Report No. FAA-CT-80-182

PROJECT PLAN FOR ELECTRONIC TABULAR DISPLAY SUBSYSTEM (ETABS) TEST AND EVALUATION

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PROJECT PLAN

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1. OBJECTIVES.

The Federal Aviation Administration (FAA) Technical Center will provide technical support to the Systems Research and Development Service (SRDS) Program Manager for Electronic Tabular Display Subsystem (ETABS) procurement, installation, and integration; conduct engineering acceptance tests; and prepare an operational evaluation of a prototype en route information processing system that will provide flight data handling functions for control sectors in Air Route Traffic Control Centers (ARTCC).

To accomplish this the Center will:

a. Provide members for the Technical Evaluation Team (TET) to evaluate contract proposals and serve as consultants to the Source Evaluation Board (SEB).

b. Provide planning information to the ETABS contractor (Sanders) for installation at the Technical Center.

c. Monitor and coordinate site preparation and equipment installation.

d. Review contractor supplies documentation.

e. Participate in design review meetings.

f. Provide logistics support for equipment and personnel during testing activities at the Technical Center.

g. Prepare traffic samples and simulator pilot operating procedures; collect and reduce experimental data; and provide operational consultation for the performance evaluation tests.

h. Prepare En Route System Support Facility (ESSF) adaptation data from the New York ARTCC and/or a modified data set used at the Technical Center.

i. Monitor the ETABS factory testing of the engineering model.

j. Monitor the 9020 — ETABS interface checkout.

k. Monitor the central computer complex (CCC) — ETABS system integration verification.

l. Monitor the system integration and verification scenarios.

m. Monitor the formal acceptance procedures when FAA assumes responsibility for ETABS from contractor.

n. Plan, develop, and conduct a system readiness test.

o. Plan, develop, conduct, and evaluate operational and engineering tests.

p. Maintain the library copy of the referenced applicable documentation.

q. Provide support, as required, on current hardware/software in the ESSF and Air Traffic Control Simulation Facility (ATCSF).

r. Aid in the development or adaptation of tests and maintenance programs for all test activities.

s. Aid in the development of acceptance criteria for all testing.

t. Recommend changes and enhancements which may be incorporated into the ETABS development effort or adopted as part of the ETABS production design.

u. Produce a report on the results of the Technical Center operational and engineering test.

v. Review the contractor-provided test requirements.

w. Review the ETABS controller user's manual.

x. Act as the test manager for the pilot study, providing control procedures, traffic samples, simulator pilot operating procedures, data collection and reduction, and ancillary services.

y. Implement system and controller performance measure, and report on the ATCSF.

z. Analyze the experimental data (describing controller operations), to determine whether ETABS would positively or negatively impact controller performance, and evaluate the degree of impact.

aa. Provide controller performance measurement criteria.

bb. Provide ETABS/CCC interface testing and analysis.

cc. Conduct reliability and maintainability studies, throughout testing, and submit reports on findings.

dd. Measure and evaluate system performance, using a hardware monitor, and report on results.

1.1 EXPECTED PRODUCT.

A report will be submitted for inclusion in the data package on the results of the performance and evaluation tests. It will document the suitability of the system for its intended application and include recommendations for system features or changes desirable in production models.

2. BACKGROUND.

In early ARTCC's, flight plan information was relayed by telephone and copied on handwritten flight progress strips. Flight strip printers (FSP) have been in use in ARTCC's for approximately 10 years. The strip printer is an adaption of an

International Business Machine (IBM) typewriter and functions as an output device from the 9020 CCC. The data base in the CCC is derived from filed flight plans. The flight data processor (FDP) element of the CCC forwards flight data to the printer in a format suitable for machine printing on a flight progress strip. Each sector that will exercise control jurisdiction over a given flight will get a flight progress strip or strips on that flight 15 minutes before the flight enters the sector's airspace. The information on the progress strip is used by the controller to separate aircraft. If a substantial change is made to the flight data on a particular aircraft, the computer data base is changed by a computer entry, and new flight strips are printed. The flight strips, as presently printed, must be torn from the printer, inserted into a strip holder, and delivered to the sector. ETABS is an electronic flight data presentation proposed to be located at en route sector positions. It is designed to replace the paper flight strips currently used as part of the National Airspace System (NAS) Stage A system to maintain aircraft flight plan information. ETABS is designed to automate many controller manual and verbal tasks and to enable the removal of FSP's and the elimination of FSP attendant activities.

An ETABS engineering model (figure 1) will be installed and evaluated at the FAA Technical Center in the ESSF. Several FAA organizations and contracted industrial firms will be involved in developing, testing, and evaluating the ETABS engineering model. These include SRDS, MITRE Corporation, FAA Technical Center, Sanders Associates, Incorporated, OAO Corporation, SRI International, Transportation Systems Center (TSC), Air Traffic Service, and Airway Facilities Service. This plan defines the functional responsibilities involved in the installation, testing, and evaluation of the ETABS engineering model. This effort will conclude with the preparation of a technical data package for use by Airway Facilities Service in procuring systems for field implementation.

A recent analysis (FAA AVP-77-31) of ETABS impact on en route air traffic control operations concluded that ETABS would be a cost efficient alternative to long-term continuance of the current system. The cost analysis included comparisons of development, implementation, operations, maintenance, and staffing costs; it was based, in part, on an assessment of the productivity impacts of ETABS on controller workload and traffic-handling capabilities. This productivity assessment quantitatively examined the task requirements of radar (R), data (D), tracker (T), and assistant (A) control positions under assumptions of current FSP and proposed ETABS operations and concluded that ETABS would reduce controller workload required for each aircraft.

The guidance on the use of strips for air traffic separation and for record purposes is contained in Agency Orders 7110.65B (Air Traffic Control) and 7210.3E (Facility Operation and Administration).

Instrument flight rules (IFR) traffic has increased in each of the last 5 years. To cope with the increased traffic and with higher speeds of modern aircraft, a faster, more efficient flight data handling system is necessary. The new system must be fail-safe and fail-soft. ETABS fail-safe and fail-soft are defined as follows:

a. In a fail-safe situation, the ETABS display system is expected to provide full operational capability continuously, except for deliberate interruptions. If a failure of sector components does occur, the data currently displayed will not be lost and will be available on call to a designated sector.

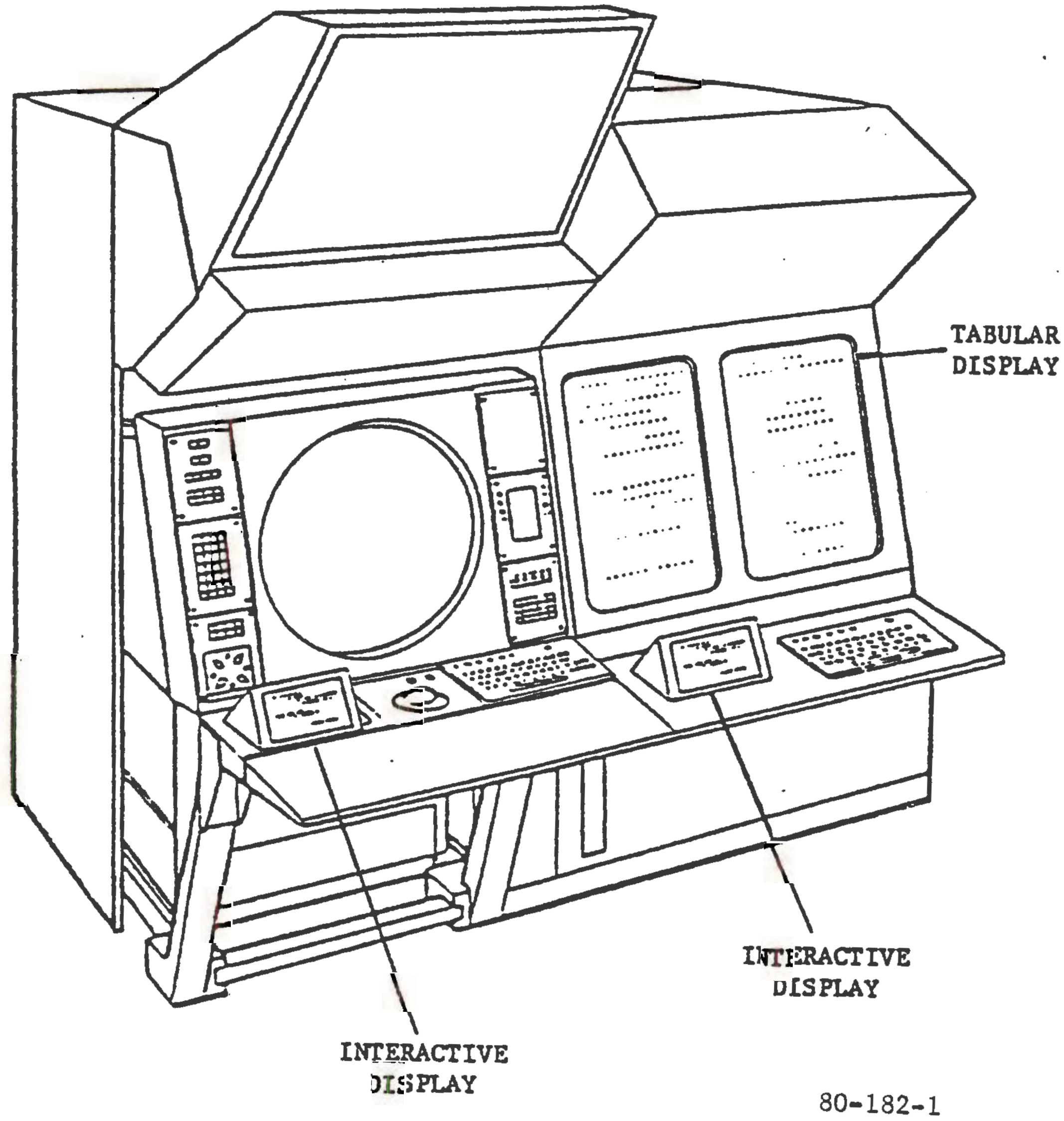

FIGURE 1. ETABS SECTOR CONFIGURATION

b. In a fail-soft situation, the system must be able to retain data for each display independently of the CCC, and it must provide the capability for continued manual entry of flight data for display.

