REPORT NO. UMTA-TX-06-0020-79-3

AIRTRANS URBAN TECHNOLOGY PROGRAM
PHASE II

VOLUME 2: IMPROVED PASSENGER COMMUNICATIONS

Vought Corporation
P. O. Box 225907
Dallas, Texas 75265

OCTOBER 1979

FINAL REPORT

Document is available to the public through the
National Technical Information Service,
Springfield, Virginia 22161

Prepared for
Dallas/Fort Worth Regional Airport Board
Dallas/Fort Worth Airport, Texas 75261

and

U.S. Department of Transportation
Urban Mass Transportation Administration
400 Seventh Street SW
Washington, D.C. 20590

Technical Report Documentation Page

1. Report No. UMTA-TX-06-0020-79-3	2. Government Accession No.	3. Recipient's Catalog No. PB80 175201
4. Title and Subtitle AIRTRANS URBAN TECHNOLOGY PROGRAM - PHASE II Volume 2: IMPROVED PASSENGER COMMUNICATIONS		5. Report Date October 1979 6. Performing Organization Code
7. Author(s) Richard S. Jacobsen and Conrad M. Schultz		8. Performing Organization Report No.
9. Performing Organization Name and Address Vought Corporation P.O. Box 225907 Dallas, Texas 75265		10. Work Unit No. (TRAIS) TX-06-0020 11. Contract or Grant No. TX-06-0020
12. Sponsoring Agency Name and Address U.S. Department of Transportation Urban Mass Transportation Administration 400 Seventh Street, S.W. Washington, DC 20590		13. Type of Report and Period Covered Final Report - Phase II Volume 2 14. Sponsoring Agency Code UTD-60

15. Supplementary Notes

AUTP is also documented in the following reports: AIRTRANS Urban Technology Program Executive Summary (UMTA-TX-06-0020-79-8); AIRTRANS Urban Technology Program, Phase I, Final Design Report (PB 291-128); IRAN Program, Phase II (PB 294-784); Phase II, Vol.1: Control System Improvements (UMTA-TX-06-0020-79-2); Phase II, Vol.3: Vehicle and Wayside Subsystems (UMTA-TX-06-0020-79-4); Phase II, Vol.4: Vehicle Fabrication, Tests and Demonstration (UMTA-TX-06-0020-79-5); Phase II, Vol.5: Systems Operation (UMTA-TX-06-0020-79-6); and Phase II, Vol.6: Severe Weather (PB 80-157696).

16. Abstract

AIRTRANS, an Automated Guideway Transit (AGT) system built by the Vought Corporation has provided transit service for passengers at the Dallas/Fort Worth Airport since January 1974. This successful deployment of AGT technology prompted the investigation of the extension of the technology. Independent assessments were made by the Transportation Systems Center and by Vought to determine what changes or improvements would be required to operate AIRTRANS in an urban application. The recommendations were: higher operating speeds; better passenger acceptance; reduced capital and operating costs; increased reliability; enhanced all-weather capability; and increased energy efficiency. The AUTP was structured into a two-phase program. Phase I was completed in 1977. The first phase covered the development and demonstration of the improvements necessary for higher speed operation, while maintaining or improving reliability, cost, and performance characteristics of the overall system. Using Phase I as a building block, other recommendations for improvements in AIRTRANS for urban applications were addressed in Phase II. This report, Volume 2, covers the Improved Passenger Communications Task activities of the Vought Corporation, during Phase II of the AIRTRANS AUTP. The primary objectives of the program were to design, build, and demonstrate: 1) an onboard television surveillance system; 2) a programmable audio-announcement unit; 3) a dynamic graphic system; and 4) a time-to-arrival display unit for passenger stations. All of these systems were built and successfully demonstrated as part of the operation of a prototype urban AGT vehicle in the Dallas/Fort Worth AIRTRANS system.

17. Key Words AGT; AIRTRANS; Audio Announcement; Automated Guideway Transit; Dallas/Fort Worth Airport; Dynamics Graphics; Television Surveillance; Time-To-Arrival; TV Surveillance	18. Distribution Statement Available to the public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

PREFACE

This report covers the Improved Passenger Communications Task activities of the Vought Corporation, an LTV Company, during Phase II of the AIRTRANS Urban Technology Program (AUTP). AUTP was authorized by Congress in the Federal-Aid Highway Act of 1976 (P. L. 94-280) and funding for Phase I was included in the Department of Transportation Appropriations Act for 1977 (P. L. 94-387). Program funding was by an Urban Mass Transportation Administration (UMTA) grant to the Dallas/Fort Worth Airport Board and third party contract to Vought. Subsequently, funding was provided for Phase II of AUTP by the Department of Transportation and related agencies Appropriations Act (P. L. 95-85).

AUTP is documented in the following reports:

- AIRTRANS Urban Technology Program Executive Summary UMTA-TX-06-0020-79-8

- AIRTRANS Urban Technology Program Phase II

  Volume 1 - Control System Improvements UMTA-TX-06-0020-79-2

  Volume 2 - Passenger Communications UMTA-TX-06-0020-79-3

  Volume 3 - Vehicle and Wayside Subsystems UMTA-TX-06-0020-79-4

  Volume 4 - Vehicle Fabrication, Tests and Demonstration UMTA-TX-06-0020-79-5

  Volume 5 - Systems Operation UMTA-TX-06-0020-79-6

  Volume 6 - Severe Weather UMTA-TX-06-0020-79-7

- IRAN Program Report No. UMTA-TX-06-0020-79-1

- AIRTRANS Urban Technology Program Phase I Final Design Report UMTA-TX-06-0020-78-1

The cooperation of a large number of people contributed to this program's success. Among these are Dennis Elliott of Dennis Elliott & Associates; Dalton Leftwich and the entire operations and maintenance staff of the Dallas/Fort Worth Airport; Steve Barsony and John Marino of UMTA; and Ron Kangas of the Transportation Systems Center.

Preceding page blank

METRIC CONVERSION FACTORS

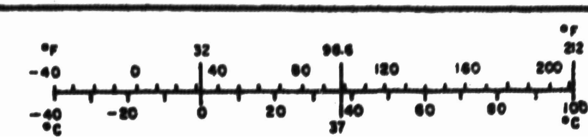
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



G9-1594-80

AUTP PROGRAM DESCRIPTION

AIRTRANS, an Automated Guideway Transit (AGT) system built by the Vought Corporation, has provided transit service for passengers at the Dallas/Fort Worth Airport since January 1974. This successful deployment of AGT technology prompted the United States Congress, the Department of Transportation (DOT) and Vought to investigate the extension of this technology. Independent assessments were made by the Transportation Systems Center of DOT (Reference (1)) and by Vought Corporation to determine what changes or improvements would be required to operate AIRTRANS in an urban application.

AIRTRANS SYSTEM AT D/FW AIRPORT

The recommendations were:

(1) Higher operating speeds

(2) Better passenger acceptance

(3) Reduced capital and operating costs

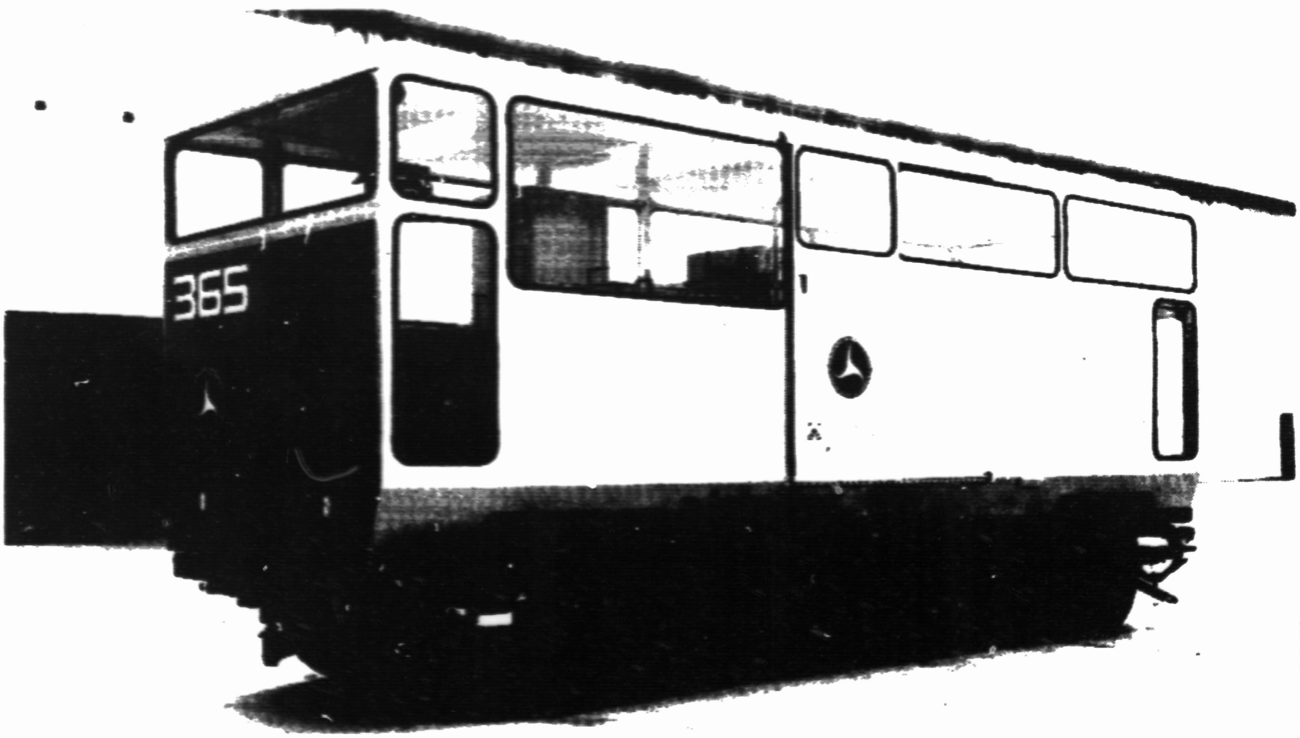
(4) Increased reliability

(5) Enhanced all-weather capability

(6) Increased energy efficiency

The successful achievement of these improvements would provide an energy-efficient urban AGT system which could intercept much of the auto and bus traffic at the outskirts of high-density urban centers. This would allow a commuter to park his car (or leave his bus) and ride the AGT system to his final destination in comfort and safety. Subsequent movements within the urban center would also be possible using the AGT system; thus, the need for auto and bus traffic in the downtown area could be reduced to a minimum.

The development of AIRTRANS system derivatives, for use in other AGT applications, began before the initial AIRTRANS system was put into revenue service at the Dallas/Fort Worth Airport. It was apparent at the outset that higher operating speeds would be required in urban settings.



G9-1594-79

PHASE I TEST VEHICLE T365

The AUTP (AIRTRANS Urban Technology Program) was structured into a two-phase program. Phase I of AUTP was completed in 1977 (Reference (2)). Briefly, the first phase covered the development and demonstration of the improvements necessary for higher speed operation, while maintaining or improving reliability, availability, cost and performance characteristics of the overall system.

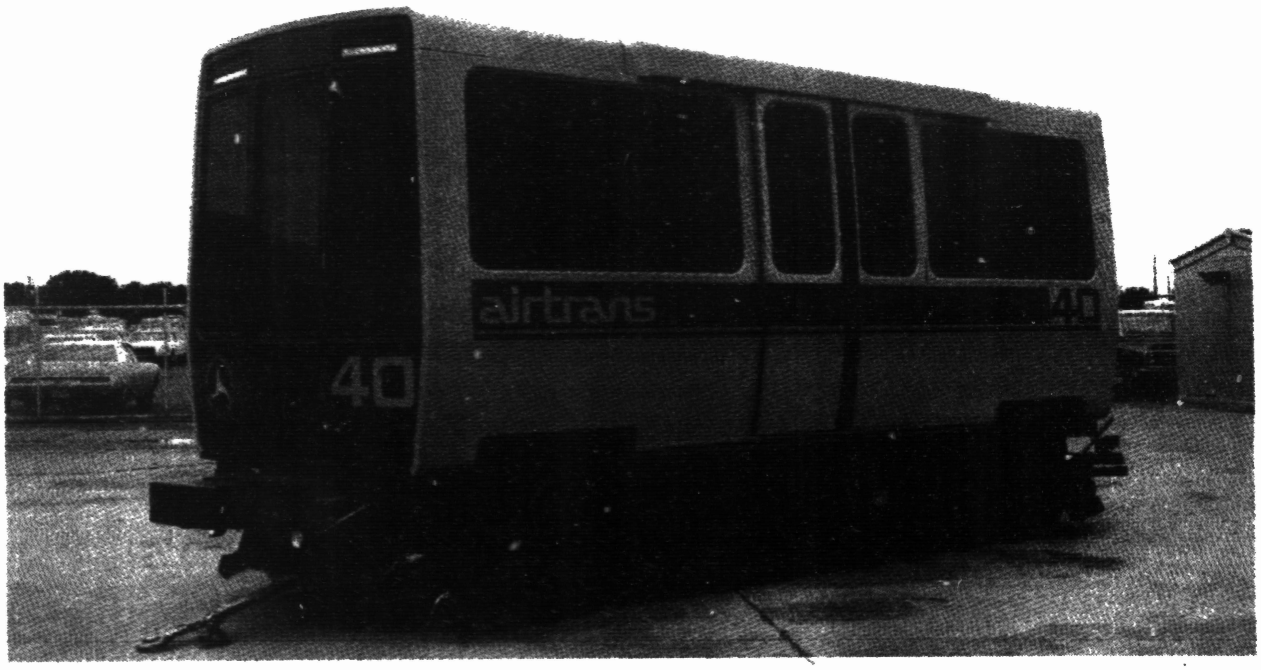
A highly instrumented engineering test vehicle (named T365) was used to demonstrate baseline and improved performance of the system.

