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OVERVIEW OF AUTOMATED TERMINAL SERVICES (ATS) TESTBED HARDWARE

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HARDWARE DESCRIPTION

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ABSTRACT

Automated Terminal Services (ATS) is a concept which was developed by the Federal Aviation Administration (FAA) to enhance the ability of pilots to see and avoid other traffic, in accordance with existing Visual Flight Rules (VFR) procedures, at certain busy nontowered airports. It involves the use of a minicomputer, interfaced with an Air Traffic Control Radar Beacon System (ATCRBS) ground station, to track beacon-equipped aircraft operating in the vicinity of these airports. By the use of computerized voice transmissions, the minicomputer offers information such as weather data and issues traffic advisories.

Following laboratory investigations utilizing flight simulators, a testbed was constructed by the FAA Technical Center and later removed to Miller Air Park near Toms River, New Jersey, for the purpose of evaluating the ATS concept (not the hardware or software per se) through the participation of volunteers from the flying public. This will be the subject of the final report by the FAA's Office of Systems Engineering Management (OSEM), AEM-20, on the ATS project.

In order to document the construction of the testbed hardware itself, this hardware description has been prepared. It gives particular emphasis to the nonstandard, noncommercial components which were developed for the testbed. It does not cover those items which are commercially available and documented in manufacturers' technical manuals, nor does it cover software, which was prepared (except for the Weather Subsystem software) by the MITRE Corporation, METREK Division, under contract to the FAA.

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1. ATS CONCEPT.

1.1 CONCEPT DESCRIPTION.

The Automated Terminal Services (ATS) concept originated in the Office of Systems Engineering Management (OSEM) of the Federal Aviation Administration (FAA) as a possible means of addressing the problem of assisting pilots operating in the vicinity of certain noncontrolled airports; i.e., airports having too few operations to justify the installation of a tower, but which have peak traffic periods during which some form of enhancement to the see-and-avoid concept is deemed highly desirable. It is also thought that ATS may have the potential to delay the installation of towers at some locations, and at others, expedite the safe and orderly flow of traffic during slower periods when tower service is shut down.

ATS is a visual flight rules (VFR) system which issues only advisories—not commmands—to aircraft operating within a designated volume of airspace around a noncontrolled airport. It is not an "automated air traffic controller." It is still up to the pilot to see and avoid other aircraft in accordance with existing VFR procedures. The intent of ATS is rather to enhance VFR flight by allowing those pilots who wish to do so, to receive advisories on traffic conditions, weather, collision threats, etc., without the need for any special equipment beyond a very high frequency (VHF) radio and Air Traffic Control Radar Beacon System (ATCRBS) transponder. These are a part of the equipment complement presently aboard most domestic aircraft, and are expected to be aboard an even greater percentage in the future.

To receive services, the pilot need only listen on a predetermined VHF frequency while dialing in a predetermined transponder code (log-in, or simply, login code). The ground-based ATCRBS decodes the beacon reply and transmits it to a minicomputer, which recognizes the login request and addresses the aircraft in computerized speech, via the specified radio frequency, with a request for identification. This identification (e.g., "blue and white Cherokee five-seven bravo") is digitized by the system and stored in computer memory (disk). All subsequent advisories, which are comprised of similarly prerecorded words and phrases concatenated by the computer into meaningful sentences, are prefixed with this identification phrase.

Upon receipt of the aircraft identification, the computer again addresses the pilot with a request to change to a discrete transponder code, which remains unique to that aircraft until the termination of services. The login procedure is completed when this code is recognized by the ATS system, which then broadcasts landing, weather, and traffic advisories. (There are means of aborting and reinitiating the login in the event of trouble.) Service terminates when the aircraft lands or when the pilot squawks still another predetermined beacon code to notify the computer that it is no longer desired. Provision is made for initiation of service to aircraft taking off from an airport served by ATS, and other pilot services are also available. For a more complete description of the system concept, see reference 1.

1.2 CONCEPT EVALUATION.

In order to evaluate the ATS concept and gain information on its probable acceptance by the flying public, MITRE Corporation, under contract to OSEM, first conducted laboratory investigations utilizing flight simulators. Encouraging results at this stage pointed to the construction of a testbed which could ultimately be used to support field trials by volunteer pilots, including general aviation pilots, to gain not only hard evidence of pilot acceptance, but also feedback on possible improvements. Such a system would not necessarily require optimized hardware or software, but would serve only for concept evaluation. A favorable response would then indicate the desirability of full development and deployment.

Under an interagency agreement with OSEM, the Naval Weapons Center (NWC) at China Lake, California, designed and built certain components of the system such as the monopulse beacon receiver, the Beacon Data Acquisition System (BDAS), and the prototype Voice Response System (VRS). These and other terms will be defined shortly.

Finally, these components and others, including off-the-shelf computer hardware, were assembled into an experimental ATS system, housed in a surplus 40-foot semi-trailer, by the FAA's Technical Center. The Technical Center also designed and built the Weather Subsystem (including software), the audio distribution system, and the experimental VRS (including certain design changes); and in conjunction with OSEM, made minor design changes to the BDAS. Concurrently, ATS software was developed by MITRE under a contract with OSEM.

2. TESTBED DESCRIPTION.

2.1 INTRODUCTION.

Broadly, the testbed may be considered to consist of three interconnected systems: the actual ATS Operating System (not to be confused with the computer's FORTRAN "operating system"), the Real-Time Monitoring System, and the Data Acquisition and Recording System. A simplified block diagram of the testbed is shown in figure 1.