3. RELATED DOCUMENTATION/PROJECTS.

3.1 FAA DOCUMENTS.

FAA-ER-110-208 — Engineering Requirement — Electronic Tabular Display Subsystem (ETABS) Engineering Model.

FAA-RD-75-138 — En Route Sector Redesign (Field Survey of Flight Strip Data).

NA-77-32-LR — Control Sector Redesign — Electronic Tabular Display Input Devices.

FAA-ED-12-2A — Engineering and Development Program Plan En Route Control.

ARD-Subprogram-122-112 — Aquisition Paper for an Electronic Tabular Display System (ETABS).

Letter, Director, Air Traffic Service to ARD-1, Requirements for an Electronic Tabular Display System (ETABS).

Selection Plan No. 81 for Electronic Tabular Display Subsystem.

FAA-AVP-77-31 — Cost Analysis of Electronic Tabular Display Subsystem En Route ATC Operational Impact.

Draft Report, Letter, Director, Air Traffic Service to ATF-1, Cost Analysis of Electronic Display Subsystem, En Route ATC Operational Impact.

LGR-8-5106 — Request for Proposal, Electronic Tabular Display Subsystem.

DOT-FA79WA-4270, Contract, Sanders Associates, Incorporated, Electronic Tabular Display Subsystem (ETABS).

DOT-FA79WA-039, Contract, OAO, CCC/ETABS Interface.

DOT-FA79WA-4311, Contract, SRI International, ETABS Cost Benefit Validation.

3.2 MITRE DOCUMENTS.

Electronic Tabular Display Subsystem (ETABS) Engineering Model Specifications, Vol.-1-7.

Vol. 6, CCC Interface Requirements Rev. 1.

3.3 SANDERS DOCUMENTS.

WCAWH Proposal, Subsystem Functional Design Electronic Tabular Display Subsystem.

Electronic Tabular Display Subsystem (ETABS) Preliminary System Design Data.

Electronic Tabular Display Subsystem (ETABS) System Design Data, Revision A.

Electronic Tabular Display Subsystem (ETABS) Interface Control Document.

Qualification and Acceptance Test Plan (ETABS) Functional Qualification Test Plan.

Equipment and Computer Test Procedures (ETABS).

4. SYSTEM/EQUIPMENT DESCRIPTION.

The ETABS will consist of the computer, display, and message entry resources necessary to support the en route sector positions. A distributed processing network concept will be used to accept, process, and distribute CCC originated data to recipient sector positions and to accept, process, and transmit controller input messages to the CCC.

The primary ETABS computer resource will be interface processors which interface directly with the CCC and with smaller processors located at each sector position. Figure 2 illustrates an ETABS configuration consisting of redundant equipment within a Common Equipment Group and Sector Equipment Groups, one for each sector position. Reference FAA-ER-110-208 for a detailed description of each ETABS component.

An ETABS hardware interface device, connected to the interface processor, will communicate with the CCC input/output control element (IOCE) and respond to commands from the CCC/IOCE.

4.1 COMMON EQUIPMENT GROUP.

The Common Equipment Group (CEG) will be capable of performing the following functions while on-line:

a. Provide communications with the CCC.

b. Provide redundant storage of all operational flight and adaptation data.

c. Distribute data and accept data from the Sector Equipment Groups (SEG).

d. Service requests from the SEG, such as: (1) program load requests, (2) data base regeneration requests, and (3) supplemental data requests.

e. Multiplex air traffic controller input messages from the Sector Equipment Groups to the CCC.

f. Provide intersector/intracenter communications.

g. Generate hard-copy data via the line printers.

h. Provide configuration management of ETABS, including automatic reconfiguration of equipment following a hardware failure.

i. Record data on magnetic tape for later analysis.

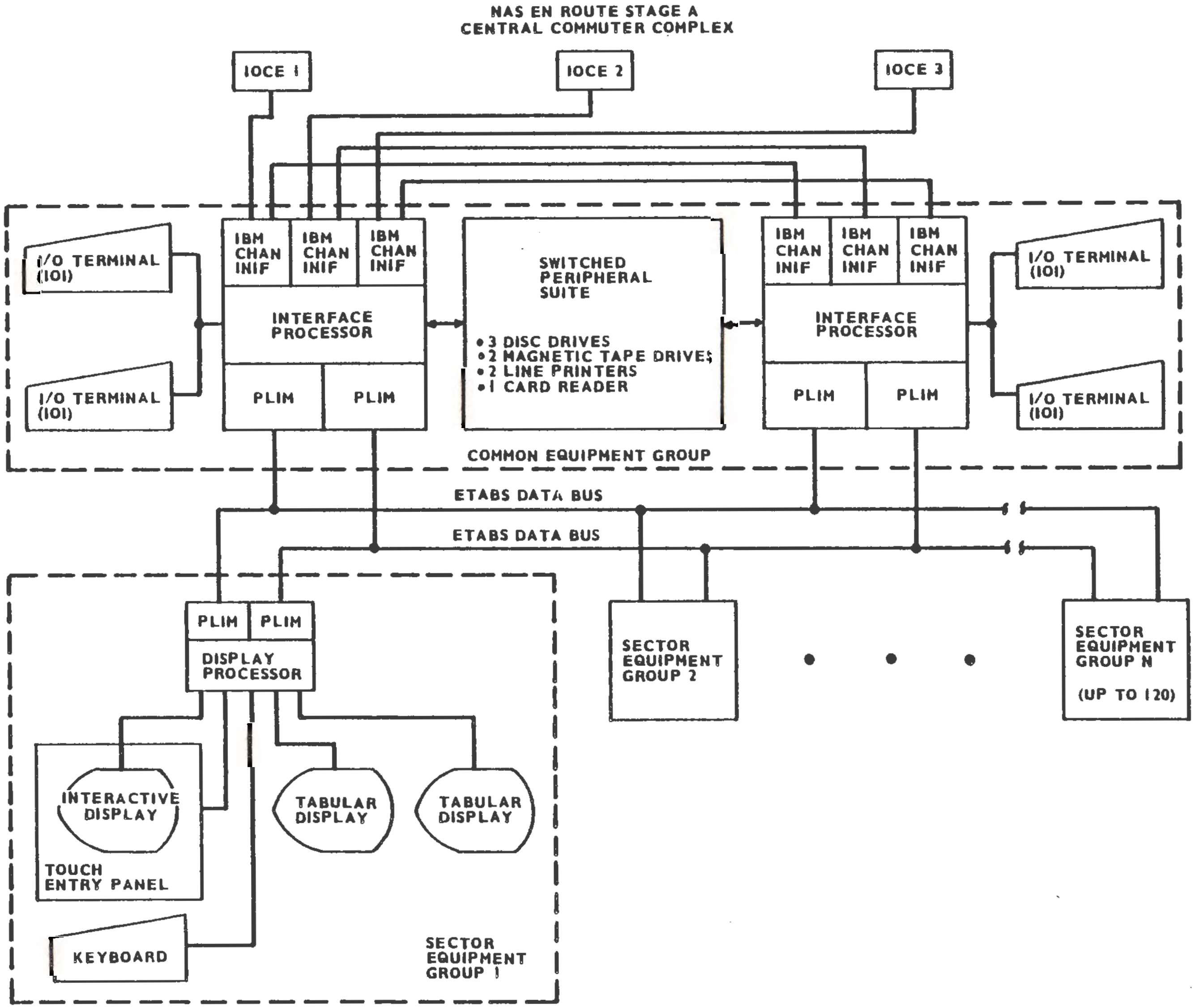

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FIGURE 2. EN ROUTE ELECTRONIC TABULAR DISPLAY SUBSYSTEM (ETABS) EQUIPMENT CONFIGURATION

j. Communicate with system operators through the input/output terminals.

