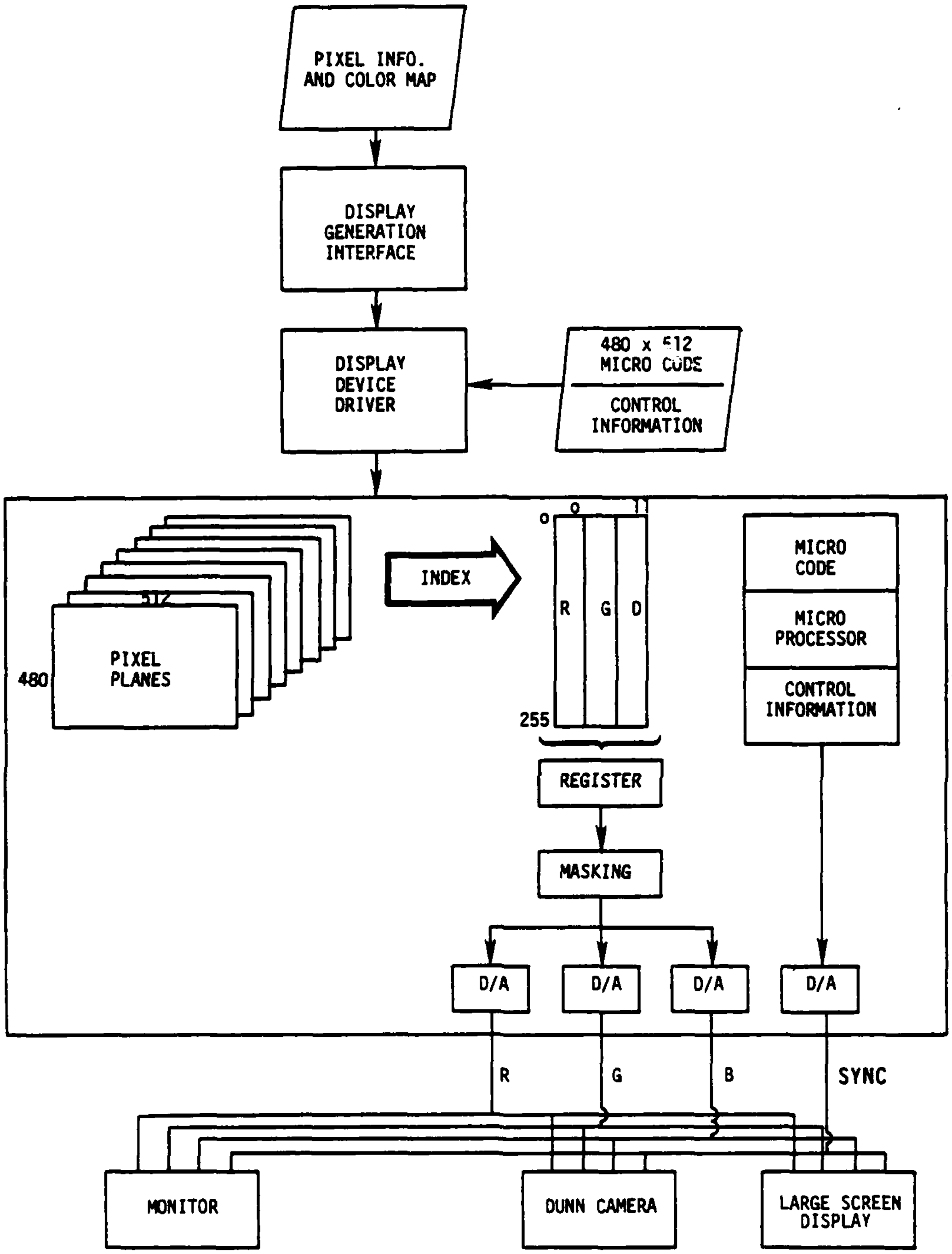



FIGURE 3-18.
DISPLAY SCHEME

The color map is a list of 256, 12-bit color values which are broken into 3, 4-bit components; red, green, and blue (RGB). The indexed color value is loaded into a control register for use by a masking scheme which directs the 4-bit segmented digital quantity to the appropriate digital to analog converter.

Meanwhile, the sync signal is being generated via the control information initially loaded along with the microcode. Each analog signal is equivalent to 1-bit of a composite video signal. In symphony the four signals provide the proper signals required to create a video picture on an RGB device.

3.3.4 Conventional Map Displays. Other mapping projects conducted in parallel with this effort explored the use of surrogate travel techniques. Realistic filming of an area is a good method of portraying the features and provides visual feedback of spatial layout. A videodisc can theoretically contain 54,000 frames. To fully use the disc as a video storage medium, filming experiments were conducted in an attempt to reduce the number of frames required to traverse an area while not disorienting the user. Video tape and disc normally run at 30 frames per second, but if the user can control the frame rate, the filming need not be done in real time. Discrete single frame images can be taken every 2, 5, 10, or 15 feet, whatever is most appropriate, looking down a street and to the side. This type of surrogate travel filming was conducted over the 10 miles of streets within the Richmond test area. A separation of 10 feet between image locations was empirically chosen based on previous filming experiments. Stills documenting the actual filming are contained on the videodisc. More specifics of the actual filming are given in Appendix C.

A collection of other maps was also included. Various sequences of a road map and USGS topographic maps were included with shots from aerial and landsat photographs.

3.3.5 Image Transfer to Video Disc. A standard RGB color monitor was used to visually verify all computer-generated picture information. This same signal could also be routed to a large screen display for audience review. To produce a videodisc it was necessary to transfer these images to a hard copy media. A device called the DUNN camera was used for this purpose. The DUNN camera is a computer controlled recording device capable of producing 8x10 Polaroid hardcopy, 35mm slides or 16mm film from an RGB source, as shown in Figure 3-19. The estimated thousand Dar-El-Mara computer-generated images were transformed to 16mm film using the DUNN camera. The limited number of computer-generated images for the Richmond test area were transferred to 35mm slides, again on the DUNN camera system. This allowed greater flexibility in filming schedules and povides a higher resolution image. Random 8x10 Polaroids were also taken for display and documentation purposes. All surrogate travel filming was shot in 16mm color. The animation photography was shot in a 35mm silent motion picture format. All other still photography was shot using standard 35mm slide film.

Since the transfer of slides to disc is a very expensive process, all 35mm slides were transferred to one single strip of 35mm motion picture film. These and other ARPA related project materials were assembled and sent to the DiscoVision Associates mastering plant in California for transfer to disc.

The disc mastering process entails a complicated sequence of actions which can be broken into four components; premastering, encoding, mastering and replication, see Figure 3-20.

