AN OVERVIEW OF THE TEXAS STATEWIDE FREEWAY TRAFFIC MANAGEMENT CENTRAL CONTROL SYSTEM

by

Charles W. Blumentritt

Texas Transportation Institute

17360 Coit Road

Dallas, Texas 75252

214/231-5362 , TexAn 343-5011

July, 1987

Prologue

This paper is a working document which describes many of the elements of the design for a freeway traffic management system. This system is highly modular, intended to furnish the building blocks for a system which has statewide application. It is an attempt to enumerate the needs of all of the targeted urban areas. In so doing, this leaves the respective Districts with the option of selecting only those system components which are relevant to a particular urban area.

This approach risks the possibility of presenting too many options. Such are the risks associated with a top-down design that is implemented in the real world of bottom-up implementation. Yet, without this approach, the pieces of the control system never do quite mesh in the way they were intended. Generally, this is discovered with the following interrogative:

Can you do this or can you add that?

The intent of this paper is to foster comments from the ultimate users of the system. These comments should answer the leading question: What operational needs do you have that cannot be satisfied by this system design?

Another basic question to be answered is: What are the objectives of your FTM system? It is acknowledged that the ranking of similar objectives vary from District to District. Once the objectives are known, the next question is: Does this system design present an orderly approach to the implementation of the stated goals?

It is likely that it will be beyond 1990 before the first system based on this design will become operational. The 1990's will usher in many more technological changes to consider. It is time to plan the incorporation of as many of these innovations as possible in FTM. The concept of simply installing a computer that controls remote traffic control devices is now over 30 years old. While that fundamental elemental relationship still prevails (much in the same way that most digital computers operate on the same principle), it is vital that new tools be employed to expand the capabilities of a control center. A major achievement can be to dispatch the benefit of real time, centralized traffic information back to the motoring public.

With these comments, the discussion will now address the control system. This discussion may tend to range beyond the bounds of the central control system. This is only to further a "systems" approach to the design. The more broad-based the scope of the design, the less likely the need for special interfaces to link the various components.

TABLE OF CONTENTS

Overall Design Structure

The design structure shown in Figure 1 relates the cooperative aspects of traffic management, which shows three jurisdictions that have control over respective traffic control devices. For this discussion, each of the three boxes represents a control computer or computers. The "system" aspect of this diagram is shown by the top line joining the boxes, which denotes linking of the computers. This is an idealized situation, worthy of achievement, but not always the reality. For example, the following exception can arise: Assume that SDHPT is controlling the freeway and the City is controlling the frontage road intersections. For system operation, SDHPT has a vehicle detector at each entrance and exit ramp. By performing a real time input/output study, it is known at all times how many vehicles are in any given freeway section. But, the exit ramp detectors are of interest to the City, since they record potential inputs to the frontage road system. They are particularly useful as a sensitivity monitor for freeway diversion. Thus, it is useful for the City to be able to monitor the exit ramp detectors. This monitoring can proceed in the fashion depicted in Figure 1, by percolating data up through the SDHPT control center and over to the City control center and then back down. This approach does not work well, however, in a decentralized logic system. The next section will briefly address the decentralized design, but suffice it to say that the SDHPT system is a distributed logic system, and data does not flow immediately from bottom to top. The solution for this particular situation is, by mutual agreement, to link the exit ramp detector's output both to the SDHPT system and to the City's intersection controlller. Other similar situations arise throughout the network, and present opportunities for shortcuts for melding system functions.

Hierarchical Design Structure

The SDHPT distributed logic control system is roughly characterized by Figure 2. This system design evolved from a need to minimize the telecommunication costs from control computer to controlled devices. As such, a large system is "partitioned" into several sybsystems, and a "satellite" computer is deployed in each subsystem to control only those devices within the subsystem. In turn, the satellite computers are monitored by a central "host" computer.

Operationally speaking, the unmanned satellite computers have timing patterns and control algorithms for freeway and frontage road control. Vehicle detector data received at the satellite is processed and used for control decisions. These data are summarized and periodically (several times a minute) forwarded upstream to the host computer. The host computer, in turn, archives these data and performs global calculations, taking into account the vehicle interchanges between satellite boundaries. On the basis of these calculations and other

4

```
┌─────────────────────────────────────────────────────────────┐
│                                                               │
│     TRAFFIC   MANAGEMENT CONTROL   NETWORK                     │
│                                                               │
└─────────────────────────────────────────────────────────────┘


        ┌──────────────┬──────────────┬──────────────┐
    ┌───────────┐  ┌───────────┐  ┌───────────┐
    │           │  │   MASS    │  │           │
    │   SDHPT   │  │ TRANSIT   │  │   CITY    │
    │           │  │           │  │           │
    └───────────┘  └───────────┘  └───────────┘

┌─────────────────────────────────────────────────────────────┐
│   TRAFFIC   CONTROL  AND  INFORMATION  DEVICES                │
└─────────────────────────────────────────────────────────────┘
```

FIGURE 1

5

FREEWAY CENTRAL CONTROL SYSTEM

```
                    ┌─────────────────────────┐
                    │   FREEWAY    CENTRAL     │
                    │  CONTROL   COMPUTERS     │
                    └─────────────────────────┘

   ┌──────────────┐      ┌──────────────┐           ┌──────────────┐
   │  SATELLITE   │      │  SATELLITE   │  • • •     │  SATELLITE   │
   │  MODEM   1   │      │  MODEM   2   │           │  MODEM   n   │
   └──────────────┘      └──────────────┘           └──────────────┘

      ┌────────┐            ┌────────┐                 ┌────────┐
      │ MODEM  │            │ MODEM  │                 │ MODEM  │
      └────────┘            └────────┘                 └────────┘

   ┌──────────────┐      ┌──────────────┐           ┌──────────────┐
   │  SATELLITE   │      │  SATELLITE   │           │  SATELLITE   │
   │  COMPUTER    │      │  COMPUTER    │           │  COMPUTER    │
   └──────────────┘      └──────────────┘           └──────────────┘
```
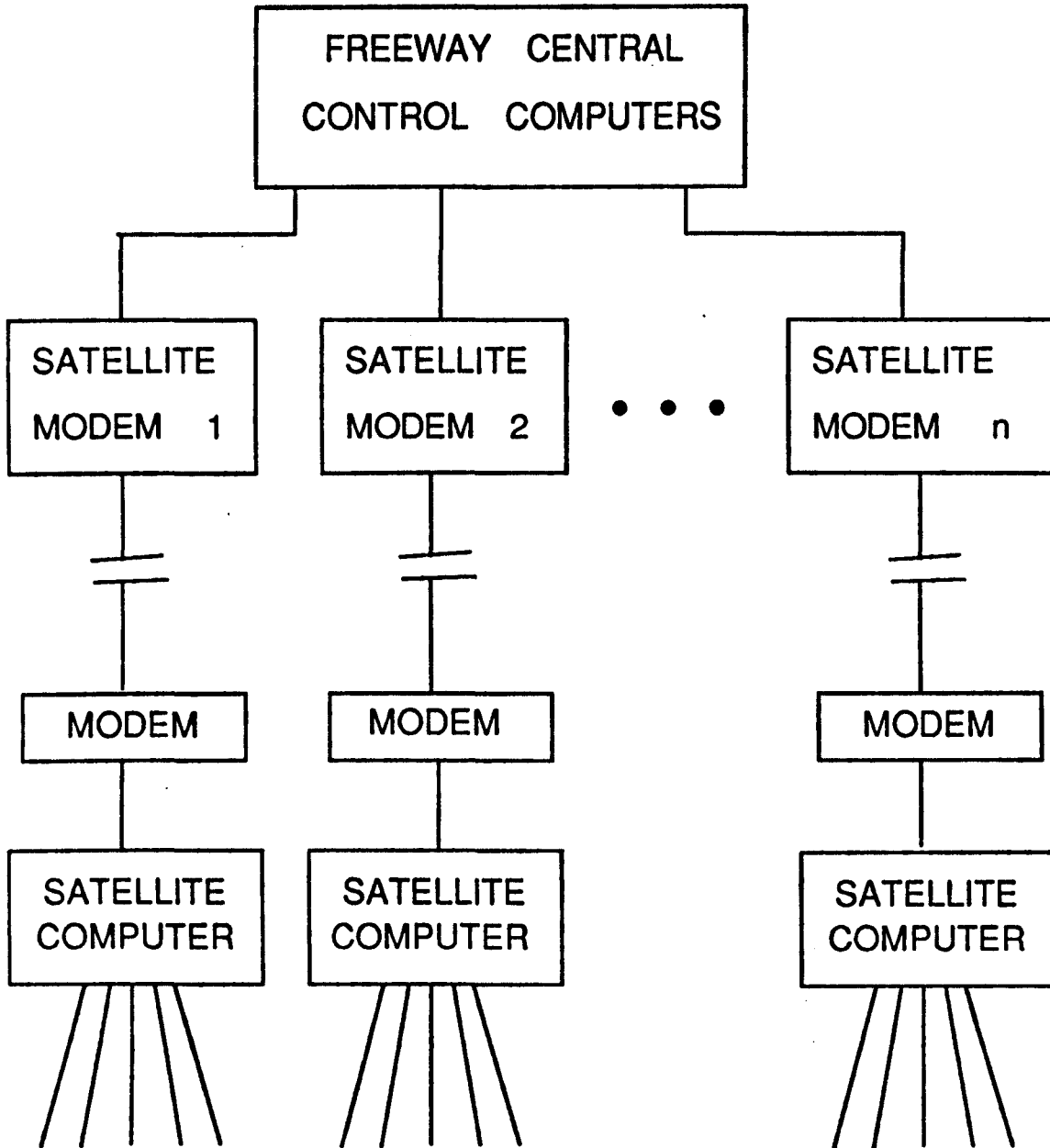
FIGURE 2

6
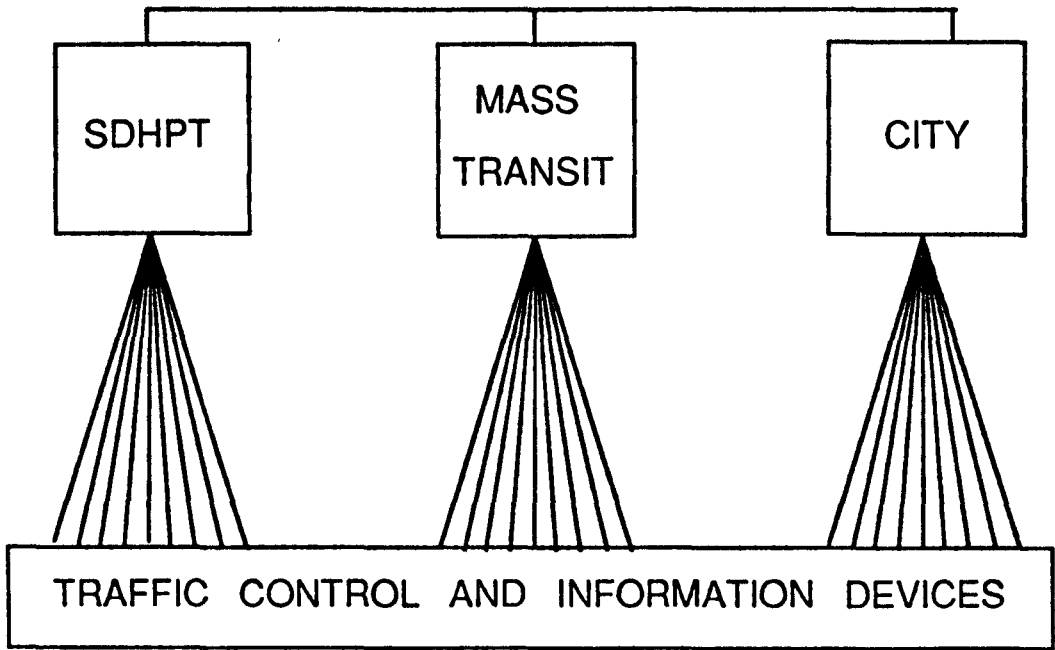
information arriving at the central site, override and pattern update commands are dispatched to the various satellite locations from the central site.

Proposed Documentation

It is proposed that a series of documents be prepared which describe various aspects of the freeway traffic management system. These can be classified as reports, but more accurately would be considered manuals. They would be maintained on disk, and would be available for online browsing or could be printed out for hardcopy reference. Updates to the Districts would be by disk or telecommunications. All of the control centers and Austin will be linked by dial-up modems on the TexAn network.

The contents of the documentation series would provide a comprehensive guide for the implementation of the design concept. This should include telecommunications system design, space requirements, control center design, site preparation, control system design, functional specifications, hardware specifications, software description, operating procedures, personnel requirements, manufacturer's literature, equipment cost, and system designs for specific urban areas (initially, Fort Worth, Houston, and San Antonio).

SHDPT Computer System

The SDHPT central control computer system, while primarily performing as a host computer to satellite control computers, may communicate with other computers as shown in Figure 3. This arrangement implements the total system control concept. The connecting links shown, either dedicated or dial-up, are not considered to be high speed links. Typically, they would provide asynchronous data transmission in the range of 2400-9600 baud. Approximately 20% of the data is bookkeeping overhead, so the effective data transmission range is 240-960 8-bit bytes per second.