The CEG will be capable of performing the following functions while off-line:

a. Perform program assemblies for the interface processor and display processor software.

b. Provide for maintenance of the equipment; that is, run maintenance programs to diagnose faults in both the CEG and SEG off-line equipments.

c. Process simulation data from an off-line CCC configuration.

d. Perform assemblies of adaptation data and output adaptation subsets for storage in the operational program.

4.2 SECTOR EQUIPMENT GROUP.

The SEG will be capable of performing the following functions:

a. Provide storage of air traffic control sector-related data base.

b. Format and display required portions of the data base.

c. Provide an interactive data entry capability.

d. Manage communications with the interface processor.

4.3 FUNCTIONAL DESCRIPTION.

This section describes the functions to be performed primarily by the ETABS software. Subsection 4.3.1 describes the functions to be performed by an on-line monitor to control the operation of the ETABS subsystem. Subsection 4.3.2 describes the display output functions associated with the presentation, maintenance, and controller manipulation of data on the electronic tabular displays. Subsection 4.3.3 describes the message entry functions designed to simplify the controller-computer interfaces. Subsection 4.3.4 describes the hardware and the software functions designed to ensure a continuity in air traffic control operations during various failure conditions. Further levels of detail can be found in the Sanders Documents and ER-110-108.

4.3.1 Monitor Function.

A real-time ETABS monitor program will control the operation of TABS subsystem. The major functions to be performed by the monitor are listed below. No distinction is made between those functions to be performed in the CEG versus those functions to be performed in the SEG's.

a. Subsystem initialization and program control.

b. Support to the application program.

c. Error analysis, reporting and reconfiguration.

d. On-line data recording.

e. Input/output management.

f. Failure mode support.

4.3.2 Display Output Function.

The display output function includes the processing and displaying of all flight and nonflight information to be presented at each sector position. The function also includes the processing and displaying of all data required to support use of the touch input device for message entry.

Data to be displayed are controlled via adaptation generated by an off-line adaptation assembler and stored within the operational program. This includes (1) formatting and identifying data fields to be displayed, (2) positioning various categories of data on available tabular display surfaces, and (3) formatting the contents of menus to be used with the touch input device in the composition of input messages.

The display function is divided into two parts: (1) a nontouchable tabular display device containing data needed for air traffic control and (2) a touchable interactive display device containing data necessary for controller interaction with the system.

4.3.2.1 Tabular Display.

The following types of information are presented in the tabular display:

a. Flight data (or entries of flight information) for active and proposed flights.

b. Meterological information.

c. Restricted area information.

d. Controller notices (NAS general information messages).

e. System clock time.

This information is presented in areas of the tabular display as defined by the adaptation in effect. The flexibility of the display output function and the adaptation will permit designation of additional areas on this display for the presentation of information not now defined.

4.3.2.2 Interactive Display.

The interactive display is used with the touch input device for controller interaction with the computer. Various areas of the display are used to initiate, compose, and verify messages for input to the system or to display computer-generated messages. The following types of information are presented in the interactive display:

a. List of aircraft identifications (AID) of the flight data entries (FDE's) displayed on the tabular display.

b. Computer alerts.

c. Flight plan readout generated when an AID in the list is touched or when a flight plan readout request is input using the keyboard.

d. Lists of message types and data in the form of menus to be used for controller message composition with the touch input device.

e. Input messages composed by the controller via the touch input device or the keyboard.

This information is presented in areas of the interactive display as defined by adaptation. The flexibility of the display output function and the adaptation will permit designation of additional areas on this display for the presentation of information not now defined.

Touchable data on this display are positioned at touch points as defined by the (hardware) touch input device. The touch of a displayed field (or data) indicates, to the software, the data selected by the controller. Several touch points can be used to define a touchable field.

4.3.3 Message Entry Function.

The ETABS message entry function, together with the display output function, provides an interactive capability for controller entry of messages. It supports uses of the touch input device, as well as use of a keyboard at the sector position. While the primary method of entry of messages is through the touch input device, the keyboard can be used to initiate and compose input messages in their entirety.

4.3.4 Failure Mode.

Hardware and software logic is provided to detect and to report failure of ETABS components, as well as a disruption of the CCC interface. Failure-mode functions will provide continued operational support to the sector position to the greatest extent possible with available equipment and with minimum inconvenience to the controller.

Redundant units are provided for the interface processor and the disk storage devices. If a failure occurs in the on-line interface processor, the standby processor will assume operational processing. If a failure of one of the two on-line disk storage devices occurs, the third device will be made available to the on-line processor. The operational data base will be preserved and updated, as necessary, on the two on-line disk storage devices. However, the availability of one storage device is sufficient to continue normal operations.

An SEG is in a failed condition when it is unable to continue to support operations at the sector. When feasible, operational data will continue to be displayed on the sector display devices following an SEG failure.

Action can be taken to transfer flight data from the failed sector to another sector. When the action is input, flight information will be transferred from the display at the failed sector to the display at the recipient sector. New flight data will be routed to the new sector.

4.3.5 CCC Unavailability.

Special software logic will be invoked within ETABS when an outage of the CCC interface is detected. The logic is designed to minimize the impact of the outage on the controller. It will be possible to update displayed flight plan readouts. Pertinent flight actions input during the CCC outage will be forwarded to the CCC when operational processing of the CCC resumes. In this way, CCC and ETABS operational data will be consistent.

During prolonged periods of time when the CCC is unavailable; e.g., following planned shutdown, ETABS will continue to support the sector positions. Provision will be made for keeping the flight data updated and for routing information between sectors. The operational data will be forwarded to the CCC following a CCC startup and used by the CCC to establish its data base. The ETABS recording capability can record all input and output data.

4.4 TEST SITE DESCRIPTION.

The FSP and ETABS tests at the Technical Center will be conducted at the ESSF with the support of the simulator pilot complex; the latter is part of the ATCSF. The ESSF is equipped to simulate the 9020D/display channel complex (DCC), 9020D/computer display channel (CDC), or 9020A/CDC CCC display channel systems that are deployed in the operating ARTCC's.

The 9020D/DCC (also called the 9020D/E) has been selected by the FAA for the FSP and ETABS comparative tests and will be adapted by the Technical Center personnel to simulate current operational data processing capabilities.

The ESSF contains 12 sector laboratories equipped to simulate operational conditions. It is provided with standard NAS Stage A consoles which include a plan view display (PVD), computer readout devices (CRD), interphone and pilot/controller voice communications interfaces, alphanumeric keyboards (ANK), a flight progress board, and an FSP. The PVD target and associated display symbols are identical to those employed in the operational centers, although the situation data are generated by computer simulation rather than field radar interrogation. Six of the sectors will be modified and adapted with the ETABS engineering model, and six will be standard FSP sectors.

The plan for the configuration of the sector lab is shown in figure 3. The configuration enables a test to be conducted with six sectors in a simulated operational mode while five of the remaining sectors support the test. For example, six ETABS-equipped sectors would be manned by test controllers who would carry out normal ATC activities. "Support" sectors, would be manned by controllers who would hand off traffic and coordinate with the test sectors. A "Trash" sector would be manned by a controller who would simulate the coordination activities required between the test sectors and other sectors not represented in the laboratory. Only the activities of the test sector controllers would be monitored and recorded for subsequent evaluation. The same procedure would be carried out during an FSP test, except that the six support sectors would become the FSP sectors and would be staffed by the test subjects and five of the ETABS sectors would provide the feeder and ghost functions.