PHASE II OVERVIEW

Using Phase I as a building block, other recommendations for improvements in AIRTRANS for urban applications were addressed in Phase II. The AUTP Phase II activities involved:

(1) Completing the propulsion and control system improvements and testing begun on test vehicle T365 in AUTP Phase I

(2) Design, fabrication and demonstration of passenger communication improvements



G9 1594-78

PHASE II PROTOTYPE URBAN VEHICLE P40

(3) Design, fabrication, test and demonstration of a prototype urban vehicle (P40), incorporating:

(a) AUTP Phase I changes to the propulsion, collectors, steering, controls and communication

(b) Doors on both sides

(c) Powered reversing

(d) Improved suspension

(e) Improved vehicle coupling

(f) Interior rearrangements

(4) Wayside electrical power improvements, including:

  (a) Solid-state wayside power controller

  (b) Power distribution simulation studies

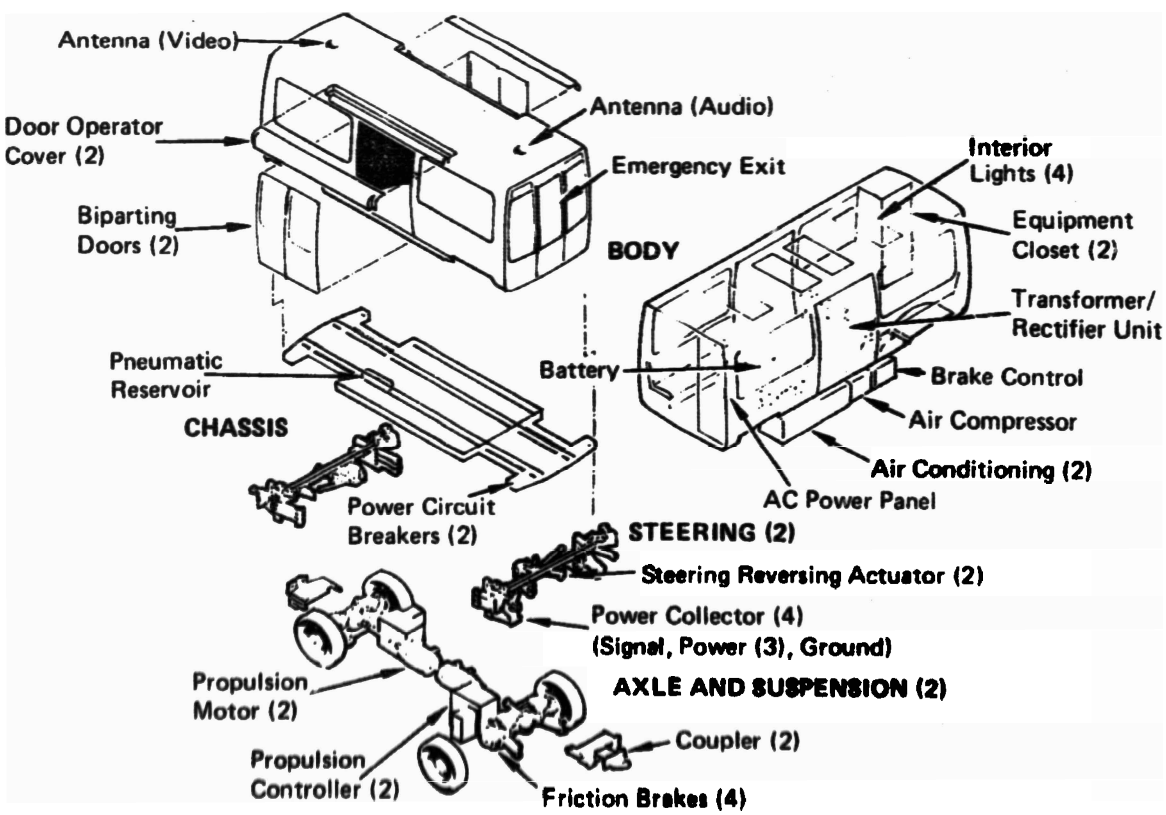
(5) AIRTRANS systems performance, operation and maintenance tasks, including:

  (a) Potential service improvements by use of higher speed, three-car trains, the addition of bypass sidings, and demand mode operation

  (b) An IRAN (Inspect and Repair as Necessary) program

(6) Analysis, design and test evaluation of subsystems affected by severe weather operation

The Phase II effort began with the continuation of the propulsion and control system tests that were begun in Phase I. Concurrent with the effort, the design and procurement for the



PROTOTYPE URBAN VEHICLE MAJOR SUBSYSTEMS

subsystems of the Phase II prototype vehicle were in work. The chassis was modified as required for the redesigned systems, and the new prototype vehicle was assembled.

The dual propulsion system and features of the redesigned steering system from Phase I were retained along with the concept of the collectors and control system. Powered reversing to permit shuttle operation was incorporated in the steering system along with elimination of the steering interconnect linkage and an increase in wheel steer angle for a smaller turning radius. A new suspension system was designed and fabricated. New specifications were written and new sources found for a pneumatic system direct-drive motor/compressor and for the heating, ventilating and air conditioning units. The AIRTRANS alternator was replaced with a specially designed solid-state transformer/rectifier. Improvements were made in the friction brake system and the pneumatic door operator. Biparting doors were incorporated on both sides of the vehicle to accommodate stations on either side of the guideway.

Dynamic graphics and the onboard TV surveillance systems were installed. The microprocessor-based control system of Phase I was modified to incorporate provisions for the dual doors, slip/slide detection, automatic reversing, automatic announcement unit (AAU), dynamic graphics and master/slave vehicle operation.

To verify the design and performance of the urban prototype vehicle, it was subjected to tests and demonstrations, both at Vought and at D/FW Airport. The knowledge and data obtained from Phase II of the AIRTRANS Urban Technology Program has been a significant step toward providing technology suitable for use in an urban environment. At the conclusion of the AUT program, the P40 vehicle was turned over to the Dallas/Fort Worth Airport and was in revenue service. In this way, further data will be gathered on this unique urban prototype vehicle, and will further assure a successful deployment of AIRTRANS into an urban environment.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

1.0 SUMMARY

1.1 PROGRAM DESCRIPTION

When the AIRTRANS people mover system began revenue service in January 1974, it became the first multiroute operational AGT system in the world. Since the AIRTRANS system is the primary mode of conveying passengers and employees between terminals and remote parking lots in one of the world's largest airports, it was necessary that passenger communications in the form of graphics and audio systems be incorporated in the basic design of both the D/FW Airport and the AIRTRANS system. During the first two years of system operation, several modifications were accomplished to improve passenger communications, including placing station attendants in the more heavily used terminals. These changes and their effects are discussed in the AIRTRANS Assessment Report (Reference (1)). Although the AIRTRANS passenger communications provisions are adequate for the D/FW Airport, deployment in an urban environment would require a more effective communication system which would eliminate the need for station attendants. Based on the recommendations made by the Transportation System Center in Reference (1), the verbal communications with potential Downtown People Mover (DPM) city planners and the preliminary data obtained in the System Safety and Passenger Security program, the following program objectives were defined:

(1) Minimize passenger confusion in the use of an AGT system

(2) Provide passenger security in unmanned vehicles

(3) Maximize patron acceptance of an AGT system

The implemented program concentrated on the vehicle related aspects of passenger communications and security since these items are common to all AGT systems. Specifically, the Phase II effort has been directed to four development tasks. These are:

(1) Develop and demonstrate an onboard TV surveillance system

(2) Design and demonstrate a programmable audio announcement unit (AAU)

(3) Develop and evaluate a dynamic graphics assembly

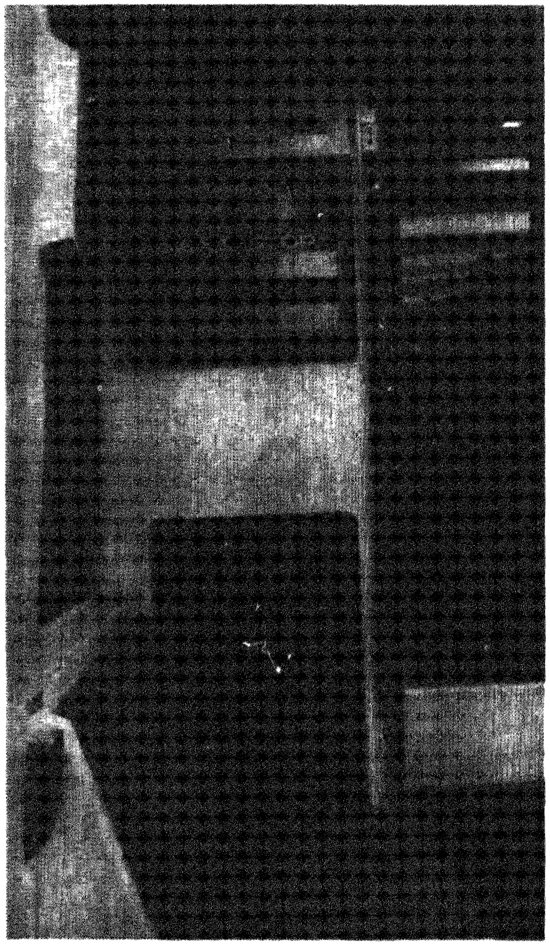
(4) Design and evaluate a time-to-arrival (TTA) display unit for use in passenger stations

These items, none of which existed at the initiation of the Phase II program, have been evaluated in the D/FW AIRTRANS system and collectively satisfy the program objectives.

1.2 RELATIONSHIP TO THE OVERALL PHASE II PROGRAM

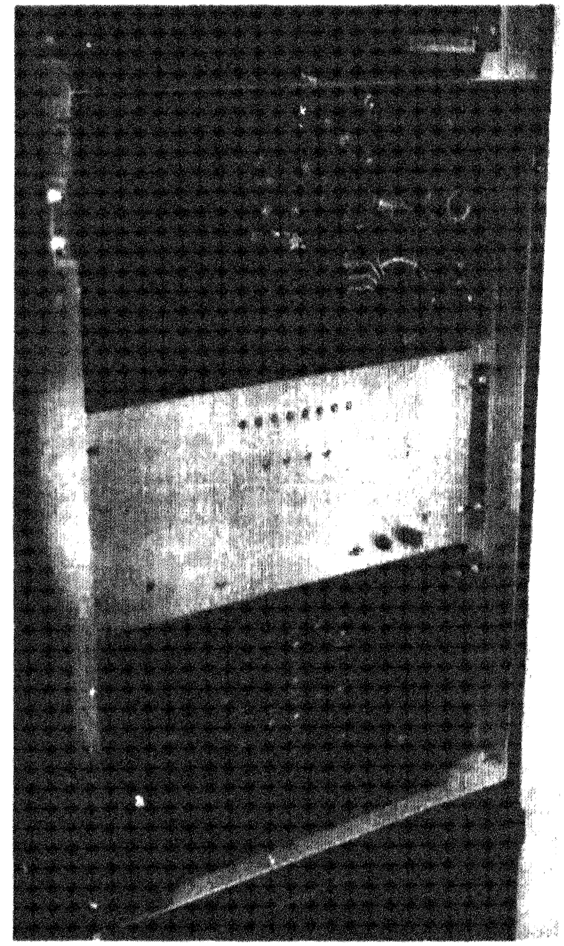
The Phase II program was comprised of six tasks. The improved passenger communications task consists of the four subtasks identified in the preceding paragraph. The overall program was directed toward demonstrating the operation of a prototype urban AGT vehicle in the D/FW AIRTRANS system. The TV surveillance camera, data processor and transceiver were mounted in the aft electronics compartment of the urban prototype vehicle as shown in Figure 1-1. The audio announcement unit was also located in this compartment. Two dynamic graphics units were provided, one on the forward panel of the aft electronics compartment and one on the aft panel of the forward electronics compartment. These units were evaluated as a part of the overall evaluation of the urban AGT prototype vehicle designated as P40. The TV surveillance wayside transceiver, data decoder and TV display units were housed in the D/FW South Parking Lot B station as shown in Figure 1-2. The time-to-arrival display was mounted in the D/FW South Parking Lot A station as shown in Figure 1-3. This display indicates the time-to-arrival of all passenger trains serving that station.

The AUTP Phase II results are documented in a series of eight reports of which this report is Volume 2. The other seven reports and the AUTP Phase I Final Report are listed as References (2) through (9).



Aft electronics compartment showing TV surveillance camera mounted above the dynamic graphics

Side view of electronics compartment (upper half) showing TV surveillance camera installation (top) and data processor/transceiver installation (bottom)



Side view of aft electronics compartment (lower half) showing audio announcement unit (AAU) installation (middle)

FIGURE 1-1 AFT ELECTRONICS COMPARTMENT

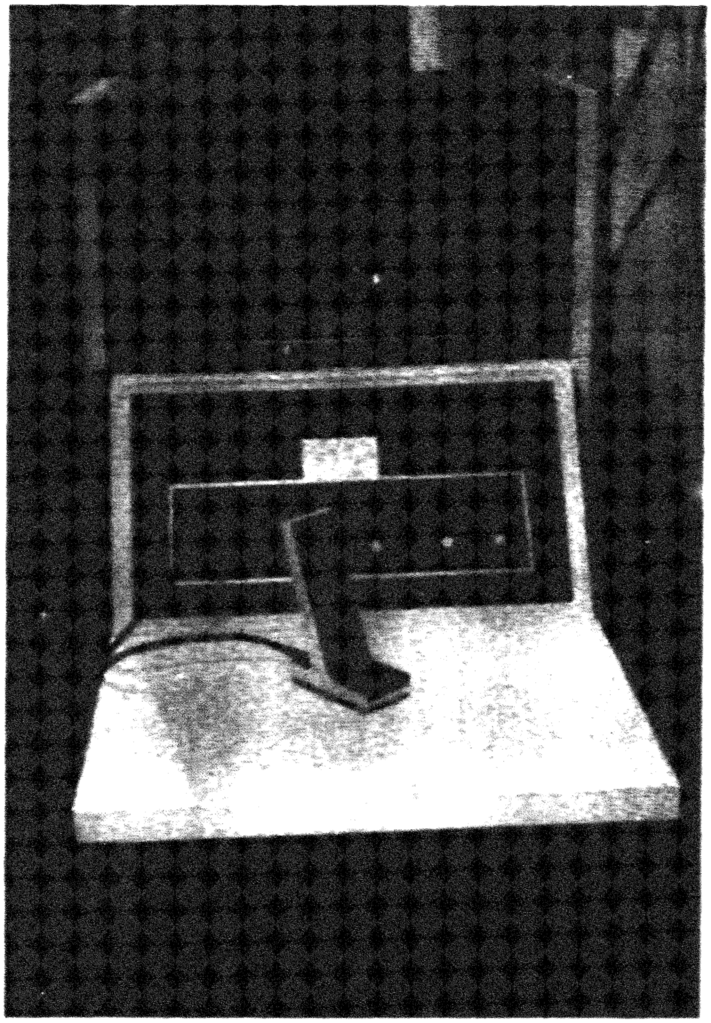


FIGURE 1-2 BASE STATION INSTALLATION (TV)