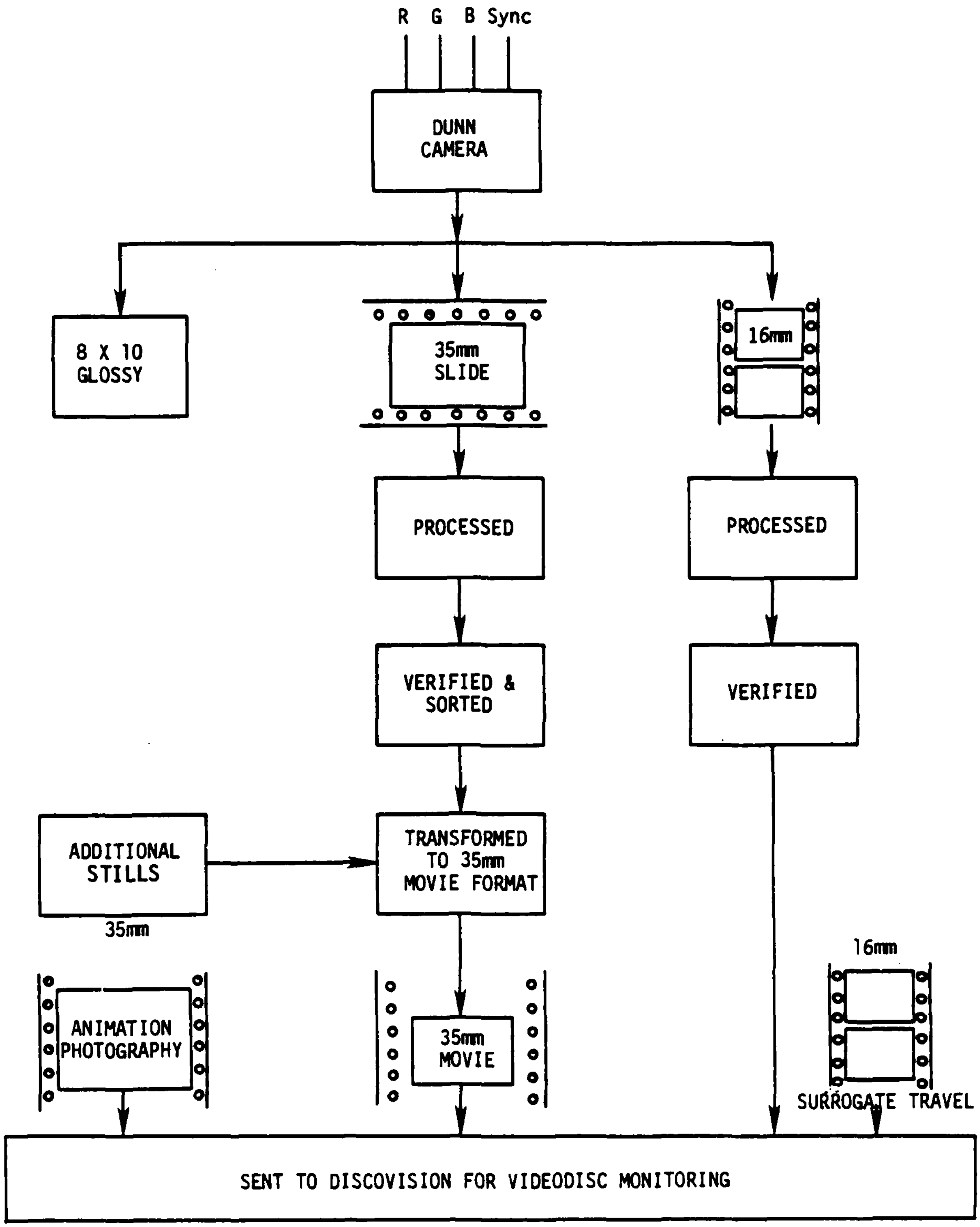



FIGURE 3-19.
IMAGE TRANSFER PROCESS

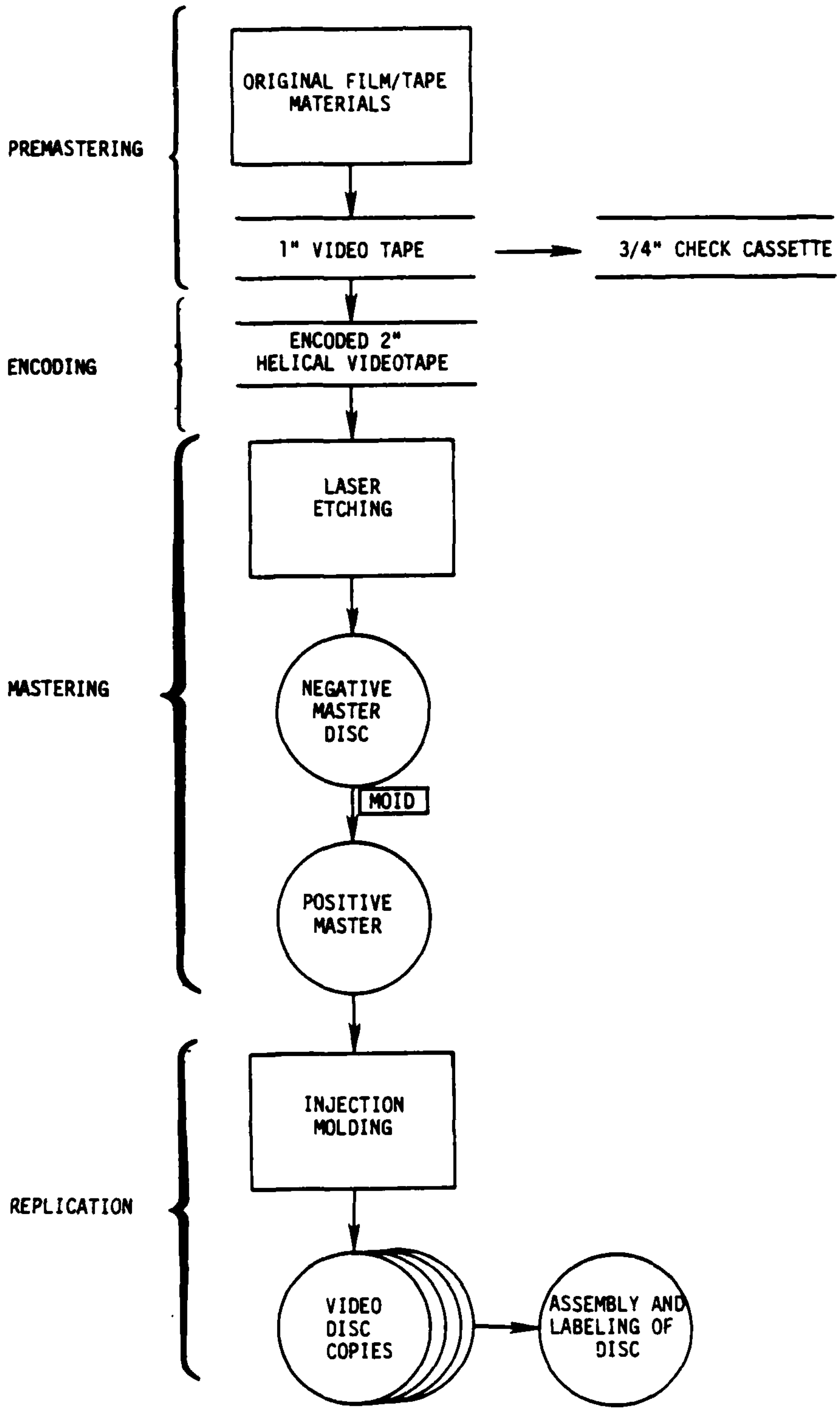



FIGURE 3-20.
VIDEODISC MASTERING PROCESS

During the premastering stage all original source materials are transferred onto one continuous 1" type C videotape. At this point a check cassette may be dubbed and sent to the producer for verification of frame accuracy and image quality. Upon quality approval, the framing information is encoded along with the visual images.

The mastering process involves converting the videotape's electronic signal into the appropriate signal required to create a negative master duplicating disc. Small pits which contain all audio and color video information required to produce a National Television System Committee (NTSC) signal are etched into the photo-resist layer of the disc. A mirror image which has raised spots corresponding exactly to the pits of the negative master is made. This positive master is called a stamper and is used in the injection molding process to produce disc replications. For large quantity replications multiple positive masters may be required due to wear in the replicating process. Videodisc players require discs to be a two-sided thickness. The final step in the disc production process is to bind two disc sides together and label each side accordingly.

## 3.4 Map Display Systems

3.4.1 The MPSTR-1 Unit Delivery System. The user's access to the video maps is through the MPSTR system illustrated in Figure 3-21. The MPSTR-1 unit was designed to let its user move quickly and naturally among the perspective views generated by computer and stored on videodisc.

The basic capability for mass picture storage is provided by a MCA Model 7820 videodisc player, which can store 54,000 full-color video frames on each side of a plastic videodisc the size of a phonograph record. Stored frames can be retrieved sequentially to provide TV images in normal motion, slow motion, reverse motion, etc. Alternatively, any of the

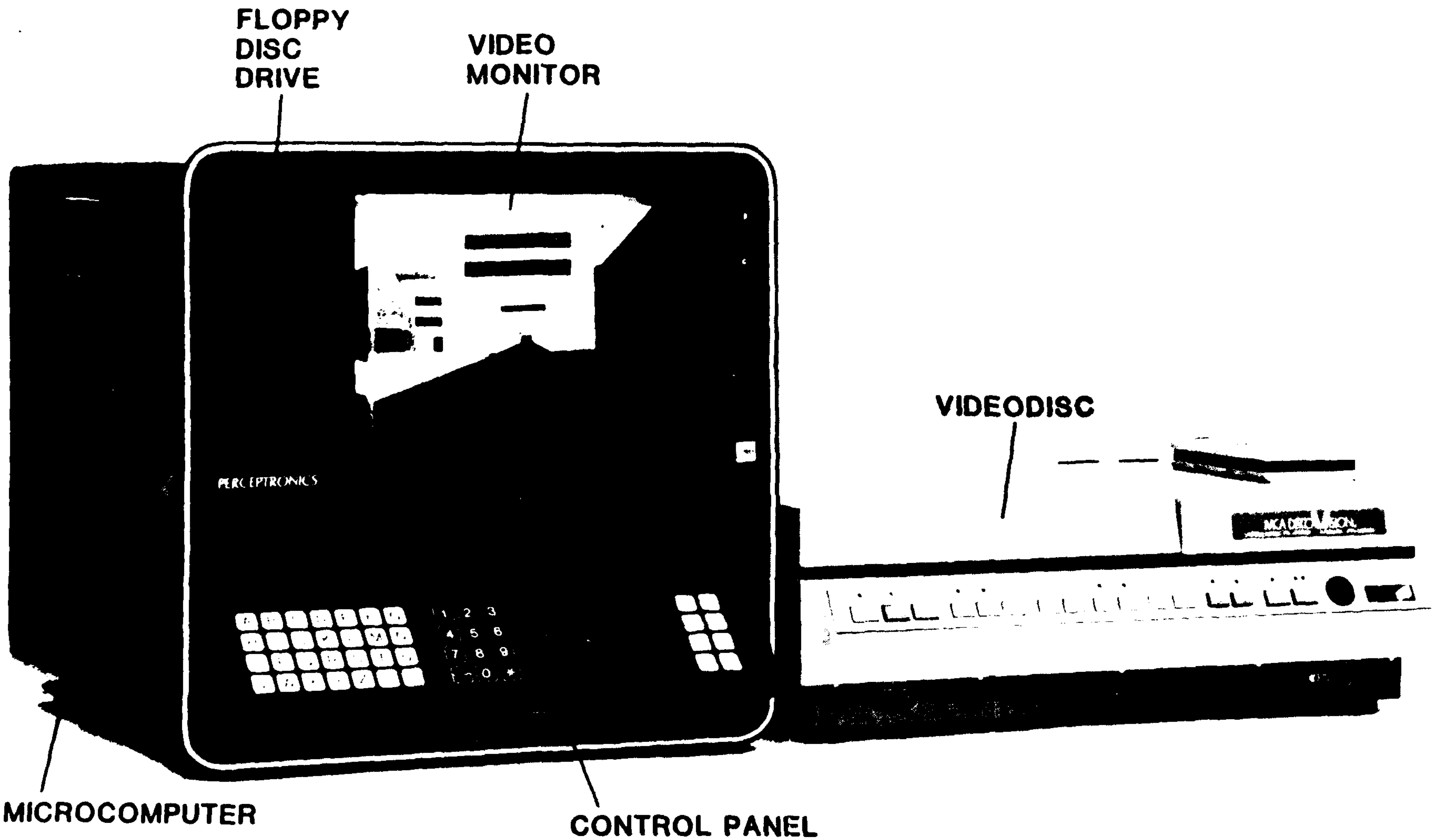



FIGURE 3-21.
PERCEPTRONICS' MPSTR SYSTEM

54,000 frames can be retrieved randomly with a maximum wait time of about three seconds. By itself, however, the videodisc player allows only the simplest type of picture access and control. More sophisticated methods of search and retrieval are made possible by the MPSTR-1 microcomputer system.