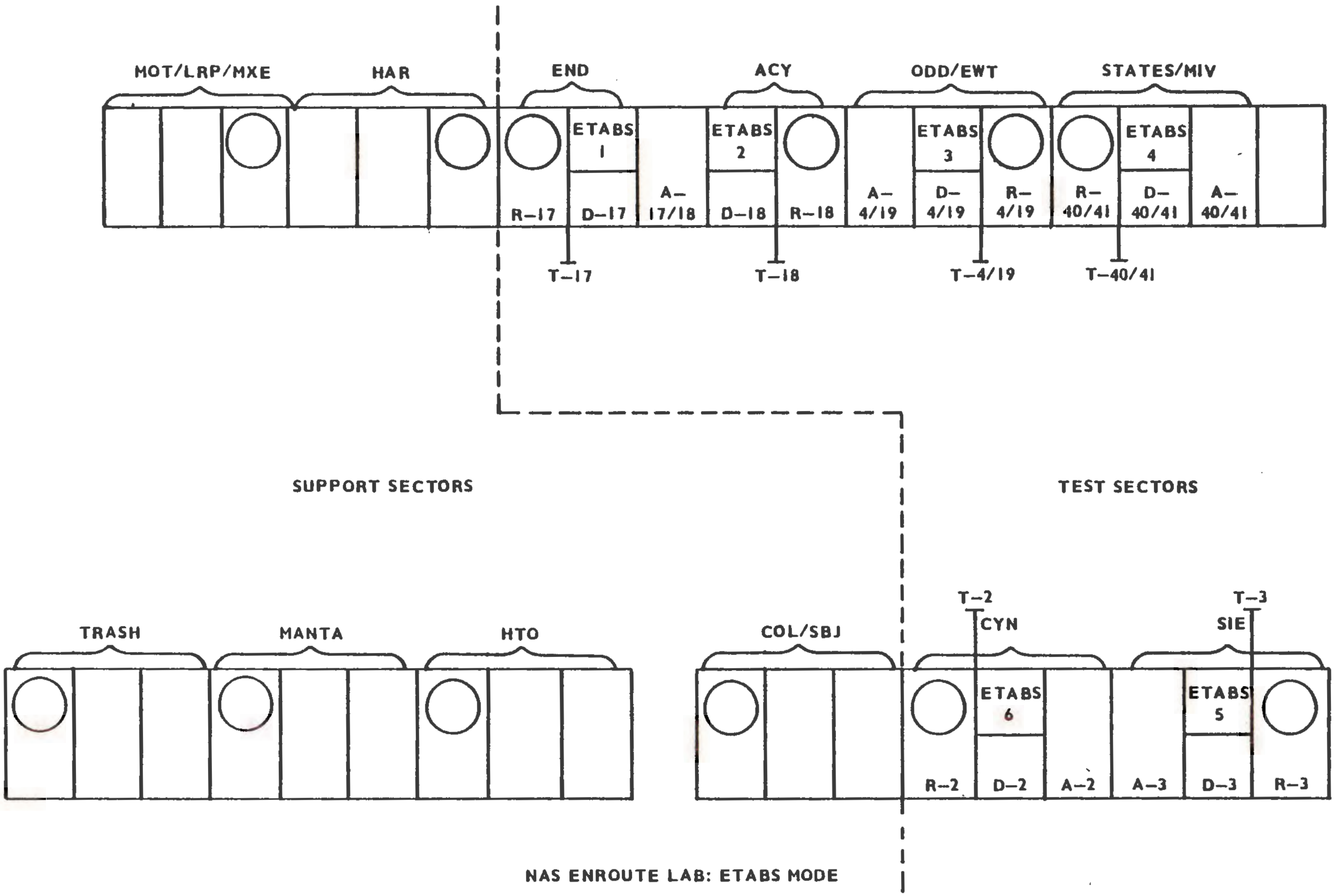

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FIGURE 3. PLANNED SECTOR EN ROUTE LABORATORY CONFIGURATION

5. DATA COLLECTION.

Data collection and testing will be divided essentially between two areas, with some possible overlap, a technical evaluation and a performance evaluation. The software evaluation will, for the most part, be included in the technical evaluation. Although the equipment configuration will vary according to the tests, the maximum configuration will consist of the ETABS subsystem, including the CEG, six lab sectors with SEG's installed in the D positions, six non-ETABS sectors, the 9020D as a quadruplex, the 9020E, the Denro Communications System, and the ATCSF. An alternate system using the 9020A and CDC may be tested by tape simulation if time permits. (See figure 4.)

5.1 TECHNICAL EVALUATION.

This will start at the completion of installation and will consist of:

a. ETABS checkout.

b. Modification of NAS en route software.

c. System integration and verification tests.

d. Operational and engineering tests.

Figure 5 shows the relationship of these tests with respect to the overall project.

5.1.1 ETABS Checkout.

Stage 1: Stage 1 consists of stand-alone hardware/software testing. All power cabling and hookup will be done. The contractor will make electrical checks and run static and dynamic diagnostics to assure the integrity of ETABS prior to interfacing it with the CCC. A stand-alone hardware/software test will be done with the off-line interface processor simulating CCC inputs and accepting output messages. In addition, failure mode processing in a stand-alone mode will be accomplished, since no CCC communications are required.

Stage 2: Stage 2 is a hardware interface integration with the CCC. All hardware and electrical interfaces will be thoroughly checked. Messages will be passed between ETABS and the CCC on all possible interface connections and verified for correctness.

Stage 3: Stage 3 is a complete functional checkout of ETABS and the interface with a program in the CCC to simulate outputs and accept inputs. During this test, all functions and combinations of functions will be exercised to the fullest extent possible. All interfaces will be active for this test.

In addition to the functional testing at the Technical Center, a reliability demonstration test will be run.

5.1.2 CCC Software Modification.

The operational program resident in the CCC, NAS En Route Stage A of the appropriate version, will be modified by the CCC software contractor, OAO, to

