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FULL DIGITAL AUTOMATED RADAR TERMINAL SYSTEM (ARTS) DISPLAY

FEDERAL AVIATION ADMINISTRATION

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PROJECT PLAN

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1. OBJECTIVE.

The objective of this project is to determine the suitability of the Full Digital Automated Radar Terminal System (ARTS) Display for operational use in automated terminal air traffic control facilities. The results of this evaluation will be presented in a final report which will serve as the basis for a future production specification.

2. BACKGROUND.

With increasing demands being made upon basic ARTS III display subsystems, and considering the useful life expectancy of 20 years for existing ARTS displays, it became apparent to the Systems Research and Development Service (SRDS) that a display replacement program for ARTS III displays should be planned. With the advent of ARTS IIIA and the intent to modify existing ARTS displays to provide an all-digital display capability, it was also apparent that major display modifications should be considered simultaneously. In order to accomplish both ends in the most expeditious manner, a Federal Aviation Administration (FAA) engineering requirement (ER), FAA-ER-D-120-007, was issued by SRDS in 1979. Subsequently, a contract was awarded to the Magnavox Corporation to develop and fabricate six engineering prototype displays. This project plan addresses the evaluation of these displays.

3. RELATED DOCUMENTATION.

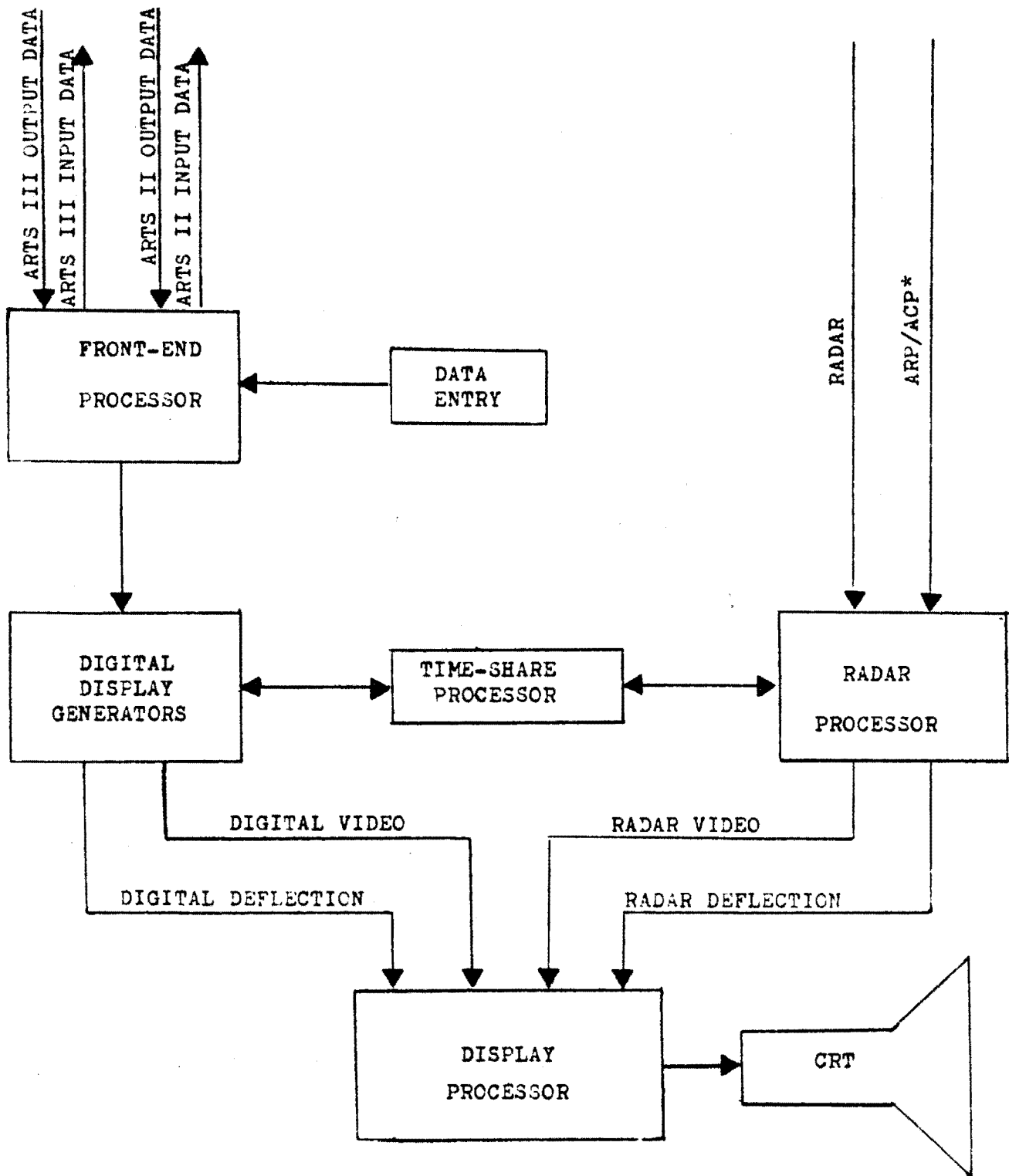
a. Engineering Requirements for a Full Digital ARTS Display (FDAD), FAA-ER-D-120-007.