The MPSTR-1 microcomputer system includes a Z80 microprocessor with 64K bytes of internal memory, a floppy disc drive, a graphics system, an interface to the videodisc player, and an interface to the control keyboard. The floppy disc memory provides file storage for data associated with each videodisc frame, so that frames can be identified by such attributes as geographical coordinates, names, internal features, etc. The graphics system allows the overlay of computer-generated text and symbols on the video images recalled from the videodisc. The keyboard interface allows for the connection of various types of specialized user control.

The MPSTR-1 system is housed in a rugged, portable console designed for command center applications. The console contains a studio-quality, 12-inch color TV monitor, a flat, touch-type keyboard which locks at various tilt positions, and the built-in microcomputer system. The keyboard-mounted controls consist of an alphabetic keyboard, a numeric keypad, eight special-function keys, and a 3-degree-of-freedom joystick.

<u>MPSTR-1 Operation</u>. Figure 3-22 shows the keyboard-mounted controls. With the help of the special function and alphanumeric keys, the user can call up an elevated or road-level view by such locators as area coordinates, road name, and road intersection. For the elevated views, the joystick lets the user "fly around" the mapped area, moving over the matrix of observation points, changing elevation, and turning around a fixed location. At road level, the user can travel along a road, look to either

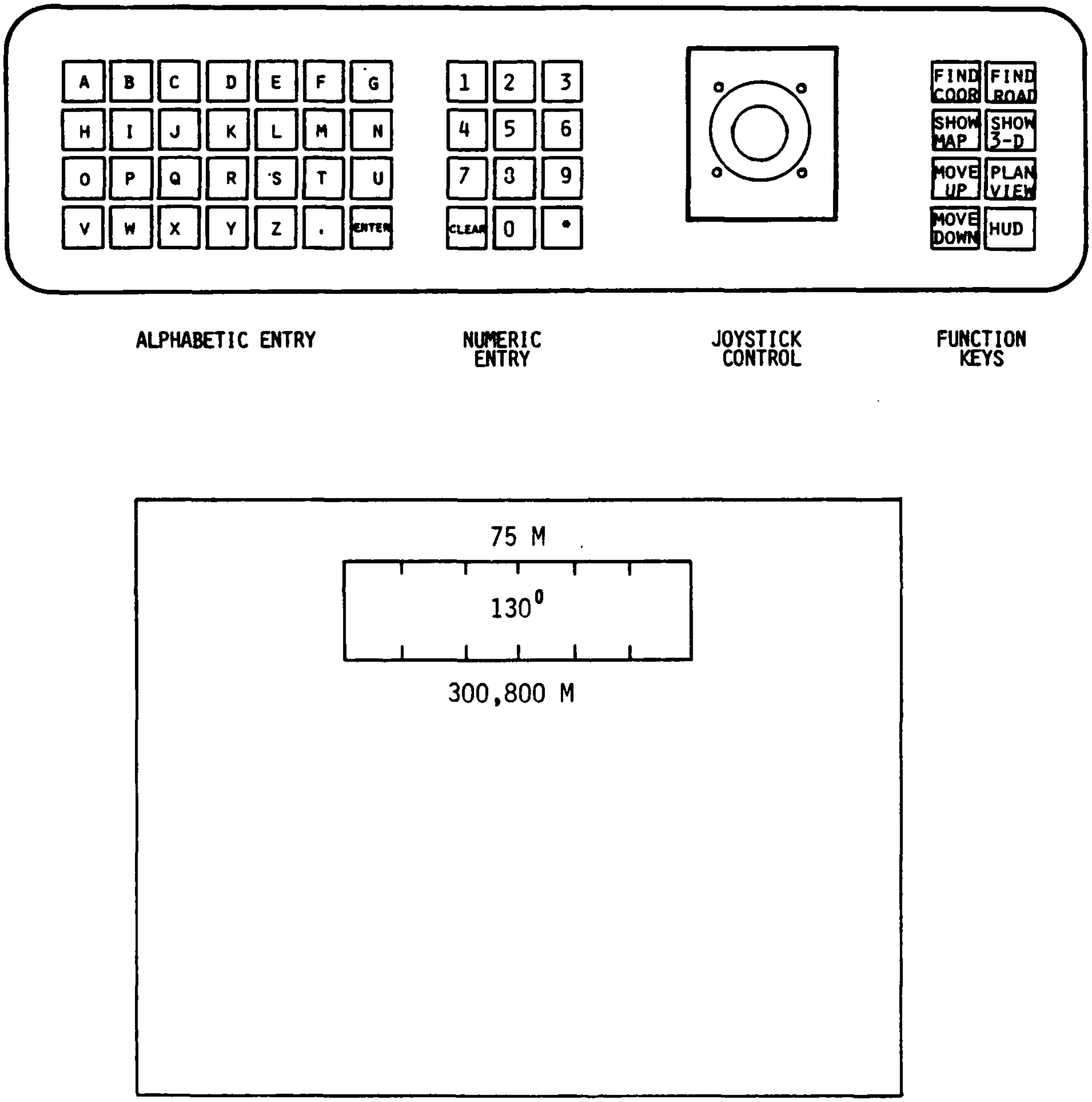



FIGURE 3-22.
MPSTRY KEYBOARD AND TYPICAL HUD

PERCEPTRONICS

side, and turn at intersections. A head-up display (HUD) can be superimposed on the picture to show compass heading, present location, and present elevation. Finally, the user can transfer between perspective and conventional map views as an aid to location and orientation.

In a typical interactive sequence, the program will first ask the user to specify a set of coordinates or a road name. By pressing FIND COOR, the user indicates that he wants to locate himself by coordinates. The program then asks for the coordinates, which he enters using the numeric key pad.

By pressing SHOW MAP, the user obtains a conventional map centered on these coordinates (in the preliminary Dar-El-Mara disc demonstrated in Washington, there were no conventional maps). MOVE UP gives the same map at a larger scale, MOVE DOWN gives the same map at a smaller scale. The joystick lets the user shift the map east-west or north-south. Pressing the HUD overlays a meter scale, north arrow, and coordinate location on the displayed map; pressing it again removes the overlay.

When the user presses SHOW 3D, he receives a perspective overview, facing north, from the "viewing tower" closest to the center coordinates of the map he was looking at. MOVE UP now gives him a view from higher up the tower, MOVE DOWN does the opposite. Rotating the joystick rotates his view around the tower. Pushing the joystick forward, back, left, or right moves him to the next tower in that direction. Pressing PLAN VIEW gives him a 3D view from the tower, looking straight down. In the 3D case, the HUD is a compass display which includes direction of view, viewing coordinates, and viewing height.

To operate at road level, the user first presses FIND ROAD, then identifies the desired road by name and by intersection or distance from the zero marker. Pressing SHOW 3D then gives him a view from road level at the specified point. At road level, the joystick is a driving/looking control. Pushing it forward moves the viewer forward on the road, pulling it backward moves him back. A twist to the left or right gives him views along the road, looking in that direction. At intersections, a set of arrows indicate when left or right turns are possible; pushing the joystick in the proper direction moves him onto the intersecting road.

The user can obtain a 3D overview of his road location by pressing the MOVE UP key. The computer selects the tower and direction of view which best encompasses his previous road position. MOVE DOWN then returns the user to road level.

3.4.2 A Talking Map Display System. Mapping information can be conveyed in a visual manner with pictures, text, and symbols, but often this additional information becomes overwhelming and can clutter a display. Narration is one way to provide this additional data without the burden of complicating the original visual source material. In conjunction with surrogate travel segments which are randomly accessible from a videodisc and a corresponding informational data base, an interactive computer-generated audio tour of an area can help present directional, feature, and location information.

To explore the concept of using computer-generated speech as a map aiding device, the Talking Map System was developed. Figure 3-23 outlines the system configuration. A PDP 11/70 time-shared minicomputer was used for system software development. All user display devices are interfaced with the minicomputer system using various controlling software and hardware devices.