2.2 ATS OPERATING SYSTEM.

The Operating System consists of the beacon system (ATCRBS), the central processing unit (CPU) and associated peripherals, the VRS, the air-ground communications system, and the Weather Subsystem.

2.2.1 Beacon System.

The beacon system is comprised of a surplus AN/TPX-42 military interrogator/receiver, a modified FAA-8043 Air Traffic Control Beacon Interrogator (ATCBI) antenna ("hog trough"), a monopulse receiver, and the Beacon Data Acquisition System. Modifications to the antenna consisted primarily of the installation of a new radio-frequency (RF) distribution matrix, a backfill antenna, and a diffracting element in front of the radiating elements. The new matrix converts the antenna for monopulse operation, and with the backfill antenna (for coverage to the rear), it also provides for integral side lobe suppression (SLS) capability, the theoretical advantage of which is that the phase centers of the directional and omnidirectional antennas are coincident, at least within ±90° of azimuth from the center of the main beam. This avoids the inevitable wide disparities of SLS

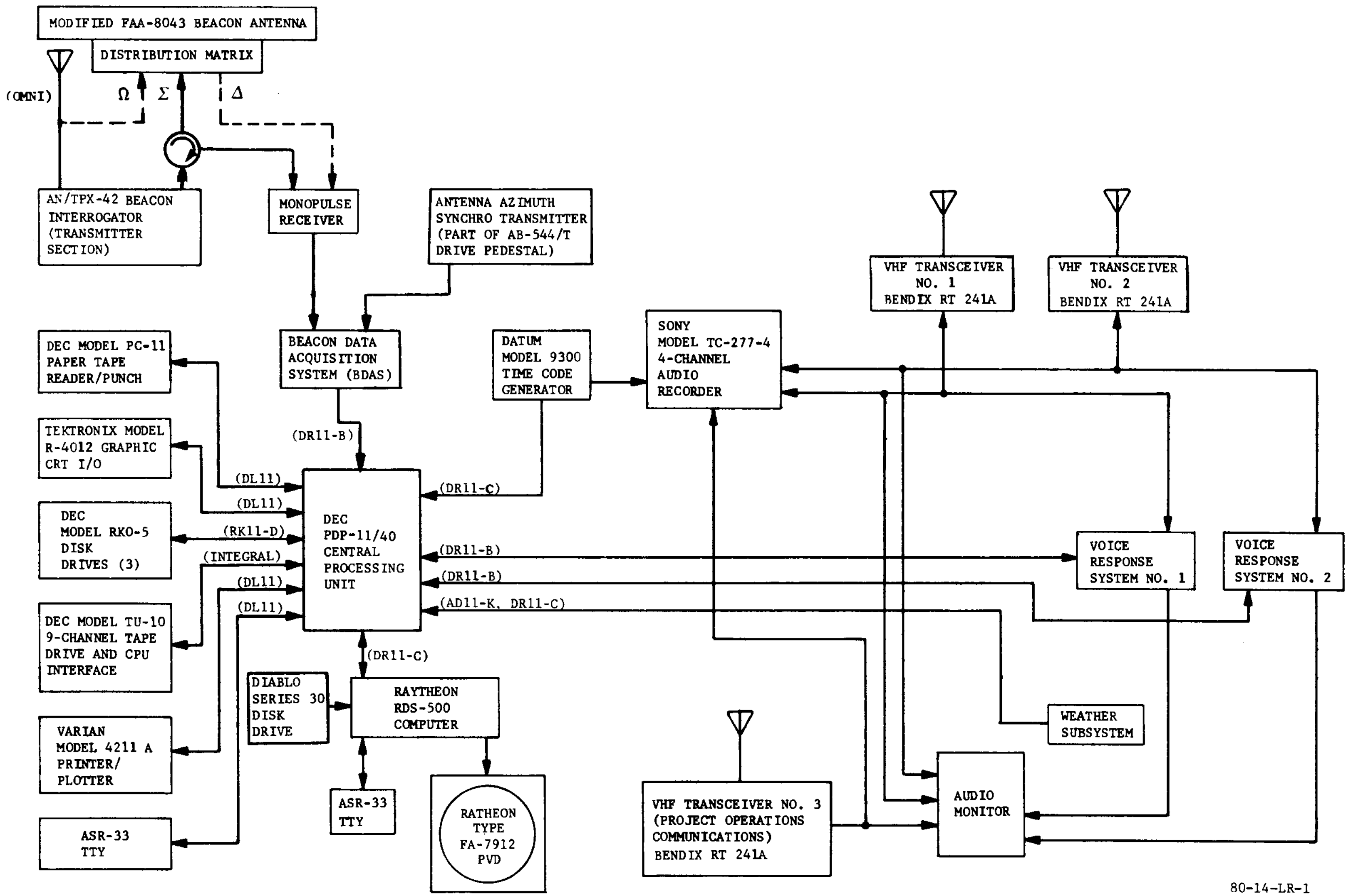

FIGURE 1. ATS SYSTEM BLOCK DIAGRAM

margin that result from the use of separate antennas. The diffracting element was designed to reduce radiation below the horizon, which would otherwise be reflected skyward by the earth, resulting, by alternate constructive and destructive interference, in the characteristic vertical lobing exhibited by all such antennas in actual use.

Because of a problem with the integral SLS system of the ATCBI (see reference 2), it was decided to abandon its use during concept evaluation, and a separate omnidirectional antenna was employed. Only the sum channel of the ATCBI surveillance antenna was used, and only the sum channel of the monopulse receiver. The antenna was rotated by a military surplus Nike-Hercules AB-544/T acquisition radar pedestal.