b. Final Design Data, Full Digital ARTS Display (FDAD), Magnavox Corporation, October 1980.

c. Final Firmware Functional Design Data, Full Digital ARTS Display (FDAD), Magnavox Corporation, November 1980.

4. EQUIPMENT DESCRIPTION.

Each of the six FDAD subsystems being procured consists of the following: (1) a 23-inch cathode ray tube (CRT), (2) solid-state programmable microprocessor-based control circuitry, (3) solid-state memory, including refresh memory, (4) display drive electronics, and (5) data entry devices. All components are mounted in a vertical display console. The FDAD subsystem (figure 1) will provide data entry, data display, and input/output interface functions with ARTS II, ARTS III, or ARTS IIIA systems. The data entry devices include an alphanumeric keyboard and a trackball slew entry device for the entry of message functions and positional data. The quicklook capability enables observation of data block information from other displays. Alphanumeric and radar/beacon data can be displayed in either a full digital mode or a time-shared mode to a 60-mile maximum display range.



*Azimuth Reference Pulses/Azimuth Change Pulses

FIGURE 1. FULL DIGITAL ARTS DISPLAY SUBSYSTEM

Programmable alphanumeric character size and an internal buffer refresh function are also included. In the time-shared mode, digital data will be displayed with analog radar/beacon target reports, radar video map, and range marks. In the digital color display mode, data will be presented in four different program-selected colors.

Two of the six displays will have a monochrome CRT with a phosphor mixture of P2, P22B, and P28 to provide long persistence (i.e., slow output decay time) for the radar sweep and short persistence for digital display data. Three monochrome digital displays will have a CRT with a P31 phosphor to provide short persistence and high brightness efficiency. One color display will have a CRT with a P49 phosphor (a mixture of red and green phosphors) which will produce the four colors of red, green, orange, and yellow.

4.1 DETAILS OF APPROACH.

Upon completion of factory acceptance testing, the FDAD subsystem will be installed in the Terminal Automation Test Facility (TATF) at the FAA Technical Center and interfaced with an ARTS III computer system. The FDAD subsystem will be substituted for the Data Entry Display Subsystem (DEDS) portion of ARTS III. After a checkout period, during which on-site acceptance test procedures will be used to establish initial operating capabilities, program verification of the software changes necessary to accommodate substitution of the FDAD subsystem will be conducted. This program verification will establish that basic ARTS III functions have not been derogated by substitution of the FDAD. After program verification, technical and operational tests and evaluations will be conducted.

