technical note technical note

Phase III CODEC Test Plan

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CTA Incorporated

September 1990

DOT/FAA/CT-TN90/16

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16. Abstract

The Federal Aviation Administration (FAA) Coder/Decoder (CODEC) Test Program will determine the suitability of low data rate digitized voice via a satellite link for air traffic control (ATC) applications. A primary concern of the FAA in assessing low data rate CODECs will be to minimize satellite bandwidth and power requirements while achieving acceptable voice performance. The final results of the FAA CODEC test plan will be analyzed and a recommendation of a low data rate voice CODEC for ATC communications will be proposed for inclusion to the Aeronautical Mobile Satellite Service (AMSS).

The FAA CODEC testing will support the validation of Standards and Recommended Practices (SARPS), prepared by the International Civil Aviation Organization (ICAO), as well as Minimal Operational Performance Standards (MOPS), developed by the Radio Technical Commission for Aeronautics (RTCA), for AMSS voice communications.

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EXECUTIVE SUMMARY

This document describes the Federal Aviation Administration (FAA) Phase III Coder/Decoder (CODEC) Test Program and the CODEC Test Bed (CTB). The CTB will be used to conduct the tests required to assess operational characteristics of low data rate voice CODECs for air traffic control (ATC) applications via a satellite network. The final results of the FAA CODEC Test Program will be analyzed and a recommendation of a low data rate voice CODEC for ATC communications will be proposed to the Aeronautical Mobile Satellite Service (AMSS) Panel. In addition, these tests will support the development of Standards and Recommended Practices (SARPS), prepared by the International Civil Aviation Organization (ICAO), as well as Minimum Operational Performance Standards (MOPS), developed by the Radio Technical Commission for Aeronautics (RTCA), for AMSS voice communications.

1. INTRODUCTION.

1.1 OBJECTIVE.

The objective of the Federal Aviation Administration (FAA) Coder/Decoder (CODEC) Test Program will be to determine the suitability of low data rate digitized voice via a satellite link for air traffic control (ATC) applications. A primary concern of the FAA in assessing low data rate CODECs will be to minimize satellite bandwidth and power requirements while achieving acceptable voice performance. The FAA will recommend a low data rate voice CODEC standard, based on the CODEC Test Program results, for inclusion to Aeronautical Mobile Satellite Service (AMSS) ATC voice communications.

The FAA CODEC testing will support the validation of Standards and Recommended Practices (SARPS), prepared by the International Civil Aviation Organization (ICAO), as well as Minimum Operational Performance Standards (MOPS), developed by the Radio Technical Commission for Aeronautics (RTCA), for AMSS voice communications.

This test plan describes the planned use of the FAA's voice CODEC Test Bed (CTB).

1.2 BACKGROUND.

The Future Air Navigation System (FANS) Committee established digital voice transmission as a requirement of AMSS. The FAA plans to use digitized voice transmission over the AMSS satellite network in an ATC environment.

The CTB is part of a continuing FAA effort to assess the technical and operational acceptability of low data rate digitized voice technology. This technology offers the promise of enhancing current ATC communications in many environments. In particular, digitized voice transmitted via satellite will improve communications for oceanic air traffic, where high frequency (HF) radio communication currently provides marginal service, and in continental airspace with low traffic density (such as, low altitude, offshore, and remote areas) where very high frequency (VHF) radio/telephone service is poor or nonexistent.

The FAA recently completed a two phase test program which evaluated and demonstrated low data rate voice CODEC technology. The test program resulted in the initiation of the Phase III Test Program.

1.2.1 Phase I Test Program.

The FAA invited manufacturers of 4.8 and 2.4 kilobit per second (kbps) data rate voice CODECs to participate in a prequalification based on subjective listening evaluation. The eight manufacturers that responded were each sent an audio cassette tape of test messages to process through their CODECs. The tape contained controller-pilot dialogue and Diagnostic Acceptability Measure (DAM) sentences.

Fourteen tapes of processed messages were returned to the FAA for evaluation (seven sets of messages processed at 4.8 kbps, six at 2.4 kbps, and one at 9.6 kbps). Excerpts from these tapes and the original unprocessed tape were edited to form a single master test tape. ATC personnel participated in a subjective listening evaluation of the master test tape and were asked to score tape recordings based on the Mean Opinion Scoring (MOS) system, an industry standard for subjective speech quality evaluation.

The results of the Phase I evaluation were intended to qualify a select number of CODECs for further testing in Phase II. Based on Phase I results, CODECs from five manufacturers were selected for evaluation in Phase II testing (Related Documents, item a).

1.2.2 Phase II Test Program.

Phase II provided the FAA with direct experience in CODEC testing and evaluation techniques. The Phase II listening evaluation focused on objective intelligibility tests as opposed to subjective opinion scoring.

A Phase II audio master test tape was prepared containing ATC test messages with controlled background noise conditions. This tape was processed through each CODEC pair. A digital error simulator was included in the test configuration to insert bit errors in the digital signal to simulate satellite link performance degradation.

Three groups of listeners were used for evaluating the CODEC processed tapes: non-ATC personnel, ATC personnel with mostly en route controller experience (Washington Air Route Traffic Control Center (ARTCC)), and ATC personnel with mostly oceanic controller experience (Oakland ARTCC).

The Phase II testing demonstrated that the performance of 4.8 kbps voice CODECs was favorable (Related Documentation, item b). As a result, the FAA plans to institute a more comprehensive Phase III CODEC testing program that will include two CODEC pairs selected because of their performance in Phase II, as well as a select number of CODEC pairs previously unavailable to the FAA for testing.

1.2.3 Phase III Test Program.

Phase III of FAA CODEC testing will be conducted using the CTB. CODEC operational performance characteristics, as well as more comprehensive CODEC evaluations, will be conducted in the CTB. The main objective of the Phase III Test Program results is to identify and recommend a low data rate CODEC standard for ATC communications in conjunction with supporting the development of AMSS low data rate digitized voice specifications for ICAO SARPS and RTCA MOPS. Section 2 describes the CTB and section 3 describes the Phase III test program.

The FAA is soliciting the participation of the following international organizations to coordinate joint activities in the Phase III Test Program.

a. Civil Aviation Authority - United Kingdom (CAA-UK)

b. International Maritime Satellite Organization (INMARSAT)

c. Canadian Ministry of Transportation (MOT)

d. Japanese Civil Aviation Bureau (JCAB)

1.3 RELATED DOCUMENTS.

a. Child, J., Cleve, R., and Grable, M., Evaluation of Low Data Rate Voice CODECs for Air Traffic Control Applications, FAA Technical Note DOT/FAA/CT-TN89/13, January 1989.

b. Child, J., Dehel, T., and Grable, M., Phase II Testing and Evaluation of Low Data Rate Voice CODEC Equipment, FAA Technical Note DOT/FAA/CT-TN89/49, August 1989.

c. Miller, C., Low Data Rate Voice CODEC Processing Delay in the AMSS Environment, ICAO Information Paper AMSSP/WGA-WP1, August 29, 1989.

d. Quackenbush, S., Barnwell, T., and Clements, M., Objective Measures of Speech Quality, Prentice-Hall, 1988.

e. Jayant, N. S., Coding Speech at Low Bit Rates, IEEE Spectrum, Vol. 23, No. 8, August 1986, pp. 58-63.

f. Sandlin, S., AMSS Test Plan, FAA Technical Note TBD.

g. Mack, M., and Tierney, J., The Intelligibility of Natural and Vocoded Semantically Anomalous Sentences: A Comparative Analysis of English Monolinguals and German-English Bilinguals, MIT LL Technical Report 792, December 1987.

h. Understanding Telephone Electronics, Howard W. Sams & Co., 1988.

i. TT-B1-1201-0030, Performance Specification, Central Office, Telephone, Automatic, AN/TTC-42(v) 1 & 2, April 7, 1976.