A greatly simplified block diagram of the BDAS is shown in figure 2. Its function is twofold. Firstly, it processes antenna and target azimuth information. Secondly, it digitizes, defruits and decodes target information, and formats it for transfer to the CPU via the DR11-B interface.

The BDAS is thoroughly documented in reference 3, as is the monopulse receiver, which, although "one of a kind," was constructed in general accordance with the FAA's Discrete Address Beacon System (DABS) monopulse specification (references 4 and 5). The reader requiring more detailed information than is contained in the following description is referred to those documents.

Referring to figure 2, information from the synchro transmitter integral to the AB 544/T drive pedestal is transmitted to the synchro-to-digital (S-D) converter, where it is digitized to 13-bit accuracy. From there it is sent to an azimuth angle decoder and computer interface, where it is formatted for transmittal to the CPU via the DR11-B interface. A test circuit consisting of a miniature synchro transmitter driven by an electric clock motor may be manually switched in place of the drive pedestal synchro for a quick check of S-D conversion, decoding, and processing.

As noted earlier, monopulse operation was not employed during concept evaluation, but because the BDAS is capable of processing monopulse video, a brief description of this capability will be given. Since this report is not intended to be a treatise on monopulse theory, suffice it to say that the standard FAA-8043 ATCBI "hog trough" antenna consists of a number of dipole radiators whose vector sum in the horizontal plane is one intense, narrow main lobe approximately 2° to 3° wide at the 3-decibel (dB) points in both the transmit and receive modes. The nominal direction to which the antenna is pointed is the longitudinal bisector of this lobe, but in practice, aircraft will normally be interrogated (and respond) over a sector several degrees wide, encompassing as many as 20 or more interrogations. While it is possible to estimate the precise azimuth of the aircraft by taking the "middle" (median) reply, if there are missed replies, or if for some reason a nonsymmetrical reply pattern is encountered, or if the antenna is not pointed precisely at the aircraft during the middle reply (a very likely occurrence), this method fails to produce results which approach the accuracy to which the aiming of the antenna may be determined.

An alternative is the monopulse concept, so named because of the fact that in theory, only one reply is needed to accurately estimate the azimuth of a target, even if the antenna is not pointed directly toward it. (In practice, there are other considerations which preclude only one reply, but the principle is nonetheless the same.)