4.1.1 Technical Evaluation.

The technical evaluation will consist of a series of engineering tests to determine the following:

- a. Maximum usable display brightnesses and linewidths for various types of data.
- b. Bandwidths of the video and deflection amplifiers.
- c. Deflection yoke setting time and system noise.
- d. Display reliability and maintainability.
- e. Effects on displayed color data caused by inducing failures in color circuitry failures of a nondestructive nature.
- f. Effectiveness of the contractor-furnished maintenance diagnostic programs.
- g. The possibility of using the "time-share" CRT for the "all-digital" configuration. This would allow a backup radar sweep to be used in the case of a computer outage.
- h. If the minimum detectable signal (MDS) can be detected accurately by the time-compressed sweep circuitry, and to determine what conditions are necessary for accurate detection.

i. Performance characteristics of the display established by measuring baseline signal levels. The minimum input operating tolerance necessary to maintain the desired performance characteristics will be determined.

If the following tests are not performed as part of the acceptance tests, they will be accomplished as part of the technical evaluation.

a. Determination of the color coordinates on the chromaticity diagram for the red and green colors of the color display by measuring tristimulus X, Y, and Z filter light.

b. Measurement of spectral response over the entire visible electromagnetic spectrum.

c. Determination of color registration, positional accuracy of data, and character legibility for all four colors.

d. Measurements of power and electromagnetic radiation.

4.1.2 Operational Evaluation.

The operational evaluation will consist of the operation of display controls and data entry devices and the observation of display qualities by air traffic control specialists (ATCS) from the FAA Technical Center and field facilities. Display subsystem features will be examined both in the digital and time-shared display modes, with and without color.

5. DATA COLLECTION.

5.1 TECHNICAL EVALUATION.

a. Display brightness and line width measurements will be determined by utilizing photometric test equipment and static test patterns that are contained in the display firmware. Brightness will be measured to the nearest foot-lambert and line width to the nearest thousandths of an inch.

b. Video and deflection amplifier bandwidth, deflection yoke setting time, and system noise will be determined through the use of frequency generators and oscilloscopes. System noise will be measured to the nearest millivolt.

c. Display reliability will be determined by recording display operation time and downtime in logs. These logs will also contain the cause of each failure. These data will be analyzed to obtain mean-time-between-failure (MTBF) statistics. Maintainability will be determined by recording all display failures, their causes, necessary corrective actions, and time to repair. These data will be analyzed to obtain mean-time-to-repair (MTTR) statistics.

d. The effectiveness of contractor-furnished diagnostic computer programs will be determined by inducing nondestructive type failures into the subsystem. Maintenance diagnostics will be used to isolate the problems and detect failure locations.

e. The effects on displayed data caused by induced nondestructive color circuitry failures will be recorded. Emphasis will be placed on the observation of color data positioning problems which would not be easily detected by the controller.

f. Tristimulus X, Y, and Z filter light measurements will be performed to determine the color coordinates on the chromaticity diagram (Kelly Chart) for the red and green colors of the color display.

g. A light spectrum analyzer will be used to determine the relative energy output of the phosphor at all frequencies over the total visible wavelength range.

h. Measurement of any electromagnetic radiation will be accomplished utilizing a radiofrequency (RF) spectrum analyzer to measure the radiofrequency interface (RFI) generated by the display between the frequencies of 1 and 100 megahertz (MHz). Power measurements will also be taken on the display's alternating current (a.c.) power input utilizing a wattmeter.

i. Color registration, positional accuracy, and character legibility of data generated in various colors will be measured with a hand-held microscope to the nearest five-hundredths of an inch.

j. In the time-share mode, the display uses a CRT with a mixture of phosphors. This mixture produces short and long persistence characteristics. The long persistence is needed to produce usable information from the radar sweep. This phosphor may cause some "smearing" of the digitally generated alphanumeric characters. The all-digital mode uses a short persistence phosphor (P31). If there was a computer failure, displays configured with this phosphor could not produce usable data from just the radar sweep. Therefore, measurements will be taken using photometric equipment and subjective analysis to determine if the all-digital mode could use time-shared CRT's.

k. MDS measurements will be performed using oscilloscopes, function generators, digital multimeters, and subjective monitoring of the display.

l. Input, signal levels and delays, and baseline performance characteristics will be measured using oscilloscopes, function generators, multimeters, and photometric equipment.

m. The layout, operation, and number of maintenance controls will be evaluated.

n. Measurement data and pertinent facts will be recorded in test logs.