2. TEST FACILITY AND EQUIPMENT.

2.1 FACILITY LOCATION AND CONFIGURATION.

The FAA's CTB will be located at the FAA Technical Center's support contractor's (CTA INCORPORATED) facility in McKee City, New Jersey. The facility will consist of two isolated sound rooms and a general equipment and work area. Figure 2.1 illustrates the configuration of the CTB.

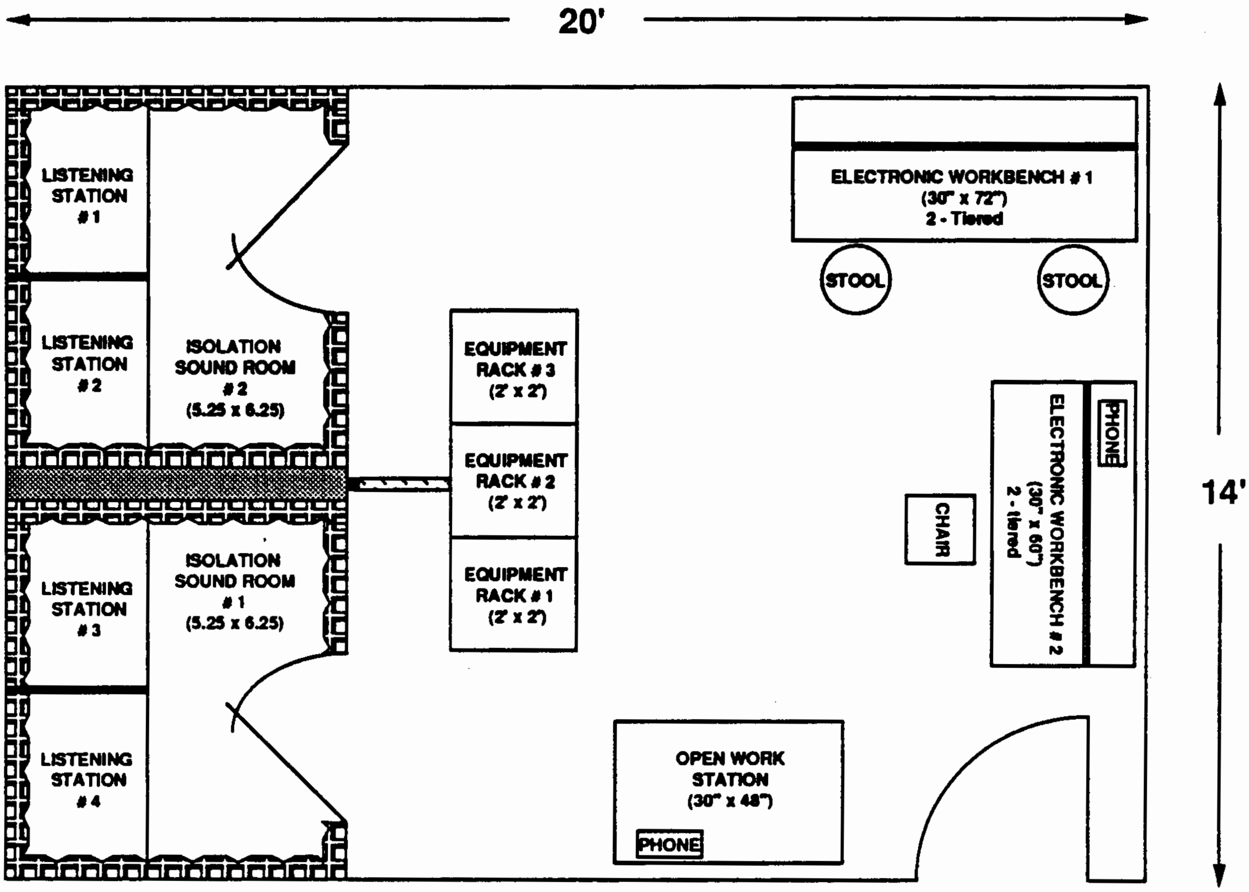

FIGURE 2.1. FAA CODEC TEST BED CONFIGURATION

2.2 FACILITY EQUIPMENT AND CONFIGURATION.

Appendix A lists the equipment required to conduct the Phase III low data rate voice CODEC Test Program. A functional diagram of the CTB equipment is shown in figure 2.2. The majority of the equipment required for the CODEC test facility will be rack mounted. Figure 2.3 illustrates the equipment rack configuration.

2.3 FACILITY CAPABILITIES.

The CTB will be used to conduct tests, demonstrations, and evaluations of low data rate voice CODECs in order to determine voice CODEC operating characteristics under the environmental conditions that may exist in ATC operations. The CTB will be multifunctional, expandable, and designed to provide rapid reconfiguration of test, demonstration, and evaluation scenarios.