The data ports required are the standard RS-232 ports. For distances up to 50', a simple twisted pair is used. For 50' to 2,000', a short haul modem is used at each end. For more remote locations, a standard modem is used. A dedicated link to the SDHPT regional computer would probably use coaxial cable instead of twisted pair. A private communication system, such as a fiber optic network, might also supply the telecommunications medium.
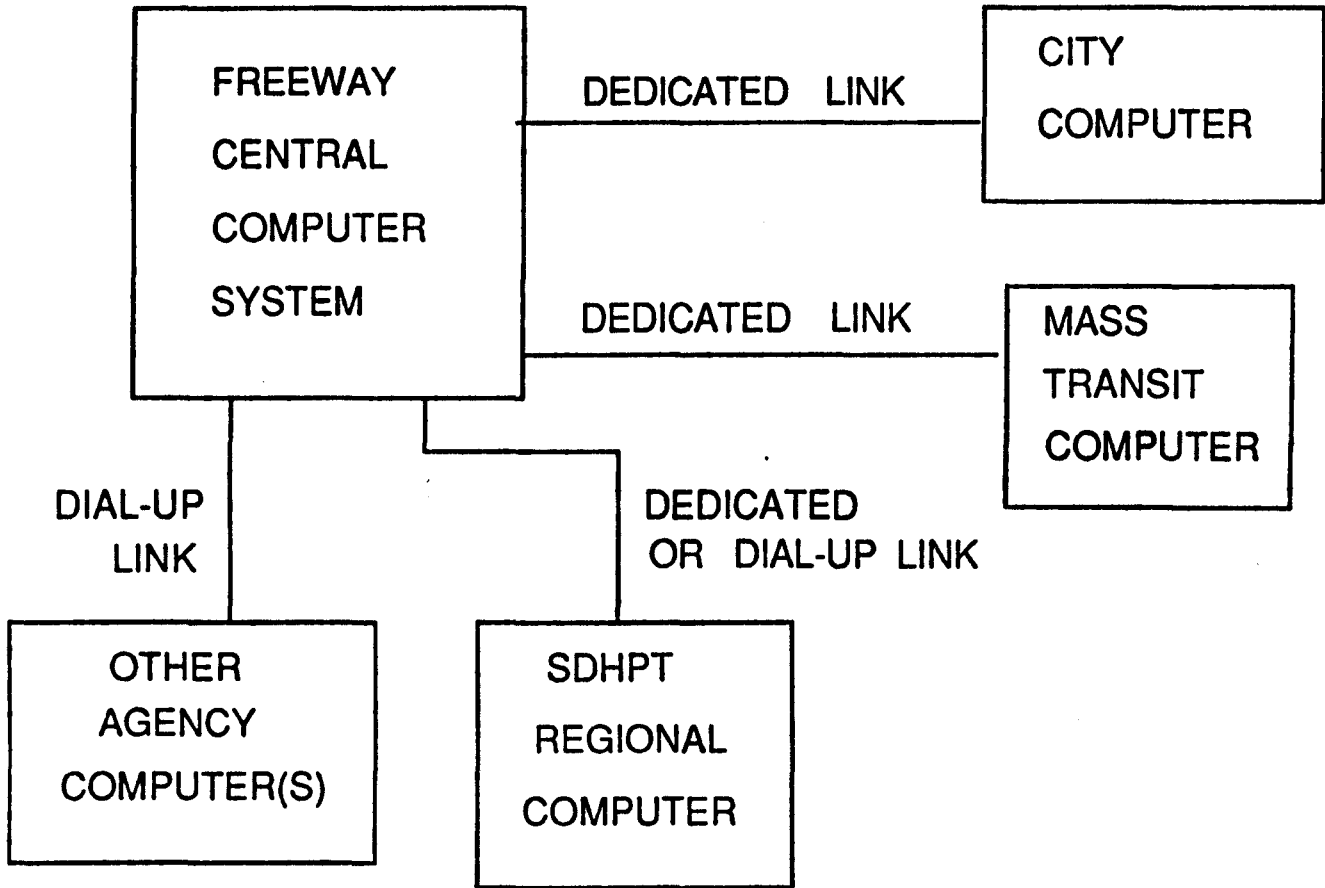
SDHPT COMPUTER SYSTEM


```
┌──────────────────┐                              ┌──────────────┐
│ FREEWAY          │      DEDICATED   LINK        │ CITY         │
│ CENTRAL          │──────────────────────────────│ COMPUTER     │
│ COMPUTER         │                              └──────────────┘
│ SYSTEM           │      DEDICATED   LINK        ┌──────────────┐
│                  │──────────────────────────────│ MASS         │
└──────────────────┘                              │ TRANSIT      │
      │        │                                  │ COMPUTER     │
      │        │                                  └──────────────┘
  DIAL-UP      │  DEDICATED
  LINK         │  OR  DIAL-UP  LINK
  ┌──────────┐  ┌──────────────┐
  │ OTHER    │  │ SDHPT        │
  │ AGENCY   │  │ REGIONAL     │
  │COMPUTER(S)│ │ COMPUTER     │
  └──────────┘  └──────────────┘
```

FIGURE 3

8

Control Center Inputs

The diverse control center inputs are represented in Figure 4. Each of these will be briefly discussed to illustrate the data composition.

1. Detector data - Vehicle detector data are preprocessed by the satellite computer and relayed upstream at periodic intervals. For want of a better number, this periodic interval may be approximately 20 seconds. Other data derived from detector data may also arrive at the same time, such as speeds, occupancy, etc. Where applicable, the 20 second record for each detector might have the following content:

Detector Record

Counts	% Occupancy	Speed
4	7	7

This record would require a minimum of 18 bits. Rounding to 24 bits to simplify the byte boundaries, this amounts to 3 bytes per detector. At 2400 baud, the number of detector records transmitted per seconds is

$$240 / 3 = 80 \text{ records.}$$

Assuming only detector records are being transmitted (which is not the case) it would be possible to transmit records for up to 80 X 20 = 1600 detectors each 20 seconds, from each satellite computer.

2. Status data - Status data is the category for the status of all field devices, where the satellite computer is also considered a field device. A primary status element is the green confirm, as well as other confirming data such as device online/offline, sign on/off, sign message received, gate open/closed, etc. Additionally, a multitude of status data is available for the satellite computer's operation, such as online/offline, pattern status, errors, device malfunction, etc.

3. TV surveillance - This visual input augments the detector inputs, and in a sense, is used to overcome the inability of detector coverage to microscopically monitor traffic flows. Its primary value is to monitor the cause of flow disruptions and determine the appropriate response. A high price is paid for TV surveillance, mainly due to the sophistication of the high bandwidth telecommunications requirement.

4. Other control computers - Other control computers supply operational information from their respective control environments. The relationship is similar to that of a satellite computer, but with more emphasis on the status aspect than the control aspect. The value of this information is in establishing
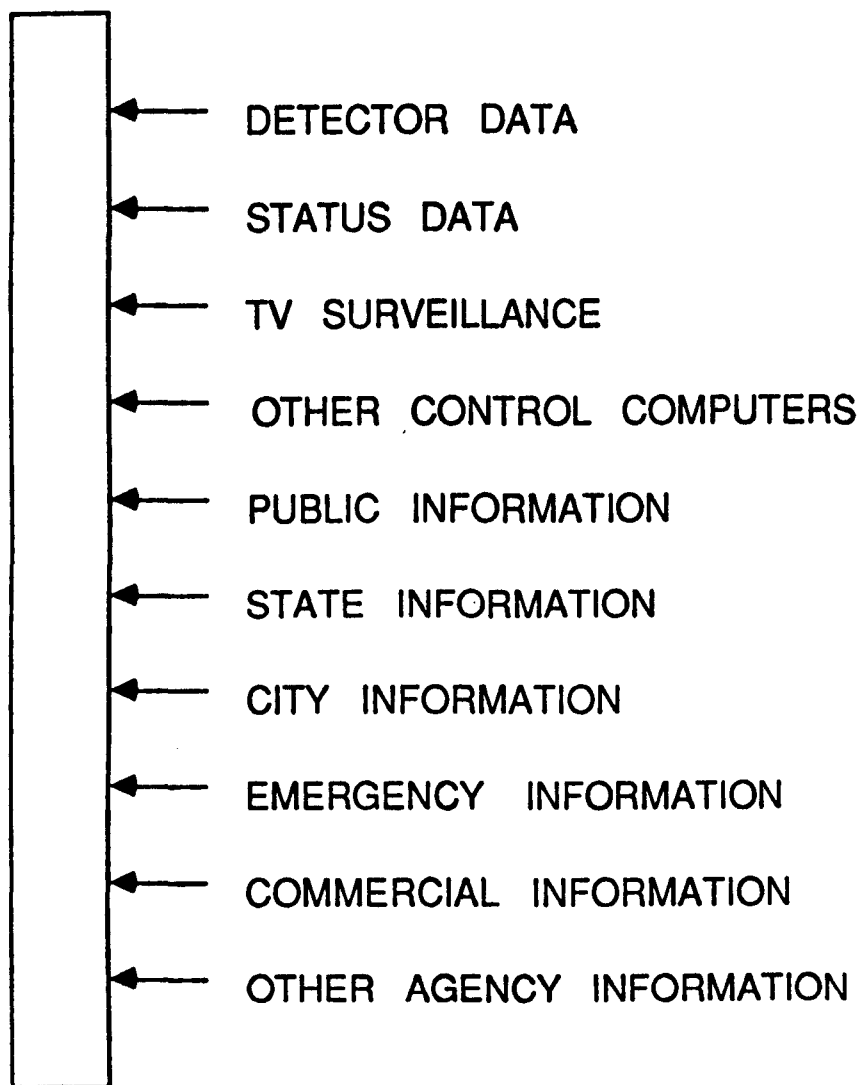
CONTROL CENTER INPUTS

← DETECTOR DATA

← STATUS DATA

← TV SURVEILLANCE

← OTHER CONTROL COMPUTERS

← PUBLIC INFORMATION

← STATE INFORMATION

← CITY INFORMATION

← EMERGENCY INFORMATION

← COMMERCIAL INFORMATION

← OTHER AGENCY INFORMATION

FIGURE 4

10

trends in traffic flows, since traffic outputs from one jurisdiction represent traffic inputs to another, and vice versa.

5. Public information - This information source originates with the public, and provides unsolicited on-site reports of incidents and equipment malfunctions, as well a complaints. The telephone is the primary channel of communication. The widespread use of cellular telephones is becoming a valuable source of traffic reports. While CB radio has diminished in popularity, it is still feasible to monitor the emergency channel.

6. State information - The state information source is from the many state employees and vehicles that traverse the system daily. Maintenance vehicles can communicate directly with the control system by radio, or indirectly through the dispatcher.

7. City information - The City's Traffic Operations group provides construction, maintenance and operation data. Some of these data may be available in a database with dial-in access.

8. Emergency vehicle information - Information from emergency services provides status of emergency runs affecting the control system.

9. Commercial information - This information subscription source is derived from commercial enterprises, mainly providing aerial traffic surveillance.

10. Other agency information - Other agencies may provide information to the control center. Among these would be agencies having jurisdiction over disaster management, transportation of hazardous materials, etc.

A summary of the voice operations input is shown in Figure 5.

Control Center Outputs

The output of the control system is more than the electronic control commands to the satellite computers. Figure 6 lists the various outputs from the center, including text and voice. This illustrates the role of the control center as an information center. Each of these outputs will be discussed briefly.