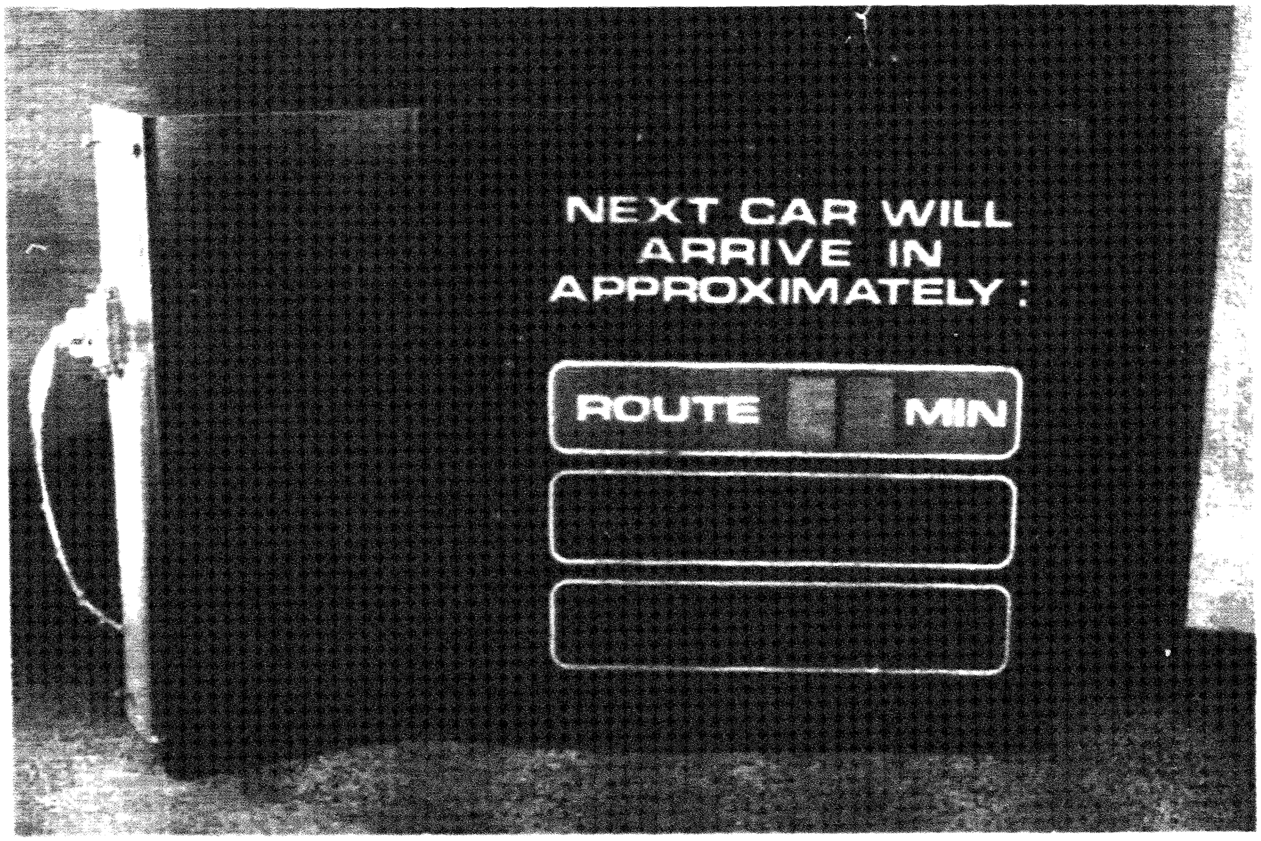


FIGURE 1-3 TIME-TO-ARRIVAL UNIT

1.3 PRIMARY OBJECTIVES AND ACCOMPLISHMENTS

The primary objectives of the Improved Passenger Communications program were to design, build and demonstrate an:

(1) Onboard TV surveillance system

(2) Programmable audio-announcement unit

(3) Dynamic graphics system

(4) Time-to-arrival display unit for passenger stations

All these systems were built and successfully demonstrated as part of the operation of a prototype urban AGT vehicle in the D/FW AIRTRANS system.

2.0 ONBOARD TV SURVEILLANCE SYSTEM

2.1 BACKGROUND

Closed-circuit TV (CCTV) systems have been in use in transit stations for several years to provide passenger security via video surveillance to a central control point. In the unmanned AGT environment, there is also concern about the problems of onboard security. In conventional transit systems, onboard operations personnel such as vehicle operators, conductors or guards provide some level of crime deterent. These people will not be present on AGT systems. Recent technological advances have made feasible the implementation of CCTV onboard a transit vehicle. The primary impediment to implementation of such systems is the data link from the vehicle to the monitoring point. Normal commercial quality TV systems require a bandwidth of 4-6 MHz for video transmission. Since the number of vehicles in an urban AGT system is likely to be large, the cost of the transmitters and the difficulty in obtaining frequency allocations has not allowed such systems to be implemented.

The first demonstration of AGT vehicle to wayside CCTV was accomplished in 1971 at the 5th International Conference on Urban Transportation in Pittsburg, PA. The demonstration utilized the "Skybus" vehicle operating in South Park Transit Expressway test track of the Port Authority of Allegheny County. The system demonstrated used a 160-foot dielectric waveguide mounted in the guideway to receive low power signals transmitted from a 3.7 GHz, 50 MW transmitter on the vehicle. This low power and "captive" pickup allowed operation without FCC license. The details of the mechanization and demonstration results may be found in Reference (10). Although the demonstration was regarded as successful, the system still did not appear to be cost effective.

In 1975, Vought and Motorola discussed a different approach to implementing a cost-effective, vehicle-borne CCTV system (Reference (11)). These discussions resulted in the Phase II demonstration of the Motorola-developed system.

2.2 DESIGN APPROACH

Since all urban deployable AGT systems require emergency voice communications between vehicles and central control, the possibility of transmitting video information over voice quality data links was examined. The primary constraint in the use of voice quality data links is the allowable bandwidth which limits the quantity of data transmitted per unit of time.

The approach taken by Motorola differs from previous techniques in that no subcarrier modulation is employed, and an address code allows polling of several units. The TV camera is a standard 525-line system, and the onboard video processor stores successive image frames. When a scene is to be transmitted to central, a single camera field is digitized and transmitted as an amplitude modulated pulse train. At central, the serial data stream is decoded, reformatted and displayed as a "snapshot" on a standard 525-line monitor. To transmit a full 650-line (horizontal) resolution frame with a fidelity of 16 shades of gray would require transmission of 1.4 megabits of information. To transmit this data at 16K symbols/second over voice-quality bandwidth would require approximately 90 seconds. A series of trade-offs were made between transmission times and picture quality to optimize the system. These trades resulted in the decision to utilize the equivalent of a 128-line picture with 16 shades of gray for the demonstration program. This reduction in transmitted picture quality requires only 64 kilobits of data per frame, and allows a frame transmission time of 3 seconds. This configuration gives resolution comparable to wire photo resolutions.

The block diagram of the demonstration system is shown in Figure 2-1. The vehicle-borne equipment consists of a Motorola Model 51161 TV camera with a SLN6503 1/2 inch lens, the video processor, and a Motorola "Maxar" simplex UHF radio. For an urban application, an inexpensive video recorder might be added so that several minutes of real-time data would be available on tape to preserve events occurring over a period of time preceding an observed event. The base station equipment consists of a Motorola "Mocom 70" simplex UHF radio, the video processor, and a Motorola Model S1254A dual TV monitor.

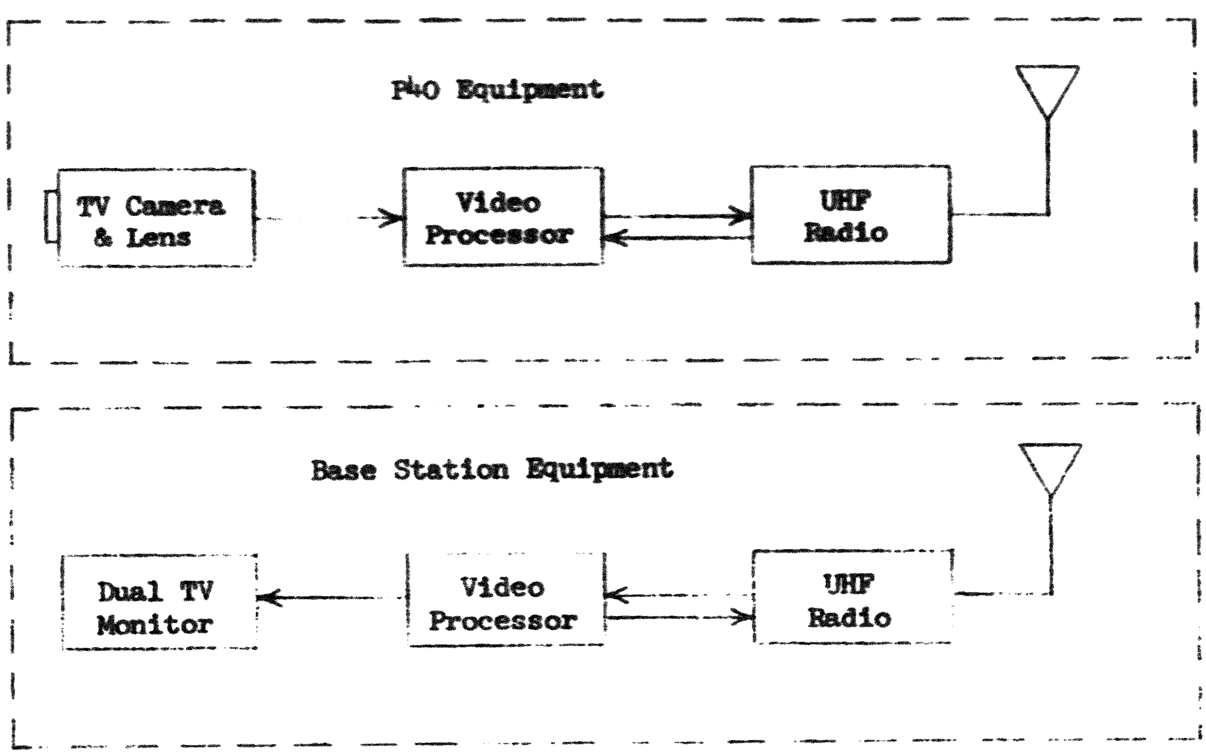


FIGURE 2-1 CCTV BLOCK DIAGRAM

The functional block diagram of Figure 2-2 shows the major elements of the mobile (vehicle-borne) equipment in greater detail. The video processor changes the 6 MHz bandwidth camera output signal into a 3 KHz baseband signal which can be transmitted over the 450 MHz (nominal) transceiver frequency. The camera signal is fed to the sync detector and four-bit A/D converter circuits. The sync detector passes the vertical and horizontal control pulses to the timing and control circuit, while the A/D converter inputs 128 pixels per horizontal line and every fourth line to the processor memory. Thus, the stored frame is a 128 by 128 matrix of pixels with, because of the 4-bit quantization, 16 shades of gray. The timing and control circuit, upon receiving an interrogation request from the receiver circuitry, formats the sync and identity bits from the last frame, turns on the transmitter, and then shifts the memory content serially to provide a 16-kilobits serial pulse stream which modulates the transmitter to provide one frame of video data over an approximate 3-second period. The shades of gray are conveyed by the amplitude of each pulse.

The base station equipment is shown in Figure 2-3. The base station video processor converts the receiver output to digital frame data via the A/D converter. The A/D converter output is fed alternately to memory No. 1 and No. 2 so that a full frame is always available for display on monitor No. 1. The timing and control module always connects the full memory to the D/A converter and in turn to CCTV monitor No. 1 for display. Thus, the CCTV monitor alternately displays the output of memory No. 1 and No. 2 as they become filled with data. The timing and control module contains a sync generator to reconstruct the horizontal and vertical sync and blanking pulses for output to the CCTV monitor.