5.2 OPERATIONAL EVALUATION.

The FDAD subsystem will be substituted for the DEDS and interfaced with the ARTS III operational program. ATCS's will observe both targets of opportunity and targets provided by ARTS III test target generator scenarios. All operating controls and features, display quality, legibility, and assistance provided by the display of information in color will be examined to determine suitability and usefulness. Display control layout and control types will be evaluated. Particular emphasis will be placed on the functional use of each color and on the use of program-selected character sizes. Fatigue factors will be considered.

Tests will be conducted both in the full digital mode (with and without color) and time-shared mode.

Controllers' subjective opinions will be determined through debriefings and the use of a questionnaire. Pertinent facts and comments will be chronologically recorded in test logs.

6. DATA REDUCTION AND ANALYSIS.

6.1 TECHNICAL EVALUATION.

Measurement data and type and quantity of FDAD circuitry failures will be presented in tabular form. Display reliability and maintainability will be determined from a statistical analysis of the failure and repair data. Test logs will be summarized.

6.2 OPERATIONAL EVALUATION.

A summary of controller questionnaires will be presented. Applicable controller comments will be included. Test logs will be summarized.

7. INSTRUMENTATION AND FACILITIES.

a. For the technical evaluation, the following instrumentation and facilities will be required:

1. A portable photometer microscope and light spectrum analyzer
2. An RF spectrum analyzer
3. Tristimulus radiometer (TRIRAD)
4. An ASR-700 data terminal
5. TATF display laboratory
6. An ARTS III computer system and computer program
7. Radar and beacon inputs from either the ASR-4 or ASR-8 radar system
8. The Texas Instruments TMS-9900 microcomputer located in the FAA Technical Center, building 55
9. Various common test equipment, such as oscilloscopes, digital multi-meters, power meters, etc.

b. For the operational evaluation, the following instrumentation and facilities will be required:

1. An ARTS III computer system and computer program

2. TATF display laboratory

3. Radar and beacon inputs from either the ASR-4 or ASR-8 radar system

8. COORDINATION AND AREAS OF RESPONSIBILITY.

8.1 ACT-152.

a. Maintainability and reliability evaluation.

8.2 ACT-210.

a. Operational consultation and review of documentation during the display development phase.

b. Operational support during factory acceptance testing.

c. Operational support, as required, during display installation and checkout in the FAA Technical Center's TATF.

d. Operational support, as required, during the program verification.

e. Origination of evaluation plan.

f. Preparation of questionnaires, test target generator scenarios, and procedures to be utilized during the operational data collection.

g. Test direction, execution, and data collection during the operational evaluation.

h. Data reduction and analysis and preparation of the final report documenting the results of the evaluation.

8.3 ACT-230.

a. Technical consultation and documentation review during the display development phase.

b. Engineering support during factory acceptance testing.

c. Origination of technical portion of evaluation plan.

d. Test direction, test execution, and data collection during the technical evaluation.

e. Engineering support, as required, during the operational evaluation.

f. Data reduction and analysis and preparation of the technical portion of the final report documenting the results of the technical evaluation.

8.4 ACT-700.

a. Display subsystem maintenance after display installation and checkout and throughout the technical and operational evaluations.

8.5 ARD-120.

a. Provision of guidance in FDAD development, test, and evaluation.

b. FDAD development, test, and evaluation.

8.6 ARD-143.

a. Consultation on software and review of documentation during the display development phase.

b. Provision of required software support during the factory acceptance, technical, and operational testing.

c. Provision of required software support during the FAA Technical Center display installation and checkout.

d. Verification of the ARTS III computer program changes required to accommodate the FDAD subsystem.

e. Provision of the necessary software expertise to interface between the display contractor, Magnavox Corporation, and the software contractor, UNIVAC.

8.7 MAGNAVOX CORPORATION.

a. Provision of required support during the display installation and check-out, program verification, and technical and operational evaluations.

8.8 UNIVAC.

a. Provision of required support during the TATF display installation and checkout, program verification, and technical and operational evaluations.

9. MILESTONE SCHEDULE.

See figure 2, Milestone Schedule.