1. Traffic signal control - The central control center only indirectly controls the traffic signals, by way of issuing temporary override commands such as during incident response, and by issuing new pattern and timing information to the satellites. The timing and pattern data can be derived through manual overrides or as a result of online system optimization techniques.
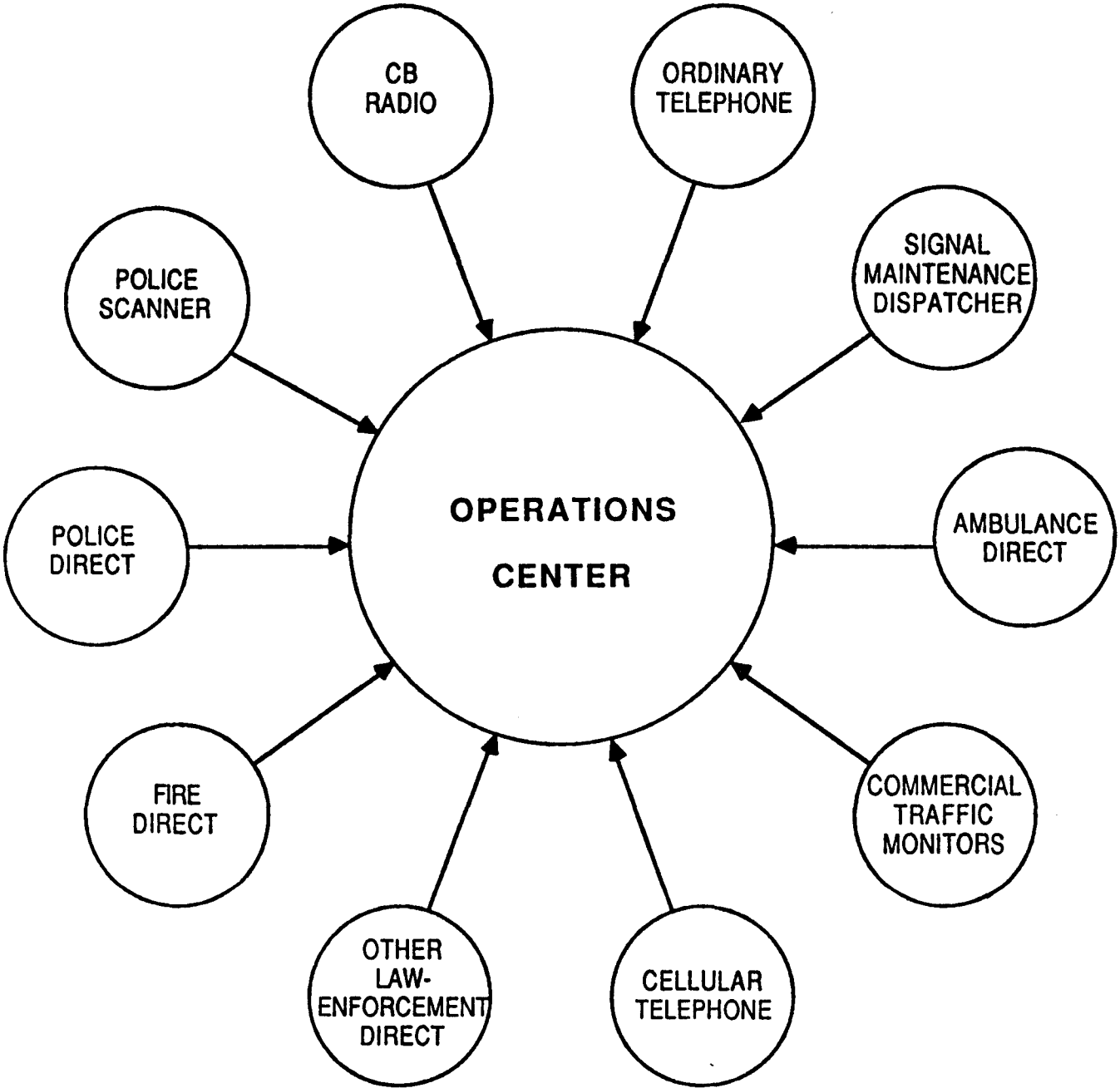
VOICE OPERATIONS
INFORMATION INPUT
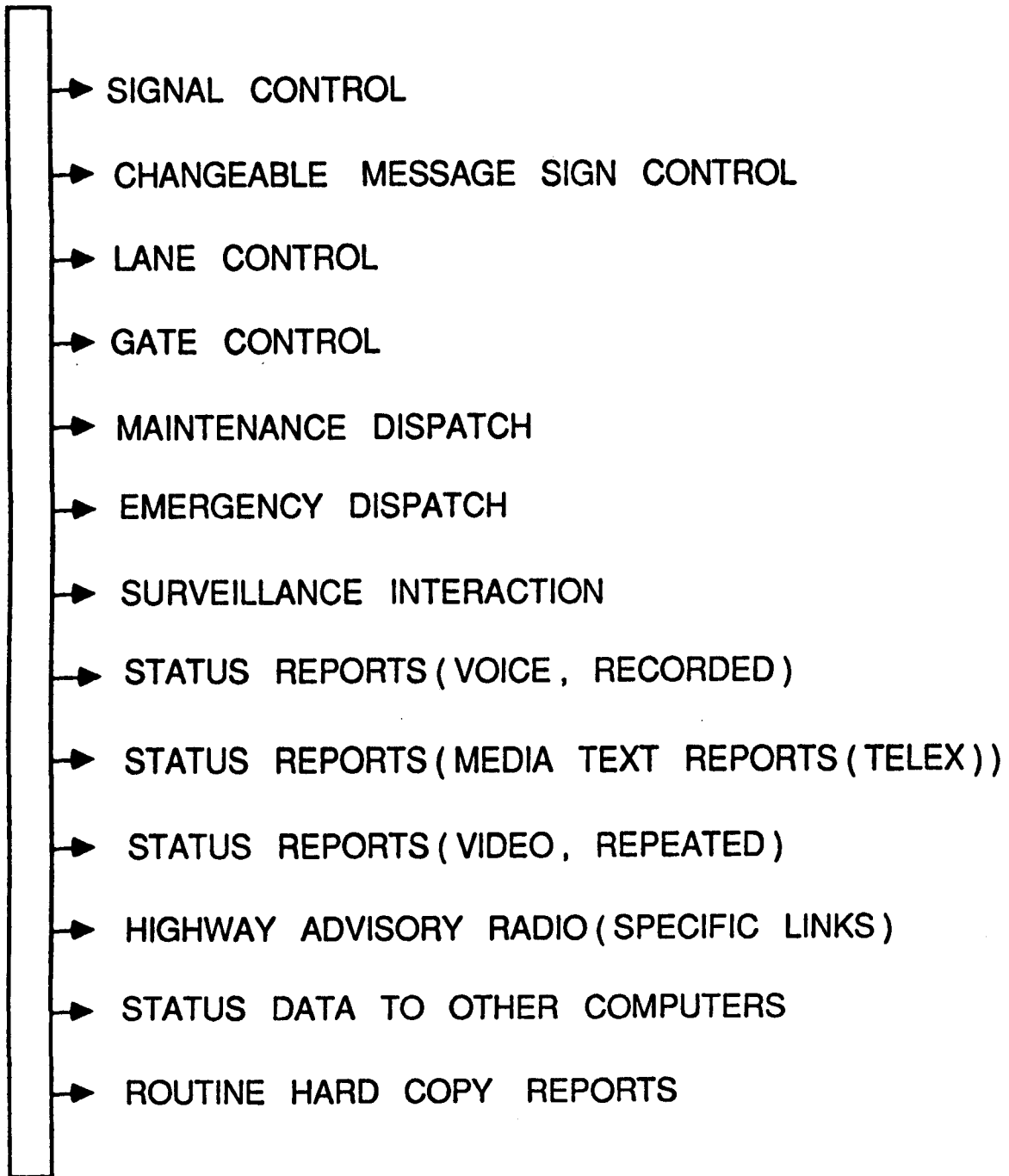

FIGURE 5

12

CONTROL CENTER OUTPUTS

(DIRECT AND INDIRECT)

- SIGNAL CONTROL

- CHANGEABLE MESSAGE SIGN CONTROL

- LANE CONTROL

- GATE CONTROL

- MAINTENANCE DISPATCH

- EMERGENCY DISPATCH

- SURVEILLANCE INTERACTION

- STATUS REPORTS (VOICE , RECORDED)

- STATUS REPORTS (MEDIA TEXT REPORTS (TELEX))

- STATUS REPORTS (VIDEO , REPEATED)

- HIGHWAY ADVISORY RADIO (SPECIFIC LINKS)

- STATUS DATA TO OTHER COMPUTERS

- ROUTINE HARD COPY REPORTS

FIGURE 6

13

2. Changeable message sign control - This control function is generally handled interactively by the operator, who is able to respond to conditions shown by the detector and TV surveillance systems. Automatic control of the signs is limited to a prompt by the system for manual authorization to proceed with a new display message.

by the operator as traffic ...

4. Gate control - Commands for opening and closing gates are manually issued by the operator, generally expected to be done with the assistance of television surveillance.

5. Maintenance dispatch - Equipment status information is received continuously at the control center from the satellite computers, and on an intermittent basis from any special device directly controlled by the control center, such as signs and gates. This information is queued and brought to the operator's attention according to critical need, ranging from loss of satellite down to a detector outage. This priority of need dictates the real time scheduling of maintenance. Normally, the numerous detector outages will be logged, with hardcopies printed at the beginning of each day for distribution to maintenance crews. Depending on system size, maintenance crews may be scheduled through a full time dispatcher. Regardless, the control center operator will have access to a maintenance radio and field telephone for interactive communication.

6. Emergency dispatch - With TV surveillance, the control center personnel are frequently in a position to be the first to call in an accident, fire, spill or other incident. Depending on system size, this may or may not be handled by an incident response team. Regardless, direct communication links are advantageous for notification of emergency services.

7. Surveillance interaction - There is a distinct advantage to the bird's eye view provided by the surveillance system, for several reasons other than traffic condition monitoring. The interaction with gate control commands has already been mentioned. Monitoring CMS bulb outage, interacting with maintenance crews for detector and signal verification, assisting emergency services, and performing traffic studies are other interative uses.

8. Status reports (voice, recorded) - Traffic condition reports are recorded frequently throughout the day on a link specific basis. The frequency increases during peak periods, and details on the occurrence and clearing of incidents are immediately reported. These audio reports may be augmented or synthesized by a voice response unit. The recordings are made on digital disk, so that random access to messages is possible. The dial-in user selects the desired link recording from a series of audio prompts and touch tone responses.

9. Status reports (media text reports - Telex) - A Telex link is available to issue traffic status reports to the news media. These reports are brief, and are largely generated by computer. Special messages are generated by the operator to cover incident reporting.

10. Status reports (video, repeated) - The video reports are generated for distribution to TV stations and public video traffic monitors. The Telex information can be a part of these data. The video and text sequence is repeated frequently, on the order of 60-120 seconds. The information transmitted is essentially a simplified sequence of scenes from the electronic display, ranging from the total network to specific freeway zooms. The sequence is entirely computer generated.

12. Status data to other computers - Operational data are routinely transmitted to the other host control computers in the system. This includes operating status and selected detector counts. The frequency of data transmission is on the order of 1-5 minutes.

13. Routine hard copy reports - The operation of the control center will produce routine hard copy reports to various persons in the organization, upon request. Available reports will include maintenance activity, detector volume summaries, flow maps, incident activity, ramp signal violations, and other special reports on request. To minimize paperwork, these reports will also be archived on a high density storage device for future reference.

Scope of Operator Intervention

The duties of the control systems operator are many and varied. A list of some of these duties follows:

1. Creates voice recordings.
2. Interacts with maintenance crews.
3. Manually overrides computer control.
4. Monitors commercial traffic reports.
5. Monitors CB emergency channel.
6. Monitors traffic status call-in recordings.
7. Maintains system operations log.
8. Monitors system status displays.
9. Manages changeable message sign settings.
10. Manages lane control sign settings.
11. Handles voice communication with other control centers.
12. Interacts with emergency services.
13. Observes traffic operations on CCTV monitors.
14. Interacts with system diagnostics.

The relationship of these tasks to other system functions will be covered in later sections.

Freeway Central Control Subsystems

The freeway central control system is comprised of a number of functional subsystems. These functional subsystems are sometimes readily identifiable with specific hardware and software modules, but frequently may either encompass or share hardware and software subsystems. An enumeration of the various functional subsystems is shown in Figure 7. In the following sections, the various subsystems will be discussed in minimum detail. Accompanying each discussion will be a block diagram illustrating the components of the subsystem. Many of these diagrams will show a "database." Unless otherwise indicated, this is a reference to the traffic operations database. Figure 8 shows the components of this database.

1. Control Subsystem (Figures 9 and 10) - The control subsystem has the primary responsibility of acquiring and processing traffic data from the satellite computers, and providing control information to the satellite computers. The monitoring of system operation is augmented by other surveillance and reporting inputs. The operator interacts with this subsystem to initiate manual overrides when normal control responses would otherwise be too slow. A rule-based expert system will supply control decisions for situations that have been previously analyzed and the appropriate responses programmed in advance. Supplementing this operation is an online simulation for additional decision information.

2. Display Subsystem (Figures 11 and 12) - The display subsystem is responsible for providing electronic displays for the large scale system displays, and the color CRT monitors. The information source for these displays is identical, and only the display devices differ. Additionally, this subsystem coordinates the acquisition and digitization of images from the TV surveillance system for routing to the same display devices. Finally, for control centers with a traditional map display, this subsystem supplies basic information to the display board interface.

3. Archiving Subsystem (Figures 13 and 14) - The archiving subsystem provides the data management function for the various other subsystems. It manages both long and short term data, which includes the master system disk and the high density storage device(s). The long term data stored includes detector data, operations and maintenance data, and image data. Detector data is periodically summarized and committed to long term storage. Data compression techniques are applied as appropriate for the type of data involved.