Advances in technology have provided a wealth of new computer interfaces. A speech synthesis device, the Votrax VS6, has the ability to produce a

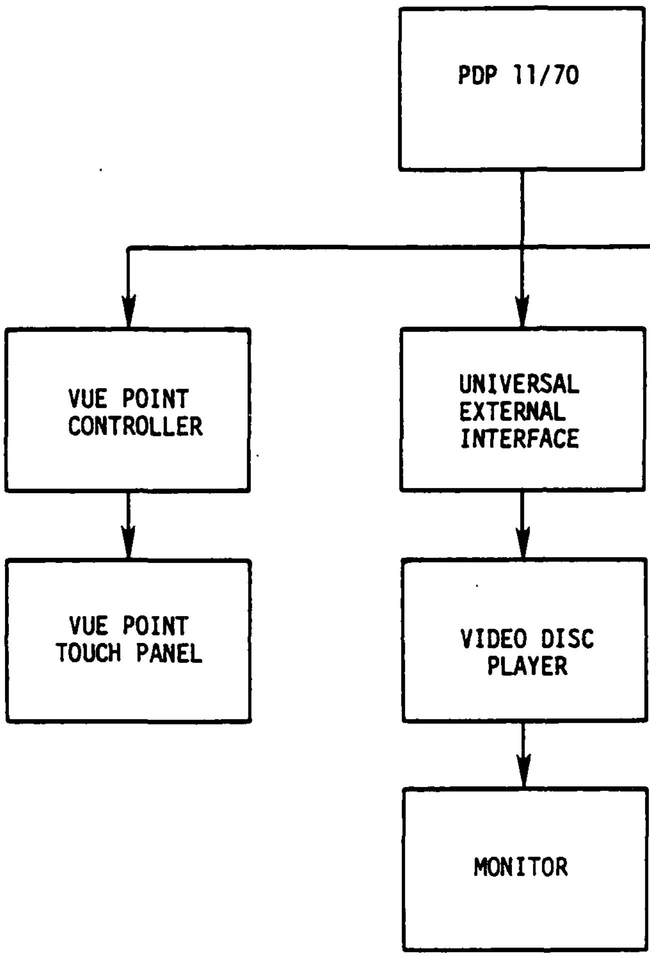



FIGURE 3-23.
TALKING MAP SYSTEM CONFIGURATION

selection of 64 atomic utterances, called phonemes, required to simulate human speech. A videodisc player is used to store a collection of visual mapping images. Under computer control, single frames and sequences of frames are randomly accessed and displayed to provide the appropriate visual material necessary for surrogate travel within an area. To control the system a touch sensitive panel, the VuePoint, was chosen as the user input device. The VuePoint is a flat panel display with sensors positioned along the panel periphery to provide a touch sensitive area. This combination of computer peripherals provides the basis for the system's potential capabilities.

Speech synthesis research has produced a variety of computer-generated speech generation techniques. Bell Labs has produced a software package called SPEAK, which applies phonetic rules to a word, thus breaking it down into phonetic components. Figure 3-24 provides a simple flow chart of SPEAK logic. A small dictionary of exceptions is checked as the word is stripped and broken into its phonetic components. Minor modifications were made to the SPEAK software to produce a random inflection. Once a word is translated into phonemes, the phonemes are routed to the Votrax for conversion to an audio signal which is then sent to a speaker for amplification to sound. Pitch, speed and volume are not computer controlled, but are hand-adjustable.

Other speech synthesis techniques require either digitization of a desired vocabulary or use pre-defined word dictionaries to store exact human replications of vocalizations. While this method is a good approach for some applications, vocabulary restrictions, dictionary production costs, and data base management complexities are obvious disadvantages. The phonetic approach to speech synthesis, on the other hand, allows a lot of vocabulary flexibility. An attempt is made to pronounce every word. Inherently, mispronunciation is a possibility since some words do not

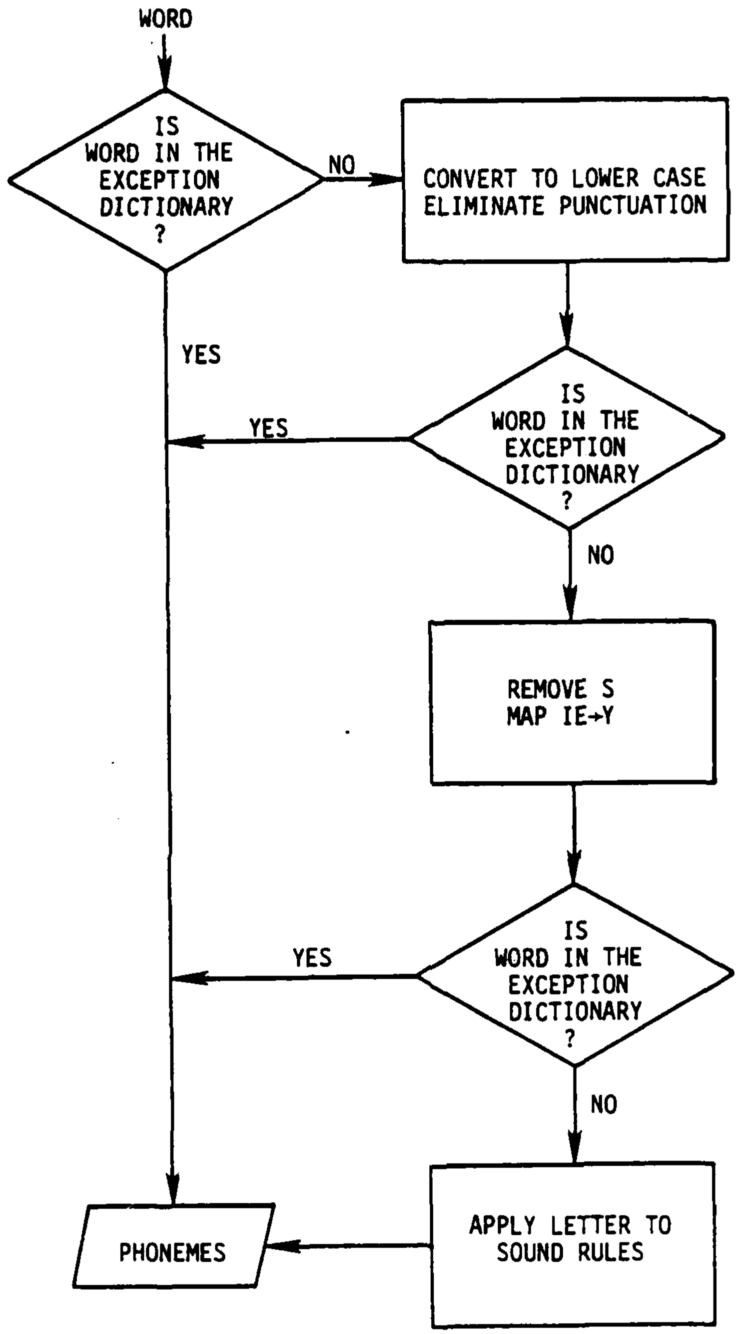



FIGURE 3-24.
SPEAK LOGIC FLOW

follow phonetic rules. "Creative" or phonetic spelling was used to enhance speech understandability, and is now recommended by Votrax as one method to produce a higher quality of speech.

Declining costs have inspired the development of new man-machine interfaces. Tactile interfaces are one of the new class of products which can provide a natural mechanism for interactive systems. A menu display of options which the user can easily read, understand and respond to, alleviates the problems related to keyboard-based interface systems. The VuePoint touch sensitive panel is a stand alone device which has a 12 row by 40 column light emitting diode (LED) flat panel display. Light sensors are aligned along the four sides of the panel. When a beam is broken a touch signal is detected. The VuePoint controller provides the capability to store up to 16 separate touch sensitive display menus for instant recall. Standard alphanumerics and a selection of special characters may be used to create any desired menu display.

A complete set of menu display page maintenance routines was written to facilitate menu experimentation. These utilities allow easy definition of character placement, touch parameters, label identifiers and page attributes. This package is a versatile application independent software package.

The second major component of the Talking Map System is the videodisc. Videodisc technology is a central theme throughout this two year effort. As previously stated, a videodisc was produced which contains a selection of mapping imagery from both a real and fictitious place. The imagery ranges from real filming to computer-generated animation to common street and topographic map material. Demonstrating the concept of computer-generated narration as a supplement to surrogate travel segments was the main thrust of the Talking Maps effort. Therefore, the majority of the visual materials are selected from the surrogate travel segments. Secondary demonstration considerations include audio introductory materials and system function explanations. Appropriate introductory and system component video materials were also included on the disc to provide a comprehensive system tutorial.

3.4.3 System Design. The Talking Maps System design is given in Figure 3-25. Two processes independently control the speech generation, and surrogate travel data base manipulation, image display, and user control interface. The speech generator functions as the narration maintenance handler while the travel controller monitors the user interface devices.

After system initialization, the speech generator, as illustrated in Figure 3-26, begins formulating narration for the current video imagery. An estimate of the amount of available time to talk is made based upon the current user travel mode. A sentence fragment of the appropriate length and content is created from the narration network. Given the current travel speed the number of frames which will be viewed is calculated from the sentence fragment length.

Once the speech generator determines the number of video frames to be viewed, the travel controller monitors the VuePoint for user input while controlling the videodisc player. If the user executes an instruction, the travel controller will update any modified status parameters and execute the instruction. Figure 3-27 gives an overview of this process.