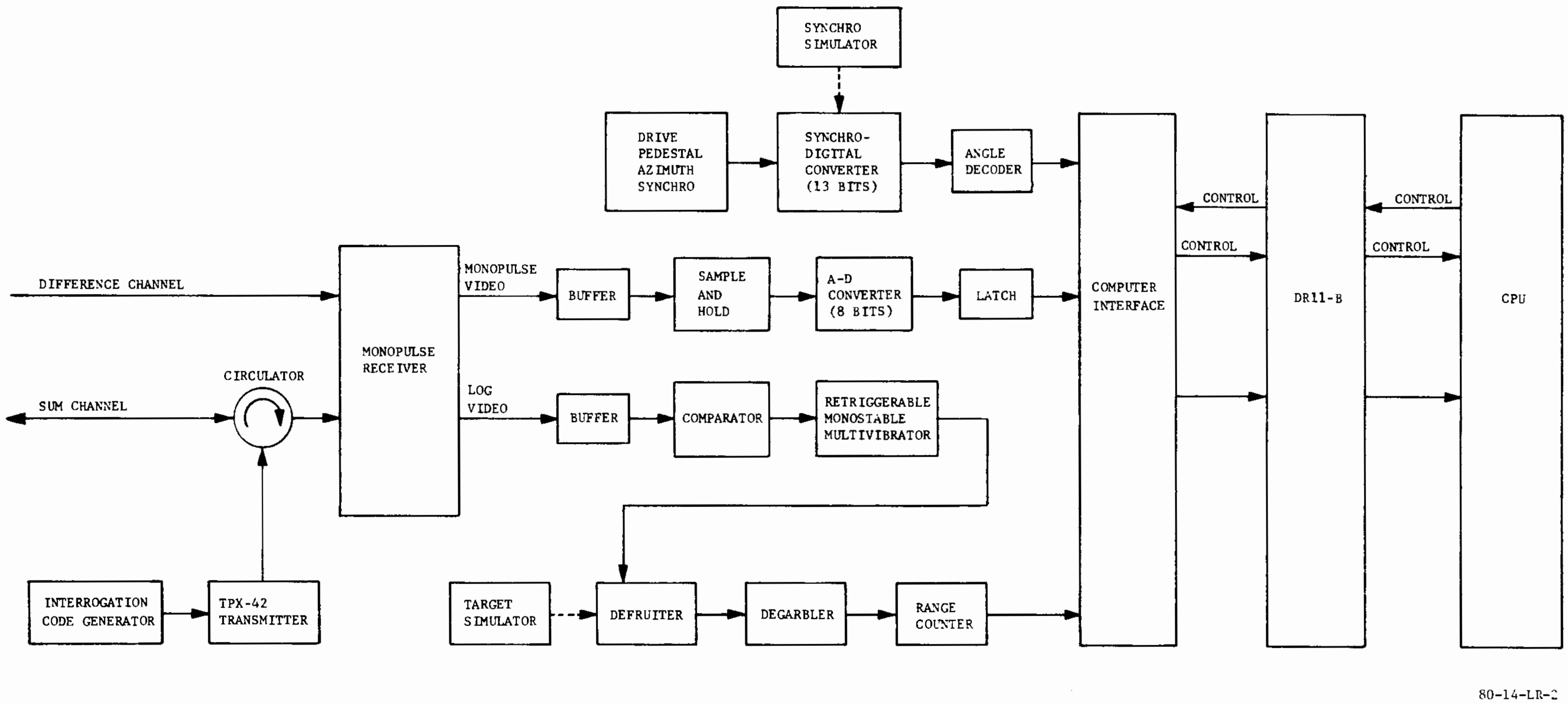

FIGURE 2. BEACON DATA ACQUISITION SYSTEM BLOCK DIAGRAM

It has been previously noted that the FAA-8043 ATCBI antenna consists of a number of dipole radiators fed by a matrix which drives each with the proper power and phase relationship to give a vector sum that produces one narrow main lobe. This is also true of the monopulse antenna in what is known as the "sum" channel. The special matrix, however, provides a second channel called the "difference" channel, which analytically makes the 8043 appear as if it were two antennas with two main lobes, one pointed slightly to the left of "boresight" (the precise mechanical aiming direction), and the other, an equal angle to the right. Interrogation is done via the sum channel, which is connected to the transmitter by a conventional circulator. The difference channel, when used, is connected directly to the monopulse receiver.

The receive outputs of the sum and difference channels, when processed by the monopulse receiver, are the "log video" and "monopulse video," respectively. (This processing may be based on either phase or amplitude relationships; in ATS it is based on phase.) The log video contains the target range and reply code information normally present in an ordinary ATCRBS installation. The monopulse video contains the so-called "off-boresight" information. This is the azimuth correction which must be applied to the synchro-generated azimuth position of the drive pedestal.

Log video from the receiver is buffered and fed to a comparator circuit, which passes only those pulses which exceed a predetermined threshold. This threshold may be continuously adjusted to barely exceed the noise floor or to exclude all but the strongest replies. Those pulses which pass the comparator activate a retriggerable monostable multivibrator ("one-shot"), the output of which is a replica of the input pulse train, but with uniform pulse width and amplitude. The pulse train is then sent to the defruiter, where asynchronous replies and other noise spikes are eliminated by passing it through a shift register and comparator. No pulse which was not received during the previous reply will pass the defruiter.

The output of the defruiter is processed by the decoder, which consists of still another shift register with taps at the proper intervals to detect framing, special position identification (SPI), and code data pulses. Declared targets are transmitted to the range counter, which measures turnaround time after compensating for delays in the airborne transponder and ground-based processing equipment. Finally, target information is formatted by the BDAS computer interface for transfer to the CPU via the DR11-B interface.

The monopulse video output is a bipolar function which very nearly approximates $\frac{1}{2}\sin\phi$, where ϕ is the azimuth correction angle and is small. This function is essentially linear for the $\pm 1^\circ$ to 2° corrections that it represents. The monopulse video is buffered, sampled, converted to an 8-bit digital word, and stored in a latch, where it is available on demand for transfer to the CPU.

2.2.2 Central Processing Unit.

The CPU consists of a Digital Equipment Corporation (DEC) PDP 11/40 16-bit minicomputer and associated peripherals, including three DEC RK05 disks, an RK11-D controller, a Tektronix R-4012 graphic cathode-ray tube (CRT) input/output (I/O) terminal, a DEC PC-11 paper tape reader/punch, and an ASR-33 Teletype. The disks store the operating program, the prerecorded digital phrases, and the pilot identifications (ID's), repectively. The CRT I/O terminal is the primary operator's console and may also be used for on-site editing and patching of programs, with the Teletype and paper tape reader/punch serving as backups.

2.2.3 Voice Response System.

The function of the VRS is twofold: (1) it digitizes aircraft identification, as spoken by the pilot, for storage on disk by the CPU for later retrieval; and (2) it converts digital information received from the CPU into intelligible speech for broadcast by VHF radio.

At this point, it may be well to briefly recall the Shannon-Nyquist sampling theorem, which states that any waveform whose highest Fourier component frequency is f may be completely determined by sampling the waveform at a frequency of $2f$. Practical considerations such as quantization error and the lack of perfectly sharp output filters prevent realization of this to the theoretical limit, but the 6-kilohertz (kHz) sampling frequency, 8-bit quantization, and active filters employed in this system produce a usable bandwidth in excess of 2,500 hertz (Hz), with fidelity subjectively comparable to that of a high-quality commercial telephone connection.

A block diagram of the VRS is shown in figure 3. Although the duty cycle of the VRS consists predominantly of reconstructing prerecorded digitized speech, it is perhaps easier to understand the fundamentals of its operation by starting with the digitizing process as used to record pilot identification. Note that the VRS is neither a speech recognition system nor a voice synthesizer; it simply digitizes human speech or any other audio-frequency signal and plays it back.

Upon recognition of the login code from an aircraft under surveillance, the CPU, under program control, will have requested pilot identification and conditioned the DR11-B interface to receive data. A squelch-sensing and conditioning circuit connected to the VHF receiver sends a signal to the DR11-B to start the recording process as the pilot starts to transmit. Audio from the VHF receiver is conditioned (its dynamic range reduced) by the compressor, which employs an active optical feedback circuit, in order to control its power-level excursion prior to digitizing. The compressor's dynamic range, which is well in excess of 60 dB, assures that regardless of the level from the receiver, which can vary with the distance, transmitted power, modulation index, etc., of the airborne transmitter, the average power level at the input to the digitizer will be very nearly constant. This, in turn, minimizes degradation of the signal-to-noise ratio caused by quantization error in the analog-to-digital (A-D) converter by facilitating utilization of its full dynamic range.