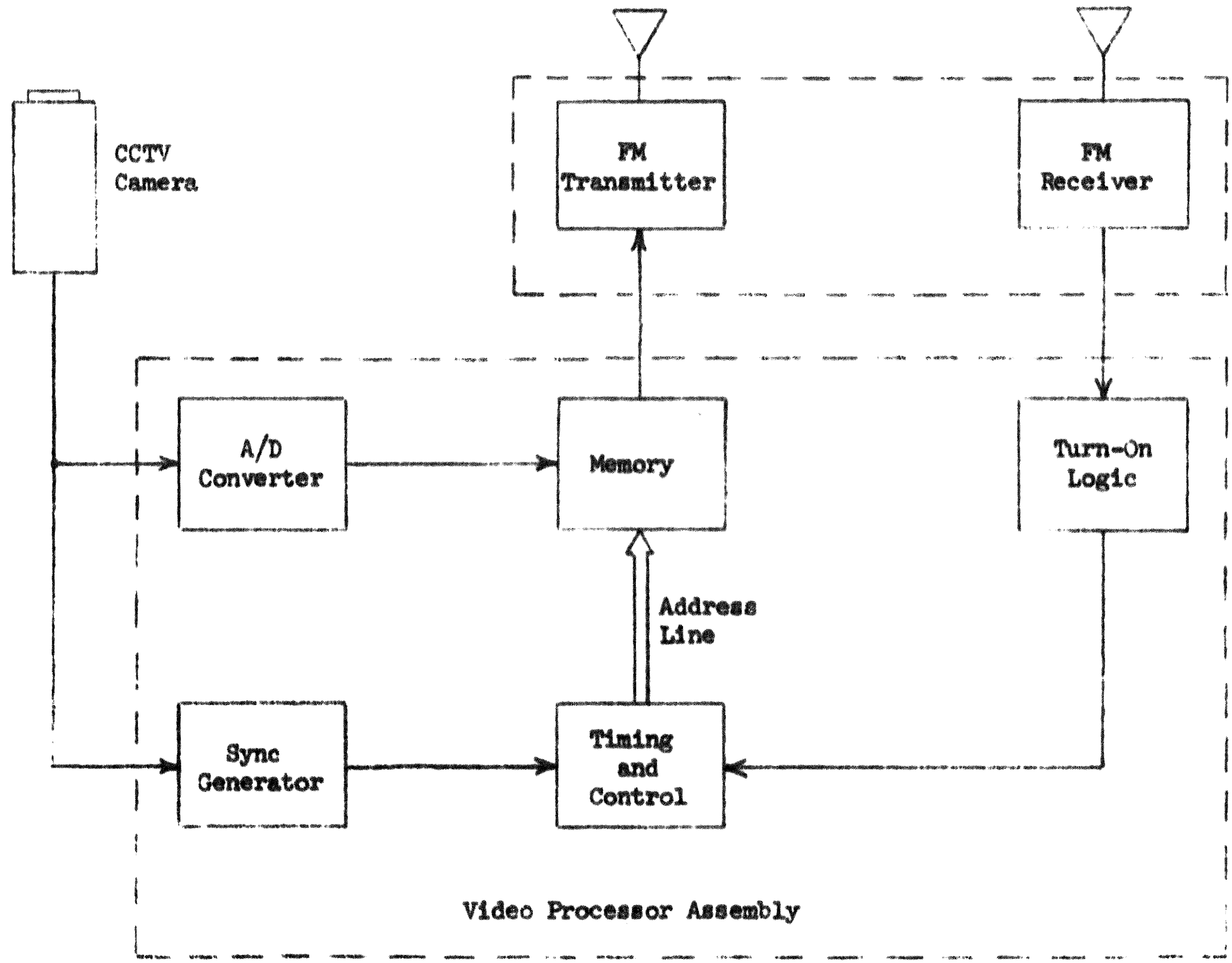


FIGURE 2-2 MOBILE EQUIPMENT FUNCTIONS

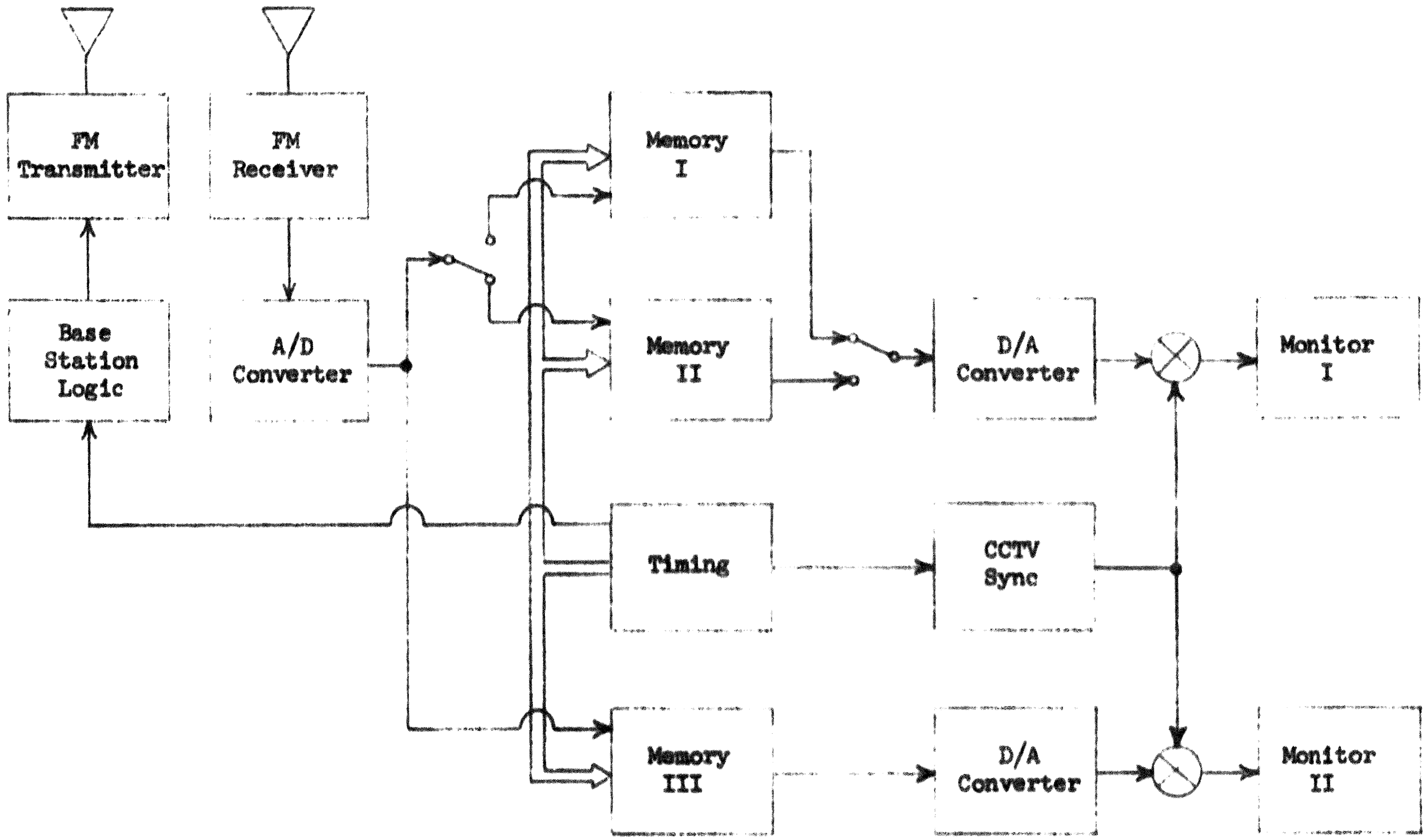


FIGURE 2-3 BASE STATION FUNCTIONS

The base logic module controls the transmitter, allowing it to be operated in the voice mode, to request a single-picture frame, or to ask for repetitive picture frames every 3 seconds. The base logic is designed to be able to poll several vehicles in succession via the repetitive interrogation mode.

A third memory, which is fed to CCTV Monitor No. 2 via a separate D/A converter, is provided to store, indefinitely, any one picture frame currently being displayed on monitor No. 1 until erased by the operator. The transfer of picture data to memory No. 3 is accomplished via operator command.

2.3 HARDWARE DEVELOPMENT

Development of a prototype system was initiated in January 1978. The onboard equipment was designed to be installed in the AUTP Phase II vehicle, and the base station was designed to be portable so that it could be installed at a convenient location in the D/FW AIRTRANS system.

The breadboard of the system was completed and demonstrated in May 1978 at the Motorola facilities in Chicago. The breadboard testing showed that picture transmission quality was essentially constant with received signals between 100 uv and 1 uv, and that usable pictures could be received at levels as low as 0.5 uv. The test setup is shown in Figure 2-4. The camera monitor via direct line is shown in Figure 2-5a. Figure 2-5b illustrates the picture quality through the video processors with the RF link bypassed via wireline. Figures 2-5c and 2-5d show the picture quality at 100 uv and 0.5 uv received signal levels, respectively.

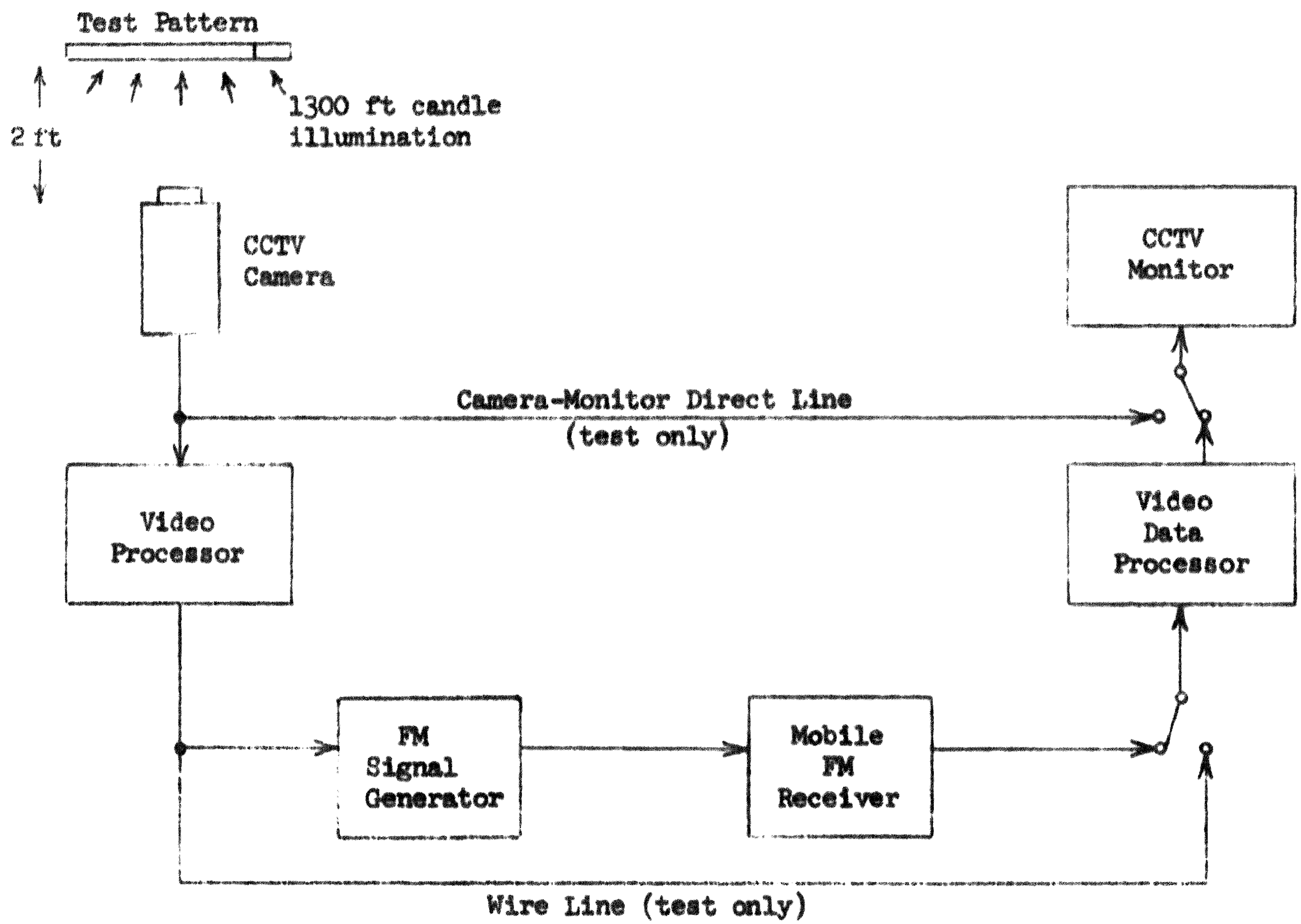


FIGURE 2-4 BREADBOARD TEST SETUP

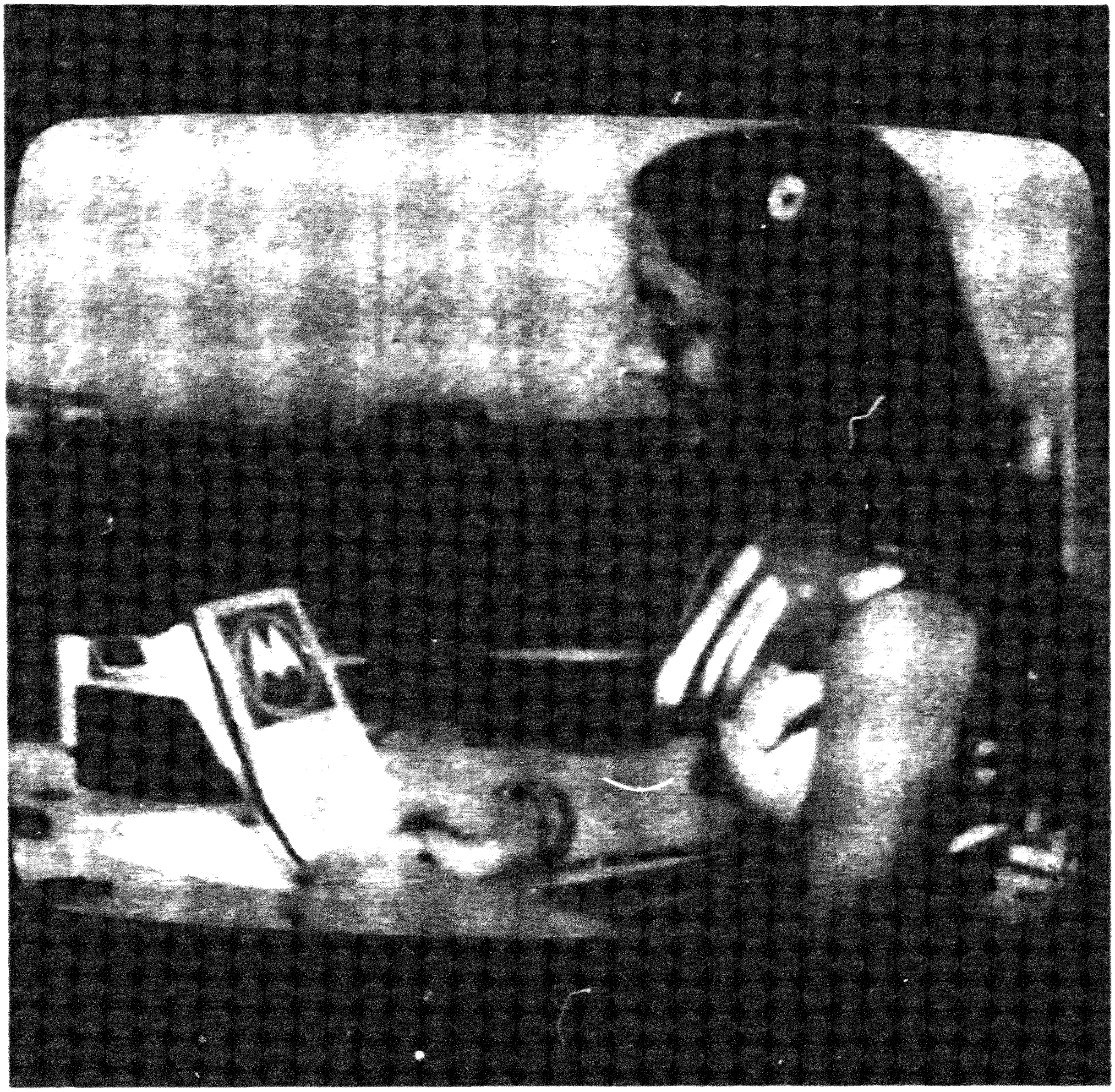


FIGURE 2-5a PICTURE QUALITY TEST (DIRECT LINE)

FIGURE 2-5b PICTURE QUALITY TEST (WIRE LINE)

FIGURE 2-5c PICTURE QUALITY TEST (100 MICROVOLTS)

FIGURE 2-5d PICTURE QUALITY TEST (5 MICROVOLTS)

In October 1978, the prototype mobile system was installed in a van and used to transmit pictures within a 2.5-mile radius of the base station. Figure 2-6 shows a representative sample of the received picture at the base station. The picture does not fill the screen of the TV monitor because narrow band TV utilizes a 1 to 1 aspect ratio as opposed to the standard CCTV 4 to 3 aspect ratio. The pictures in Figure 2-5 do not reflect the same situation because the photographs have been made to accommodate the square format.