The basis of the surrogate travel concept is interactively viewing imagery, be it computer-generated or actual photography, of an area along pathways. Natural pathways such as streets are obvious examples. To use this imagery sequences of views are stored on videodisc for quick random accessibility. Aerial travel has been confined to discrete views from

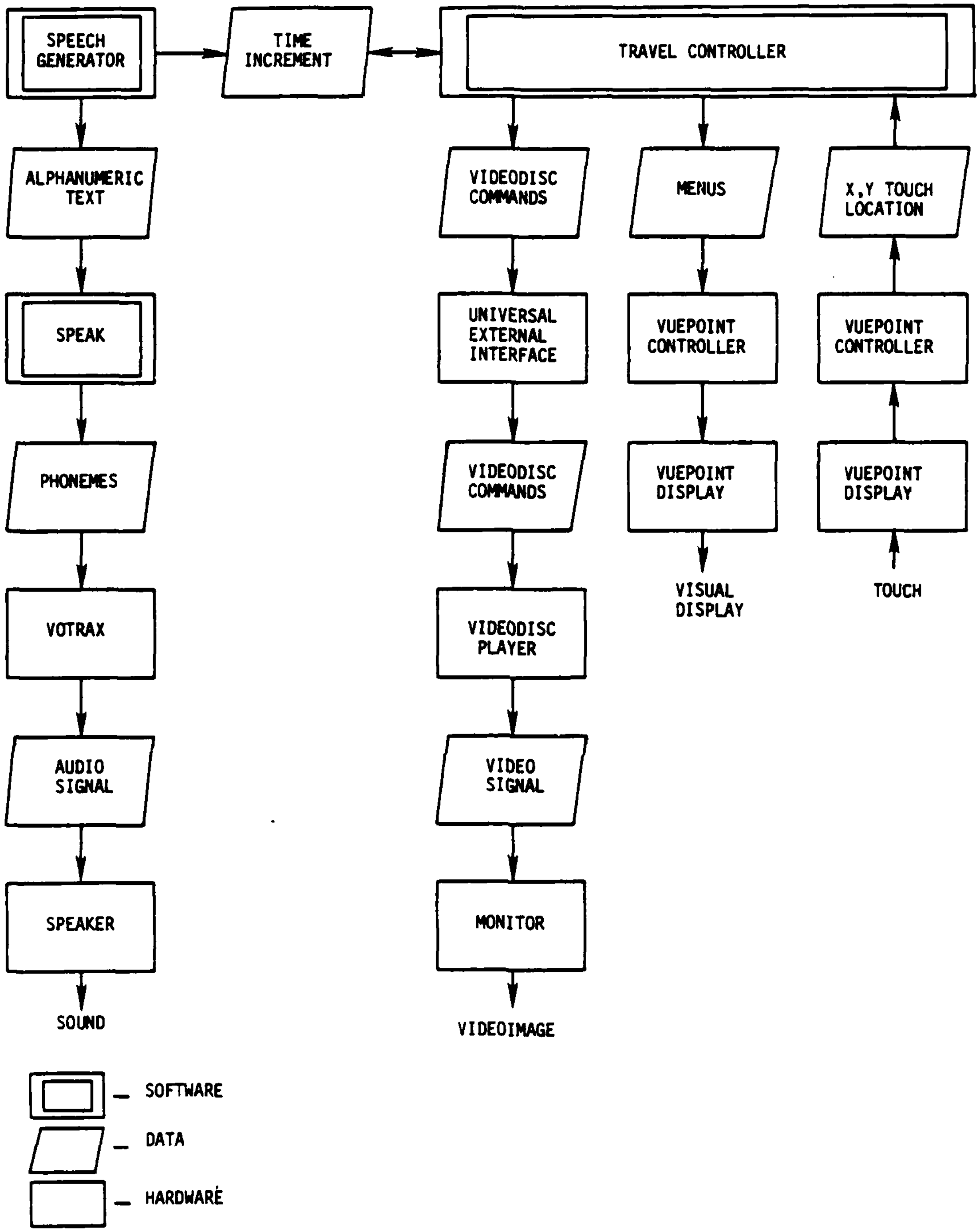



FIGURE 3-25.
TALKING MAP SYSTEM DESIGN

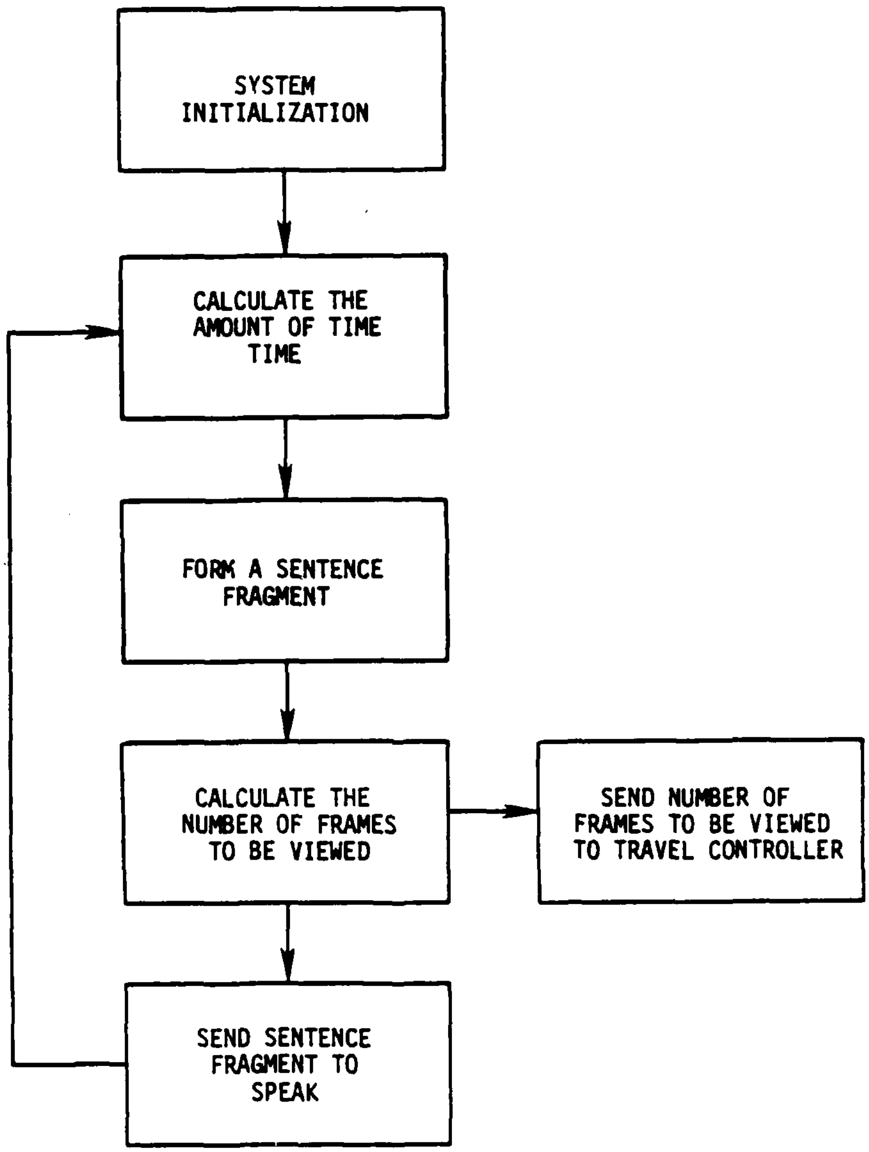



FIGURE 3-26.
SPEECH GENERATOR OVERVIEW

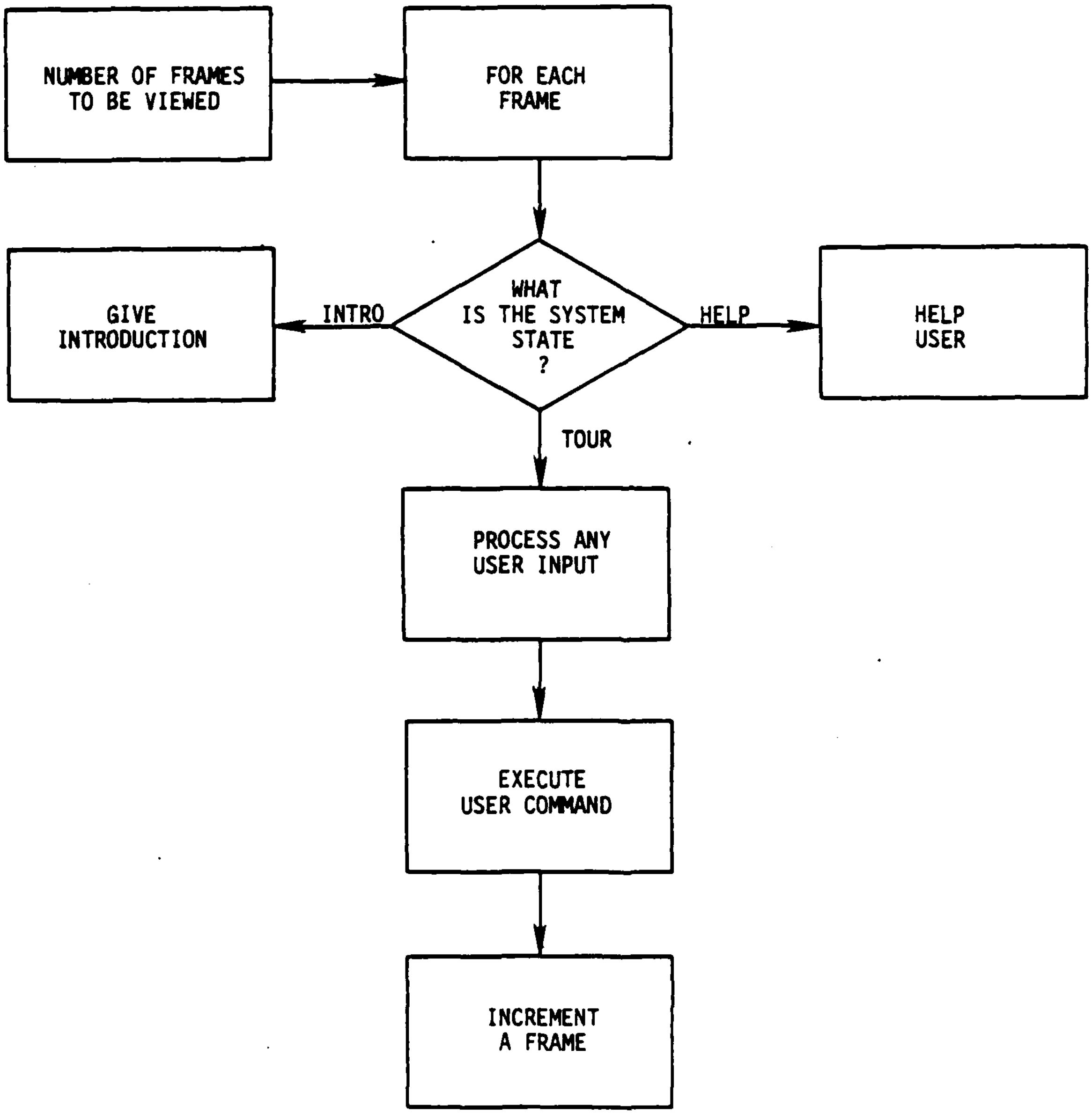



FIGURE 3-27.
TRAVELER OVERVIEW

"lookout towers" located in a grid pattern. From each tower nine views, one looking directly downward, and eight looking out over the horizon in forty-five degree increments, are available at different levels.

An associated data base is required to define the network of streets, intersections and aerial towers. Street information includes; video-disc frame numbers, cultural features, and directional information. Intersections are used as a means to link streets. Aerial towers also have associated linkage and frame information. This collection of data provides the groundwork of the dynamic information necessary to produce interactive narration.

3.4.4 Functionality. The user interacts with the Talking Maps system via the VuePoint touch panel, views images on a color monitor and receives audio narration from the Votrax. The color monitor is a common piece of equipment. Everyone is familiar with a television set. The Votrax speech synthesis device is new and the voice is a bit unnatural. Empirical evidence indicates an overwhelming increase in understanding after a few minutes of listening. To aid the user in becoming familiar with the Votrax "accent," text for the accompanying narrative is provided on the VuePoint. This allows the listener to read along as the Votrax is talking.

Touch sensitive devices are also relatively new. To overcome any fears or anxieties, in the beginning the VuePoint specifically asks the user to touch the panel. A choice of a long or brief introduction is available to acquaint the user with the VuePoint, the touch sensitive areas and their functions.

Instructions on the touch panel allow the user to control direction and speed of travel. The panel is divided into three main areas. Special instructions are along the right, speed controls on the bottom, and movement controls in the center left. The special controls allow you to end the tour, ask for help, and turn the narration on and off. To control your rate of travel while moving along the ground, speeds are listed along the bottom of the panel. The movement controls are in the center of the panel. These controls allow the user to move about the area. Three instructions: move, look and twirl are used in conjunction with a directional dial to allow the user freedom of movement while maintaining orientation. The directional dial is a ring of the symbols; N, NE, E, SE, S, SW, W, and NW, located directly in the center of the panel. The direction of travel always remains at the top of this dial. To move in a certain direction, touch move and then the directional dial. The user may also look in another direction by touching look, and the directional dial. Twirl will give the user a three hundred and sixty degree spin. A rise and fall instruction are provided to allow aerial travel. Touching rise will relocate the user to the closest aerial position. From that position the user will be looking directly downward, with north at the top of your screen. The directional dial maybe used to look out over the horizon in any of the eight available directions.

The "HELP" instruction is a special function which allows the user to halt travel and ask for help concerning any of the menu display instructions. Once the system's explanation is complete, travel resumes and control is returned to the user.

# 4. CONCLUSIONS

This two year videodisc-based mapping project has revolved around:

- Producing an automatic interface between an existing digital data base, DLMS, and a system which will produce three-dimensional computer-generated color images, the TV System.
- Extensive testing and upgrading of the TV System.
- Production of a videodisc with a large selection of mapping images.
- Design and production of the MPSTR-1 display unit.
- Design and implementation of the Talking Maps System.

The following is a brief discussion of results, conclusions, and suggestions for further similar map research.

DLMS Data. The DLMS level two data is not of sufficient density, or quality to produce extremely realistic, accurate three-dimensional images. The data is often vague, occasionally inaccurate, and incomplete. The resulting images would be useful for large regional familiarity, but are not reliable enough for location of specific buildings without extensive hand-massaging and verification. Future development of a level-three data base source should be investigated. If the DLMS data were to be used as a base of information to be hand-modified, an automatic method to visually inspect cultural feature analysis manuscript placement and verification, along with interactive tools to create, place, and move features would be very useful. Incorporation of a plotter to create a quick two-dimensional plan view of an area should also be considered. DMA may be able to provide leads on work previously conducted in the two-dimensional plotting of the DLMS data.