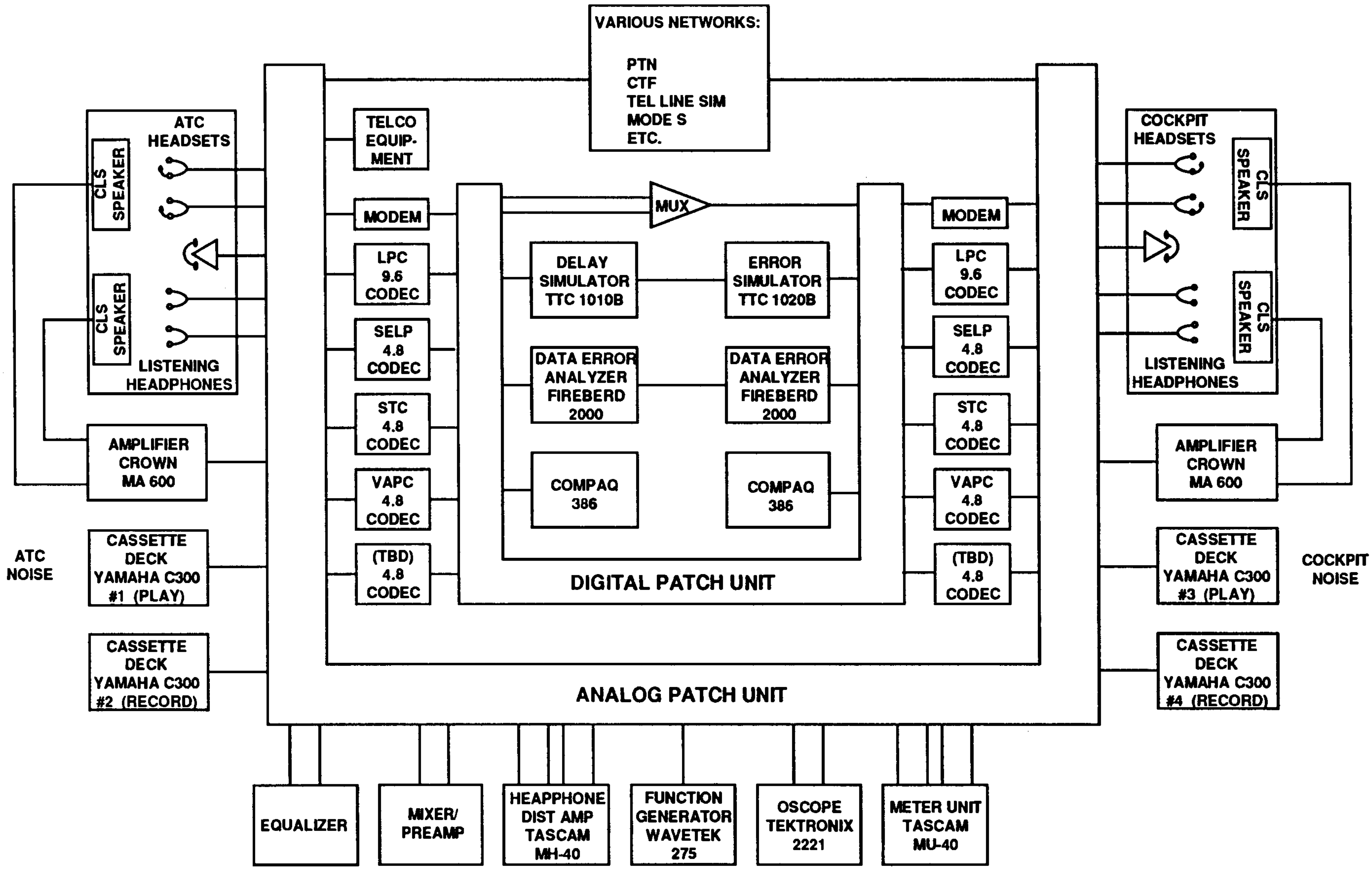

FIGURE 2.2. CTB EQUIPMENT FUNCTIONAL DIAGRAM

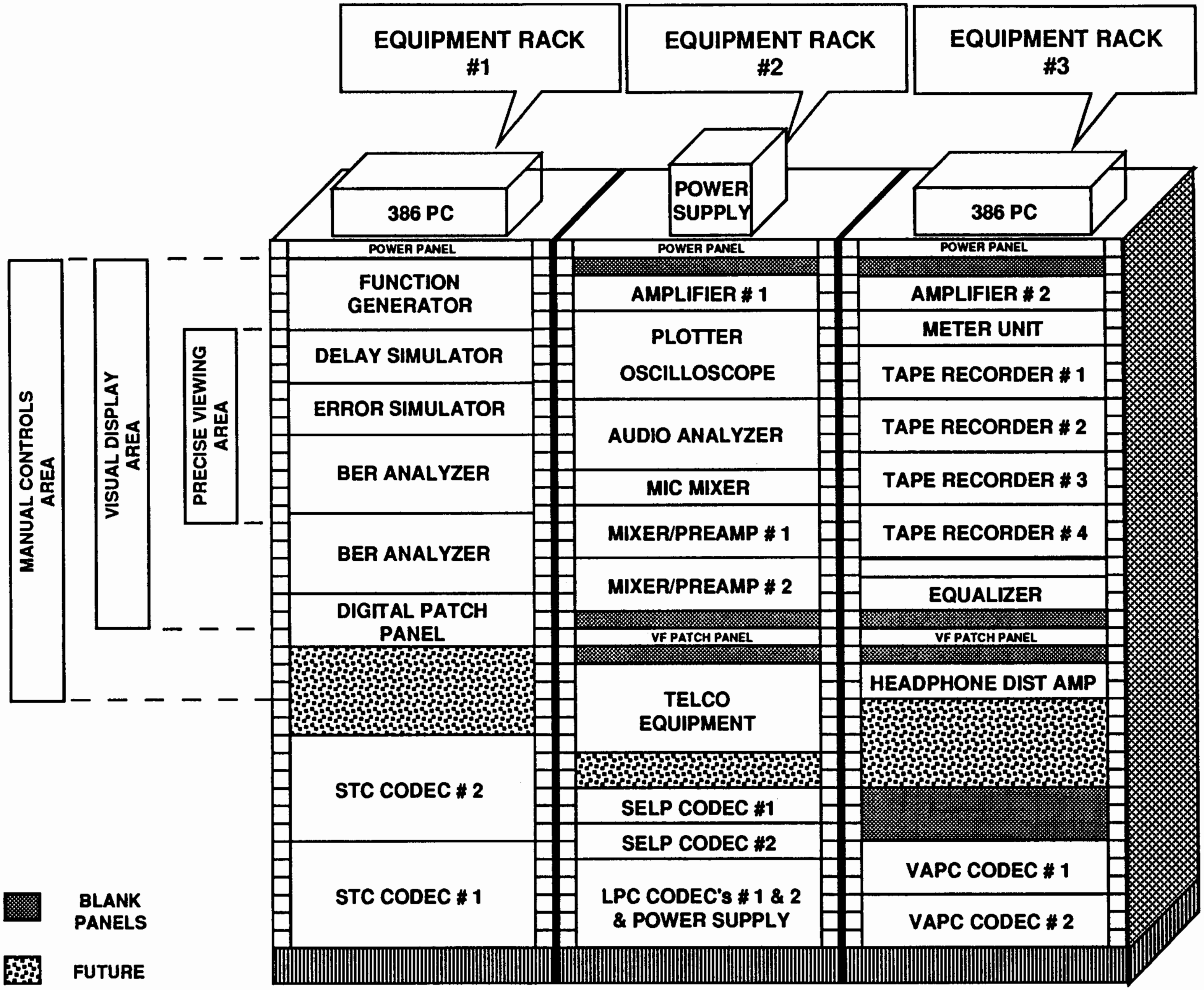

FIGURE 2.3. CTB EQUIPMENT RACK CONFIGURATION

The CTB will provide a realistic environment, featuring two sound isolation rooms, to evaluate low data rate CODECs. One isolation room will represent an ATC station; the other will represent a cockpit. Each room will be equipped with two wall-mounted speakers, monitors for display, related headsets (ATC and pilot), and 4-inch thick, sound-absorbing material lining the room interior. The isolation room configuration is shown in figure 2.4.