Thus conditioned, the audio signal is sent to the sample-and-hold circuit where it is sampled at the 6-kHz rate and sent to the A-D converter to be digitized to 8-bit accuracy.

Because the CPU is a 16-bit machine, it would be very wasteful of memory to store the samples in this form. Therefore, the A-D output is paralleled into two latch circuits (two banks of D-type flip-flops). Since the latches will store data only when their respective clock (CLK) inputs are active, it is necessary only to employ a two-phase, 3-kHz clock to stack two successive values. Thus formatted, the two samples are transmitted as one 16-bit word by the DR11-B to the CPU random access memory (RAM), which acts as a buffer, and thence to the Aircraft ID disk. Approximately 5 seconds' worth of ID audio (30,000 8-bit samples per ID) may be sequentially stored in this fashion before the recording cycle times out.

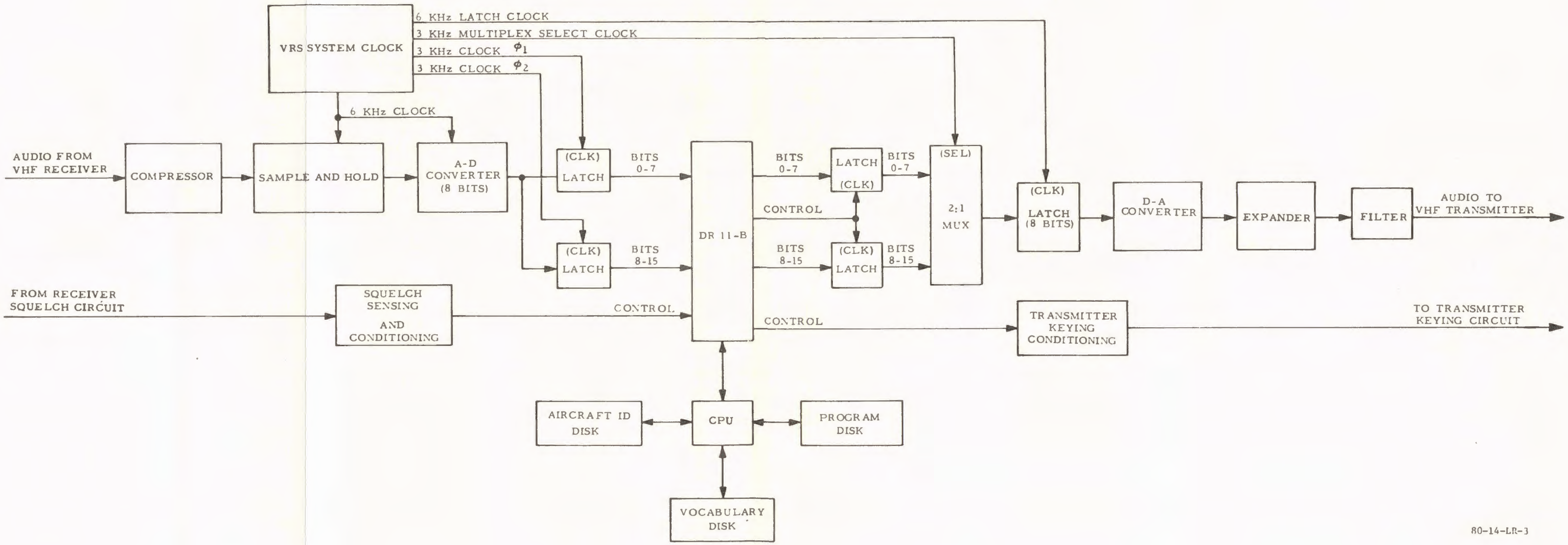

FIGURE 3. VOICE RESPONSE SYSTEM BLOCK DIAGRAM

Audio reconstruction is simply a reversal of this process. Under program control, either the Vocabulary disk or the Aircraft ID disk is searched as required and successive 16-bit binary words extracted and sent by the CPU to the DR11-B. From there they are clocked into a latch and sent to a bank of eight 2:1 digital multiplexers. Bits 0 to 7 are connected to the first inputs of the multiplexers, and bits 8 to 15 to the second inputs, respectively. The multiplexers act as double-throw switches, with one input being transmitted to the output when the SELect input is low, and the other input being transmitted to the output when the SELect input is high. Thus the single-phase 3-kHz MULTIPLEX SELECT clock permits reconstruction of the bit stream as originally digitized.

The bit stream is then sent to another latching circuit where successive 8-bit words are held for one sample period; i.e., until replaced by the following word. Successive digital words from the latch are sent to the digital-to-analog (D-A) converter and restored to their respective analog levels to re-create the original waveform within the constraints previously discussed. The output waveform is then expanded to its proper dynamic range and filtered to remove high-frequency components (i.e., the "stairstep" of the waveform is smoothed).

A separate keying/conditioning circuit, under program control, converts the DR11-B logic levels to levels suitable for keying the transmitter.

2.2.4 Air-Ground Communications System.

The air-ground communications system consists of two Bendix model RT 241A VHF aircraft transceivers, having a maximum power output of 10 watts each, which drive roof-mounted circularly-polarized swastica antennas. Transmitter keying is done under program control by the CPU via keying circuits in the VRS units. Receiver squelch is also tapped and made available, via the VRS, to the CPU through one of the DR11-B control channels. This information is required for ID recording during the login procedure.

A third RT 241A transceiver is employed independently for project management communications.