Dar-El-Mara. The Dar-El-Mara data base has been an undying source of visual imagery. Its compact yet complete description has provided experimental opportunities which would not otherwise have been feasible.

Automatic Interface. Generalized routines were written for DLMS data extraction and verification, and could be used for any DLMS related project. A limited selection of the total available features, as listed in Appendix B, were realistically modeled. Provisions were made to expand the modeling to any number of features with all unmodeled features scaled to size and appropriately labeled.

Picture Production System. Picture production times were unacceptably slow for images of any complexity. Several approaches could be considered to help solve this problem; additional preprocessing software to extract and process only visible features, use of a large main frame instead of a minicomputer, reduction and restructuring of the main processor, TVSHOW, to decrease running time. Several enhancements which could be made to the TV System to facilitate scene modeling would include:

- A priority scheme which would allow placing of certain objects on or within others, e.g., a car on a road, but would disallow other object overlapping, e.g., a tree in a house.
- An attracting scheme to place houses near roads, line roads with trees, place vegetation around houses, etc.
- A scheme which would fade colors to grey as they recede into the distance.
- Anti-aliasing of sharp color boundaries to reduce the stair-stepping affect.
- A method to allow high and low resolution modeling of objects as well as trees.

Talking Maps System. Speech synthesis is a rapidly changing technology. Since the inception of this project, Votrax has developed several versions of speech synthesis devices which contain firmware similar to the Bell Labs SPEAK software. This new hardware and firmware package is one-third to one-tenth (depending on model and capability) the cost of the original Votrax hardware. Any further use of speech synthesis should include an up-to-date survey of both equipment and simulation techniques. The development of touch sensitive devices has also progressed rapidly. Any requirement for the use of a touch sensitive interface should include an up-to-date survey of the current technology. The Vuepoint by comparision is an expensive device. Newer touch panels can be directly overlayed onto a color monitor thus providing more flexibilty in the visual display. Surrogate travel in particular seems to more naturally require the use of a joy stick type of interface for simulating driving, walking, or any similar directional function.

MPSTR Delivery System. The available part of the Dar-El-Mara data base has been successfully demonstrated with the MPSTR interactive retrieval system. User interaction with the 3-D views is natural, as intended. The continuous sequence of images provided by the system gives the impression of moving freely around the actual locale. (The recent introduction by MCA of the Model 7820-02 player, with faster response time, will improve the retrieval system even more.) Informal evaluation of the unit has revealed the following points:

- MPSTR was not conceived as a travel simulator, in the sense of attempting to reproduce exactly the experience of vehicular movement (with the exception of the road segments). Its high "viewing points" are widely spaced, providing broad overviews of the surrounding terrain. Nevertheless, the feeling of movement within the mapped space is quite strong. It may be that in a free travel system for open terrain, view points can be spaced well beyond those typical for a road-based "driving" system.

- The MPSTR system uses only a single videodisc player. Thus rotations around a point are executed very smoothly, because the frames are adjacent on the disc, but brief "blank outs" are experienced in moving from point to point. However, as long as the user has a reasonable idea of where the jump will take him or here, user will not suffer from lack of orientation.

- With MPSTR, the user has the capability to move independently of the direction of view. On the elevated views, for example, the user may look northward and move eastward. On the ground, the user may move forward while looking left or right. This capability does not seem to be essential. On the ground, it is frequently disorienting. With elevated views, it often destroys the feeling of flying, forcing the user to think of the underlying gridwork. If movement on a grid were restricted only to the direction of view, operation would be simpler and overall orientation might be even better.