FREEWAY CENTRAL CONTROL SUBSYSTEMS

CONTROL

DISPLAY

ARCHIVING

OPERATOR INTERACTION

REPORTING / DOCUMENTATION

INCIDENT DETECTION

INCIDENT RESPONSE

REMOTE ACCESS

PUBLIC ACCESS

VIDEO SURVEILLANCE

FIGURE 7

17

DATABASE COMPONENTS

TRAFFIC
COUNTS

CONSTRUCTION
DATABASE

TRAFFIC
PATTERNS

SCHEDULED
MAINTENANCE
DATABASE

OPERATING
RULES

SPECIAL EVENTS
CALENDAR

FIGURE 8

18
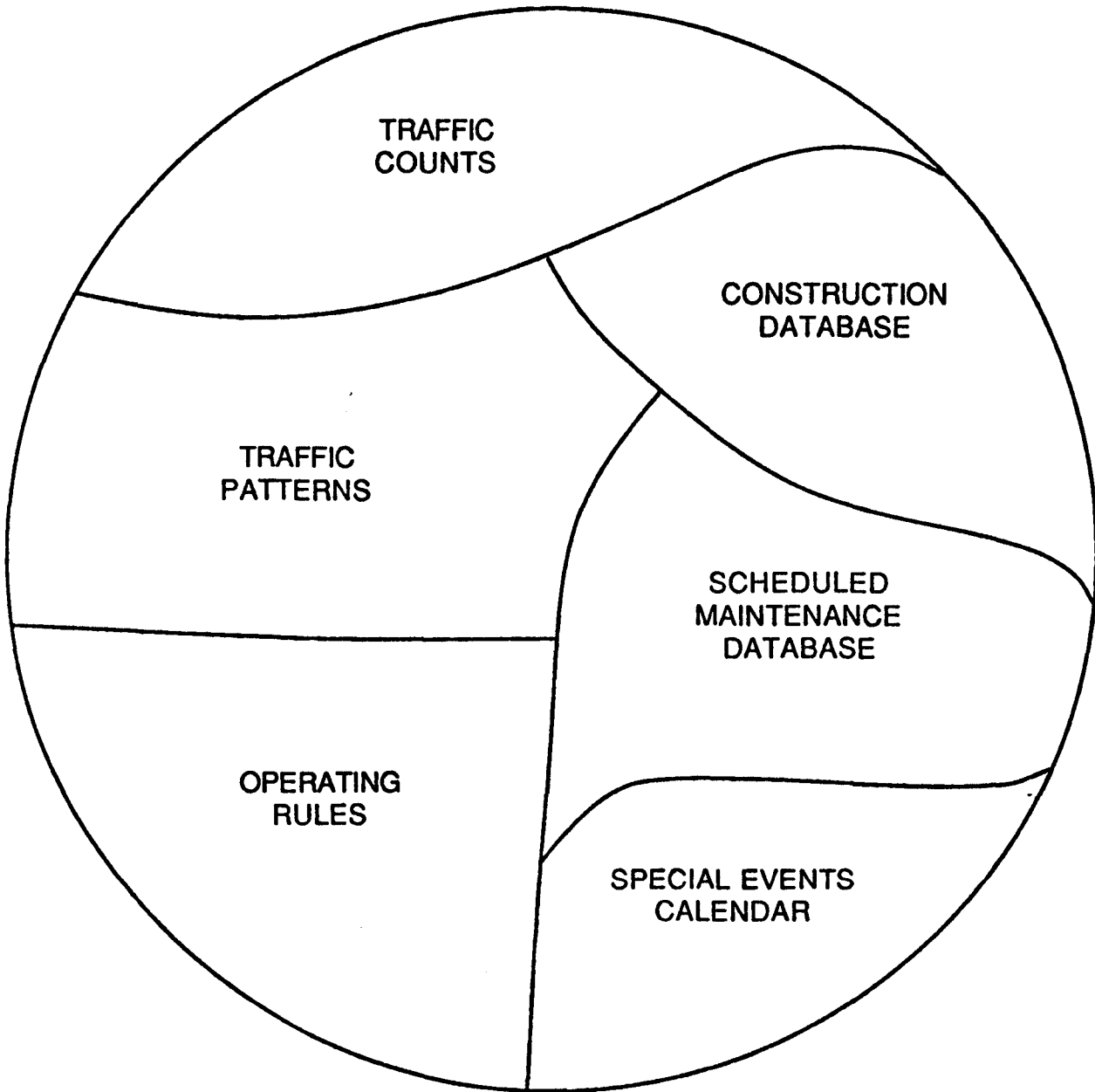
CONTROL SUBSYSTEM

MAJOR FUNCTIONS

    MONITORING TRAFFIC CONDITIONS

    MONITORING TRAFFIC CONTROL OPERATION

    UPDATING CONTROL PARAMETERS

    TEMPORARY OVERRRIDES

FIGURE 9

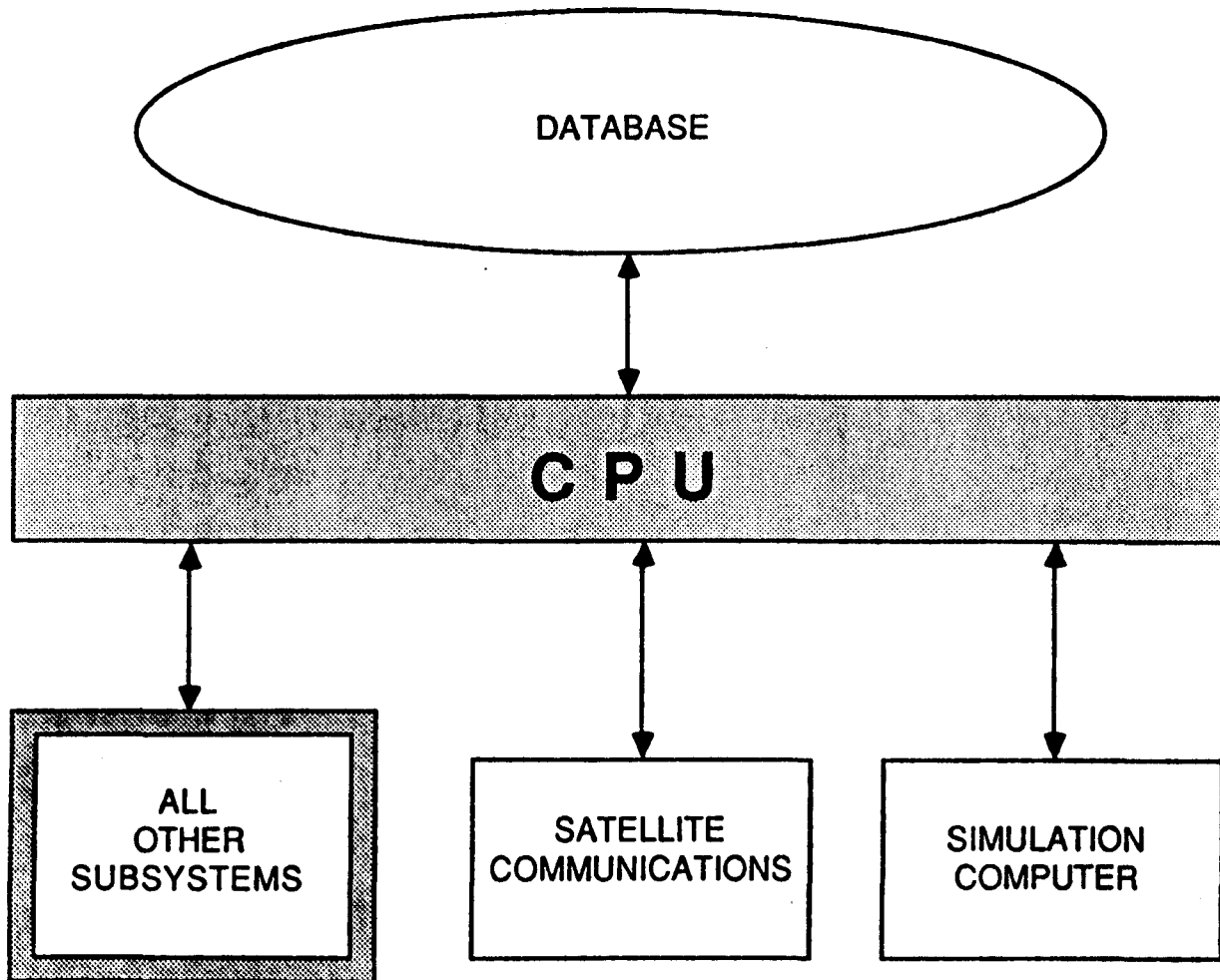*19*

CONTROL SUBSYSTEM

FIGURE 10

20

DISPLAY SUBSYSTEM

MAJOR FUNCTIONS

DISPLAYS SYSTEM MAPS

PROVIDES ZOOM DISPLAYS

PROVIDES GRAPHIC OVERLAYS

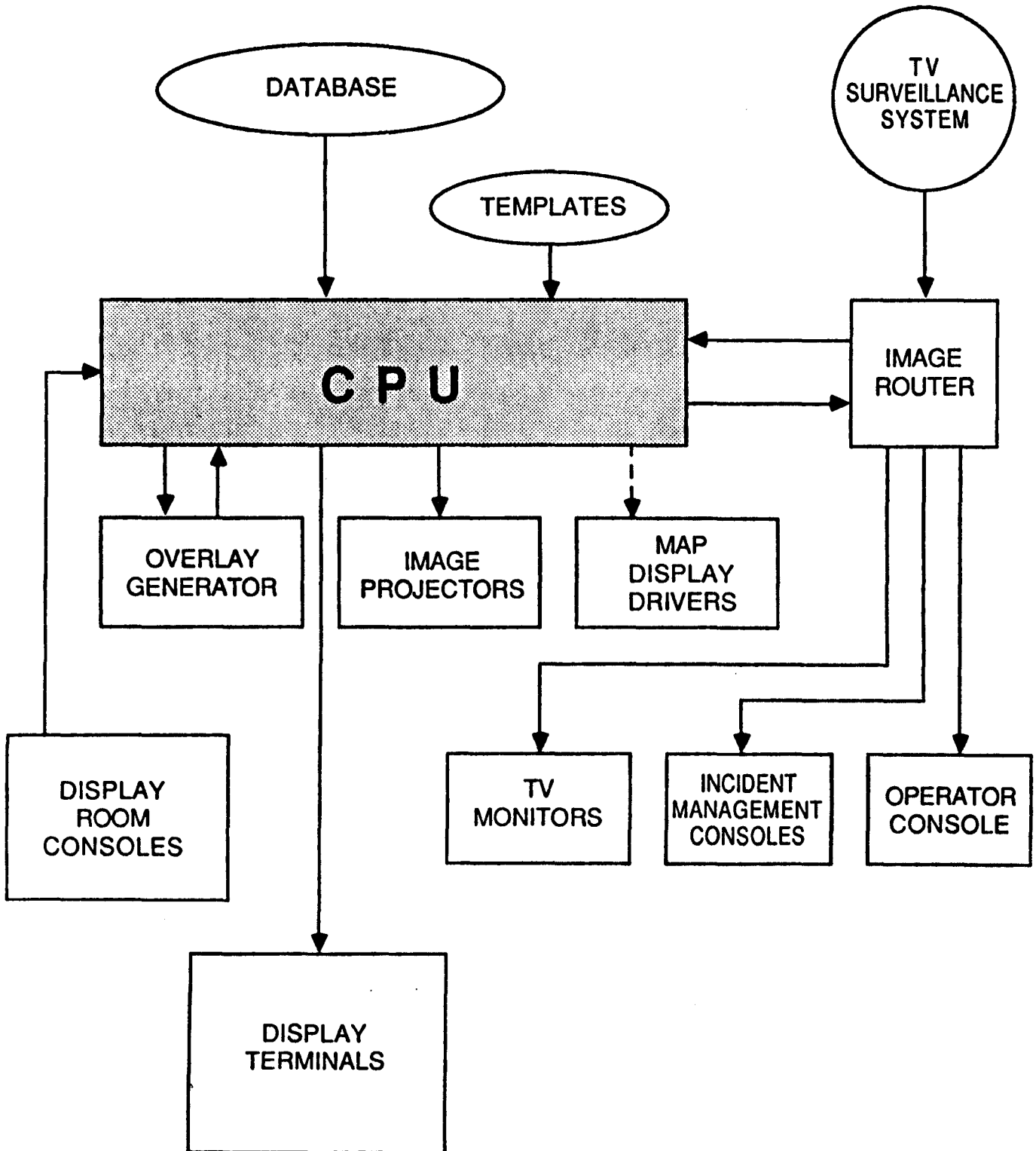FIGURE 11

21

DISPLAY SUBSYSTEM

FIGURE 12

22

ARCHIVING SUBSYSTEM

MAJOR FUNCTIONS

    SUMMARIZES TRAFFIC AND OPERATION DATA

    STORES SHORT TERM DATA

    AGGREGATES AND COMPRESSES DATA FOR LONG TERM STORAGE

    STORES IMAGE DATA

FIGURE 13

23

ARCHIVING SUBSYSTEM

C P U

Tape Drive

CD ROM

Floppy Disks

Link To SDHPT Regional Computer
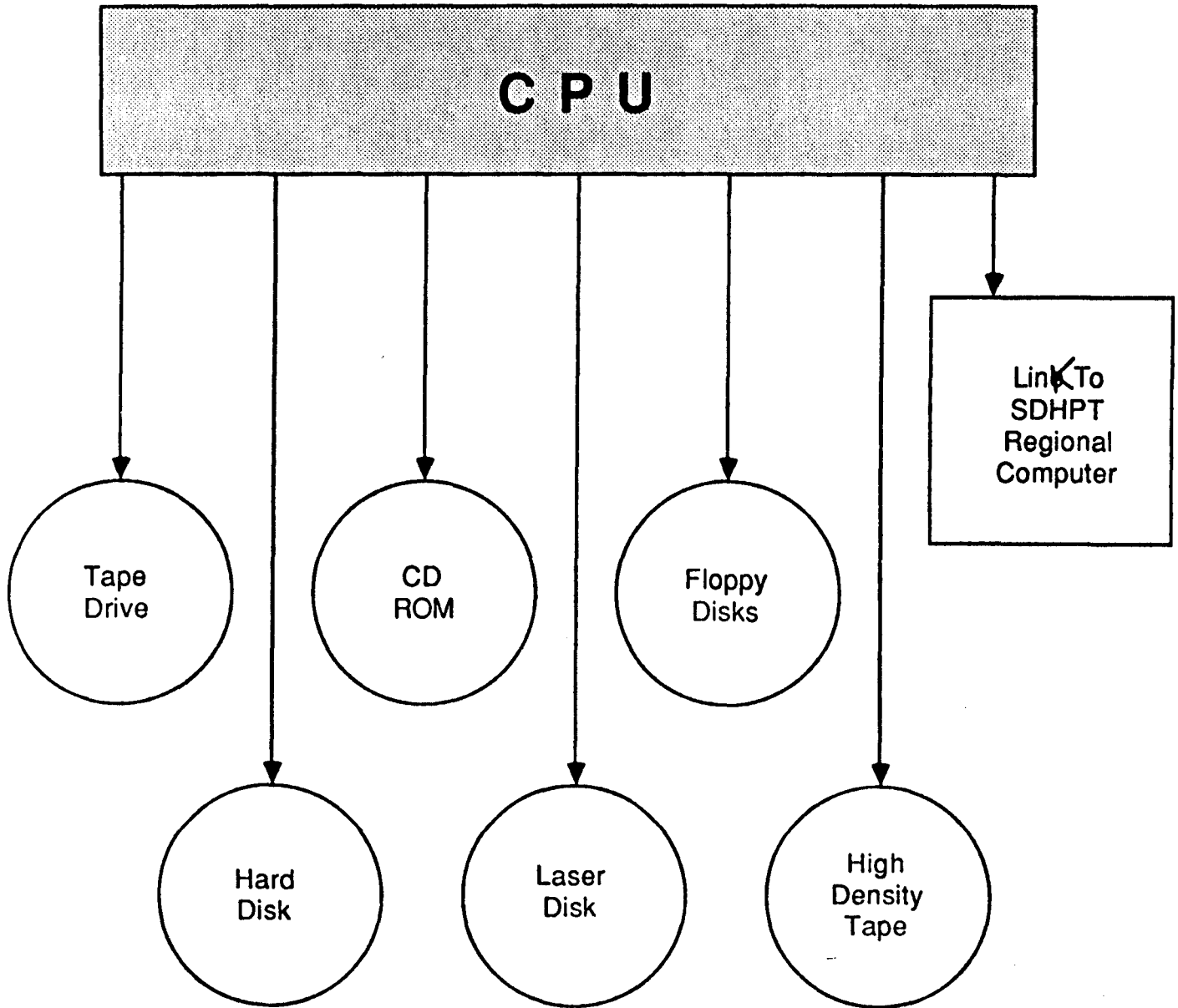
Hard Disk

Laser Disk

High Density Tape

FIGURE 14

24

4. Operator Interaction Subsystem (Figures 15 and 16) - The operator interaction subsystem provides the link between the operator and the remaining subsystems. This basically consists of providing the displays for operator interaction, accepting operator responses from various devices, interpreting the response, and supplying the appropriate command to the appropriate subsystem. The basic input device for normal system control is a touch screen, supplemented by the venerable keyboard as needed for specialized inputs. Specialized menus and status information are handled by this subsystem.

5. Reporting/Documentation Subsystem (Figures 17 and 18) - The reporting/ documentation subsystem produces hardcopy reports for the system's operation. Routine reports include maintenance activities, summarized count data, traffic trends, operation activities, and incident statistics. Special reports are produced on demand. Additionally, this subsystem maintains the system documentation dataset, available for browsing online or printing out the latest copy.

6. Incident Detection Subsystem (Figures 19 and 20) - The incident detection subsystem includes the various algorithms that are used for online incident detection. In this regard, the detector database is monitored constantly for clues. At the same time, the satellite computer status information is monitored for reports of incident detection. Upon detection of an incident, the operator is notified via the operator interaction subsystem for display of an alarm, and request for a visual confirmation. As a source of very early incident detection, the machine monitoring of detector inputs is augmented with normal observation of traffic operations with the TV surveillance subsystem. Incident alarms are issued both to the operator and the incident response team.