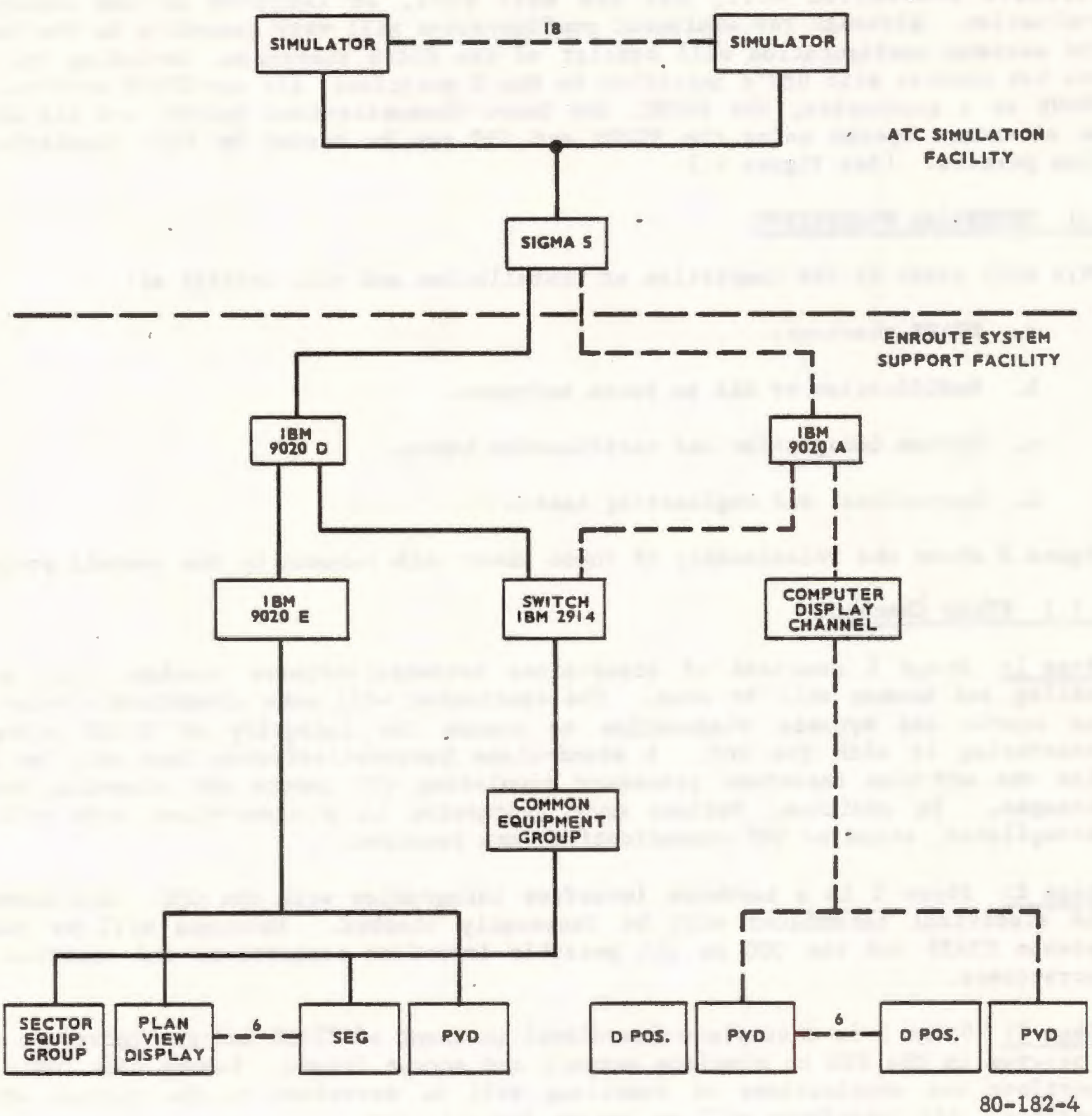

FIGURE 4. ETABS MAXIMUM CONFIGURATION

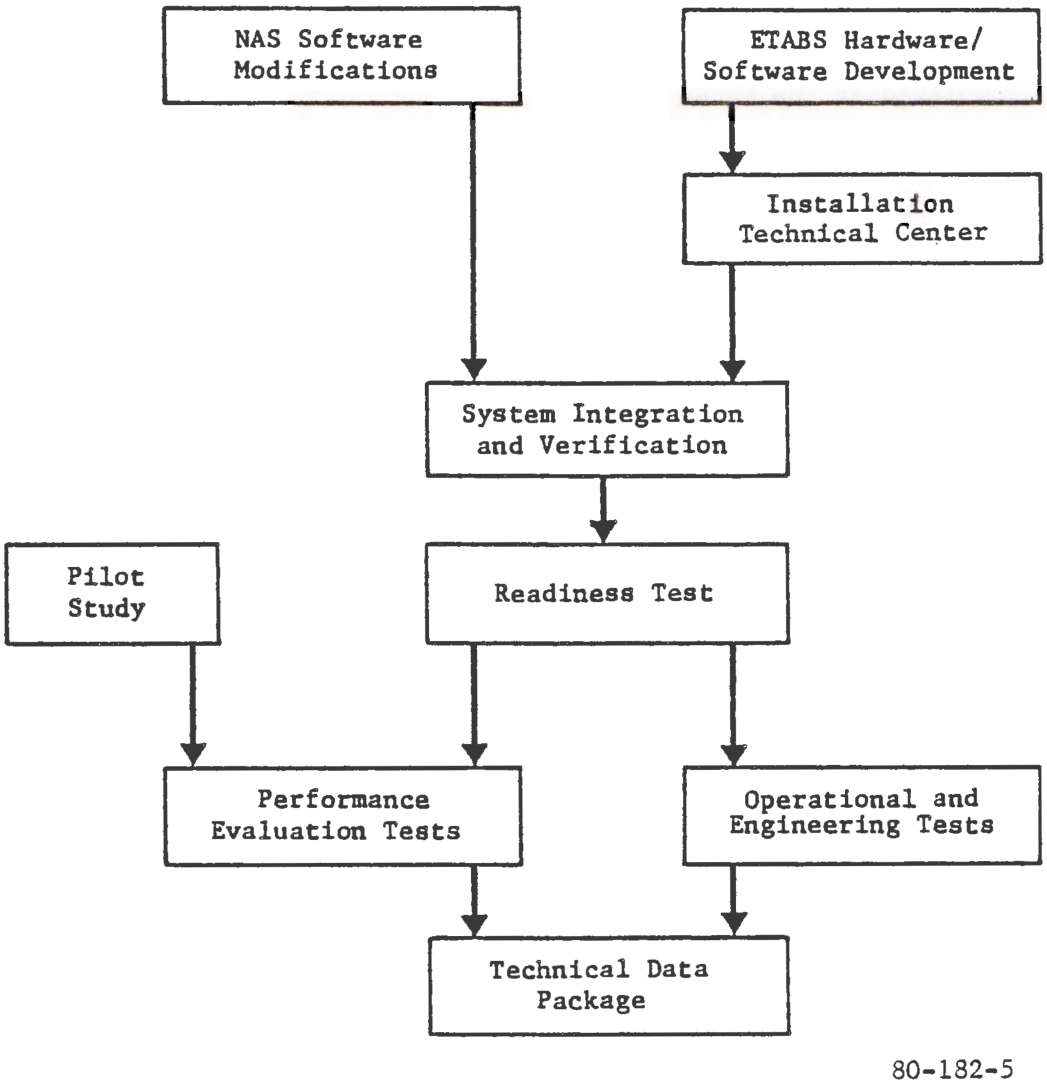

FIGURE 5. ETABS PROGRAM FLOW

accommodate the ETABS capabilities. After an appropriate requirements analysis period, the CCC software contractor will publish change pages to the Computer Program Functional Specifications which detail all the modifications required to the CCC. These requirements will include the ETABS-CCC input/output requirements contained in the Interface Control Document prepared by the ETABS contractor. Subsequently, the CCC software contractor will publish changes to the Program Design Specifications of the CCC. A design review will be held before coding begins. The CCC software contractor will also submit, for approval, a formal qualification and acceptance test plan and will conduct an acceptance test for the software modification. The CCC software modification will be done in a timely fashion so that it is finished at the same time Stage 3 of the ETABS installation plan is completed at the Technical Center.

5.1.3 System Integration and Verification Tests.

Tests will be conducted at the Technical Center to verify all requirements of ETABS with a complete operational system of ETABS hardware and software and CCC program modifications that accommodate ETABS. All the equipment, software, and electrical interfaces will have been tested and approved on a stand-alone basis or with simulated drivers prior to the start of this test. The system verification tests will be done in stages in order to isolate various functions and ameliorate the debugging process.

The ETABS contractor and the CCC software contractor will have the responsibility of planning, running, analyzing, responding to failures, and documenting these tests. Each contractor will have prime responsibility for different aspects to the testing. The tests are divided into two parts: (1) CCC — ETABS interface messages and (2) complete functional verification. More specific aspects of these phases are given in the following sections.

During all system verification tests, the pseudo-site adaptation and the universal data set (UDS) will be used. In this data set, situations are simulated that will exercise all possible ETABS and en route software features.

5.1.3.1 CCC — ETABS Interface Messages.

This first level of tests will verify that all messages going between ETABS and the CCC will be handled properly. All of the interface paths will be exercised; i.e., each IOCE to interface processor connection. All messages exchanged by the CCC and ETABS for normal and exceptional messages are monitored for correctness. A tape or series of tapes will be built to simulate flight plans and other messages entering the CCC at various rates.

The CCC software contractor (OAO) has prime responsibility to plan and conduct these tests. The ETABS contractor (Sanders) will review the plan and contribute to the test runs and analysis. The following is a stepwise test progression that can be done to orderly proceed in the test phase.

<u>Step 1:</u> Flight plans will be introduced into the CCC one at a time, and the output of ETABS will be monitored closely to verify the correctness of the data before another plan is entered. Flight plan contents will vary in order to exercise as much logic in the CCC and ETABS as possible.

Step 2: Amendments to flight plans will be entered into the CCC from ETABS, as part of the test tapes, manually via an R-position interactive keyboard or by other appropriate means to exercise the message update capabilities. The amendments will be input one at a time so that the correctness of the ETABS display can be monitored. In addition, other types of messages will be input, such as handoffs and holds, to verify their proper handling.

Step 3: Flight plans will be introduced into the CCC at ever increasing rates and in bursts to ensure that the CCC, interfaces, and ETABS can work for a peak load. The increase will be done in steps to ensure proper operation at each increased rate.

Step 4: Amendment messages will also be input into the CCC along with the higher rate of flight plans. Eventually, in step 4, the combination of flight plan inputs and amendments should be equal to the peak load required of the system.

5.1.3.2 Functional Verification.

A complete functional verification of the system will be accomplished. The ETABS contractor will have prime responsibility for planning and conducting these tests. The CCC contractor will have a major support role in conducting the tests. Two distinct processing modes will be tested.

5.1.3.2.1 CCC — ETABS Normal Mode Processing.

During this level of tests, all the possible message inputs and outputs of both the CCC and ETABS will be simulated for the normal mode of processing; the CCC — at least one interface processor, two disk units, one line printer, etc. — and at least one of the sector positions will be up. Flight plans will be input one at a time, and messages will be composed one at a time so that the appropriate responses can be verified. In addition to the allowed messages, a representative set of inappropriate messages will be generated to test the error detection logic. All functions will be simulated, including nonflight messages and computer response messages such as clear text messages.

5.1.3.2.2 CCC — ETABS Failure Mode Processing.

Several different failure mode conditions can exist when the CCC, ETABS, or items within these subsystems go down for a period of time. Each of these conditions will be simulated.

At the successful completion of the interface tests, ARD-140 will assume the primary responsibility for the ETABS equipment and modified CCC software. The ETABS contractor and CCC software contractor will now take support and maintenance roles for the rest of the ETABS testing.

5.1.4 Operational and Engineering Tests.

The operational and engineering tests will determine the operational suitability of ETABS for use in the En Route Air Traffic Control System. These include a readiness test for the performance evaluation, operational tests, and engineering tests. These are described in more detail in the following sections. ACT-210 has primary responsibility for planning, conducting, analyzing, and documenting these tests.

5.1.4.1 Readiness Test for Performance Evaluation.

A system readiness test will be conducted to establish that the system, simulation laboratories, data reduction and analysis tools and techniques, and related procedures are in a state of operational readiness for the subsequent performance evaluation and operational tests. These tests must necessarily be performed prior to the performance evaluation tests. Specific items that need to be established include the following:

a. The proper adaptation for the ETABS system, the ESSF and the ATCSF to simulate the six designated sectors of the New York ARTCC.

b. The accuracy of the data going between the simulation facilities for the traffic samples.

c. The correct application of control procedures within the simulation. The control procedures are those delineated in the New York ARTCC Standard Operating Procedures Manual and New York ARTCC letters of agreement with adjacent centers, terminal facilities, and military organizations.

d. The final set of controller-operating procedures, the duties and responsibilities of the R and D controller in using the ETABS displays and data entry devices, that were specified in preliminary form by SRI.

e. The simulator operator procedures for running the pilot consoles in the ATCSF.

f. The verification of the data collection and reduction analysis programs.

g. The ensurance that the air-to-ground and interphone communications are working properly.

h. The determination of values for all ETABS and CCC adaptable parameters to be used for the start of performance evaluation and operational tests. These would include the placement of data areas on the ETABS displays and the information content of the flight data entry format levels.