- The "head-up-display" overlay provides the user with a ready reference to his or here location and direction of view. It also allows quick cross-referencing to conventional maps, viewed separately or on the video display. Without such a reference, it is possible to get very lost, particularly with the restricted field-of-view typical of vicarious travel displays. In addition, the ability to occasionally turn off the HUD both clears the view for complex scenes, and provides an incentive toward learning the terrain. However, there is a limit to the amount of information which can be comfortable included on a HUD. A second screen for auxiliary material might be a preferred approach, depending on the amount of information that needs to be presented.

It is possible to conceive of several interesting extensions of the MPSTR delivery system. Although the software currently supports a particular 3D application, it can easily be modified for other intelligence storage and retrieval tasks.[1] The user interface, which is based on modular switch elements and a printed overlay, can be simply and cheaply matched to new system requirements. Addition of a standard interface card would adapt the MPSTR-1 to act as an intelligent terminal in a large computer network. This means that variable realtime data could be added to a map or 3D display in the form of tactical symbols, comments, etc. Similarly, the built-in graphics system of the MPSTR-1 could be used to "write-in" such information from the control panel. Finally, two or more MPSTR-1 stations could be linked by wire, by telephone, or by radio, so that a particular videodisc frame and supplemental data appearing on one system simultaneously appears on the others. Very little information is passed over the connecting link, since the communicating systems have their own independent picture storage and graphics capabilities.

[1] For example, associated aerial photographs, ground photographs, and text descriptions of mapped locale and its key features can be added to the videodisc, and retrieved by the same mechanism.

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# APPENDIX A

## DMA DLMS CULTURAL FEATURE HEIGHT REQUIREMENTS AND RULES

| | Surface Material Category Size Requirements | | | | SMC Change Requirements* | | Height Differential Requirements | | | Rules |
|---|---|---|---|---|---|---|---|---|---|---|
| SMC | Min. Length | Min. Width | Min. Height | Min. Roof Cover | Min. Length | Min. Width | Min. Height Diff. | Min. Length | Min. Width | Note |
| 1 | 30(100) | 30(100) | 3(10) | 6% | 15(50) | ANY | NOT REQUIRED | | | 1,5,6,8 |
| 2 | 30(100) | 30(100) | 3(10) | 6% | 15(50) | ANY | NOT REQUIRED | | | 2,5,6,8 |
| 3 | 30(100) | 30(100) | 5(15) | 6% | 60(200) | 60(200) | 10(30) | 30(100) | ANY | 5,8 |
| 4 | 60(200) | 60(200) | 5(15) | 6% | 60(200) | 60(200) | 10(30) | 60(200) | ANY | 5,8 |
| 5 | 30(100) | 30(100) | 5(15) | -- | -- | -- | -- | -- | -- | -- |
| 6 | 30(100) | 30(100) | -- | -- | -- | -- | -- | -- | -- | 4,5,7 |
| 7 | 600(2000) | 150(500) | -- | -- | -- | -- | -- | -- | -- | 9,12 |
| 8 | 150(500) | 150(500) | -- | -- | -- | -- | -- | -- | -- | -- |
| 9 | 100(300) | 100(300) | -- | -- | -- | -- | -- | -- | -- | 5,10 |
| 10 | -- | -- | -- | -- | -- | -- | -- | -- | -- | 3,5 |
| 11 | 150(500) | 150(500) | -- | -- | -- | -- | -- | -- | -- | -- |
| 12 | 60(200) | 10(30) | 8(25) | -- | -- | -- | -- | -- | -- | 3,5,11 |
| 13 | 150(500) | 150(500) | -- | -- | -- | -- | -- | -- | -- | -- |

TABLE 2-100/200-2 LEVEL 2 - SURFACE/HEIGHT SPECIFICATIONS
(Dimensions in Meters (Feet))

*SMC change within other surface material areas (urban areas) 1-4

Refer to Pages 23 and 25 for notes.

NOTES FOR TABLES 2-100/200-1 AND 2-100/200-2

NOTE: (1) Height differential grouping is not required within an SMC 1 area. SMC change not required for SMC 1 areas within an SMC 2 area.

(2) Height differential grouping not required within an SMC 2 area. SMC change is not required for SMC 2 areas within an SMC 1 area.

(3) All open areas within an urban area (SMC 1-4) will be described as an SMC 10 or SMC 12 depending upon its predominant content. Minimum size requirements 150m x 150m (500'x500') Level 1, 60m x 60m (200'x200') Level 2. All of the land area on the manuscript will be described as SMC 10 (soil) for the background material. Open areas within urban areas are defined as areas having 5% or less roof coverage and surrounded by SMC 1, 2, 3 or 4 buildings.

(4) To minimize the fragmentation of rivers, those narrower sections between SMC 6 river segments (areal portrayal) that are at least 100 meters (300 ft) wide at Level 1, or less than 30 meters (100 ft) at Level 2, shall be portrayed as linear features. Length and width measurements for inland water areas shall be made at the normal water level. Tidal water area measurements shall be made at mean high water. (NOTE: See Unique Significant Features for details of mud/tidal flats.)

(5) Open areas within wooded areas will be described as SMC 10 (soil). Minimum size requirements of open areas are 300m x 300m (1000'x1000') Level 1 and 60m x 60m (200'x200') Level 2. Open areas within wooded areas are defined as areas having less than 51% trees and less than 5% buildings. SMC 1 through 4 and 6 areas may be shown within a wooded area if applicable surface/height specifications are met. The above minimum size requirements will also apply to SMC 10 areas falling within SMC 8, 9, 11 and/or 13 areas.

(6) Surface material or height differential groupings (areas) smaller than 150m x 150m (500'x500') Level 1 or 30m x 30m (100'x100') Level 2 shall be portrayed as a point or line feature.

NOTES FOR TABLES 2-100/200-1 AND 2-100/200-2 (CONT'D)

(7) Features that are surrounded by or cross water areas are of particular importance. Refer to the Unique Feature Specifications for minimum size requirements of such features as causeways, islands and bridges. Bodies of water will not be grouped together to meet the areal specification requirements for SMC 6 areas.

(8) The minimum width of 2 meters or 5 feet will be recorded on the FADT even if the actual width is less than 2 meters or 5 feet. Two meters or five feet is the minimum unit of measure to be recorded for any feature.

(9) The minimum size requirements refer to mud/tidal flats.

(10) Refer to Unique Feature Specifications, Chapter 2, Section 400, for airfield runway and taxiways minimum size requirements.

(11) Recorded tree height is standardized at 16 meters or 50 feet for trees less than 30 meters (100 feet) tall, and at 30 meters (100 feet) for trees taller than 30 meters (100 feet).

(12) This note pertains to sand dunes. The minimum size requirements are:

Level 1: Length and width = 3000 meters (10,000 feet)
Level 2: Length and width = 600 meters ( 2,000 feet)

Portrayal of desert or sand areas other than sand dunes, sand bars or mud/tidal flats is not required.

# APPENDIX B

## DMA DLMS FEATURE IDENTIFICATION DEFINITIONS

502. Industry

The industrial category is comprised of the area and facilities, including buildings, utilized by those establishments engaged in the extraction of raw materials, the processing of these materials and the production of intermediate and finished products.

Extraction Industry (General)
- Quarry
- Gas/Oil Derrick
- Offshore Platform
- Offshore Platform with Derrick
- Mine Shaft Superstructure

Processing Industry (General)
- Chemical Processing Plant
- Metal Processing Plant
- Sewage Treatment Plant
- Evaporator Mining (Settling Basins, Sludge Ponds)
- Coke Plant
- Blast Furnace

- Refinery
- Catalytic Cracker
- Flare Pipe

- Power Plants (General)
- Hydro-electric Power Plant
- Thermal Power Plant
- Transformer Yard
- Substation

- Solar Energy Electrical Collection Panels
- Solar Energy Heat Collection Panels

Heavy Fabrication Industry (General
- With Flat Roof
- With Flat Roof and Monitor
- With Gable Roof (Pitched)
- With Gable Roof (Pitched) and Monitor
- With Sawtooth Roof
- With Curved Roof

Light Fabrication Industry (General)
- With Flat Roof
- With Flat Roof and Monitor
- With Gable Roof (Pitched)
- With Gable Roof (Pitched) and Monitor
- With Sawtooth Roof
- With Curved Roof

Disposal (General)
- Scrap Yard
- Metal Ore Slag Dump
- Tailings, Waste Piles
- Strip Mine

Associated Structures (General)
- Building
- Smokestack
- Conveyor
- Pumping Station
- Bridge Crane
- Rotating Crane
- Rotating Crane on Tower
- Cooling Tower
- Hopper
- Dredge, Powershovel, Dragline

## 503. Transportation

The transportation category consists of the area and facilities utilized in moving materials and people from place to place on land.

Railroads (General)
- Elevated
- Railroad Yards/Sidings (Moderate to Heavy Activity)
- Raildoad Yards/Sidings (Light Activity)
- Railroad Yards/Sidings (Empty)

- Storage and Repair Building
- Railroad Terminal Building
- Railroad Station
- Railroad Control Towers
- Roundhouse

Roads (General)
- Elevated
- Causeways

Bridges (General)
- Suspension
- Cantilever
- Arch
- Truss
- Moveable Span
- Bridge Towers
- Deck

Conduits (General)
- Pipelines (Above Ground)
- Aqueducts
- Penstocks, Flumes

Associated Structures (General)

504. <u>Commercial/Recreational</u>

The commercial category consists of the area and buildings where the major business activities and recreational facilities of the urban area are conducted.