7. Incident Response Subsystem (Figures 21 and 22) - The incident response subsystem is generally a person or persons, rather than a machine subsystem. Depending on the size of the control system, this subsystem may be manned by the operator, or by incident response team specialists. In either case, their role is to respond to incidents in a timely manner which expedites the clearing of the incident. To accomplish this, the team first assesses the extent of the incident and determines the necessary services to handle the incident. The appropriate services are then notified. It is assumed that the operator has received the same incident alarm(s), and is simultaneously issuing control system commands (including sign messages) to temporarily override programmed system operation. The operator also notifies other system control centers.

The response team also initiates video recording, video image printing and/or digital image capture as needed. Finally, the response team logs its response action.

OPERATOR INTERACTION SUBSYSTEM

MAJOR FUNCTIONS:

RECEIVES MANUAL INPUT

DISPLAYS MENUS

INTERPRETS INPUTS

DISPATCHES COMMANDS

FIGURE 15

26

OPERATOR INTERACTION SUBSYSTEM

```
        ╭──────────╮
        │  MENUS   │
        ╰────┬─────╯
             │
             ▼
   ┌──────────────────────┐         ┌──────────────┐
   │                      │         │              │
   │        C P U         │────────▶│   DISPLAY    │
   │                      │         │              │
   └──▲──────────▲──────▲─┘         └──────────────┘
      │          │      │
      │          │      │
┌──────────┐  ┌──────────────┐
│ KEYBOARD │  │ TOUCH SCREEN │
└──────────┘  └──────────────┘
      │
      │
┌──────────────────────────────────────────────┐
│                                                │
│     OTHER MANUALLY-CONTROLLED HARDWARE         │
│                                                │
└────────────────────────────────────────────────┘
```
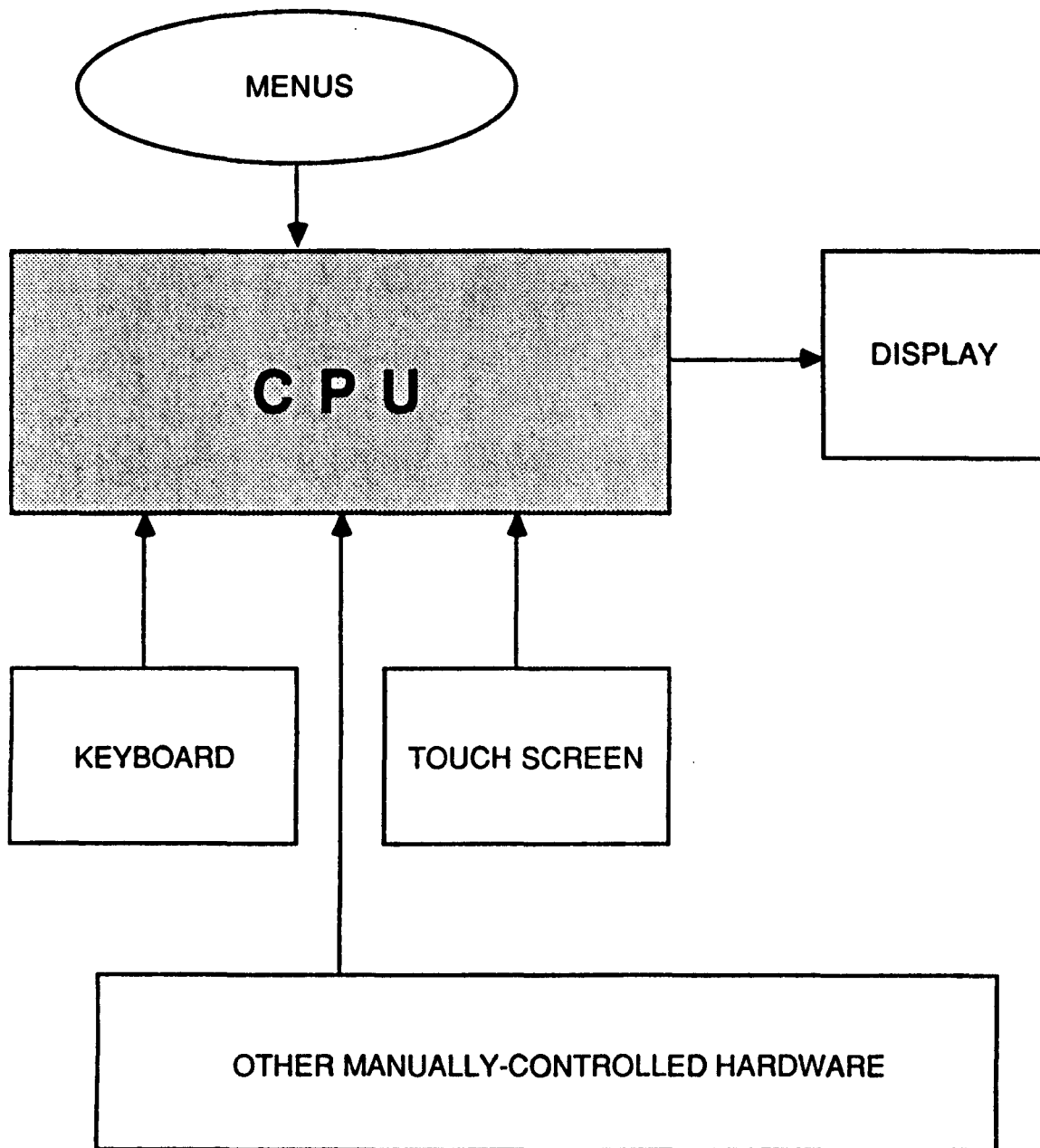
FIGURE 16

27

REPORTING / DOCUMENTATION SUBSYSTEM

MAJOR FUNCTIONS:

      PRODUCE OPERATION REPORTS

      PRODUCE MAINTENANCE REPORTS

      SYSTEM DOCUMENTATION PUBLISHING
         AID

      ONLINE DOCUMENTATION DISPLAY

      SPECIAL REPORTS
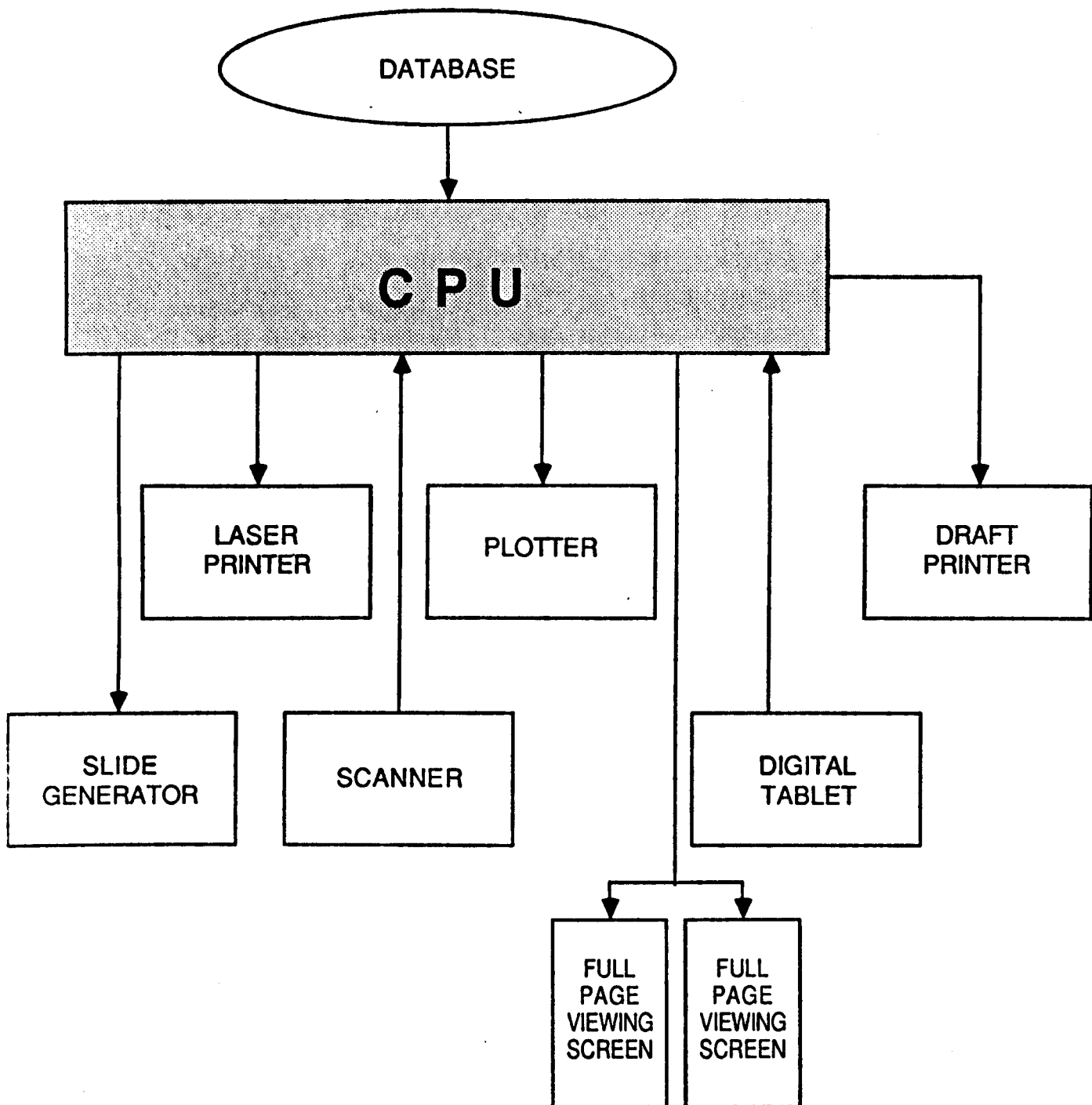
FIGURE 17

REPORTING/DOCUMENTATION SUBSYSTEM

FIGURE 18

29

INCIDENT DETECTION SUBSYSTEM

MAJOR FUNCTIONS:

ELECTRONIC MONITORING OF DATABASE

MONITORS SATELLITE COMPUTERS FOR
INCIDENT REPORTING

VISUAL MONITORING OF VIDEO SURVEILLANCE

ISSUES OPERATOR ALARMS

FIGURE 19

30

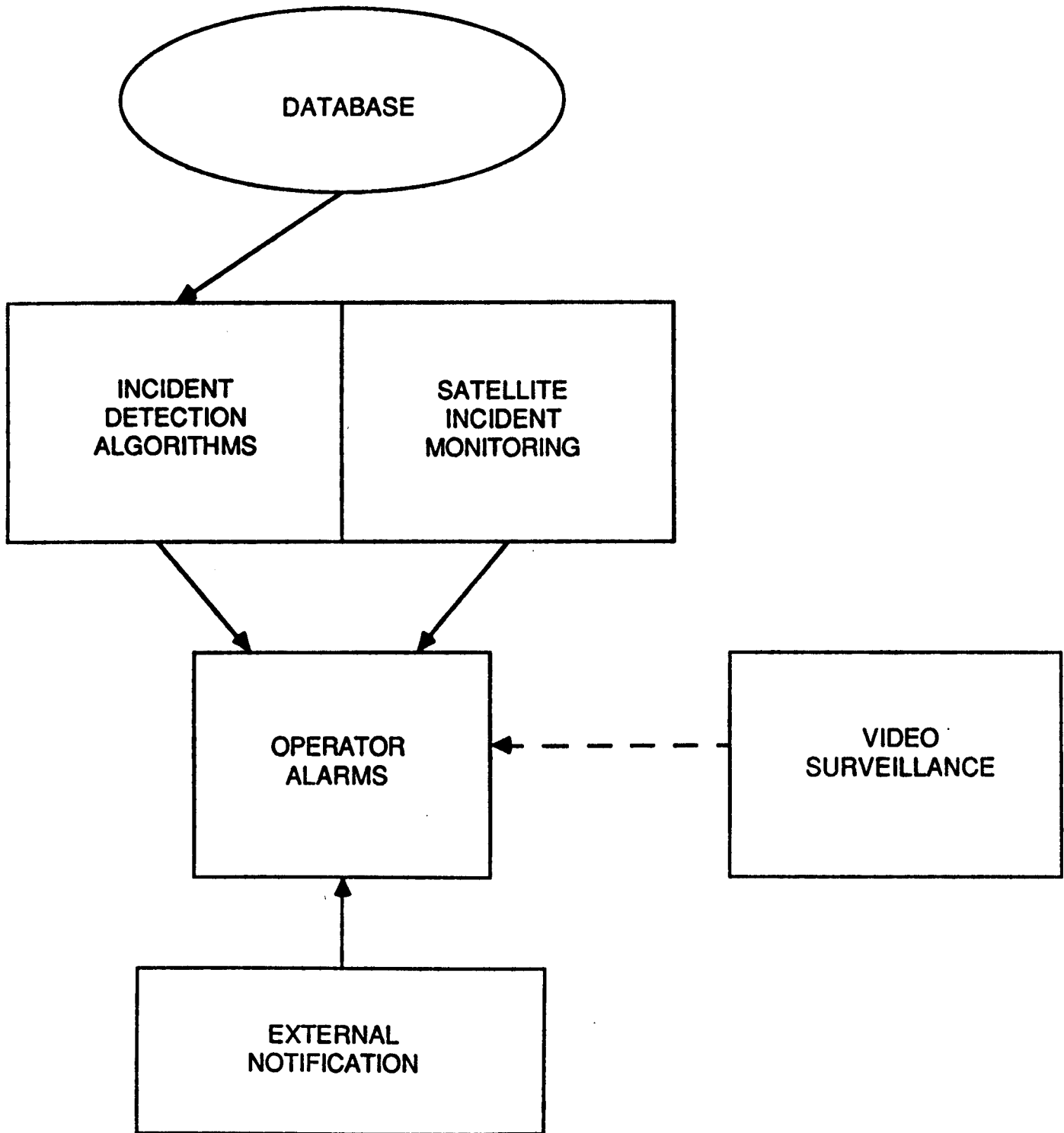# INCIDENT DETECTION SUBSYSTEM
FUNCTIONAL DIAGRAM

FIGURE 20

31

INCIDENT RESPONSE SUBSYSTEM

MAJOR FUNCTIONS:

RESPONDS TO SYSTEM ALARMS

CONTACTS EMERGENCY SERVICES

INTERACTS WITH EMERGENCY TEAMS

DOCUMENTS RESPONSE ACTIONS

INITIATES VIDEO RECORDING / HARDCOPY

NOTIFIES OTHER CONTROL CENTERS

FIGURE 21

INCIDENT RESPONSE SUBSYSTEM
FUNCTIONAL DIAGRAM

VIDEO
SURVEILLANCE

EMERGENCY
SERVICES

RADIO &
TELEPHONE
COMMUNICATION

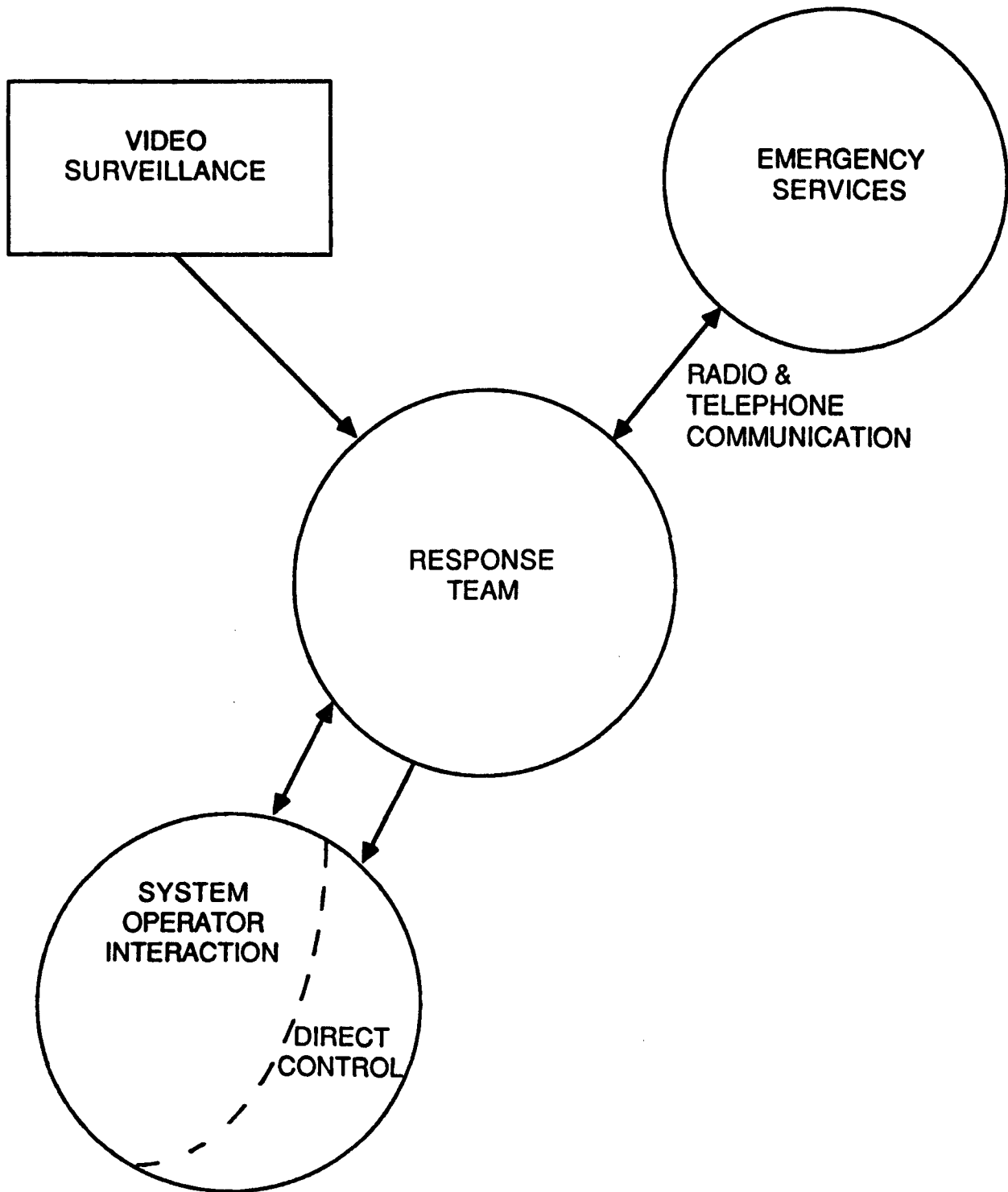RESPONSE
TEAM

SYSTEM
OPERATOR
INTERACTION

DIRECT
CONTROL

FIGURE 22

8. Remote Access Subsystem (Figures 23 and 24) .- The Remote Access Subsystem provides the system interface for remote access to the control system by authorized users. Typically, this link is for programmers, remote hardware diagnostic access, and any other functional requirement that can be handled by a computer terminal inside the control center, including display of fast scan TV surveillance images. Dialup baud rates up to 9,600 bits per second are supported. Long distance calls are handled by the TexAn network, and local calls are handled on the regular telephone system. This subsystem responds to an authorized list of local telephone numbers. When a local call is received by the remote access subsystem, the subsystem qualifies the call with a password sequence, hangs up, and dials the remote terminal. When the terminal answers, a second password sequence establishes the level of access permitted. TexAn calls only require the second password sequence to establish a connection.

9. Public Access Subsystem (Figures 25,26, and 27) - The Public Access subsystem manages the flow of image, voice, and text data to the public and/or intermediaries. A limited interaction is provided by touch tone telephone.

The system operator interacts with this subsystem to input text messages and voice recordings on disk. The subsystem in turn supplies a number of information categories to the public. Among these are the transmission of text messages over the Telex link to subscribers, such as radio and TV stations. The voice recordings, on disk for random access, are transmitted continuously to the respective HAR links. A public dial-in audio response system provides the same messages over the telephone. The desired link (or links) is (are) established by an initial dialogue and touch tone response by the caller.

This subystem also issues a fixed sequence of requests to the display subsystem. A series of display images is cycled over two ports, one digital and one analog. Each display image reflects an animated display image of a different section of the network. This output is directed to TV stations and overhead remote monitors in public viewing areas. Additionally, other digital ports are connected to touch screen monitors at floor level in public areas, such as shopping malls.

10. Video Surveillance Subsystem (Figures 28 and 29) - The video surveillance subsystem consists of the analog CCTV system terminating at the control center, plus some additional equipment for digitizing, processing and storing image data. Also included is equipment for voice control of cameras and a switching distribution system for selecting and routing CCTV images to various points in the control center.

This subsystem will also provide the interface to the emerging technology of TV based vehicle detection.