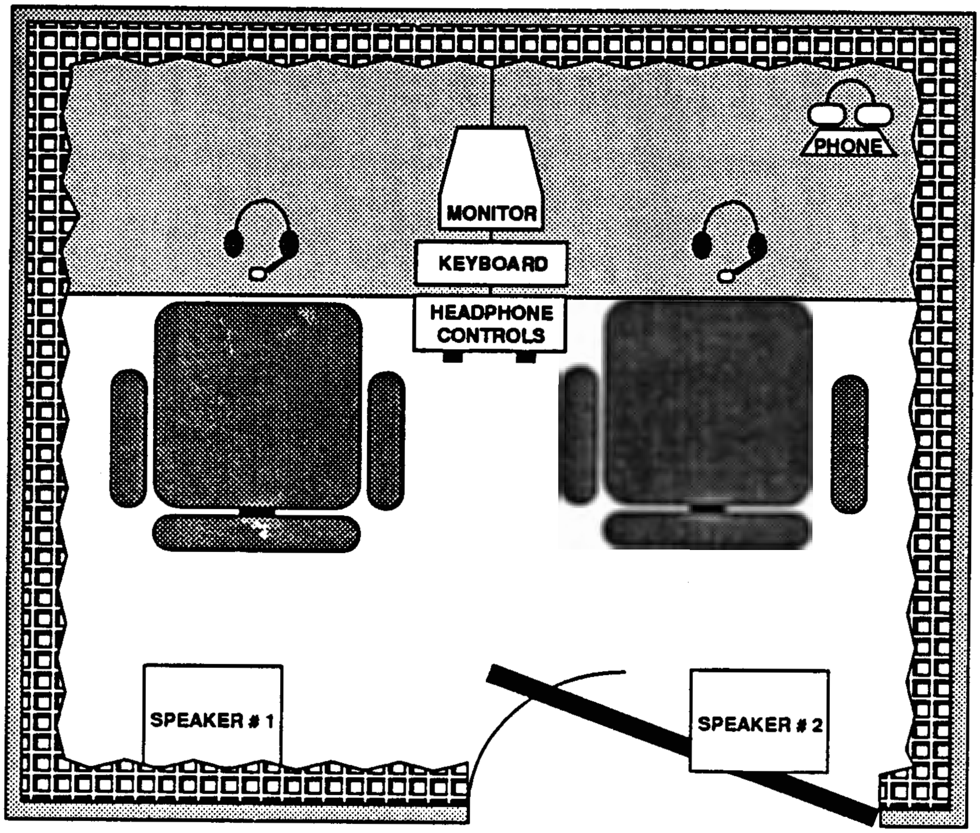

FIGURE 2.4. ISOLATION ROOM CONFIGURATION

The ATC and cockpit isolation rooms will be used for live demonstrations and evaluations during the Phase III Test Program. In addition, the isolation rooms will be used for general purpose voice recording sessions and listening evaluations.

The general equipment and work area contains electronic work benches. The benches provide the space required to work on CODECs, circuit boards, and interface assemblies.

2.4 VOICE CODECS.

CODECs from approximately five manufacturers are scheduled for testing in the CTB during Phase III. A 9.6 kbps CODEC pair using the British

Telecommunication Research Laboratory (BTRL) multipulse-excited Linear Predictive Coding (LPC) algorithm will be used for the Phase III Test Program because of its selection by the AEEC (Airlines Electronic Engineering Committee) as the standard algorithm for aeronautical telephone service. The BTRL voice CODEC will provide a baseline for comparison of the 4.8 kbps CODECs being tested.

A 4.8 kbps CODEC pair using a Stochastically Excited Linear Prediction (SELP) algorithm and a 4.8 kbps CODEC pair using a Sinusoidal Transform Coder (STC) algorithm were selected for testing because of their superior performance in the previous two phases of FAA CODEC evaluations.

In addition, two CODEC pairs will be included in Phase III testing that were previously unavailable for FAA testing: a 4.8 kbps CODEC pair using the University of California at Santa Barbara (UCSB) Vector Adaptive Predictive Coding (VAPC) algorithm and a 4.8 kbps CODEC pair using a Nippon Electric Company (NEC) algorithm. The UCSB voice CODEC was originally developed for NASA/JPL for use in their Mobile Satellite Experiment (MSAT-X).

Federal Standard 1016, entitled "Telecommunications: Analog to Digital Conversation of Radio Voice by 4,800 Bit/Second Code Excited Linear Prediction (CELP)," has been proposed by the Department of Defense (DOD) for the conversion of analog voice to a 4.8 kbps digitized form. When hardware becomes available, the FAA plans to obtain a pair of CODECs implementing the CELP algorithm for testing.

Other algorithms may be considered in future testing if hardware becomes available. Candidate algorithms for such testing are Improved Multi-Band Excitation (IMBE) and Vector Sum Excitation Linear Prediction (VSELP).

3. TEST PLAN AND PROCEDURES.

During the Phase III Test Program, the following tests are scheduled to be conducted:

a. Test 1 - CODEC Processing Delay.

b. Test 2 - Phase III Acceptability/Intelligibility Tests.

c. Test 3 - Extreme Background Noise Evaluation.

d. Test 4 - Network Demonstrations.

e. Test 5 - Non-Native Speaker Evaluations.

f. Test 6 - Voice Storage and Packet Demonstration.

g. Test 7 - DTMF and Supervisory Signaling.

The FAA will conduct the above tests with the following objectives:

a. Evaluate the performance and demonstrate the capabilities of low data rate voice CODECs for ATC applications.

b. Specifications support for the development of low data rate digitized voice for ICAO SARPS and RTCA MOPS.

c. Recommendation of a low data rate voice CODEC standard for AMSS ATC communications use.

The FAA will make a CODEC standard recommendation based primarily from the results of Test 2. These results will be presented in a tabular form similar to table 3.0.

3.1 TEST 1 CODEC PROCESSING DELAY.

3.1.1 Purpose.

This test will measure empirically specific back-to-back voice CODEC processing delays. These measurements will be compared to the calculated delays provided by the CODEC manufacturers and a proposed back-to-back 4.8 kbps CODEC processing delay requirement will be submitted for SARPS. In addition, the back-to-back processing delay of the BTRL CODEC pair will be measured and used to define the AMSS voice transfer delay requirement for the ICAO SARPS and RTCA MOPS.

3.1.2 Introduction.

A limit to the total transmission delay, using a 4.8 kbps CODEC, must be specified for AMSS. This allowable delay must not adversely affect transmission of voice safety messages. The free space transmission path delay between an aircraft and a ground earth station via a geosynchronous satellite will range from approximately 235 to 270 milliseconds. The exact path delay depends on the location of the aircraft and earth station antennas with respect to the longitudinal position of the satellite over the equator. Although this is the primary source of delay, additional sources encountered in the end-to-end transmission path (such as coding, digitizing, interleaving, modulation, etc.) must be accounted for in determining total transmission delay. ARINC Characteristic 741 suggests the total system delay (including processing time, propagation delay, and subsystem delays) in a one-way (earth-to-satellite-to-earth) aeronautical satellite communications link should not exceed 400 milliseconds. Characteristic 741 also suggests the maximum back-to-back CODEC processing delay should not exceed 65 milliseconds (based on a 9.6 kbps rate). Lower data rate CODECs generally require a longer processing time which is expected to exceed 65 milliseconds (Related Documents, item c).