2.2.5 Weather Subsystem.

A block diagram of the Weather Subsystem is shown in figure 4. This subsystem measures, in real time, wind speed, wind direction, temperature, and altimeter setting. The windspeed sensor is a conventional three-cup anemometer (Belfort Instrument Company model 1250B) which drives a precision miniature direct current (d.c.) generator, the output of which is proportional to speed. The wind direction sensor is a conventional vane (Belfort model 1227) which drives a three-phase "d.c. synchro" circuit. This is simply a closed circular potentiometer with three taps, one every 120°. Diametrically opposed wipers, driven by the vane, are at ground potential and 10.24 volts, respectively. The position of the vane may then be uniquely determined by measuring the voltages at each of the taps (see figure 5). Both of these sensors are type-certified by the United States Weather Bureau.

The signals from the sensors are filtered to remove brush noise and sent to an A-D converter (DEC AD11-K) which, under computer control, sequentially samples their values at such a high rate as to be virtually instantaneous. The sampling interval is under software control. A complementary speed and direction indicator panel is placed in parallel for convenient monitoring by project personnel.

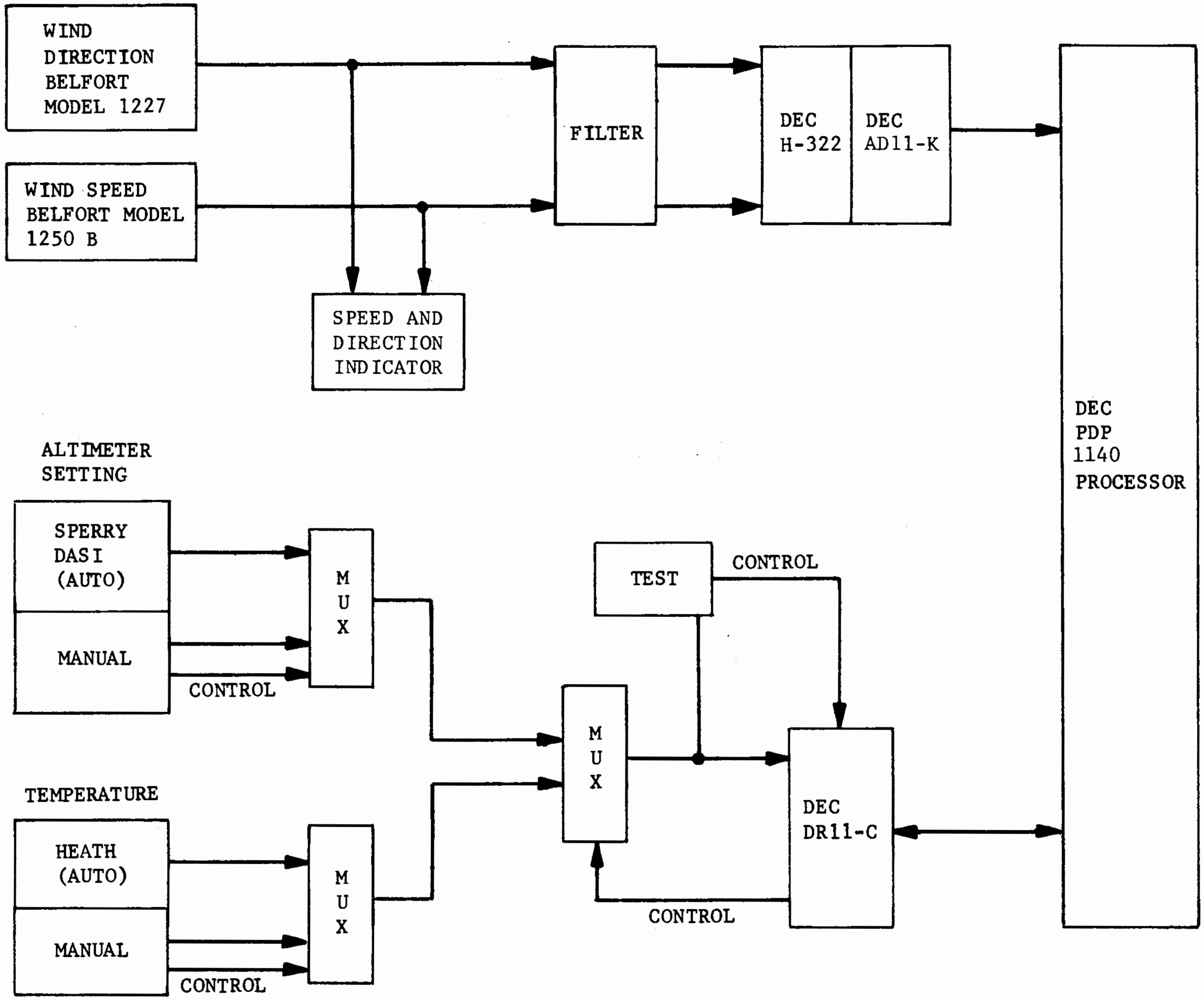

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FIGURE 4. WEATHER SUBSYSTEM BLOCK DIAGRAM