5.1.4.2 Operational Tests.

System operational tests will determine the usability of ETABS with respect to operability, human factors, and degraded capability, due to all types of failures, and its suitability for use as the only flight data presentation system for both radar and nonradar environments. ETABS must handle all jobs currently served by paper flight progress strips. These tests are those required in addition to the performance evaluation tests. These operational tests will include, but not be limited to the following:

a. Nonradar flight control.

b. Human factors evaluation.

c. Varied traffic situations.

d. All failure modes for CCC and ETABS.

e. One-man sector operation in low traffic density.

f. Operational transition from FSP's to ETABS.

5.1.4.3 Engineering Tests.

Engineering tests fall under two major categories — reliability and maintainability tests and computer performance measurement tests.

Maintenance and repair information will be acquired throughout the testing program. Special tests will be run with simulated or real failures included. These tests will examine ETABS failure mode processing, as well as ease of repair. An MTTR (mean time to repair) will be estimated for various failures. A reliability/maintainability report will be issued summarizing the Technical Center's findings at the end of the entire testing program. Also, an assessment of the features in the CEG to support ETABS operation will be made. These include startup/startover procedures, peripherals handling, and preventative maintenance operations.

Computer performance measurement and evaluation of ETABS and the impact on the CCC will be done periodically throughout the testing. This includes CPU utilization, memory utilization, throughput, and response times.

5.2 OPERATIONAL TESTING.

After the completion of the technical evaluation, the operational testing will begin. With the exception of the experimental design tests (which require no software support) and the system verification tests (which will use a simulation tape on the 9020D and the configuration in figure 5), the remaining tests will use the entire system as shown in figures 4 and 5.

The testing will be divided into two parts: the Technical Center Operational Evaluation Program, and the SRI International Cost-Benefit Study. These will be run serially, for the most part, with some possible overlap. The human engineering will span the entire testing and will be done jointly by TSC and ACT-210. Approximately 100 test subject controllers, in groups of about 25 each, will be provided from field ARTCC by Air Traffic Service throughout the test period. Each group will be trained, briefed, and debriefed, as required. In addition, they will receive training literature prior to coming to the FAA Technical Center. TSC will generate an ETABS Operational Procedures Manual (a user manual) as part of this package. Center personnel will provide the remaining documentation for area familiarization.

Prior to testing, Technical Center personnel will generate a site adaptation of the CCC Operational Program, NAS-A3D2.7, based on the New York ARTCC area and traffic samples. They will also generate control procedures based in the above. All efforts will be coordinated with Air Traffic Service.

5.2.1 The FAA Technical Center Operational Testing.

These tests will generally follow the flow diagram in figure 6, keeping in mind that flexibility will be maintained to allow on-the-spot changes, as required.

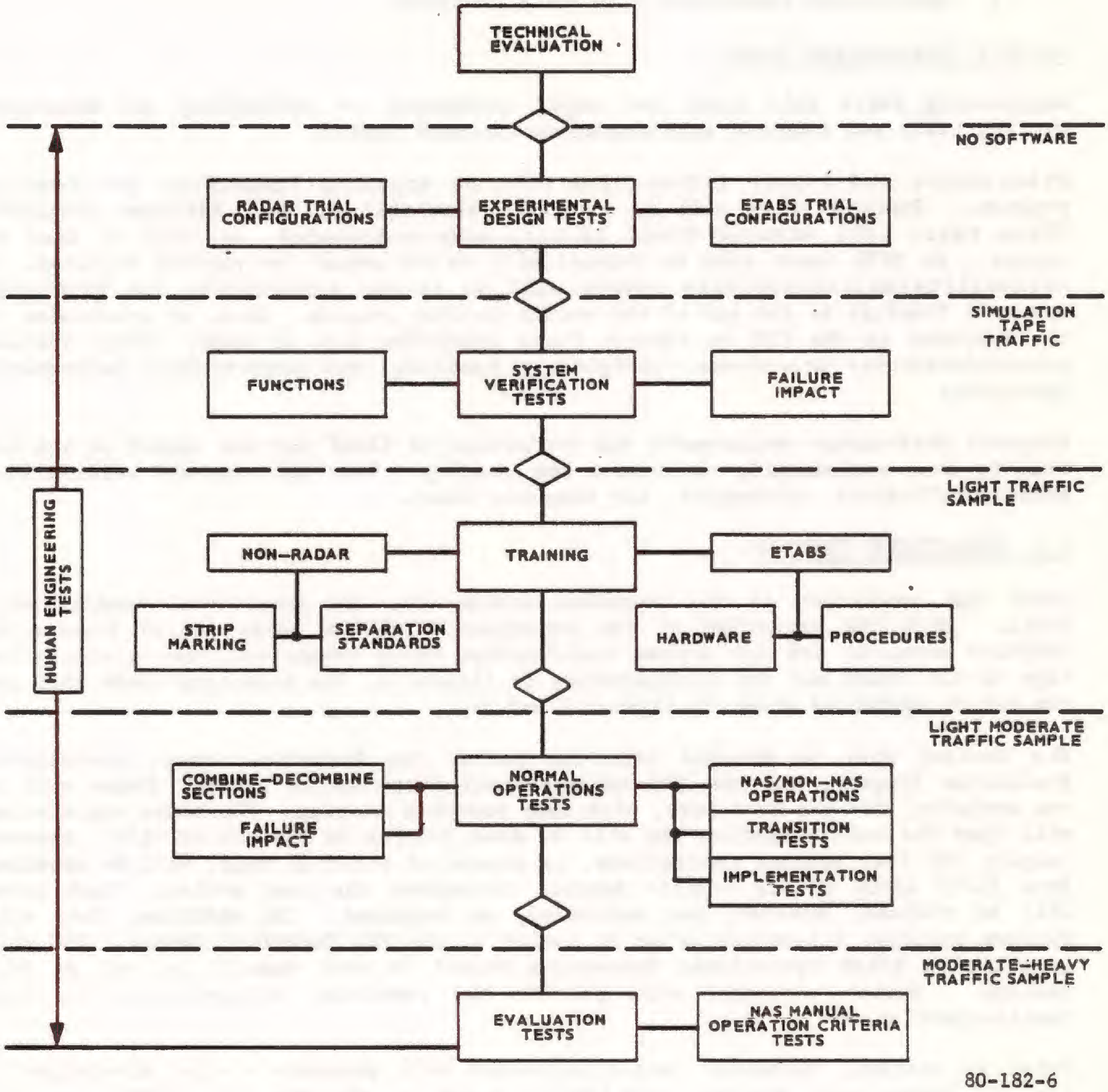

FIGURE 6. TECHNICAL CENTER OPERATIONAL EVALUATION PROGRAM

After each phase a decision point will be reached which may require regrouping and retesting or permit going ahead. It is anticipated that approximately 60 test runs of 2 1/2 hours each will be needed to collect adequate data. Comparison tests involving both ETABS and non-ETABS sectors will be run separately so that only six sectors will be used at any one time for evaluation purposes. However, all 12 sectors will be used at once to provide support sectors.

5.2.1.1 ATC Operations Evaluation Testing.

The operational evaluation program (figure 6) consists of six basic phases: human engineering tests, experimental design tests, functional tests, controller training, NAS evaluation criteria tests, and ATC operations evaluation tests. Each phase is a separate effort with an attending support requirement. A brief description and/or objective(s) of each phase follows.

5.2.1.1.1 Human Engineering Tests.

An independent plan for accumulation of specific data for human factors measurements and analysis will be prepared and supported by the Transportation Systems Center (TSC). It is anticipated and expected that a major share of this support will be provided in the early phases of planning for application to experimental design tests in order that the most utilitarian of sector designs may be included in evaluation testing. Follow-on support in data collection, interpretation and analysis for guidance, and report purposes to accomplish project objectives is desired. Periodic oral consultation and guidance to ensure compliance to basic human engineering principles, where possible, will be requested.

5.2.1.1.2 Experimental Design.

These tests and investigations are designed to determine hardware and software flexibility/limitations and to select sector and staffing configurations for operations evaluation testing.

5.2.1.1.3 Functional Test.

These are "single-thread," baseline type tests, followed by system load in minimum and maximum configuration, with and without NAS associated operations. Some failure and recovery tests are also included in this phase.

5.2.1.1.4 Controller Training.

Intensive "hands-on" familiarization training, with rotation through all sector configurations, will be conducted during comprehensive system exercises. Refresher training in nonradar separation standards, strip-marking, and procedures may be administered, if required.

5.2.1.1.5 NAS Evaluation Criteria Tests.

Operational tests, inclusive of the identical sectors used in ETABS testing, will be conducted in a NAS radar and nonradar environment to collect data from current operations to be used as one form of evaluation criteria against which to measure the performance of ETABS.

5.2.1.1.6 ATC Operations Evaluation Tests.

Moderate and heavy traffic samples will be used to determine suitability of the ETABS for air traffic control purposes. Measures of utility and controller workload will be recorded. System design deficiencies will be noted, resolved if feasible, or recorded for recommended correction at a later date. Test procedures for air traffic control, provided by Air Traffic Service, will be used throughout the evaluation test series. Procedures may be modified to accommodate a correction in design deficiencey.