The calculated end-to-end processing delay (provided by the CODEC manufacturers) for each CODEC algorithm, scheduled for testing during Phase III, is:

TABLE 3.0. FAA LOW DATA RATE CODEC RECOMMENDATION CRITERIA

	RECOMMENDATION CRITERIA	BTRL (LPC, 9600)	AT & T (SELP, 4800)	MIT LL (STC, 4800)	UCSB (VAPC, 4800)	NEC (TBS, 4800)	TBS (CELP, 4800)
ACCEPTABILITY MOS SCORES	DAM/ATC (QUIET, 0.1% BER)						
	DAM/ATC (ATC ROOM, 0.1%)						
	DAM/ATC (COCKPIT, 0.1%)						
	MEAN @ 0.1%						
	DAM/ATC (QUIET, 1%)						
	DAM/ATC (ATC ROOM, 1%)						
	DAM/ATC (COCKPIT, 1%)						
	MEAN @ 1%						
INTELLIGIBILITY DRT SCORES	DRT/ATC (QUIET, 0.1% BER)						
	DRT/ATC (ATC ROOM, 0.1%)						
	DRT/ATC (COCKPIT, 0.1%)						
	MEAN @ 0.1%						
	DRT/ATC (QUIET, 1%)						
	DRT/ATC (ATC ROOM, 1%)						
	DRT/ATC (COCKPIT, 1%)						
	MEAN @ 1%						
	MEASURED DELAY						
	COST per CODEC BOARD						
	LICENSING (ROYALTY FREE)						
	ALGORITHM/SOURCE CODE						
	GEAR SHIFT (2.4, 4.8, 9.6)						
	CARD SIZE						
	H/W BLOCK DIAG, SCHEMATIC						
	DSP CHIP AVAILABILITY						
	PASS 300/600/1200 BPS						
	PASS DTMF						
	RESYNCHRONIZATION TIME						
	AVAILABILITY						

CODEC	ALGORITHM	DATA RATE (bps)	DELAY (ms)
BTRL	LPC	9600	40
AT & T	SELP	4800	156
MIT LL	STC	4800	120
UCSB	VAPC	4800	60
NEC	[TBS]	4800	[TBS]
[TBS]	CELP	4800	[TBS]

These values will be validated through testing.

Other delays must also be taken into account when assessing the end-to-end delay of an AMSS voice circuit. Among these delays are timing constraints associated with the burst mode of operation in the outbound direction and AMSS equipment delays associated with arranging data for transmission within the C-channel frame structure.

3.1.3 Test Method.

The test configuration that will be used to measure CODEC processing delay is illustrated in figure 3.1.3. Measuring the delay will involve operating the CODECs back-to-back. A function generator, producing a low frequency burst signal, will provide the input. A dual trace oscilloscope, triggered on the leading edge of the burst signal, will be used to measure the time delay between the input and output signals. The resulting delay measurement will be equivalent to the CODEC processing time. Each CODEC is to have two delay measurement trials to ensure correct instrument calibration. This will be followed by 25 test measurements used to measure the delay.

3.1.4 Data Collection and Analysis.

The test data sheet that will be used to record the measurements for each trial is shown in figure 3.1.4. The mean of the measured delays will be compared to the calculated delays from the manufacturers. The standard deviation will be calculated to describe the variability of the delay measurements. A hard copy of the oscilloscope displays will be analyzed and appended to the test report. The final results of the delay measurement tests will be analyzed and a recommendation of a maximum back-to-back 4.8 kbps CODEC processing delay limit will be proposed for inclusion in the ICAO AMSS SARPS and the RTCA AMSS MOPS.

3.1.5 Test Report.

The results, conclusions, and recommendations of Test 1 will be provided in a separate test report prepared in accordance with FAA Order CT 1710.2B, Preparation and Issuance of Formal Reports, Technical Notes, and Other Documentation.

3.1.6 Schedule.

Conduct Test	May 1990 - June 1990
AMSSP Information Paper	July 1990

3.2 TEST 2 PHASE III ACCEPTABILITY/INTELLIGIBILITY TESTS.

3.2.1 Purpose.

This test will evaluate each voice CODEC pair on acceptability as measured by MOS, and intelligibility as measured by Diagnostic Rhyme Test (DRT), in a simulated aeronautical satellite environment. Specifications for MOS and DRT values will be developed and recommendations will be made in accordance with the ICAO SARPS and RTCA MOPS for AMSS.

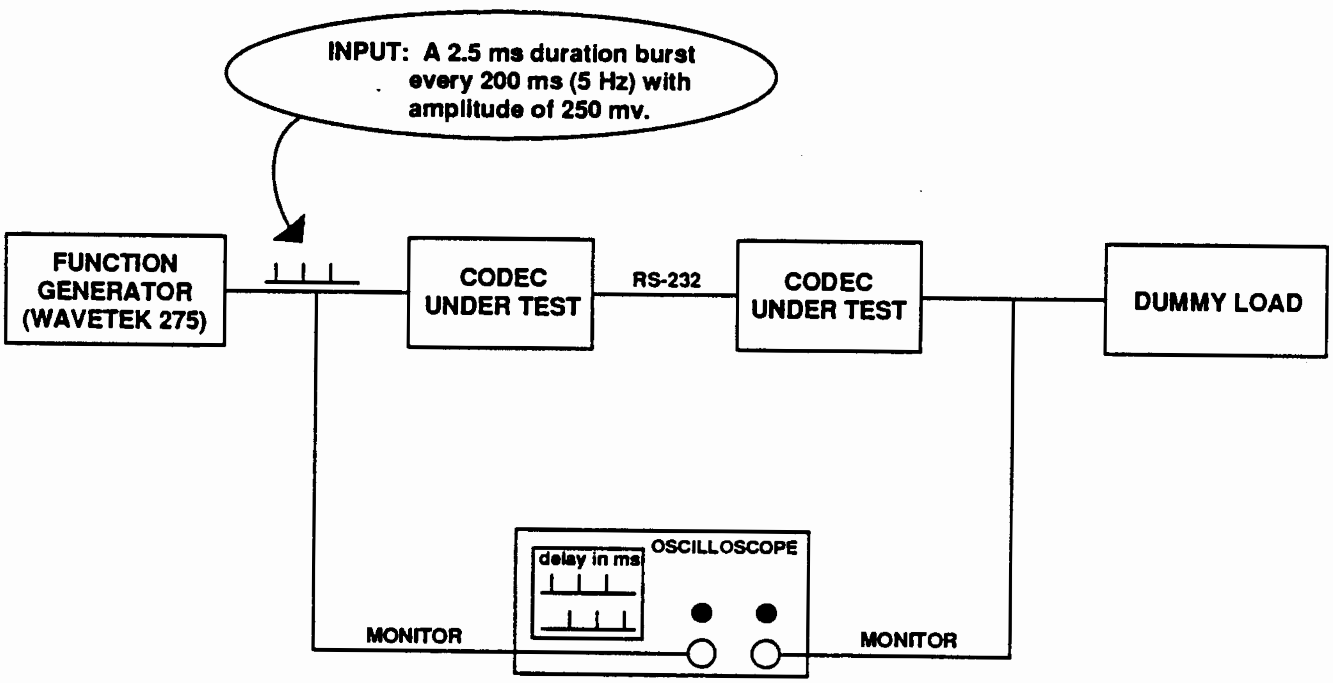

FIGURE 3.1.3. CODEC DELAY MEASURE CONFIGURATION

	CODEC DELAY IN MILLISECONDS					
CODEC →	LPC 9600	SELP 4800	STC 4800	VAPC 4800	??? 4800	??? 4800
CD	40	158	120	60	***	***
MD TRIAL # 01						
MD TRIAL # 02						
MD TRIAL # 03						
MD TRIAL # 04						
MD TRIAL # 05						
MD TRIAL # 06						
MD TRIAL # 07						
MD TRIAL # 08						
MD TRIAL # 09						
MD TRIAL # 10						
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MD TRIAL # 18						
MD TRIAL # 19						
MD TRIAL # 20						
MD TRIAL # 21						
MD TRIAL # 22						
MD TRIAL # 23						
MD TRIAL # 24						
MD TRIAL # 25						
MEAN						
SD						

*** - To Be Supplied.

CD - Calculated Delay provided by manufacturers.

MD - Measured Delay.

SD - Standard Deviation.