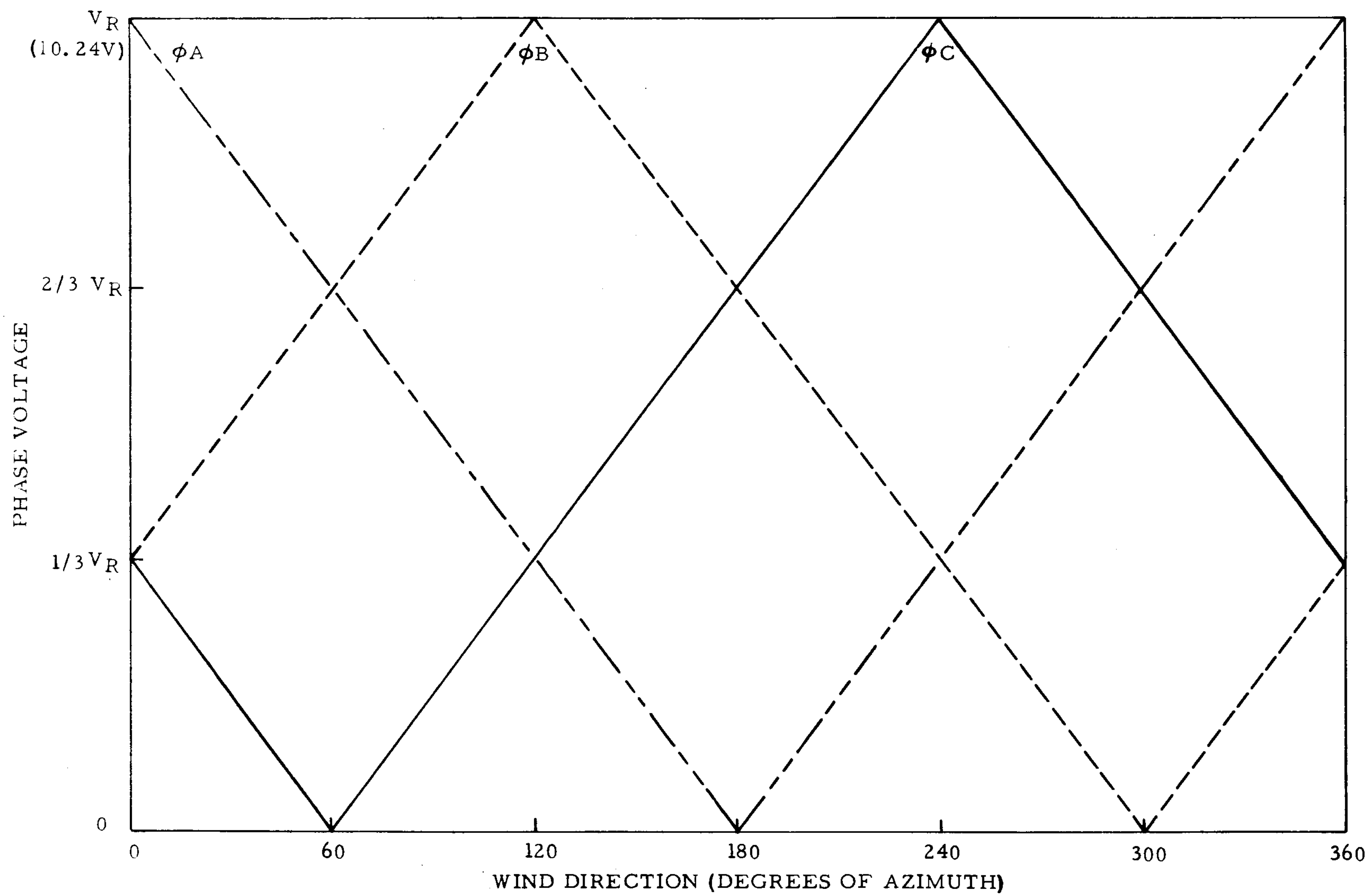

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FIGURE 5. D.C. SYNCHRO PHASE VOLTAGES

The temperature sensor was built from a commercially available (Heathkit model ID-1390A) electronic thermometer kit. Its accuracy was verified by the Technical Center Standards and Calibration Laboratory. The temperature-sensing element consists of a pair of semiconductor diodes in series, the thermal variation of the forward voltage drop of such diodes being the basis for temperature measurement. Taps across the binary coded decimal (BCD) digital readout circuits, isolated by drivers, feed a 2:1 digital multiplexer, the other input to which is a thumbwheel switch for manual entry of temperature data in the event of failure of the electronic unit. The output of this multiplexer is, in turn, fed to another, which is shared with the altimeter setting function, selection being done under computer control.

Altimeter setting is obtained from an electronic Digital Altimeter Setting Indicator (DASI), built for other purposes to FAA specifications (reference 6). It utilizes a vibrating membrane as a sensor. As with the temperature sensor, the BCD readout circuits were tapped, isolated, and fed, via multiplexers, to the central processor through a standard digital interface. Also, as with the temperature sensor, provision is made for manual entry of altimeter setting independent of the ATS software.

A test circuit, controlled by an internal switch in the Weather Subsystem hardware, permits a quick check of all DR11-C data lines from there to the CPU.

2.3 REAL-TIME MONITORING SYSTEM.

The Real-Time Monitoring System consists of a Raytheon type FA-7912 plan view display (PVD), a Raytheon RDS-500 computer to drive the display, an ASR-33 Teletype unit to initiate the display program, and a Diablo Series 30 disk drive (with controller) in which the display program is stored. Also part of the Real-Time Monitoring System is an audio monitor for all voice transmissions and a Bendix RT 241A VHF transceiver for project operations communications.

2.4 DATA ACQUISITION AND RECORDING SYSTEM.

The Data Acquisition and Recording System is comprised, in addition to the CPU, of a DEC TU-10 9-track digital recorder, a Sony Model TC-277-4 4-track audio recorder, a Datum model 9300-767 Intra-Range Instrumentation Group format B (IRIG-B) time-code generator, and a Varian model 4211A printer/plotter.