All phases are directed toward evaluation of the ETABS for ATC operations use. Results of operational testing will be documented in a report which will indicate the degree of suitability of the system as a replacement for paper flight progress strips. If applicable, recommendations for desired system features or design changes necessary for improved system performance will be included.

5.2.1.2 Data Collection.

Since this area is still in the planning stage, a description of data collection methods under consideration will be given.

For the most part, data will be collected by direct observation. The observer, ideally an experienced air traffic controller or a person expert in this type of testing, will note actions, functions, and workload of the test subjects and will play particular attention to difficulties with or deviations from the procedures specified that may arise. Briefings before and debriefings after each test period, along with questionnaires submitted by the test subjects, will augment the subjective observational data collected.

In addition, several processed data collection methods are under consideration. The number and type of key strokes made by the controller will be recorded by ETABS and stored on the tape recorder. The messages to and from the interactive display will be recorded by ETABS. For non-ETABS this same data will be collected via the system analysis recordings (SAR) program in the 9020D. This will provide a comparison between the two systems. Video recording of the tabular display may be used to collect filed flight plans to be compared with the flight strips used in non-ETABS. The MS-68 hardware monitor may be used to compare the loading effect of ETABS on the 9020D and its selector channels against non-ETABS. In the field of voice communications, the ATCSF capability to record switch closures on point-to-point communications lines will be used. An alternate method is to use the MS-68, if available, to record the number of point-to-point contacts, the duration of each contact, and the total time spent in communicating for each point. Another alternate method is voice recording, if time would permit the voluminous task of data reduction.

The SAR tapes will be used to collect such data as: conflict alert, PVD outputs, traffic samples, and other parameters. ETABS will record the data base and CCC entries on tape. These will be used to resolve problem areas after the test runs.

5.2.2 TSC Testing.

TSC will collect data from the other tests using the data collection methods outlined in these tests, although the data and analysis may be different.

5.2.3 SRI International Testing at the Technical Center.

SRI is to generate a test plan and procedures and define their test measures. No information is available at this time.

6. DATA REDUCTION AND ANALYSIS.

Data reduction and analysis will be accomplished as follows:

a. The data checksheets used in the technical areas and the direct observations will be compiled on summary sheets for evaluation. This will be done manually.

b. SAR tapes with a printout from the high-speed printer will be used to reduce data in those areas associated with SAR.

c. The MS-68 hardware monitor will provide a reduced data output for those areas which may use it.

d. The ATCSF communications analyzer will provide compiled data, if used.

e. Controller questionnaires will be compiled manually, along with notes from the briefings and debriefings.

f. The OS Job Shop (9020D) will be called on to help reduce data wherever possible.

ETABS will, however, record the data base and CCC entries. This will be used to resolve problem areas after test runs.

7. INSTRUMENTATION AND FACILITIES.

ETABS testing will require the use of the ESSF during the qualification and acceptance tests and both the ESSF and the ATCSF during the performance evaluation tests.

In the ESSF, the DCC will be used, including the 9020D and the 9020E. An IBM 2914 switch leased for the test period will be used between the CCC and the CEG to provide both interface isolation and switching capability to the 9020A. This will allow evaluation of the 9020-CDC system, time permitting. In the ESSF Lab, up to 12 sectors will be used — 6 with SEG's installed and 6 with present standard configurations. All position M-1 consoles are being modified to accept ETABS SEG consoles. This will permit the evaluation of variations to the standard sector configuration, if time is available. The interim Denro Communication System will be used to provide intersector communication and to provide controller contact measurements from the switch closure outputs supplied. A monitor system, similar to the Test Data, Inc., MS-68 hardware monitor, may be required to record controller communications, contact numbers, durations, and routings, if these data are necessary. In any case, the MS-68 hardware monitor or its replacement may be used to measure ETABS loading on the CCC interface.

ETABS performance evaluation tests will require the use of the ATCSF, including the Sigma 5 with a standard interface to the CCC and up to 18 simulators with pilots to provide targets based on the scenario used.

8. COORDINATION AND AREAS OF RESPONSIBILITY.

8.1 FAA TECHNICAL CENTER.

One of the Center's prime responsibilities is to support SRDS in the installation and integration of ETABS into the ESSF and carryout the items listed in the Request for End-Item Support. The Technical Center, specifically the ATC Applications Branch, ACT-210, is also responsible for the administration and conduct of the qualification and acceptance tests and the performance evaluation tests. This includes the coordination of all FAA, TSC, and contractor activities and personnel at the Center. It also includes the establishment of the test environment required.

8.1.1 ATC Applications Branch, ACT-210.

The branch personnel are responsible for the Center's participation in the project, as stated above. In addition, they will provide hands-on training for the test subjects required for the performance evaluation tests.

8.1.2 Systems Integration Branch, ACT-230.

This branch is requested to provide consultation and advice on human factors, as needed for the performance evaluation tests.

8.1.3 Simulation Systems Branch, ACT-240.

This branch is requested to provide support in the use of the ATCSF during performance evaluation tests.

8.1.4 Technical Services Branch, ACT-63.

This branch is requested to provide support in supplying drawings and illustrations for maps, documentation, and reports. They are also asked to provide photos, as required. In addition, printing of documentation and reports will be required.

8.1.5 Supporting Services Branch, ACT-53.

Even though the contractor, Sanders, will mount the equipment, this branch is requested to provide support in preparation of the ESSF for the installation.

8.1.6 Engineering and Construction Branch, ACT-54.

This branch is requested to provide consultation and advice for the installation of ETABS into the ESSF.

8.1.7 Advanced Engineering and Planning Section, ACT-721.

This section is requested to provide planning for integration of ETABS into the ESSF, and for allocation of space. They are also requested to supply documentation and advice on the use and capabilities to the interim Denro Communications System for data collection.

8.1.8 Customer Services Branch, ACT-720.

This branch is requested to supply support for integrating ETABS into the ESSF and testing, as required.

8.1.9 Hardware Engineering Branch, ACT-730.

This branch is requested to provide engineering support, consultation, and advice throughout the project for ETABS integration and operation in the ESSF. This may include operation of the subsystem after the termination of contractor's 2-year support period, if required.

8.1.10 Software Engineering Branch, ACT-740.

This branch is requested to provide software support throughout the project. This may include management of the software to be completed under the 2-year contract with Sanders.

8.1.11 Production Branch, ACT-760.

This branch is requested to provide support throughout the project in operating and scheduling of ESSF. Also, they are requested to perform data reduction through their workshop.

8.2 OTHER FAA ORGANIZATIONS.

8.2.1 Systems Research and Development Service (SRDS).

8.2.1.1 ATC Systems Division En Route Branch (ARD-110).

a. Provides the program manager who will:

1. Exercise executive authority over the planning, direction, and control of the program. Executive authority is the right to direct, change, or stop an action when deemed to be in the best interest of the program.

2. Indentify, coordinate, and integrate the efforts of all participating organizations within the FAA to ensure effective and timely completion of the development program.

3. Monitor the activities of contractors involved in the program and assure that their technical efforts are in accordance with contractual requirements.

4. Supervise the preparation of all required program documentation.

5. Assure the application of appropriate configuration management procedures to the program.

b. Provide a technical officer on all contracts associated with ETABS; these include contracts with Sanders, OAO, and SRI.

c. Review and approve all contractual documentation developed by the ETABS contractor, CCC contractor, and test contractor. These include all requirements documents; system design data; all test requirements, plans, procedures, and report; installation documents, interface control documents, and evaluation reports.

d. Provide all the testing equipment and contractor support for accomplishing the testing of the existing system, if necessary.

e. Identify requirements and resources necessary to support the testing efforts.

f. Ensure that logistics support is planned, funded, and available to support testing. This includes responsibility for providing the necessary funds to meet the travel and per diem of full performance level (FPL) controllers to and from the Center to participate in the performance evaluation tests.

g. Provide guidance and assistance to assure that qualified maintenance and operational personnel are available during testing.

h. Provide planning and guidance information to all activities which interface with this effort to aid in the timely implementation of supporting activities.

i. Develop acceptance criteria, with support from the Technical Center/ ACT-210 and the user services, in accordance with contractual requirements. This includes acceptance of all associated documentation.

j. Review and record recommendations for changes and enhancements which may be incorporated into the ETABS development effort or adopted as part of the production ETABS design.

k. Receive and evaluate advice from the research and development elements of SRDS on future developments as they may impact the ETABS development activities.

l. Prepare technical data package for Airway Facilities Service.

<u>8.2.1.2 ATC Systems Division Computer Program Development Branch (ARD-140)</u>.

a. Reviews all contractual documentation developed by the ETABS contractor, CCC contractor, and test contractor.

b. Participates in all technical reviews of the requirements, design data, test plans, and procedures.

c. Supports the Program Manager in all activities accomplished at the Center. This would primarily include day-to-day review of the CCC program modification progress and the operational, engineering, and performance evaluation test progress.

d. Specifies the adaptation data for the universal data set (UDS) for ETABS.