Commercial Buildings (General)
- With Flat Roof
- Circular with Flat Roof
- With Gable Roof
- With Curved Roof

Recreational Activities (General)
- Enclosed Stadium
- Open-ended Stadium
- Dome Stadium
- Grandstand
- Athletic Field

- Amusement Park
- Roller Coaster
- Ferris Wheel
- Artificial Mountain

Display Signs (General)
- Advertising Billboards
- Scoreboard
- Overhead Highway Sign

Associated Structures (General)
- Drive-In Theater Screens

505. <u>Residential/Agricultural</u>

The residential category is comprised of the area and associated buildings where the civilian or non-military population live.

Multi-Family Dwellings (General)
- Apartments/Hotels with Flat Roof
- Apartments/Hotels with Gable Roof

Single Family Dwellings (General)
- Mobile Home

The agricultural category is comprised of the structures involved with agricultural activities.

Agricultural Buildings (General)
- Stockyard/Holding Pen
- Windmill (Truss)
- Windmill (Solid)

Associated Structures (General)
- Cemetery Buildings

506. Communications/Transmission Facilities and Tower Types

Communication facilities are used for transmitting information from place to place. The communication category includes telephone, telegraph and radio facilities as well as other forms of electronic features such as powerline pylons, and associated structures.

Communication Towers (General)
Radio/Television, Tower Type "A"
Radio/Television, Tower Type "I"

Microwave Tower, Type "A"
Microwave Tower, Type "I"

Miscellaneous Towers (General)
Observation Tower
Tower on Structure

Power Transmission Towers (General)
Powerline Pylons, Type "A"
Powerline Pylons, Type "H"
Powerline Pylons, Type "I"
Powerline Pylons, Type "Y"

Associated Structures
Communication Buildings

507. Governmental and Institutional

The governmental and institutional category is comprised of the area and facilities, primarily buildings, which constitute the seat of legal, administrative or other governmental functions of a country or political subdivision, as well as public service institutions such as universities, churches and hospitals.

Government (General)
Capital Building
Administration Building
Prison
Palace
Castle

Institutional (General)

School
With Flat Roof
With Gable Roof

Hospital
With Flat Roof
With Gable Roof

Observatory
With Dome Roof

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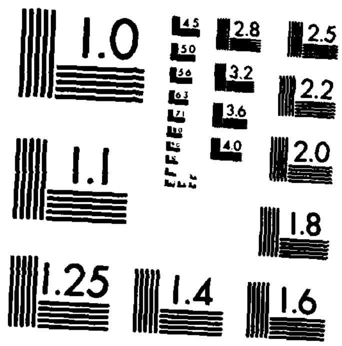


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Houses of Religious Worship (General)

Associated Structures (General)
- Steeple
- Monument/Obelisk
- Arch
- Pyramid

508. Military/Civil Installations

The military/civil category consists of the area and facilities utilized by the air, naval and ground forces for waging war, for training and for sheltering and transporting personnel and material, as well as the area and facilities used for transporting non-military goods and personnel by sea and by air.

Airport/Airbase (General)
- Control Tower
- Terminal/Base Operations
- Hangar with Flat Roof
- Hangar with Curved Roof
- Runways and Taxiways
- Aircraft Parking Areas

Airport/Airbase Electronic Navigation Aids (General)
- Radar Reflectors, Uni-Directional
- Radar Reflectors, Bi-Directional
- Radar Reflectors, Omni-Directional
- VOR/VORTAC/TACAN Facility
- Radar Antenna with Radome
- Radar Antenna, Tower Mounted with Radome
- Radar Antenna
- Radar Antenna, Tower Mounted
- Radar Antenna, Vehicle Mounted
- Approach Lights Framework
- GCA Facility

Runway Approach Lighting System (General)

Maritime Features (General)
- Breakwater/Jetty
- Wharf/Pier
- Drydock
- Lock
- Off-Shore Loading Facilities
- Exposed Wreck

Maritime Navigation Aids (General)
- Navigation Light-Ship (Permanently Moored)
- Lighthouse

Ground (General)
- Barracks, Curved Roof
- Barracks, Flat Roof
- Barracks, Gable Roof
- Motor Pools
- Garage, Curved Roof
- Garage, Flat Roof
- Garage, Gable Roof
- Depots

Associated Structures (General)
- Administration Building
- Engine Test Cells
- Wind Tunnels

509. Storage

The storage category is comprised of the area and facilities for holding or handling liquids or gases, bulk solids, and finished products.

Tanks (General)
- Cylindrical, Flat Top
- Cylindrical, Dome Top
- Cylindrical, Peaked/Conical Top
- Cylindrical, Peaked/Conical Top, Tower Mounted
- Spherical
- Spherical with Column Support

- Blimp
- Bullet
- Telescoping Gasholder (Gasometer)

Closed Storage (General)
- Silo
- Grain Elevator
- Grain Bin
- Water Tower (Building)
- Ordnance Storage Mounds

Open Storage (General)
- Mineral

Associated Features (General)
- Warehouses
- Vehicle Storage Area
- Vehicle Parking Area
- Aircraft Storage Area
- Ship Storage Area

510. Landforms, Vegetation and Miscellaneous Features

The landforms and vegetation category is comprised of the area which most closely describes the surface landscape characteristics or natural scenery. This category will also include such features as levees, walls and fences.

Ground Surface (General)
- Soil
- Sand/Desert
- Sand Dunes
- Marsh/Swamp
- Rice Paddies
- Smooth Solid Rock
- Boulder Field/Lava
- Rocky Rough Surgace
- Dry Lake
- Mud/Tidal Flats

Surface Features (General)
- Levees/Embankments
- Walls
- Cliffs
- Dams
- Water Intake Towers
- Fences

Salt Water (General)
- Salt Water, Sea State
- Salt Water, Sea State, Subject to Ice
- Salt Water, Subject to Ice
- Salt Pans

Fresh Water (General)
- Fresh Water, Sea State
- Fresh Water, Sea State, Subject to Ice
- Fresh Water, Subject to Ice
- Waterfall

Vegetation (General)
- Orchards/Hedgerows
- Deciduous Trees
- Evergreen Trees (including Mangrove and Nipa)
- Mixed Trees (Deciduous and Evergreen)
- Tundra
- Vineyards

Snow/Ice Areas (General)
- Permanent Snow
- Permanent Ice -- Glacier/Ice Cap
- Pack Ice (Temporary)
- Polar Ice Pack

Regional Features (General)

# APPENDIX C

## SUMMARY OF SURROGATE TRAVEL FILMING OF RICHMOND TEST AREA

## FILMING SUMMARY

### PROJECT INFORMATION

| | |
|---|---|
| 1. Contract name & number | TACMAPS, MDA903-76-C-0241 |
| 2. Program manager | Dr. Judith Daly |
| 3. Prime contractor | Perceptronics |
| 4. Subcontractor | Comunicado |

### CAMERA CREW

| | |
|---|---|
| 1. Cinematographer | Ms. Carol Rudisill |
| 2. Assistant(s) | Ken Hoen |
| | Officer Zimmerman |
| 3. Developer | Commonwealth Film Labs |
| 4. Recommendations | Good prices and quality |

### LOCATION OF FILMING

| | |
|---|---|
| 1. Location | West end of Richmond, Va. |
| | All streets within 1 square mile |
| | |
| 2. Interior or Exterior | Exterior, ~10 miles |

### SEASONAL & TIMING INFORMATION

| | |
|---|---|
| 1. Date of shoot | Dec. 18 - Dec. 19, 1980 |
| 2. Time of day | 10 a.m. - 2 p.m. |
| 3. Number of days required | Two |
| 4. Weather conditions | Partly cloudy |
| | 40° - 50° |

CAMERA CONFIGURATION

| | |
|---|---|
| 1. Type of camera(s) | Bolex 16mm |
| 2. Number of camera(s) | Two |
| 3. Position of camera(s) | Facing forward and right |
| 4. Type of len(s) | 5.5mm wide angle |
| 5. Type of film | Ektachrome Commercial |
| 6. Amount of film | 10 100 foot rolls |
| 7. Distance between frames | ~10 feet |

DETAILS FOR EXTERIOR FILMING

| | |
|---|---|
| 1. Type of vehicle | ~~Station wagon~~ |
| 2. Approximate speed of vehicle | 5 m.p.h. |
| 3. Type of mount(s) | Limpet - 3 suction cups |
| 4. Placement of mount(s) | Hood of car |
| 5. Triggering mechanism | Wheel, and control boxes built for DARPA by Peace River Films |

DETAILS OF INTERIOR FILMING

1. Method of camera movement
2. Camera configuration
3. Additional lighting

NOTES ON PRODUCTION Officer Zimmerman of the Richmond Police assisted in traffic control on busy streets at a cost of $10.00/hour. Photographs of the film set up were taken and will be included on the disk. The film was edited by Comunicado and a work print was made to be sent to DVA. Due to the seasonal positioning of the sun, there is some glare which could be eliminated by filming later in the year. Reducing vehicle speed to 5 m.p.h. eliminated almost all blurring in close foreground.

NOTES ON MASTERING This film should fill about half of one side of a videodisc. It has been submitted on three inch core as requested by DVA.

END

FILMED

FEB. 1988

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