Depending on the software used, the TU-10 may record individual sweeps, or only declared targets. The TC-277-4 records all ATS air-ground communications, project air-ground communications and signals from the time-code generator.

Playback is accomplished via the Raytheon RDS-500 and FA-7912 PVD. In addition, the Tektronix R-4012 CRT terminal may be used in the "plot" mode as a backup to replay missions. The Varian 4211A may be used to produce hard copies of the CRT display.

3. SUMMARY.

The foregoing has been intended to acquaint the reader with the Automated Terminal Services (ATS) testbed hardware configuration. Where off-the-shelf hardware has been used, recourse should be had to the respective manufacturer's technical manuals. In the case of nonstandard items such as Weather Subsystem and the Voice Response System (VRS), a more detailed description has been given; and with the drawings listed in appendices A and B, sufficient documentation exists to support subsequent efforts in these areas.

For information regarding testbed software, see references 7 and 8. The final report on the ATS concept evaluation will be published by the Office of Systems Engineering Management (OSEM), AEM-20.

4. REFERENCES.

1. A Description of the Phase 1 Automated Terminal Services Concept, MITRE Corporation, Final Report, FAA Report EM-76-6, November 1976.

2. Results of Flight Test Evaluation of ATS Surveillance Antenna, NAFEC, Letter Report, NAFEC Report NA-79-33-LR, April 1980.

3. Digital Aircraft Transponder Acquisition System, Naval Weapons Center (Code 3955), Informal Report, NWC Technical Memorandum 3128, February 1977.

4. DABS Monopulse Summary, MIT Lincoln Laboratory, Summary Report, FAA Report RD-76-219, February 1977.

5. Discrete Address Beacon System (DABS) Sensor, FAA, Engineering Requirement, FAA ER-240-26, Section 3.4.3, November 1974.

6. Altimeter Setting Indicator, Digital Readout System, FAA, Engineering Requirement, DOT-FA-E-2569, May 1973.

7. Operator's Guide for the Automated Terminal Services Test Bed at Robert J. Miller Airpark, Tom's River, N.J. (ATS Version 1.7), MITRE Corporation, Working Paper, MITRE WP-12632, Rev. 1, October 1979.

8. Automated Terminal Services Test Bed Software Description, MITRE Corporation, Working Paper, MITRE WP-13561, April 1979.

APPENDIX A

FAA TECHNICAL CENTER DRAWINGS[1]

AUTOMATED TERMINAL SERVICES SYSTEM

DRAWING NO.	TITLE	LATEST REVISION
XD-2817[2]	AUDIO ENCODER/DECODER (PART OF VOICE RESPONSE SUBSYSTEM)	9/18/79
XD-2824[2]	VRS COMPANDER/FILTER SCHEMATIC DIAGRAM	6/25/79
XD-2825	VRS AUDIO DISTRIBUTION/SWITCHING BLOCK DIAGRAM	10/31/77
XD-2847	ATS AUDIO RACK INTERWIRING AND AUDIO CONTROL PANEL	10/31/77
XD-2848	ATS AUDIO RACK INTERWIRING	10/31/77
XD-2849	ATS AUDIO CONTROL PANEL SYSTEM #1 AND SYSTEM #2	10/31/77
XD-2850	AUDIO ENCODER/DECODER POWER & INDICATOR WIRING	10/31/77
XD-2864	ATS WEATHER SUBSYSTEM	11/14/79
XD-2894	WEATHER SUBASSEMBLY INPUT/OUTPUT CABLING	9/18/79
XD-2896	WEATHER SUB ASSEMBLY HEADERS CIRCUIT CONNECTIONS WIND DIRECTION/SPEED ANALOG CIRCUIT	10/2/79
XD-2900	ATS WEATHER SUBSTATION	5/1/78
XD-2901	WEATHER SUBASSEMBLY CABLE CONNECTIONS	11/14/79
XD-2903	ATS WEATHER SUBSYSTEM POWER SUPPLY & FEED CIRCUITS WIND-SPEED-DIRECTION CIRCUITS	9/14/79
XD-3013	ATS PEDESTAL MOTOR CONTROL	10/10/79

(1) The actual drawings may be obtained through the Technical Services Branch of the Management Services Division.

(2) Original drawing by Naval Weapons Center; redrawn with additions by the FAA Technical Center.

APPENDIX B
NAVAL WEAPONS CENTER DRAWINGS[1]
AUTOMATED TERMINAL SERVICES SYSTEM

DRAWING NO.[2]	TITLE
SK 3500628	LOG VIDEO DIGITIZER BEACON DEGARBLER
SK 3500634	AZ LATCH BEACON DEGARBLER
SK 3500635	COMPUTER INTERFACE BEACON DEGARBLER
SK 3500636	A/B SELECT ALT. DCD-ALT/MSG SELECT BEACON DEGARBLER
SK 3500638	DR11 B INTERCONNECT BEACON DEGARBLER
SK 3500667	RANGE LATCHES & SELECT BEACON DEGARBLER
SK 3500668	FIFO MULTIPLEXER BEACON DEGARBLER
NONE[3]	PULSE RECOGNIZER AND DEFRUITER CIRCUIT BEACON DEGARBLER
NONE[3]	BEACON DEGARBLER LOGIC-BLOCK DIAGRAM

(1) The actual drawings may be obtained through the Technical Services Branch of the Management Services Division.

(2) All drawings, Code Ident 12934.

(3) These are reproduced in reference 3.