The prototype system was delivered to Vought in November 1978 and demonstrated as a part of the AUTP Phase II design review. The mobile portion of the system was installed in the AUTP P40 vehicle in May 1979, and the base station equipment was installed in the electronics room of the AIRTRANS South Parking B station in July 1979.

FIGURE 2-6 PROTOTYPE DEMONSTRATION

2.4 TEST PROGRAM

The TV base station was installed in remote passenger station 5EB, and has been demonstrated with the vehicle operating throughout the airport. Coverage is possible throughout the airport except from within Braniff subterminal 2WB. The unit has shown a greater range than the 2 miles anticipated. Approximately 2.7 miles are being covered, which includes the north end of the airport.

A business mobile license K07983 was secured from the Federal Communications Commission for demonstration of the system.

The transmitter power level was 2 watts and the operating frequency was 469.5375 megahertz.

Disregarding the limitations of 3-second picture from transmission time, evaluation of the TV surveillance demonstration is subjective and can only be discussed in the following qualitative manner based upon observation:

(1) Picture resolution at the base station monitor remained constant with only slight perturbations as the vehicle progressed around the AIRTRANS system.

(2) Occasionally, electromagnetic (EMI) noise lines were present within the received picture, but none were observed which seriously obscured reception.

(3) The vehicle passing from bright sunlight to the darker terminal areas caused only minor change in quality of base station reception.

3.0 IMPROVED AUDIO ANNOUNCEMENT UNIT

3.1 BACKGROUND

Most transit systems utilize an onboard public address system operated by the driver or conductor to convey audio information to the passengers. AGT systems, having no onboard operators or attendants, must provide audio information by alternate means. The simple AGT systems such as Tampa and Seatac airports only have one route and initilized simple prerecorded messages and standard tape decks. The AIRTRANS system, however, operates five separate routes serving a total of 14 stations which imposes a unique set of requirement on an audio announcement (AAU) system. The AAU must select one message out of the 14 available and play the selected message within 5 seconds after having received a wayside command designating the station being approached. The AIRTRANS AAU utilized four modified commercial-grade 8-track cartridge players for this purpose. The cartridge tape decks were modified so that each deck had eight playback heads instead of the usual four heads and endless loop cartridges with a single announcement on each track. The electronic control circuitry then decoded the wayside command, selected one of the four tape decks and one of the eight tape heads to play the correct announcement. Although the concept was good, the maintenance requirements for the tape decks were excessive and the operational life of the decks was unsatisfactory. The D/FW AIRTRANS staff has recently scrapped these units and installed a single cassette playback unit which has a single announcement telling the passengers to observe the signs as they enter the station. This solution, of course, is not satisfactory for the visually impaired or already confused or disoriented passenger.

3.2 DESIGN APPROACH

As a part of a Vought research and development program in the 1975-77 time period, the requirements for AAU performance were reviewed. The AIRTRANS requirement of 5-second access time for any AAU announcement was found to be unnecessarily restrictive since, even in a multiple route system, stations must come up in a fixed sequence. The revision of the requirement to recognize this geographic constraint allows an alternate approach to be utilized; namely, recording all of the station announcements in sequence on a single tape. Then, by recording an identification code on a second track on the tape, the AAU can utilize route code information in combination with the memory of the last announcement made to advance the tape to be in position to play the next announcement. An experimental breadboard AAU, utilizing a high quality commercial cassette recorder and an 8-bit microprocessor, was fabricated and demonstrated at D/FW AIRTRANS in 1975. This unit, shown in Figure 3-1, operated in revenue service prior to the AUT Program over a 60-day period with no discrepancies or malfunctions. Review of the design and performance of this unit led to the design of the unit to be

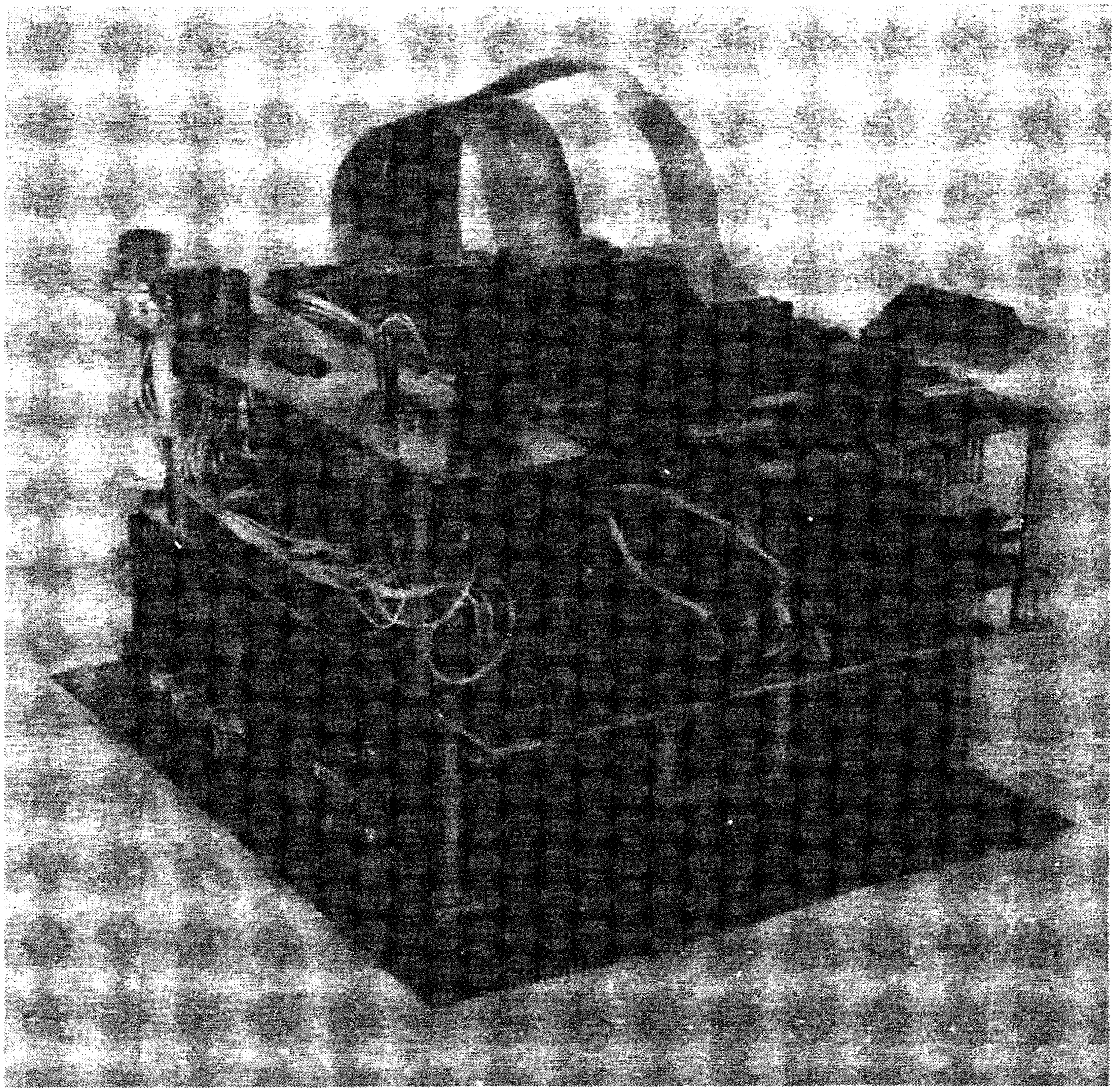


FIGURE 3-1 EXPERIMENTAL AAU BREADBOARD

demonstrated on the AUT Program. The tape player used in the experimental unit, although of excellent quality, was very expensive and unnecessarily complex for this application. A survey of available tape decks was made and a unit found which was specifically designed for this application. The unit selected, a Phideck Model III, is environmentally qualified, relatively inexpensive, and easy to maintain. The experimental unit microprocessor was also replaced with a National "SC/MP" board so that program language would be common to the vehicle control electronics microprossor. The block diagram of the AUTP AAU is shown in Figure 3-2, and the AAU breadboard units are depicted in Figure 3-3. It should be noted that the AAU micro-processor also contains the program to control the dynamic graphics unit to be described in Section 4.0 Since both units utilize the same data, and the "SC/MP" microprocessor has more than adequate capability, the decision was made to utilize it rather than implement a separate processor for the dynamic graphics.