REMOTE ACCESS SUBSYSTEM

MAJOR FUNCTIONS:

    PROVIDES REMOTE USER TERMINAL
        LINK TO SYSTEM

    TRANSMITS DISPLAY IMAGE FORMATS

    INTERFACES TO DISPLAY SUBSYSTEM

FIGURE 23

35

REMOTE ACCESS SUBSYSTEM

DATABASE

TV SURVEILLANCE
FRAME GRABBER

C P U

MODEM

MODEM

TEX-AN
LINE
(PASSWORD ACCESS)

PUBLIC
LINE
(PASSWORD/RECALL
/PASSWORD ACCESS)

REMOTE
USER
TERMINAL

REMOTE
USER
TERMINAL

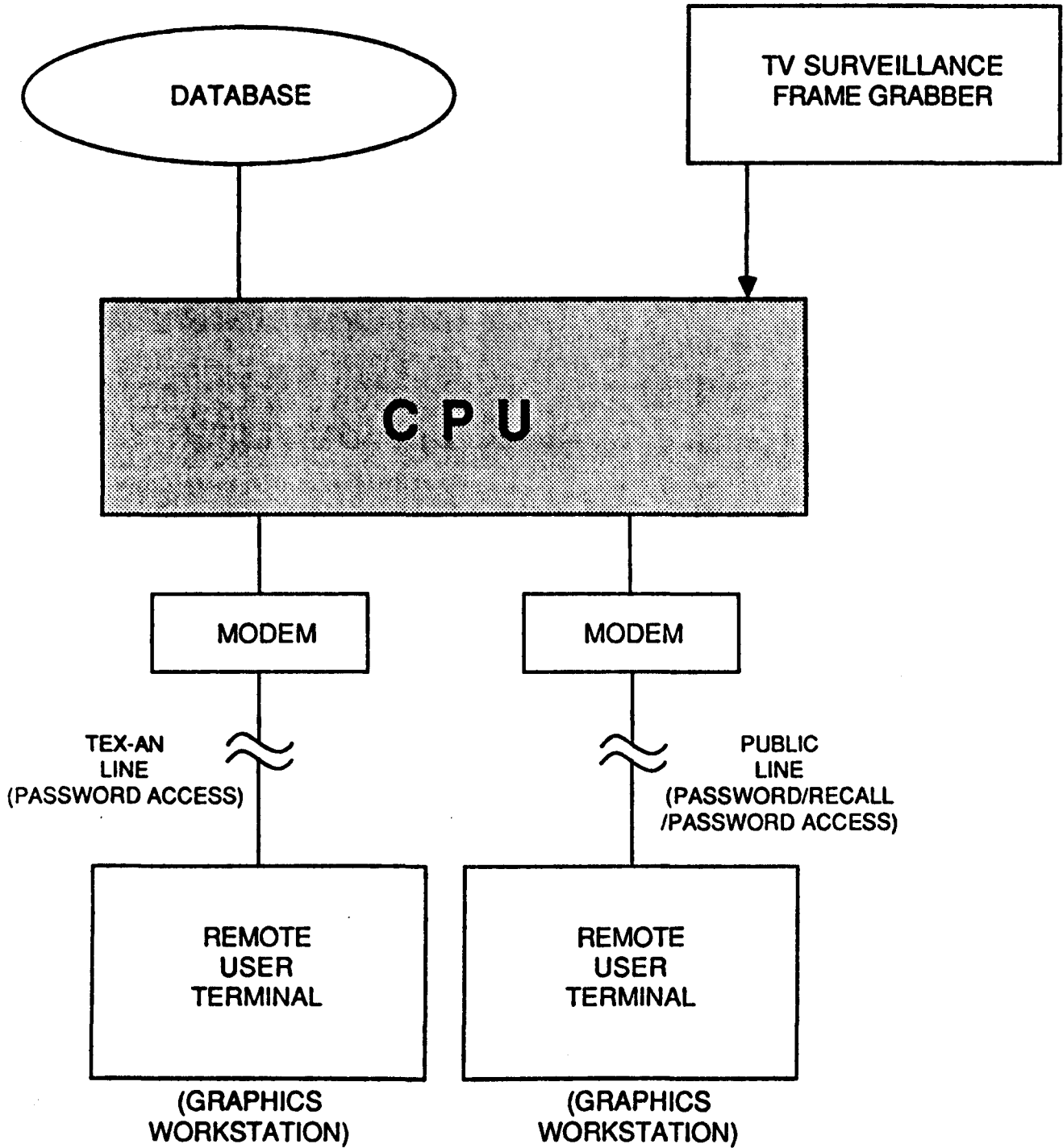(GRAPHICS
WORKSTATION)

(GRAPHICS
WORKSTATION)

FIGURE 24

36

PUBLIC ACCESS SUBSYSTEM

MAJOR FUNCTIONS:

RECEIVES TEXT MESSAGES FROM OPERATOR

TRANSMITS TEXT MESSAGES VIA TELEX

RECORDS OPERATOR'S VOICE MESSAGES ON DISK

INTERFACES TO DISPLAY SUBSYSTEM

TRANSMITS DISPLAY IMAGES TO TV STATIONS AND OTHER DESTINATIONS

PROVIDES AUDIO RESPONSE TO TELEPHONE QUERIES

FIGURE 25

PUBLIC ACCESS (1)
SUBSYSTEM

OPERATOR

TEXT
MESSAGES

VOICE
RECORDING(S)

(TELEX)

RECEIVING
ORGANIZATIONS,
SUCH AS RADIO
STATIONS

HIGHWAY
ADVISORY
RADIO (HAR)

FIGURE 26

PUBLIC ACCESS SUBSYSTEM (2)

DATABASE

CPU

DISPLAY SUBSYSTEM

AUDIO RESPONSE UNIT

TRAFFIC STATUS RECORDER

TELEPHONE DIAL-IN

TELEPHONE DIAL-IN

BROADCAST IMAGE GENERATOR

DIGITAL

ANALOG

MODEM

TV STATION SUPPLIED EQUIPMENT
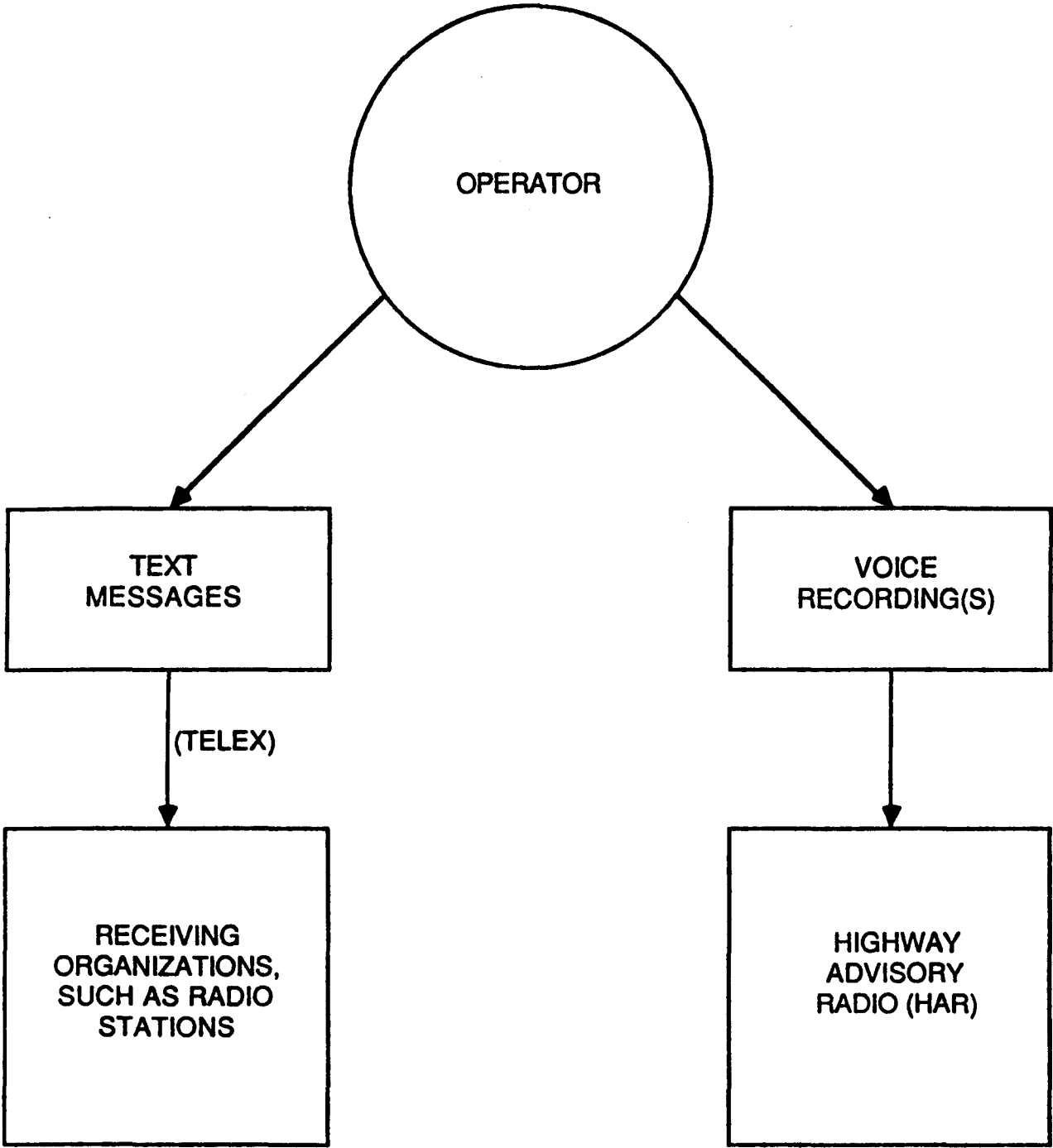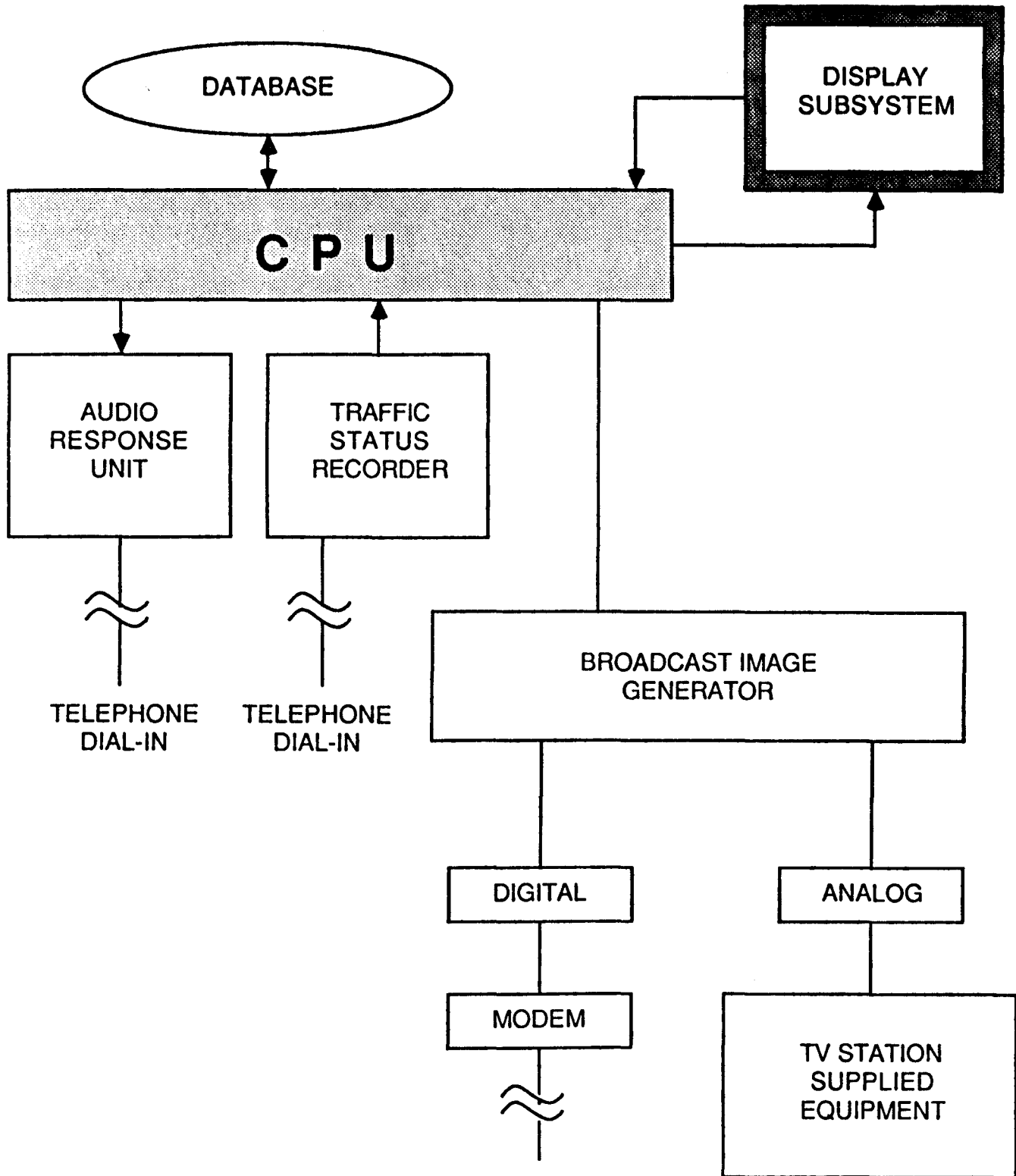
FIGURE 27

39

VIDEO SURVEILLANCE SUBSYSTEM

MAJOR FUNCTIONS:

PROVIDES VISUAL MONITORING OF
TRAFFIC OPERATIONS

RECORDS VIDEO SCENES

PROCESSES IMAGES ELECTRONICALLY

FIGURE 28
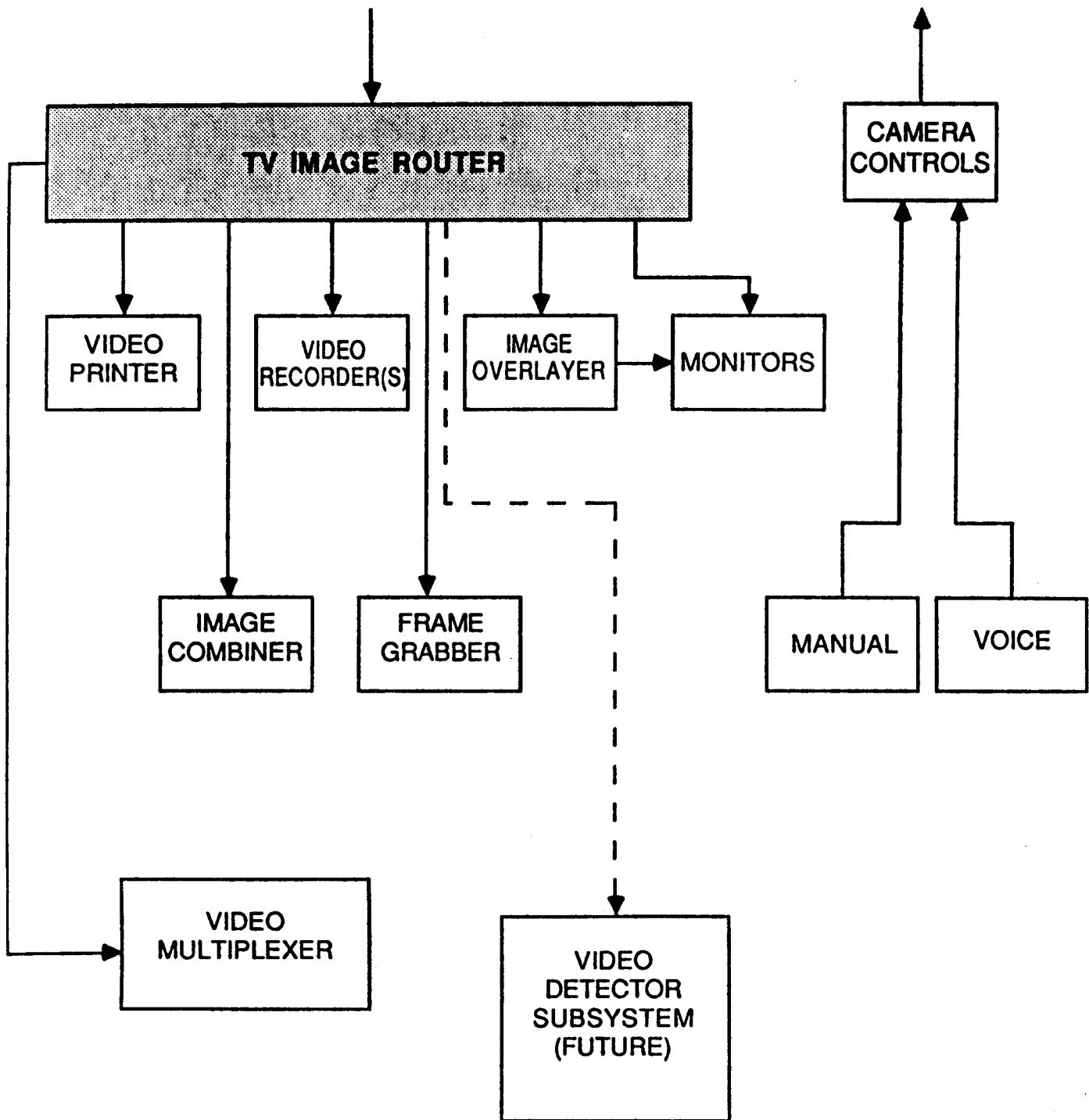
40

VIDEO SURVEILLANCE SUBSYSTEM

```
                    ↓
┌──────────────────────────────────────────┐          ┌──────────────┐
│            TV IMAGE ROUTER                 │          │   CAMERA     │ ↑
└──────────────────────────────────────────┘          │  CONTROLS    │
   │     │         │         ┊     │      │            └──────────────┘
   │     ↓         ↓         ┊     ↓      │               ↑        ↑
   │  ┌──────┐  ┌────────┐  ┊  ┌────────┐ │           ┌──────┐
   │  │VIDEO │  │ VIDEO  │  ┊  │ IMAGE  │→│           │MONITORS│
   │  │PRINTER│ │RECORDER(S)│ │OVERLAYER│ └─────────→ │MONITORS│
   │  └──────┘  └────────┘  ┊  └────────┘             └──────┘
```

┌──────────┐   ┌──────────┐
│ VIDEO   │   │ IMAGE   │
│ PRINTER │   │RECORDER(S)│
└──────────┘   └──────────┘

┌──────────┐   ┌──────────┐
│ IMAGE   │   │ FRAME   │
│ COMBINER │   │ GRABBER │
└──────────┘   └──────────┘

┌──────────┐   ┌──────────┐
│ IMAGE   │   │MONITORS │
│OVERLAYER │   │   │
└──────────┘   └──────────┘

┌──────────────┐
│ VIDEO   │
│ MULTIPLEXER │
└──────────────┘

┌──────────────┐
│   VIDEO   │
│ DETECTOR   │
│ SUBSYSTEM   │
│ (FUTURE)   │
└──────────────┘

┌──────────┐   ┌──────────┐
│ MANUAL │   │ VOICE   │
└──────────┘   └──────────┘

FIGURE 29

41

Central Control Computer Configuration

The central control computer configuration is represented by a complex of computers shown in Figure 30. At this preliminary stage, the host computer is a Digital Equipment Corporation (DEC) MicroVAX, running uder the VMS or UNIX operating system. Numerous peripheral computers are utilized, filling the role of satellite communicators and dedicated subsystem controllers (such as display, archiving, etc.). The peripheral computers are IBM PS/2 Model 80's, running under OS/2 or the UNIX operating system. The various computers are connected by an Ethernet Local Area Network (LAN).

Minimum Starting Configuration

The minimum starting configuration for the total software development effort is shown in Figure 31. This includes the host computer and a satellite communicator/subsystem computer. The dial-up modem shown is for remote access by the programmers.
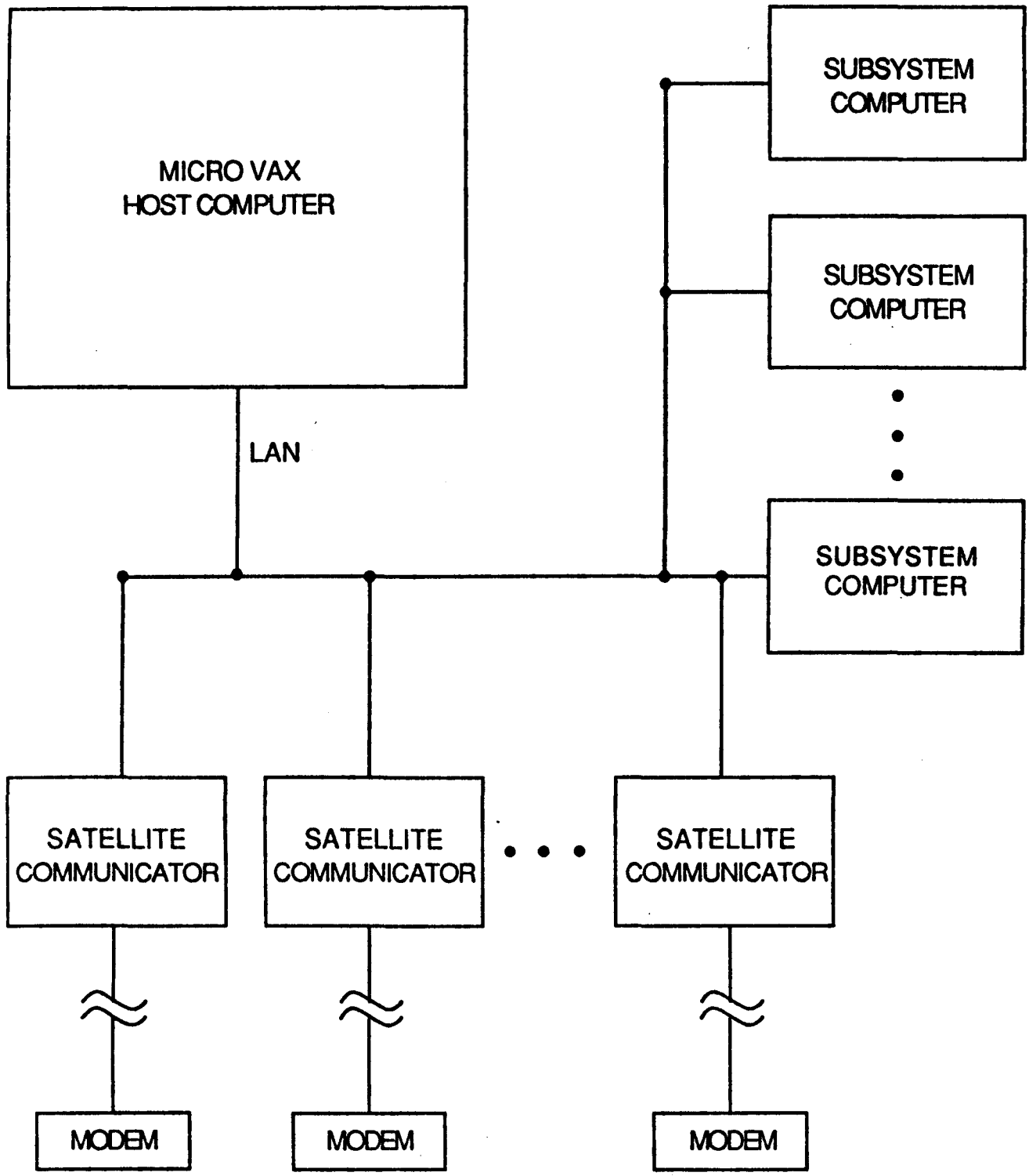
CENTRAL CONTROL COMPUTER CONFIGURATION

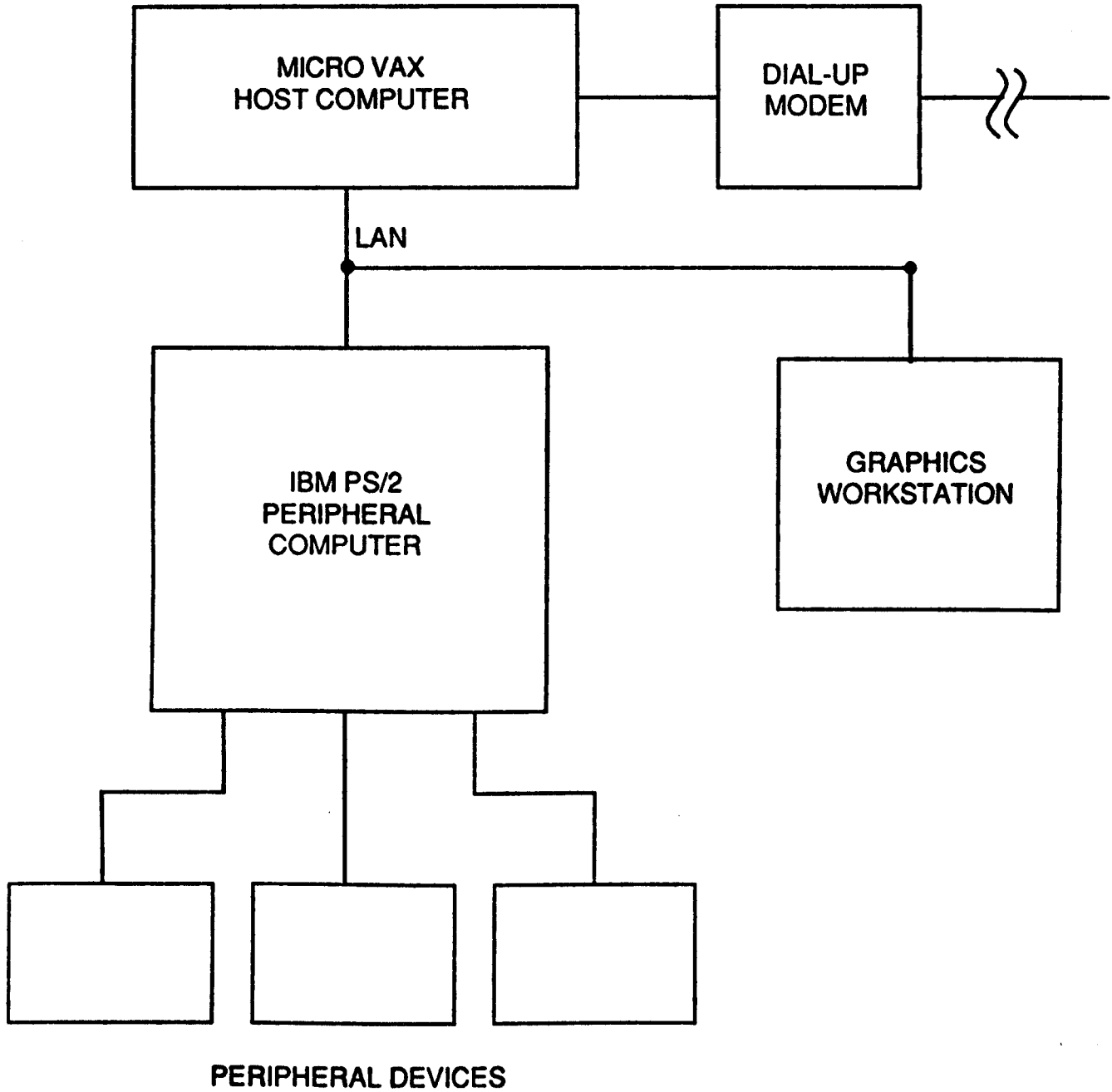

FIGURE 30

43

MINIMUM STARTING CONFIGURATION

PERIPHERAL DEVICES

FIGURE 31

44