8.2.2 Airway Facilities Service (AAF-300).

a. Provides membership to working groups, committees, and boards as may be required in support of ETABS development.

b. Participates in the performance evaluation and engineering tests in order to become familiar with the maintenance aspects of the ETABS equipment.

c. Participates in technical evaluations, reviews documentation, reviews and accepts the technical data package.

d. Recommends changes and enhancements which may be incorporated into the ETABS development effort or adopted as part of the production ETABS design.

8.2.3 Air Traffic Service.

a. Provides membership to working groups, committees, and boards as may be required in support of ETABS development, AAT-100 (300/500).

b. Provides input to the test plans for the operational and performance evaluation tests at the Technical Center, AAT-100 (300/500).

c. Participates in technical evaluations, reviews documentation, reviews and accepts the technical data package, AAT-100 (300/500).

d. Provides the NAS En Route Stage A operational programs that will be revised to permit operation of ETABS, AAT-500.

e. Provides members for the pilot study, operational and performance evaluation test teams and, in particular, field controllers that will operate the equipment and be used as test subjects in evaluating the system, AAT-100.

f. Recommends changes and enhancements which may be incorporated into the ETABS development effort or adopted as part of the production ETABS design, AAT-100 (300/500).

NOTE: AAT-100 (300/500) indicates that AAT-100 has the lead on that item with AAT-300 and AAT-500 providing input, as required.

8.3 ETABS CONTRACTOR (SANDERS/ARCON).

a. Provides the ETABS engineering model hardware and software per the engineering requirement and ETABS contract, including all documentation and drawings.

b. Provides preliminary and final system design data for a timely review of the ETABS design.

c. Provides an interface control document.

d. Prepares and submits a site preparation plan.

e. Provides test program plan and test procedures for factory tests and site acceptance tests at the Center.

f. Provides installation plan.

g. Conducts factory tests using simulated external system inputs.

h. Assumes responsibility for equipment delivery including moving equipment into the facility and placing it at its designated location.

i. Assumes responsibility for physical installation, checkout (including software debugging), and maintenance, until acceptance.

j. Performs acceptance tests on ETABS. Final contractual acceptance will depend upon the contractor meeting the requirements of the contract.

k. Provides all tests and maintenance programs that operate within ETABS.

l. Provides technical support, as required, during all test activities.

m. Provides membership to working groups, committees, and boards as may be required in support of ETABS development.

n. Recommends changes and enhancements which may be incorporated into the ETABS development effort or adopted as part of the production ETABS design.

8.4 CCC CONTRACTOR (OAO).

a. Performs requirements analysis for the modification of the operational CCC software to include the capability of interfacing with ETABS.

b. Prepares a requirements document that specifies the changes.

c. Prepares and submits all design data for the CCC modification for review by ARD-110.

d. Prepares and submits a test plan for the integration of the change into the baseline operational program.

e. Prepares and submits a test plan for the integration of ETABS with the CCC, which includes the modified operational program.

f. Provides the modified version of the CCC software for use in ETABS performance evaluation testing.

g. Conducts the CCC-ETABS interface tests in order to bring the entire system into readiness for the performance evaluation tests.

h. Supports all test activities, as required in problem resolution.

i. Performs computer performance measurements of ETABS impact on the CCC.

j. Recommends changes and enhancements which may be incorporated into the ETABS development effort or adopted as part of the production ETABS design.

8.5 PERFORMANCE EVALUATION TEST CONTRACTOR (SRI).

a. Provides a test requirements document for the performance evaluation tests, as well as the evaluation of impacts following the tests.

b. Specifies the site environment for the performance evaluation tests which include the sector configurations, traffic, manning, etc.

c. Specifies the support software needed for the performance evaluation tests which include traffic samples and data reduction and analysis (DR&A) programs.

d. Specifies the controller operating procedures for the tests.

e. Participates in the running of system readiness tests. These tests are used to verify the procedures and equipment configurations to be used following the performance evaluation tests.

f. Participates, as required, in the running of the performance evaluation tests.

g. Defines all the data required to be recorded during the experiments and ensure its capture for performing the cost/benefit analysis of ETABS.

h. Performs the evaluation of ETABS in comparison to flight strip operations.

i. Produces a report documenting controller performance and system cost comparison of ETABS versus FSP operations.

j. Recommends changes and enhancements which may be incorporated into the ETABS development effort or adopted as part of the production ETABS design.

8.6 TRANSPORTATION SYSTEMS CENTER (TSC).

a. Prepares an ETABS users manual for controller test subjects.

b. Develops and evaluates special controller and system performance measures, and develops necessary software to provide information to evaluate ETABS. Publishes a report on the results.

c. Participates in design and documentation review for the ETABS contract and the performance evaluation test contract.

d. Reviews all specifications and designs relating to human factors.

e. Provides consultation and support to SRDS on performance and evaluation testing; human factors, controller performance measurement and evaluation, experimental design, and operational analysis.

f. Recommends changes and enhancements which may be incorporated into the ETABS development effort or adopted as part of the production ETABS design that will be specified in the technical data package.

9. MILESTONE SCHEDULE.

The milestone schedule is found in figure 7.

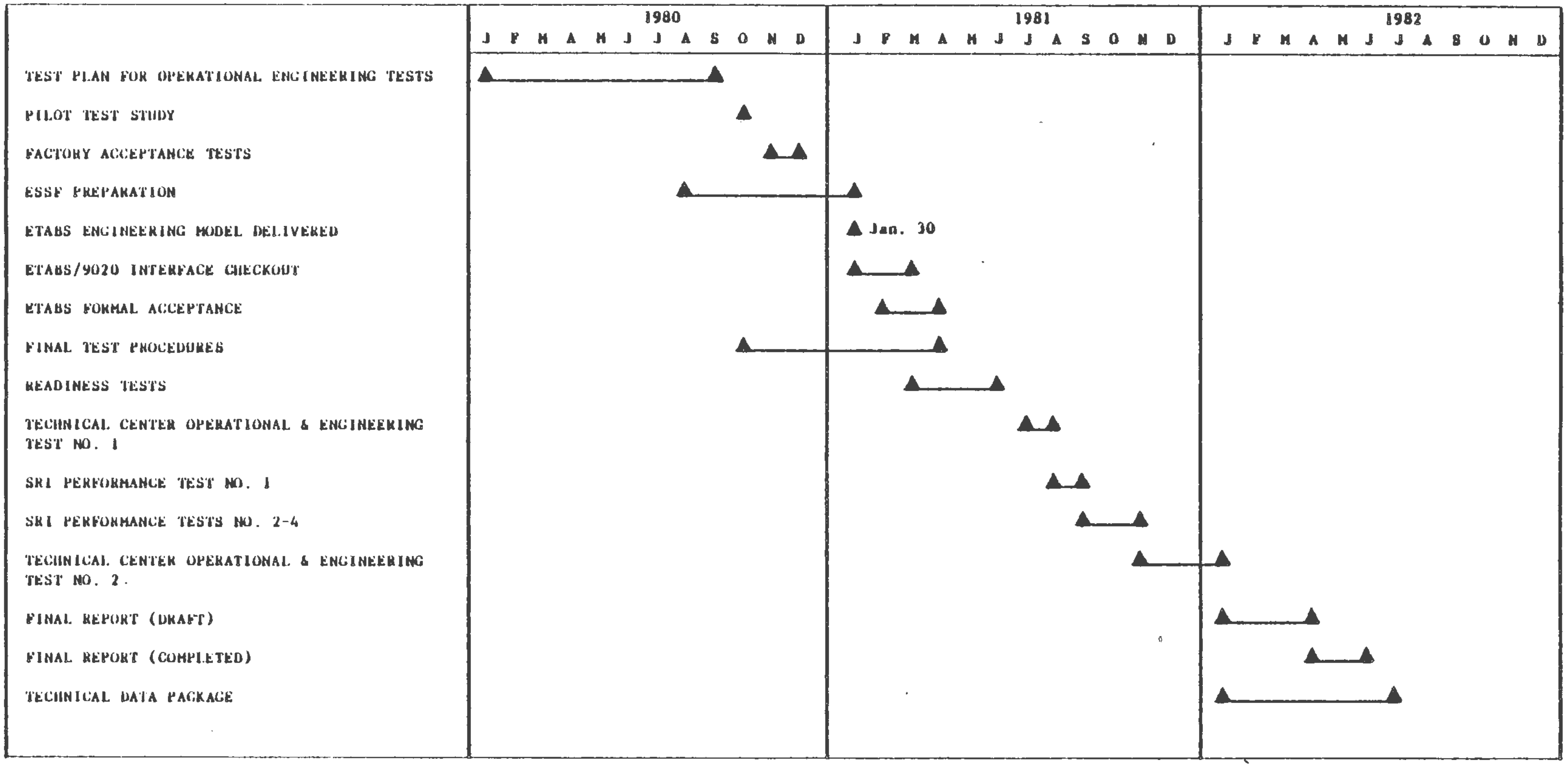

FIGURE 7. MILESTONE SCHEDULE