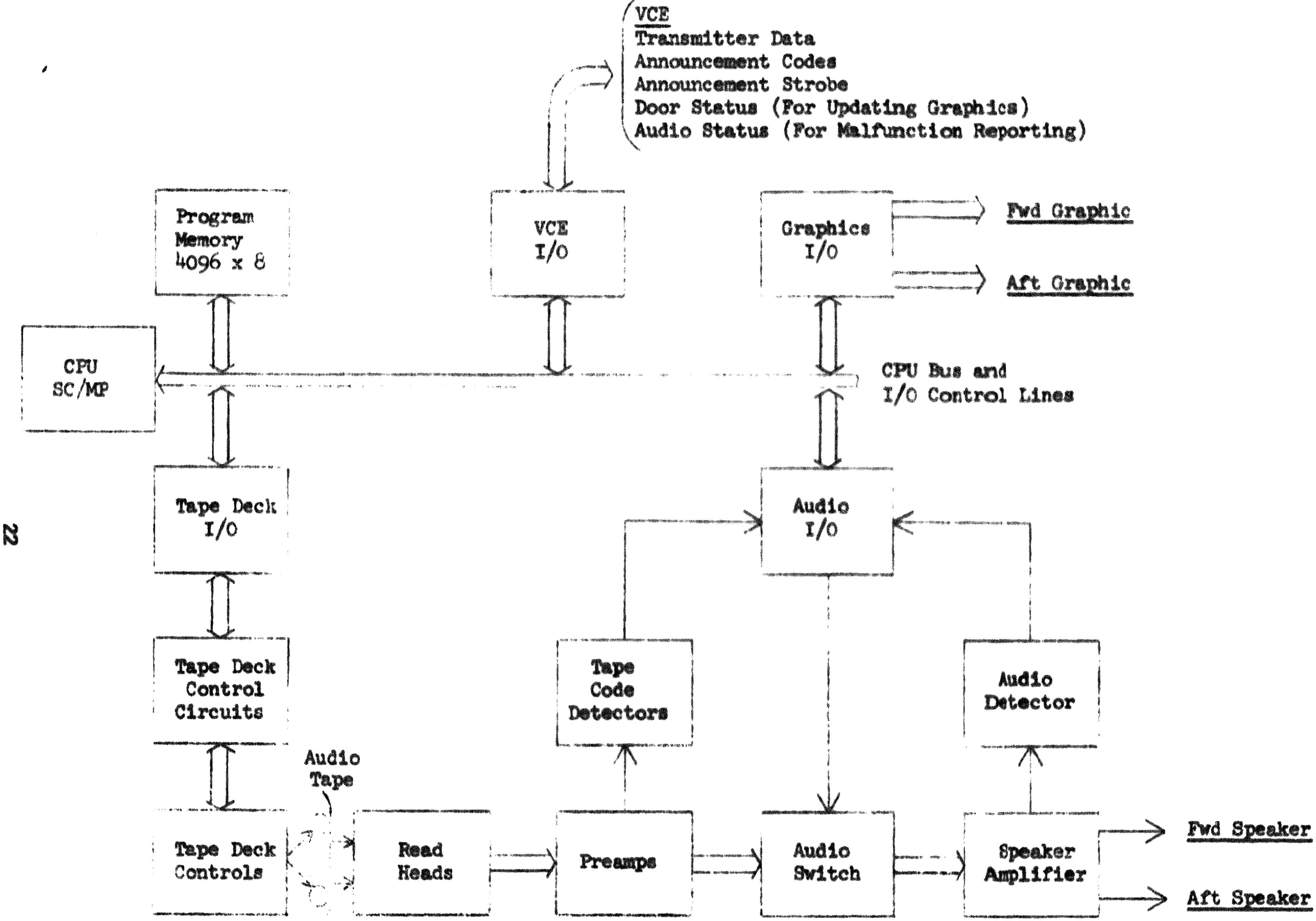


FIGURE 3-2 AAU BLOCK DIAGRAM

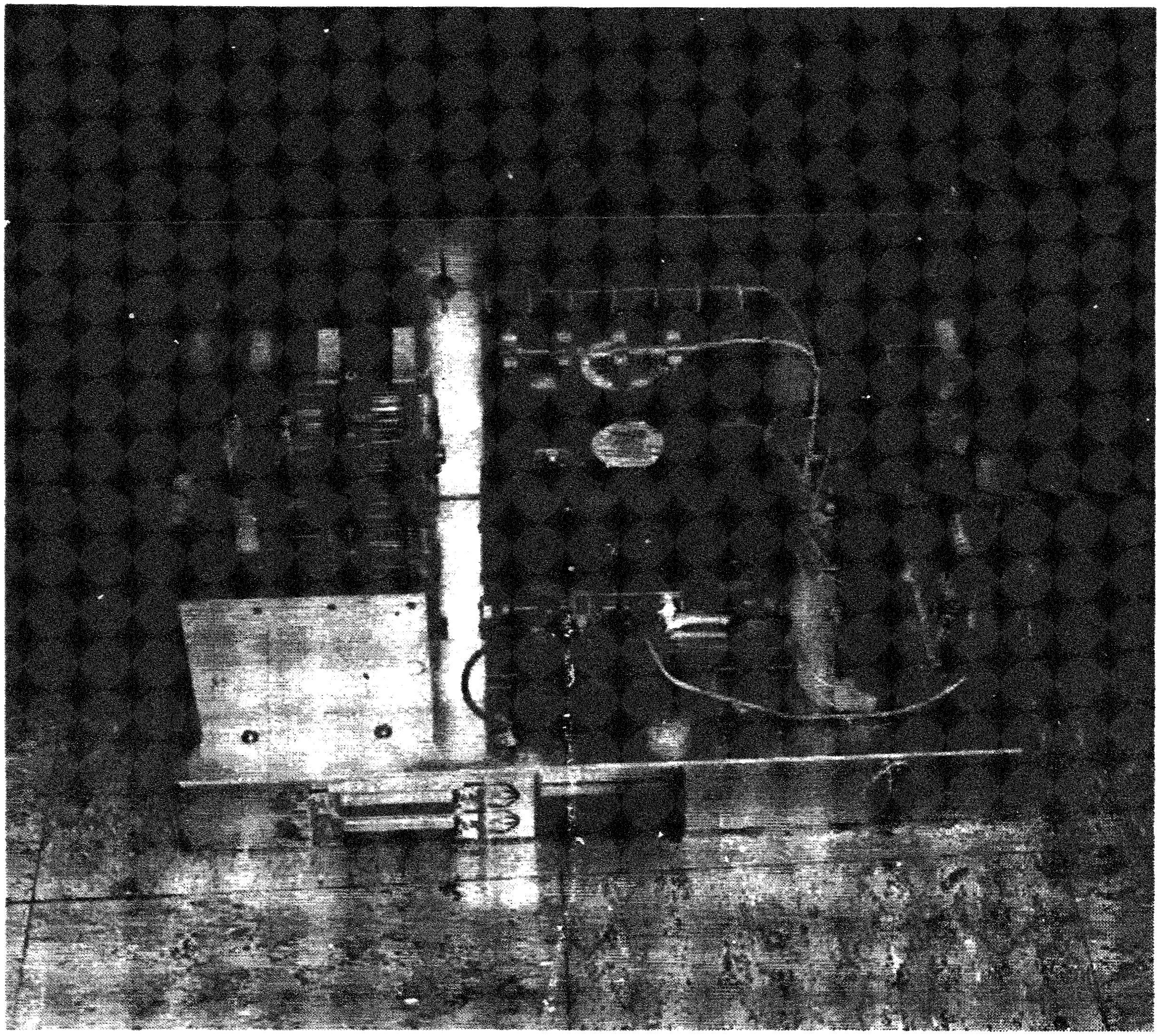


FIGURE 3-3 AUTP PHASE II AAU BREADBOARD

3.3 HARDWARE DEVELOPMENT

The AUTP audio announcement unit was initially fabricated and tested on test vehicle T365 in the summer of 1978. Although some minor EMI problems were encountered, the unit appeared to operate satisfactorily. During the time period when T365 was being converted to the P40 configuration, the AAU was modified to add the dynamic graphics interface and to properly interface the new vehicle control electronics. Additionally, EMI protection was added in the form of a shielded enclosure and internal bypass capacitors on sensitive circuits. This unit was then installed and checked out on the P40 vehicle in July 1979.

3.4 TEST PROGRAM

The AAU was tested in the laboratory prior to installation onboard the P40 vehicle for final evaluation. The laboratory test facility is shown in Figure 3-4. The test equipment consisted of:

(1) AAU breadboard and speakers

(2) SC/MP microprocessor development systems for debugging the software

(3) Teletype to support the debug system

(4) Word generator to generate route codes

(5) Test panel for setting up announcement codes, strobes and various other signals for testing the AAU

(6) Card reader for loading the machine language program into the assembler

(7) IMP 16 development systems for program assembly

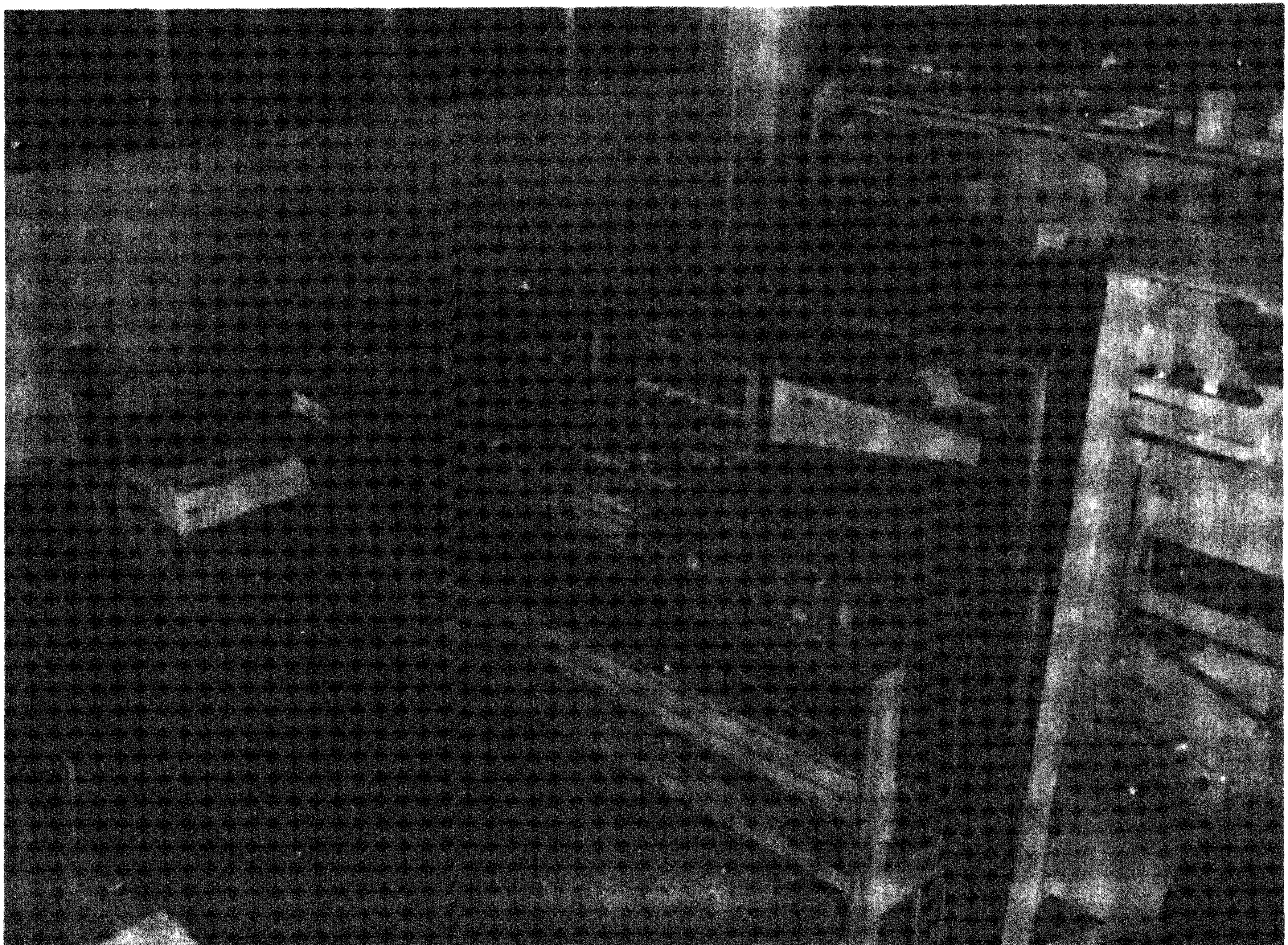


FIGURE 3-4 AAU DEVELOPMENT TEST SETUP

(8) Tape reader and tape punch for generating and loading the software object module

(9) Power supplies

The objectives of the laboratory tests were as follows:

(1) Verification of Station Announcements

This test consisted of addressing each of the 14 stations, and verifying that the proper announcements were made.

(2) Verfication of Route Detections

This test consisted of selecting all available passenger station routes, and verifying that only the proper station announcement for the selected route was made.

(3) Immunity to Invalid Codes

This test consisted of strobing the AAU with invalid announcements and route codes and verifying that the AAU does not respond to invalid codes.

(4) Timing

The duration of all announcements and the time between announcements were measured. This data was used to verify that enough travel time exists between stations to allow the AAU to search for and find the appropriate station announcement prior to arrival at the station.

(5) Reliability

All stations and all routes were repeatedly strobed to verify that the AAU would consistantly respond correctly.

(6) Audio Quality

The audio was subjectively tested for quality and intelligibility.

Initial tests onboard P40 revealed some EMI problems in the form of aborted announcements. The unit was modified to increase the EMI immunity, and subsequent testing in the guideway has demonstrated satisfactory and reliable performance.

4.0 ONBOARD DYNAMIC GRAPHICS

4.1 BACKGROUND

The AIRTRANS system provides both dynamic and static graphics in the stations, and static graphics only onboard the vehicles. The initial graphics provided were very confusing, and several iterations of both static and dynamic displays were required to achieve adequate displays. Even today, passengers occasionally choose the wrong route because they do not properly interpret the graphics in the station. This condition is particularly acute in a multiroute system such as AIRTRANS since a passenger can board a train which does not serve his destination and not be aware of that fact from any information available to him onboard the train. This experience, plus data gathered from DPM planners and the System Security and Passenger Safety program, led to the definition of an onboard dynamic graphics system which would provide both route and destination information to the passenger.

4.2 DESIGN APPROACH

A human factors analysis was conducted to ascertain the requirements in terms of visibility and size of display characters. There are only two practical locations for a dynamic display onboard the vehicle: a double-face panel hung from the ceiling in the center of the vehicle or a set of two panels mounted on the electronics cabinets at the ends of the vehicle. The latter location was chosen since it permitted use of a display utilizing large characters. The minimum character size in terms of readability at those locations was determined to be 1-1/4 inches in height. A market survey was then conducted to determine availability of various display types. Included in the survey were electromechanical, incandescent, light emitting diode (LED), planar gas discharge and liquid crystal display (LCD) elements. Table 4-1 summarized the advantages and disadvantages of each element type.

TABLE 4-1 ADVANTAGES AND DISADVANTAGES OF DISPLAY ELEMENT TYPES

Display Type	Advantages	Disadvantages
LED	Low cost. Reliable.	Small. Washout in bright light.
Liquid Crystal	Large (2 to 3 inches). Good Visibility in bright light.	Fragile. Temperature sensitive. Life = 50,000 hours.
Planar Gas Discharge	Available in 20-character rows	Small (0.65 inch maximum). Washout in bright light.
Electro Mechanical	Large (2.7 to 4.7 inches). Good visibility in bright light. Presently being used in ground transportation.	Very poor reliability.
Incandescent Modules	Fairly good visibility in bright light.	Small. Poor reliability.
Passive Backlit or Edgelit	Easy to read. Easy to build.	Large size for large amounts of data. Washout in bright ambient light.

The LCD elements were chosen, primarily because of their tolerance to wide variations in ambient light and the large character size (up to 3 inches) available. Sizing studies finally resulted in the selection of 2-inch elements for the display panel. Figure 4-1 shows the panel configuration selected.