FIGURE 3.1.4. CODEC DELAY TEST DATA SHEET

3.2.2 Introduction.

3.2.2.1 Acceptability Tests.

Past FAA voice CODEC testing involved only previously recorded CODEC processed audio. The FAA Phase III acceptability tests will focus on real-time operation of voice CODECs in a simulated ATC environment. The "realistic scenario" will be centered around the isolation rooms representing an ATC station and a cockpit station. A separate acceptability test will focus on a comparison between VHF/HF communications and CODEC processed speech.

One of the most common forms of acceptability evaluation for subjective speech quality is the MOS system. The speech material normally used in this approach is a set of phonetically balanced DAM sentences (Related Documents, item d). In the simplest form of the test, an MOS evaluator rates the acceptability of the processed sentence on a scale of 1 to 5. An MOS score of 5 indicates perfect quality, a score of 4 or more indicates high quality ("toll-quality" in the telephony field), while MOS scores of 3 to 4 are referred to as "communication-quality" (Related Documents, item e). The current ARINC Characteristic 741 quality objective suggests the output quality is acceptable to most people (as demonstrated by an MOS rating of 3.25 or better), where the input Bit Error Rate (BER) is no worse than 10E-3 (based on 9600 bits per second (bps) data rate). In the FAA testing, both DAM sentences and ATC dialogue sentences will be used for acceptability testing.

3.2.2.2 Intelligibility Tests.

The intelligibility of digitized voice communications will be evaluated, using objective measures, to determine its correlation with a subjective evaluation of acceptability for each CODEC.

One of the most common forms of intelligibility testing is the Diagnostic Rhyme Test (DRT) or Modified Rhyme Test (MRT). This test is based on listeners' ability to distinguish between rhyming words. DRT scores are given in percent of correct answers. The current ARINC characteristic quality objective suggests intelligibility based on DRT or MRT is 92 percent or better under quiet conditions and 87 percent under Airborne Command Post (ABCP) noise levels (at 9600 bps data rate). In the FAA testing, both rhyming word pairs and ATC dialogue/phrases will be used for an intelligibility testing.

3.2.3 Test Method.

One of the isolation rooms within the CTB will accommodate two ATC personnel, the controller and his assistant. They will be equipped with standard controller headsets. A display monitor and keyboard will provide the ATC personnel with pseudo ATC related tasks so that their mental load will not concentrate on voice communications exclusively. ATC room background noise will be played through the speakers at the appropriate levels during the evaluations.

The other isolation room will also accommodate two people, a pilot and copilot. They will be equipped with standard aviation headsets.

A display monitor and keyboard will also provide the pilot and copilot personnel with pseudo ATC related tasks so that their mental load will not concentrate on voice communications exclusively. Cockpit background noise will be played through the speakers at the appropriate levels (based on FAA N-40 aircraft cockpit noise recordings) during the evaluations.

Figure 3.2.3 illustrates the equipment configuration that will be used for the Phase III acceptability testing. The controller headsets and aviation headsets will be connected to a voice CODEC audio interface panel. The CODEC pair under test will be connected back-to-back in a full-duplex mode via the link delay and error simulators using an RS-232 interface. The delay simulator duplicates the delay conditions of approximately 270 milliseconds, typical of satellite communications links. The error simulator will be programmed to induce randomly distributed errors and burst error conditions that are typical of satellite link impairments.

The speech message material that will be used for this test is in appendix B. It includes ATC dialogue, DAM sentences, and DRT word pairs. These test scripts will provide the material for the "realistic" tests as well as provide the basis for ATC related actions (ATC dialogue only) by controllers and pilots who will be the test participants.

Seven ATC personnel and seven pilots will participate in the acceptability evaluations. The evaluation forms that will be used are shown in appendix B.

Tape recordings will be made of the ATC personnel and pilots using the CODEC processed voice of the appendix B material under the above conditions. These recordings will be used for an independent intelligibility measure. A separate group of non-ATC personnel will listen to the tapes and fill out the intelligibility test form in appendix B. It should be noted that Phase II testing demonstrated that the ATC personnel and non-ATC personnel test results were essentially the same.

In addition, separate acceptability tests will be conducted to compare VHF/HF voice communications with CODEC processed voice.

Archive tapes of sample VHF and HF communication ATC dialogue will be obtained from Aeronautical Radio Incorporated (ARINC) and the Canadian MOT. Dialogue excerpts from these tapes will be transcribed and reread by ATC and pilot personnel. Tapes of these readings will be processed through CODECs. Comparisons will be made of the original radio communications to the CODEC processed speech through acceptability testing.

3.2.4 Data Collection and Analysis.

Acceptability measures (e.g., MOS scores) will be determined for the ATC dialogue and DAM sentences by the FAA under various noise and BER conditions. Intelligibility measures (e.g., DRT scores) will also be determined for the ATC dialogue and DRT word pairs by the FAA under various noise and BER conditions.

An independent evaluation laboratory, such as Dynastat, Inc., will be contracted to perform evaluations subsequent to the FAA CODEC testing. Only CODECs that were determined to be acceptable to the ATC community will be