Although low-temperate sensitivity (increased response time) is listed in Table 4-1 as a disadvantage of LCD elements, it does not limit operation in an urban application, provided the

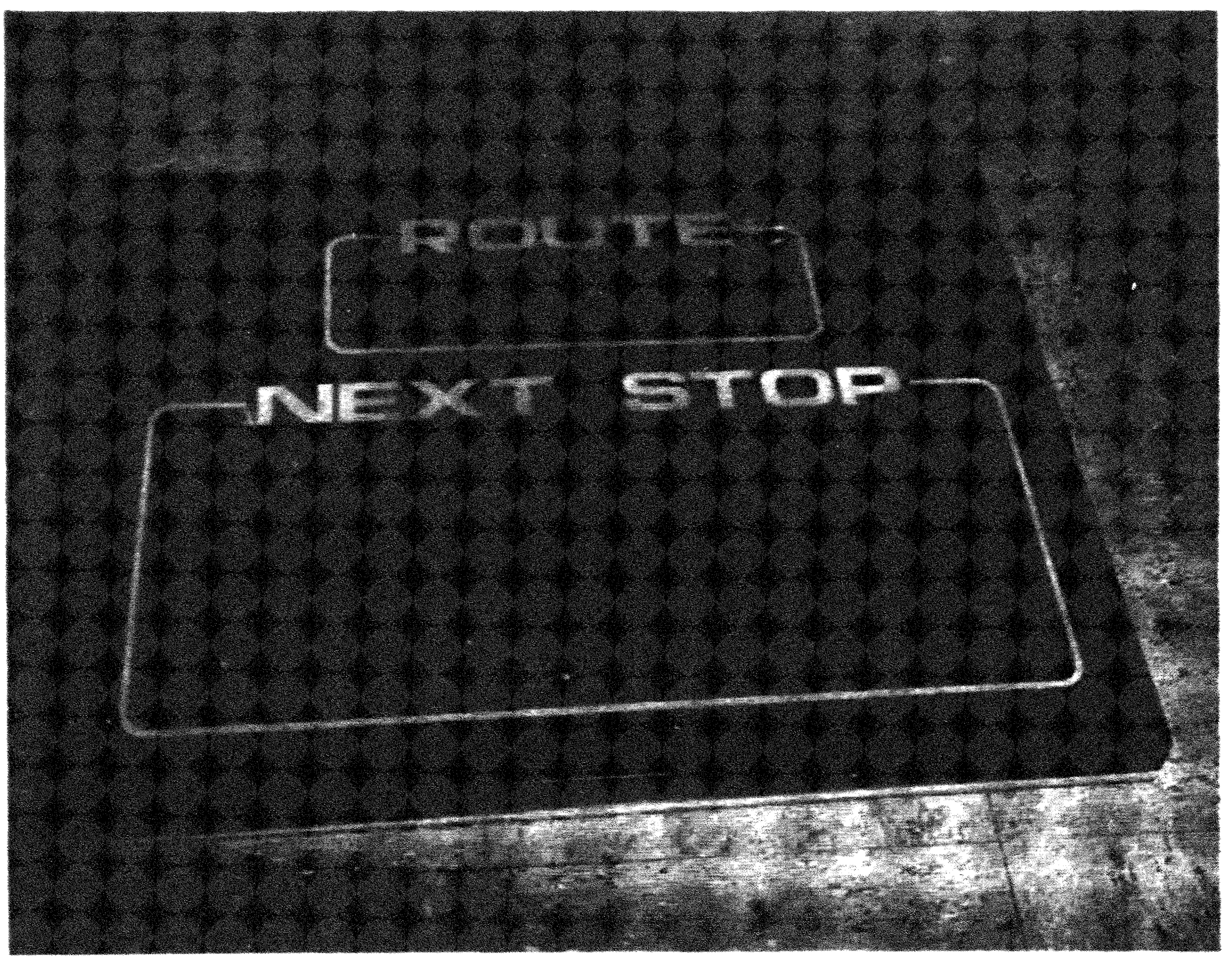


FIGURE 4-1 DYNAMIC GRAPHICS PANEL LAYOUT

increased time is taken into account during the design. Typical specification design sheets list the following LCD temperature limits:

(1) Operating Temperature −20° to +80°C (−4° to +176°F)

(2) Storage Temperature −30° to +80°C (−22° to +176°F)

Response (rise and decay) times of LCD elements are a function of temperature. Nominal response is 50 milliseconds at 25°C (77°F), increasing to 200 milliseconds at 0°C (32°F) and to 1 second at −20°C (−4°F). Any type of degradation or loss of performance is reversible upon warmup. Furthermore, the LCD is installed within an environmentally controlled vehicle or station interior - which for overnight, cold-climate storage has provision for layover temperature control. For extended periods of cold-climate storage, the vehicle must be conditioned before any electronic equipment, including graphics, can be expected to perform within design limits.

In order to minimize the wiring outside of the displays, the decision was made to utilize the AAU microprocessor to decode and format the data for the display panels. Figure 4-2 shows in block diagram form the functional elements of the dynamic graphic system. The display elements are excited by a 5-volt 80 Hz source in the AAU. The element segments are individually turned on and off by latch circuitry. The AAU sends the latch loading data and addresses serially to segment groups. The Dynamic Graphics program causes the display to activate upon door closure to show both route and next station. As the vehicle stops at the station, the door open command causes the "next station" portion of the display to go blank. It remains blank until the doors close, signifying departure from the station. Since both the messages and the activation/deactivation of the display are software controlled, modification to either is easily accomplished.

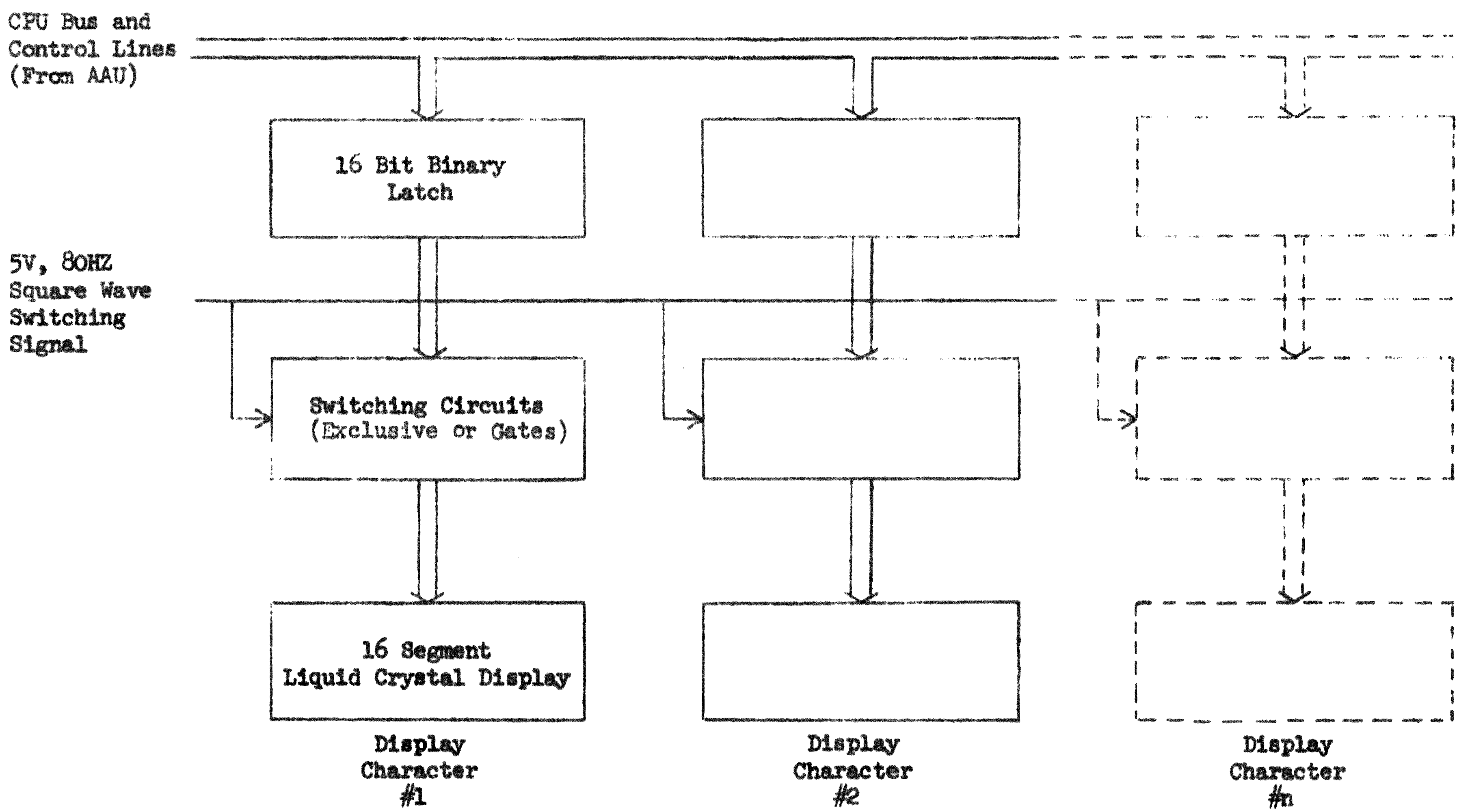


FIGURE 4-2 DYNAMIC GRAPHICS BLOCK DIAGRAM

p

4.3 HARDWARE DEVELOPMENT

Because of the relatively recent emergence of large liquid crystal display (LCD) elements, several sample elements were obtained and installed in a test setup to evaluate the three segment types available: reflective, transmissive, and transflective. The reflective segments were selected because of their wide viewing angle and readability over a wide range of ambient light intensities. Tests over approximately 500 hours showed no discernable degradation in performance in any of the sample units. The segments are sensitive to pressure applied to the face of the unit however, so the assembly (design) assures protection of the individual segments. Construction details are shown in Figure 4-3. The segments are mounted to relatively large printed circuit cards (3 by 21 inches), with the cards being mounted, using spacers, behind a plexiglass panel. The finished assemblies were tested under laboratory conditions in conjunction with the AAU described in Section 3. The initial

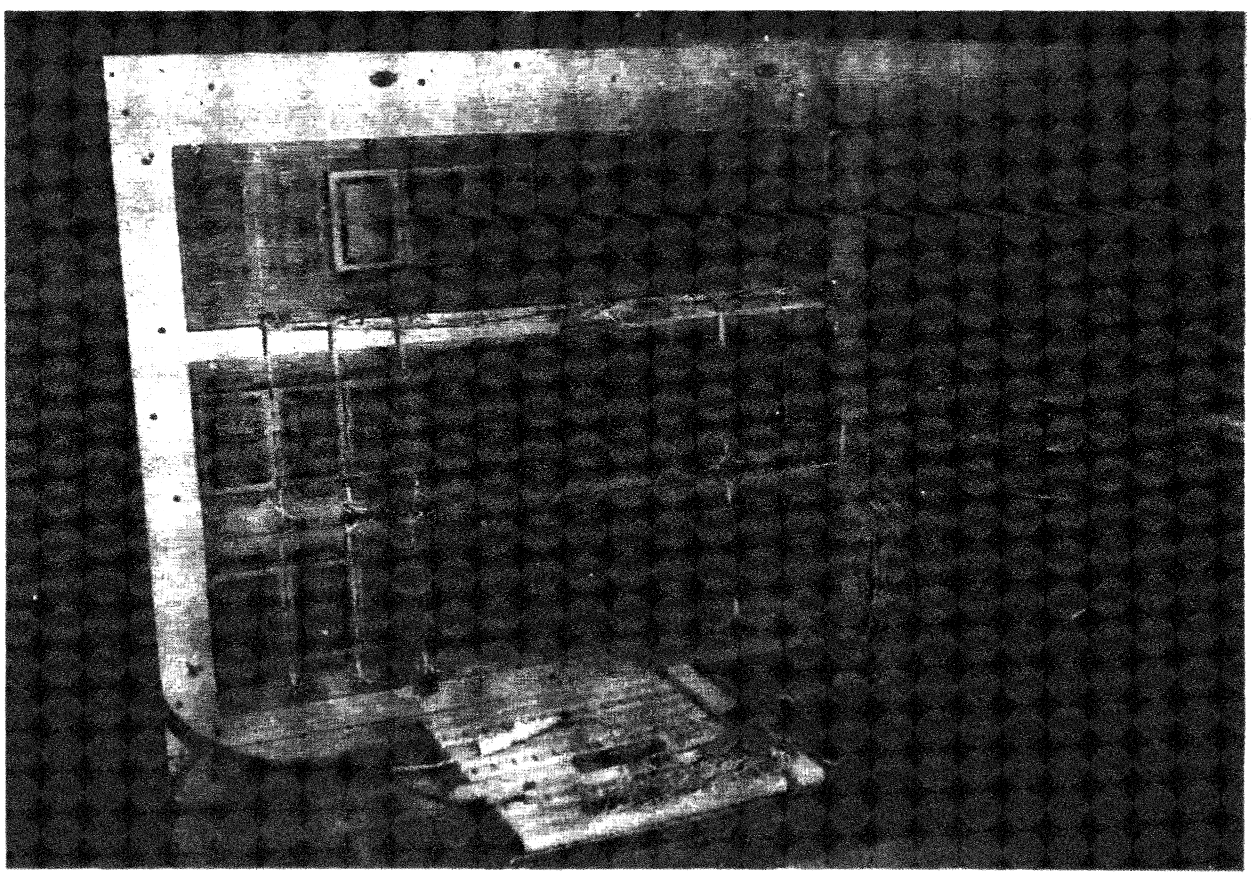


FIGURE 4-3 DYNAMIC GRAPHICS CONSTRUCTION DETAILS

checkout of the revised software revealed that the program as written exceeded the 4K of memory provided in the AAU microprocessor. The software was modified to delete dynamic graphics on test routes so that memory expansion would not be required. The two graphics display units and the AAU were then installed and checked out on the P40 vehicle in July 1979.

4.4 TEST PROGRAM

Initial test of the dynamic graphics onboard the P40 vehicle revealed intermittant problems. These problems were created by the EMI susceptability of the AAU which drives the graphics. Design changes were made to the AAU to improve EMI compatibility. Subsequent testing in the guideway at the D/FW Airport has demonstrated reliable and satisfactory performance of the system.

5.0 TIME-TO-ARRIVAL DISPLAY

5.1 BACKGROUND

In the existing AIRTRANS system, a passenger waiting at a station has no way of knowing when his vehicle will arrive. This is particularly vexing to a passenger on a tight schedule. It is believed that the same type of frustration will exist in a DPM system without some form of time-to-arrival display. Thus, a time-to-arrival (TTA) display was developed and demonstrated at a D/FW AIRTRANS station.

5.2 DESIGN APPROACH

The AIRTRANS central computer has all the information required to compute the estimated time-to-arrival of the next vehicle to a particular station. It was therefore decided to modify the software at Central Control to provide the estimated time-to-arrival information. This information is then transmitted to the remote location multiplexer (RLM) located in the station. The time-to-arrival display receives the the data from the RLM, decodes it and activates the appropriate display elements.

5.3 HARDWARE DEVELOPMENT

The rationale for selecting display elements for the vehicle graphics (see Section 4.2) is pertinent to the TTA display. For this reason the same LCD elements used in the vehicle graphics are used for the station TTA display. Much of the housing hardware was also borrowed from the vehicle display with the exception of the front panel with its fixed graphics. In addition, an extension was added to the back plate to facilitate mounting the display to the existing station graphics. Figure 5-1 is a photograph of the completed TTA display unit. Note that the hardware has the potential to display the time-to-arrival information for up to three different routes. However, the station selected for this demonstration is only served by a single route.

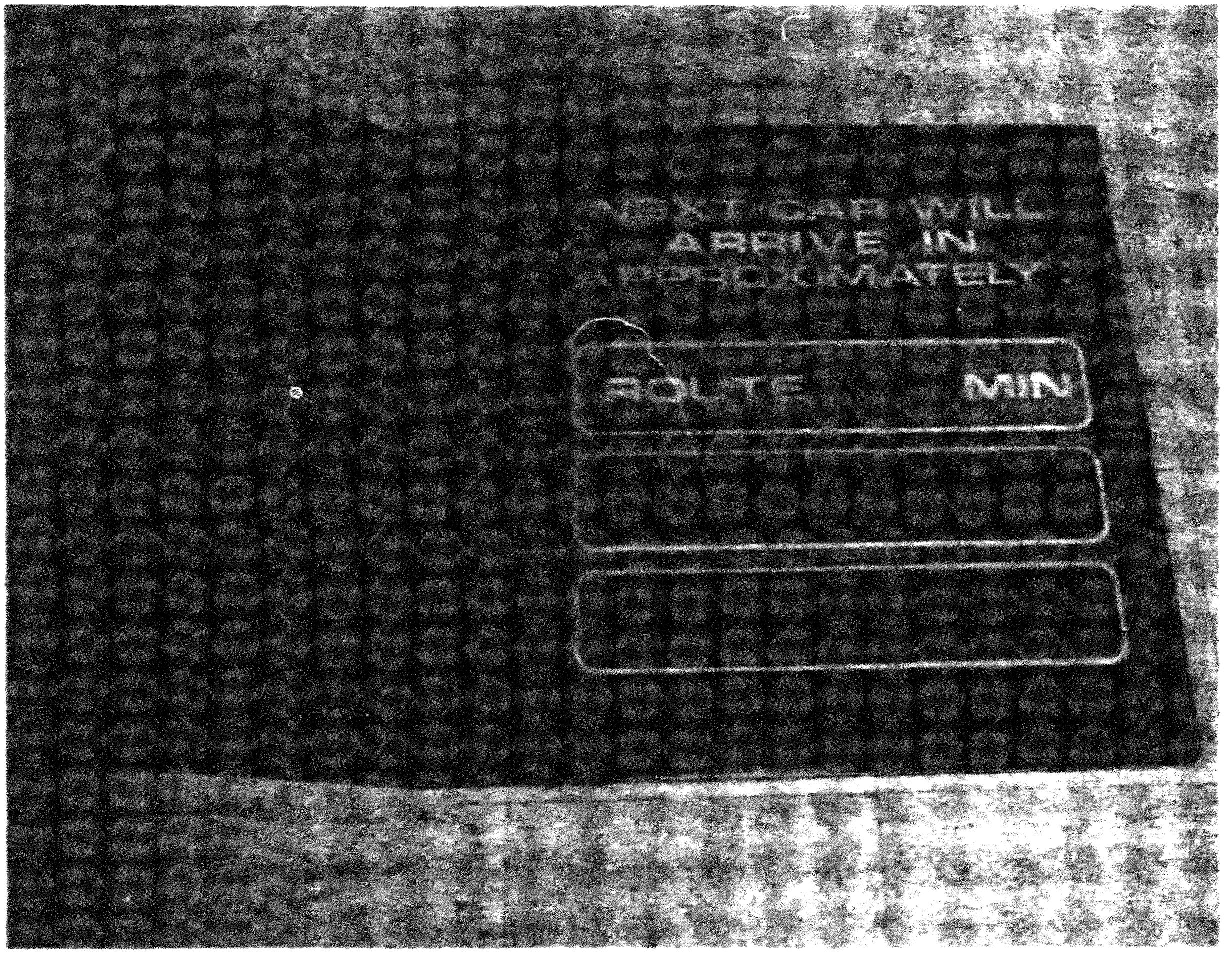


FIGURE 5-1 TIME-TO-ARRIVAL UNIT

Drive to the TTA display is accomplished by software additions to the existing AIRTRANS supervisory data system (SDS). A new software task was generated for the AIRTRANS central processor unit (CPU). This TTA task utilized existing antibunching software data to provide a list of wayside control blocks that are time removed from 5EA arrival on 1-minute intervals. The TTA task is triggered by occupancy of each these specific control blocks by passenger trains routed for the 5EA station. It should be noted that the software was generalized to accommodate other passenger stations and routes. The TTA task bookkeeps all trains on the 5EA route and transmits a simple two-digit decimal code to the affected (in this case 6W) terminal processor unit (TPU) via existing communication formats. The 6W TPU software was modified to process the new TTA message from central and include its data in the 5E remote location multiplexer (RLM) output command set. The final software addition to the AIRTRANS SDS included the modifications of the 5E RLM software to add the new output word set to the added TTA hardware.

The displayed time of the TTA is then the normal bunch controlled time to arrival of the next train servicing the 5EA station. This information is not modified for breakdowns or other delays, but will absorb the removal of a train from the 5EA route.

The two digits of binary-coded decimal at the 5E RLM drive a standard "normally open" relay output board (eight discrete outputs) module located at the RLM. These signals are decoded by the TTA electronics which then activate the appropriate LCD elements for showing the estimated time to arrival of the next AIRTRANS vehicle. A schematic of the TTA electronics and interconnecting wiring to the RLM (MOD COMP) computer is shown in Figure 5-2.

5.4 TEST PROGRAM

The TTA unit was tested in the electronics laboratory prior to temporary installation of the unit in the D/FW South Parking Lot A station. The unit has been demonstrated in this installation and proven to operate satisfactory.

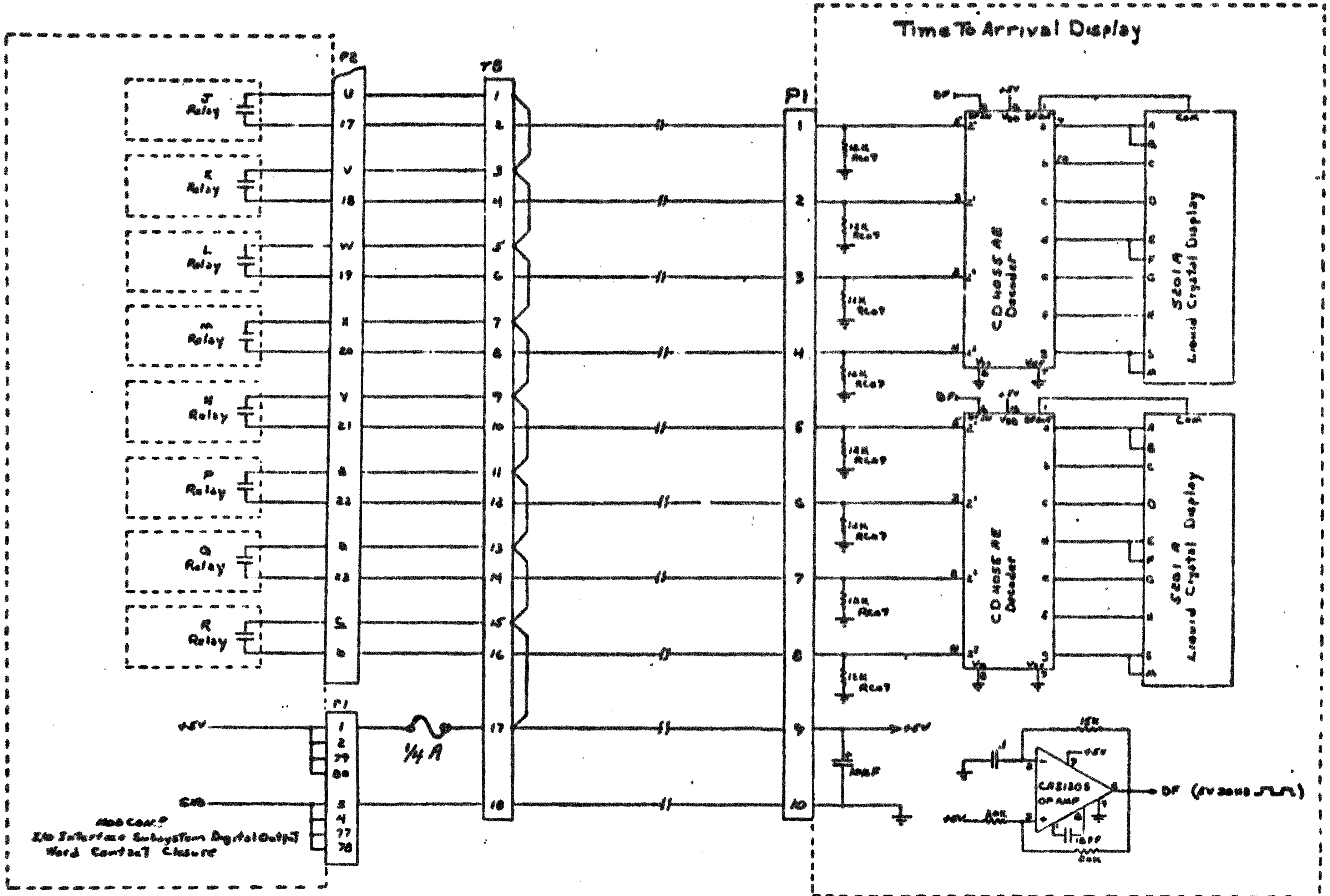


FIGURE 5-2 TIME-TO-ARRIVAL UNIT SCHEMATIC

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 ONBOARD TV SURVEILLANCE

Vought's position in regard to the onboard TV surveillance task is not to pass judgment upon the usefulness or effectiveness of the system, but to implement and demonstrate the hardware. This task was accomplished in that both vehicle-borne and base station equipment were integrated within the D/FW AIRTRANS system, using test vehicle P40, and demonstrated.

The TV surveillance equipment functioned as planned and specified for this application utilizing a single vehicle. The potential user must recognize the inherent limitation of the 3-kilohertz fm transmission rate which requires 3 seconds for the transmission of the digital data to reconstruct a single frame of the picture as viewed by the carborne camera. Therefore, the most effective way to utilize this hardware in a specific people mover scenario has not been established. Questions concerning quantity and placement of cameras in the vehicles, effectiveness of viewing during rush hours, base station configurations, use of video recorders, etc, must be addressed for each specific application as it arises.

One of several ways of utilizing the system is discussed below:

(1) The base station video monitor is automatically switched from vehicle to vehicle within the operating fleet.

(2) The switching rate and length of time spent in displaying a single video frame from a single vehicle are controlled variables which must consider the 3-kilohertz transmission rate limitations.

(3) The base station observer would have the capability to manually override the automatic sequencing and to lock in on a single vehicle. The observer could be alerted to problems on a vehicle by receipt of an emergency call, by receiving radio transmission of loud noises within the vehicle or by other means.

(4) Each vehicle could incorporate a real-time video tape system activated by the base station observer in response to the emergency call.

6.2 IMPROVED AUDIO ANNOUNCEMENT UNIT

The audio announcement unit (AAU) developed for the AUTP program is working well. Except for the initial EMI problems, which have been resolved, no hardware failures or malfunctions have been reported after more than 3,000 miles of operation onboard the P40 passenger vehicle. It appears that the goal of developing a low-cost, reliable, easily maintained audio announcement unit for an AGT environment has been met.

Further improvements to the AAU could probably be realized by replacing the tape deck and cassette with a solid-state digital memory for storing the audio announcements. Solid-state memories for audio storage had been considered for the AUTP program, but was not used because the cost at that time would have been prohibitive. However, recent advances in memory technology, particularly in bubble memories, indicates the time has come for practical audio storage in solid-state memories. The advantages of solid-state audio storage are twofold. First, it would enhance the system reliability. A well designed solid-state AAU would be nearly maintenance free. Second, the solid-state AAU would have near instantaneous access to all the announcements, which would eliminate the time consuming search for the next announcement on a tape cassette. It would also eliminate the rather complex software required to determine the next announcement for the particular route for which the vehicle is scheduled.

6.3 ONBOARD DYNAMIC GRAPHICS

The onboard graphics developed for the AUTP program meets the program goals of providing the passenger with current information regarding vehicle routes and station stops. No failures or malfunctions have been reported on the two graphic displays installed onboard the P40 prototype vehicles after more than 3,000 miles of vehicle operation. Public acceptance of this type of display awaits the deployment of the prototype vehicle into revenue service.

Some questions still remain as to the long-term reliability of the large liquid crystal display elements used in the graphics. Initial mortality, during lab checkout of these units, was high. However, once the weak elements had been weeded out, no further failures were noted. An indication, at least, of their long-term reliability should be obtained by monitoring the performance of the graphics during operation of P40 in revenue service.

6.4 TIME-TO-ARRIVAL DISPLAY

The hardware required to implement a time-to-arrival display is straight forward, simple and inexpensive. In a system where a central monitoring computer is in communications with a station, it seems appropriate to provide the passenger with information regarding arrival times.

REFERENCES

1 Urban Mass Transportation Administration, Assessment of Operational Automated Guideway Systems - AIRTRANS (Phase I), UMTA-MA-06-0067-76-1, September 1976.

2 Urban Mass Transportation Administration, AIRTRANS Urban Technology Program Phase I Final Report, UMTA-TX-06-0020-78-1, January 1978.

3 Urban Mass Transportation Administration, AIRTRANS Urban Technology Program Phase II, Executive Summary, UMTA-TX-06-0020-79-8, October 1979.

4 Urban Mass Transportation Administration, AIRTRANS Urban Technology Program Phase II, Volume 1 - Control System Improvements, UMTA-TX-06-0020-79-2, October 1979.

5 Urban Mass Transportation Administration, AIRTRANS Urban Technology Program Phase II, Volume 3 - Vehicle and Wayside Subsystems, UMTA-TX-06-0020-79-4, October 1979.

6 Urban Mass Transportation Administration, AIRTRANS Urban Technology Program Phase II, Volume 4 - Vehicle Fabrication, Tests and Demonstration, UMTA-TX-06-0020-79-5, October 1979.

7 Urban Mass Transportation Administration, AIRTRANS Urban Technology Program Phase II, Volume 5 - Systems Operation, UMTA-TX-06-0020-79-6, October 1979.

8 Urban Mass Transportation Administration, AIRTRANS Urban Technology Program Phase II, Volume 6 - Severe Weather, UMTA-TX-06-0020-79-7, October 1979.

9 Urban Mass Transportation Administration, AIRTRANS Urban Technology Program Phase II, IRAN Report, UMTA-TX-06-0020-79-1, August 1978.

10 Technical Report 765 (Skybus Demo) GAS Labs., Inc.

11 Motorola, Inc., A Video Surveillance System for Public Transportation Vehicle Using 2-Way Land-Mobile Radio, Daniel P. Brown.