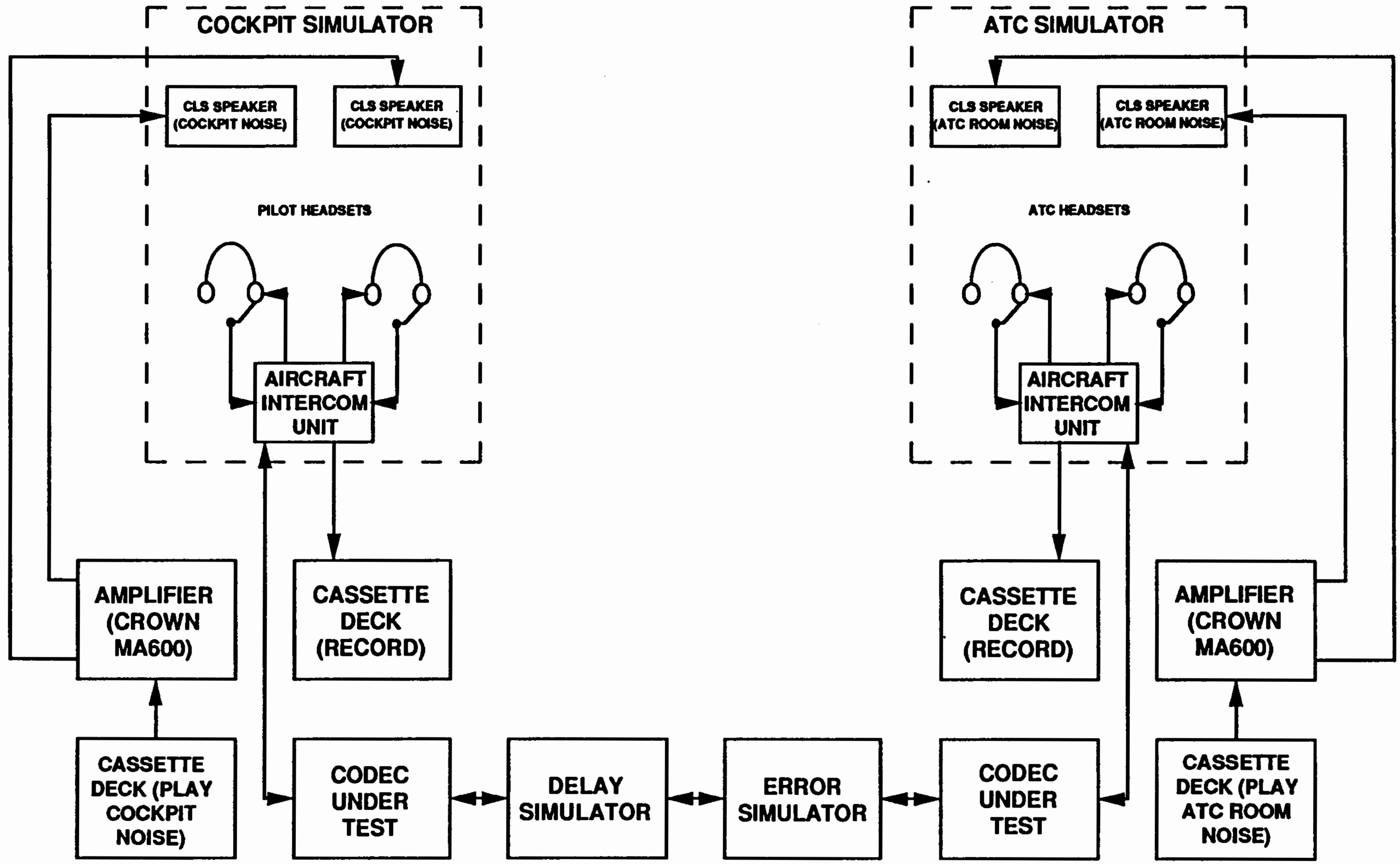


FIGURE 3.2.3. ACCEPTABILITY TESTING CONFIGURATION

evaluated by the independent laboratory. The results of the independent testing will be compared to the FAA's to develop a level of confidence.

The final results of the acceptability/intelligibility evaluations will be analyzed and recommendations of acceptability and intelligibility requirements will be proposed for inclusion in the ICAO AMSS SARPS and the RTCA AMSS MOPS for ATC communications. In addition, all MOS and DRT scores will be recorded in table 3.0 as part of the criteria for a standard low data rate voice CODEC recommendation.

3.2.5 Test Report.

The results, conclusions, and recommendations of Test 2 will be provided in a separate test report prepared in accordance with FAA Order CT 1710.2B, Preparation and Issuance of Formal Reports, Technical Notes, and Other Documentation.

3.2.6 Schedule.

Conduct Test	July - December 1990
Test Report	January 1991

3.3 TEST 3 EXTREME BACKGROUND NOISE EVALUATION.

3.3.1 Purpose.

This test will determine performance of voice CODECs exposed to extreme cockpit noise levels (above 100 decibel (dB) where 0dB = 0.0002 microbar). The results of this test will be used to determine appropriate noise specifications related to the use of digitized voice for ICAO SARPS.

3.3.2 Introduction.

The Phase II CODEC tests included cockpit noise levels of up to 83 dB (measured at cruise condition in the FAA N-40 aircraft). The results showed noise levels of this magnitude degraded CODEC performance when using a professional omnidirectional microphone. The FAA has not formally tested CODECs at levels above this magnitude. This extreme background noise has implications to domestic applications. This test will be conducted in conjunction with Test 2 due to convenience, but the results will be included in a separate report on CODEC performance in domestic applications.

A recent Sound Pressure Level (SPL) reading in the FAA's Aerocommander aircraft measured SPL up to 110 dB. The SPL in a helicopter cockpit is expected to be higher. The FAA will evaluate these conditions using standard aviation headsets instead of omnidirectional microphones. Most aviation headsets have noise attenuating characteristics that vary depending on application. The FAA will use a David Clark Model headset rated to function acceptably in noise levels up to 120 dB SPL.

3.3.3 Test Method.

A helicopter cockpit background noise source tape will be recorded using a Yamaha (C-300) professional tape recorder and a wide dynamic range omnidirectional microphone aboard the FAA Technical Center's Sikorsky S-76 and Bell (Huey) UH-1N helicopters. The microphone will be strategically placed in the helicopter cockpit to record airstream and engine noises as well as extraneous noises. A SPL meter will be used to measure the noise level at the microphone during recording. This will establish an SPL reference for playback and rerecording in the CTB.

Recordings were already made in the FAA's Aerocommander aircraft using the same procedure above. These background noise source tapes will be used as in Test 2, as part of the Acceptability and Intelligibility tests, conducted in high background noise.

3.3.4 Data Collection and Analysis.

The data collection and analysis section for Test 3 will be identical to that same section in Test 2. Refer to section 3.2.4 for details.

3.3.5 Test Report.

The results, conclusions, and recommendations of Test 3 will be provided in a separate test report prepared in accordance with FAA Order CT 1710.2B.

3.3.6 Schedule.

Conduct Test	August 1990 - December 1990
Test Report	January 1991

3.4 TEST 4 NETWORK DEMONSTRATIONS.

3.4.1 Purpose.

This test will demonstrate the effects on voice quality of interfacing CODECs to various outside communication networks. These networks include the public switched telephone networks (PSTNs) and the AMSS network via the FAA Communication Test Facility (CTF). The information obtained from this test will be used to validate the system level voice requirements in the RTCA AMSS MOPS.

3.4.2 Introduction.

In ATC applications, CODEC processed voice may be transmitted via other communication networks (besides the satellite link) depending upon the location of the end users. The additional transmission impairments in PSTNs and dedicated networks impose a major concern to the FAA and require further investigation.

3.4.2.1 PSTN.

When the CODEC for the terrestrial end of an AMSS circuit is located at the ground earth station (GES), the CODEC processed voice has to be transmitted via an analog or digital telephone circuit to the ARTCC. The potential effects of the telephone circuit quality on the CODEC processed voice will be investigated.

3.4.2.2 AMSS.

CODEC processed voice will be transmitted to the CTF, relayed over the satellite link, and returned to the CTB via terrestrial network for analysis.

3.4.3 Test Method.

For the PSTN demonstration, an interface box will be built to interface a balanced 600 ohm XLR-3 connecter output of a professional tape recorder to an RJ11 phone connecter. Figure 3.4.3a shows part 1 of the configuration for the PSTN demonstration. The master recordings from Test 2 will be played through the phone system at various locations to evaluate the effects of processed and reconstituted speech.

Part 2 of the PSTN will include the master scripts being read through the same phone system to the same locations to be recorded at the opposite end as shown in 3.4.3b. The end recording will then be processed through each CODEC.

Parts 1 and 2 will allow evaluation of the transmission of the voice signal over the analog telephone link before and after CODEC processing.

In addition, a telephony channel simulator will be used to simulate the effects of digital pulse code modulation (PCM) telephone services on CODEC processed voice. The above test methodology used for the analog PSTN demonstration will be used with the PCM simulator. The final CODEC and PSTN/PCM simulated processed audio tapes will be edited for a demonstration tape and undergo an informal comparison to the CODEC processed audio tapes.

The CTB/CTF interface and testing will be defined in the AMSS Test Plan (Related Documents, item f).

3.4.4 Data Collection and Analysis.

Not required as this is a demonstration only.

3.4.5 Demonstration Report.

The results, conclusions, and recommendations of Test 4 will be provided in a separate demonstration report prepared in accordance with FAA Order CT 1710.2B.

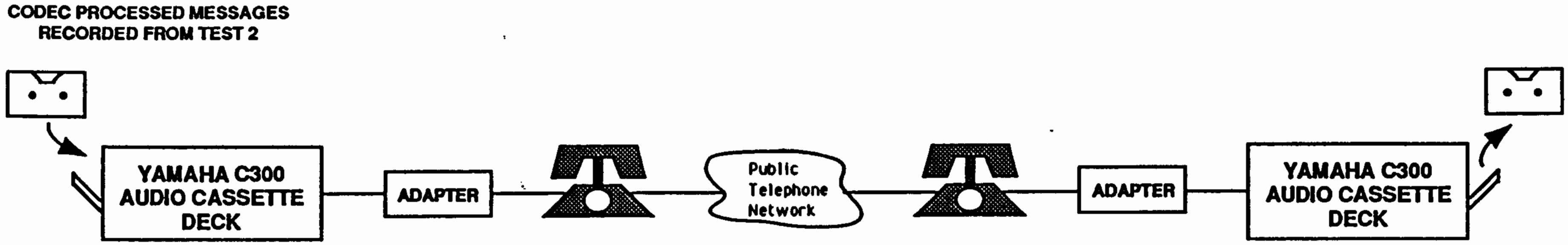
3.4.6 Schedule.

Conduct Demonstration	September 1990 - January 1991
Test Report	February 1991

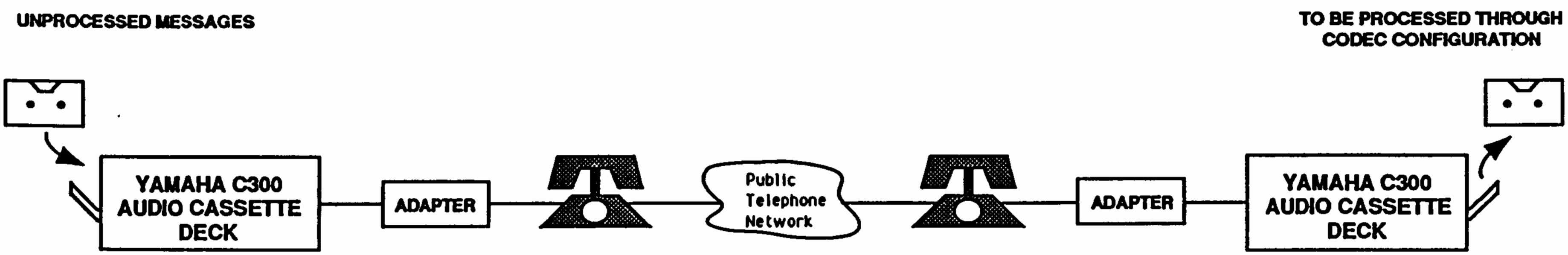
3.5 TEST 5 NON-NATIVE SPEAKER DEMONSTRATION.

3.5.1 Purpose.

This test will demonstrate the effects of foreign language and English in foreign accents on CODEC performance. The following languages are expected to be included: Spanish, French, Italian, Russian, German, and Japanese.



a. TRANSMISSION OF VOICE SIGNAL OVER THE ANALOG TELEPHONE LINK AFTER CODEC PROCESSING



b. TRANSMISSION OF VOICE SIGNAL OVER THE ANALOG TELEPHONE LINK BEFORE CODEC PROCESSING

FIGURE 3.4.3. CODEC TESTING WITH PSTN

3.5.2 Introduction.

Native controllers who are exposed to non-native pilots, on occasion have difficulty communicating in an ATC environment. Voice CODECs might add to this difficulty when processing certain non-native inflections. This could be of concern to oceanic controllers who are constantly exposed to non-native speaking pilots.

A recent study revealed that, "Overall, the bilinguals (non-native) made more errors than the monolinguals did in response to both natural and vocoded (at 8.0 kbps) speech" (Related Documents, item g). The overall errors indicated that the bilingual vocoded speech performed worse than the bilingual natural speech, monolingual vocoded speech, and monolingual natural speech, respectively. This study was performed using German-dominant German-English bilinguals and English monolinguals speaking semantically anomalous sentences. The FAA will include a variety of language groups to demonstrate the performance of bilingual CODEC processed speech. The advances of the low data rate CODECs included in Phase III are expected to improve this performance.

3.5.3 Test Method.

The foreign language demonstration is available to any country who wishes to supply the FAA with an input tape. It is expected that the aforementioned nationalities will be included. Both male and female speakers from each nationality will be asked to participate in the voice recordings. They will be asked to read the FAA supplied master script material in appendix A in both their foreign language and English with their foreign accents to be recorded. Each participating country will also be encouraged to provide additional relevant material, if desired. Each recording will be processed through each CODEC pair with various predetermined simulated satellite link impairments. The processed recordings will be sent to their respective countries for evaluation. A demonstration tape of all languages recorded will be prepared.

3.5.4 Data Collection and Analysis.

Each of the CODEC processed tapes will be sent to their respective countries for an informal evaluation. The FAA will collect the results and a determination of future testing and/or recommendations of improvement in voice intelligibility for specific language groups will be made.

3.5.5 Test Report.

The results, conclusions, and recommendations of Test 5 will be provided in a separate test report prepared in accordance with FAA Order CT 1710.2B.

3.5.6 Schedule.

Conduct Demonstration	August 1990 - February 1991
Test Report	March 1991

3.6 TEST 6 VOICE STORAGE AND PACKET DEMONSTRATION.

3.6.1 Purpose.

The test will demonstrate packet technology and its affects on voice CODECs when used for voice storage and delayed retrieval.

3.6.2 Introduction.

Packet communications techniques may be employed in future aeronautical satellite communications systems. The packet approach will allow the controller or pilot to transmit prescribed computer stored voice messages or reports upon a push button command. The FAA is interested in packet switching technology used with voice CODECs for the storage and delayed retrieval of voice messages between ATC controller and pilot. The FAA CTB will be used to demonstrate how low data rate CODEC voice messages can be transmitted and received over a digital communications link employing an X.25 communications protocol.

3.6.3 Test Method.

Figure 3.6.3 shows the configuration of the voice storage and packet demonstration. A pair of X.25 packet assembler/disassemblers (PADs) with 1200 baud audio frequency shift keying (AFSK) will be used to simulate the packet communications link. The PADs are supported at each end of the simulated link with a menu operated packet communications terminal software program installed in each microcomputer (PC). The PCs shown in figure 3.6.3 will serve as the transmit and receive voice terminals, respectively. At the transmit end, voice will be digitized by the sending CODEC then sent via an RS-232 bisynchronous bus to the transmit voice terminal (TVT) PC and stored as a HEX data file. Upon keyboard command at the TVT PC, the voice message will be sent via X.25 packet communications to the receive voice terminal (RVT) PC and stored as a HEX data file. Upon keyboard command at the RVT PC, the digitally stored voice message will be sent via an RS-232C bisynchronous bus to the (receive) CODEC. The digital voice message will be decoded and synthesized into analog voice form for evaluation.

3.6.4 Data Collection and Analysis.

Not required as this is a demonstration only.

3.6.5 Demonstration Report.

The results, conclusions, and recommendations of Test 5 will be provided in a separate test report prepared in accordance with FAA Order CT 1710.2B.

3.6.6 Schedule.

Conduct Demonstration	February 1991 - April 1991
Test Report	May 1991

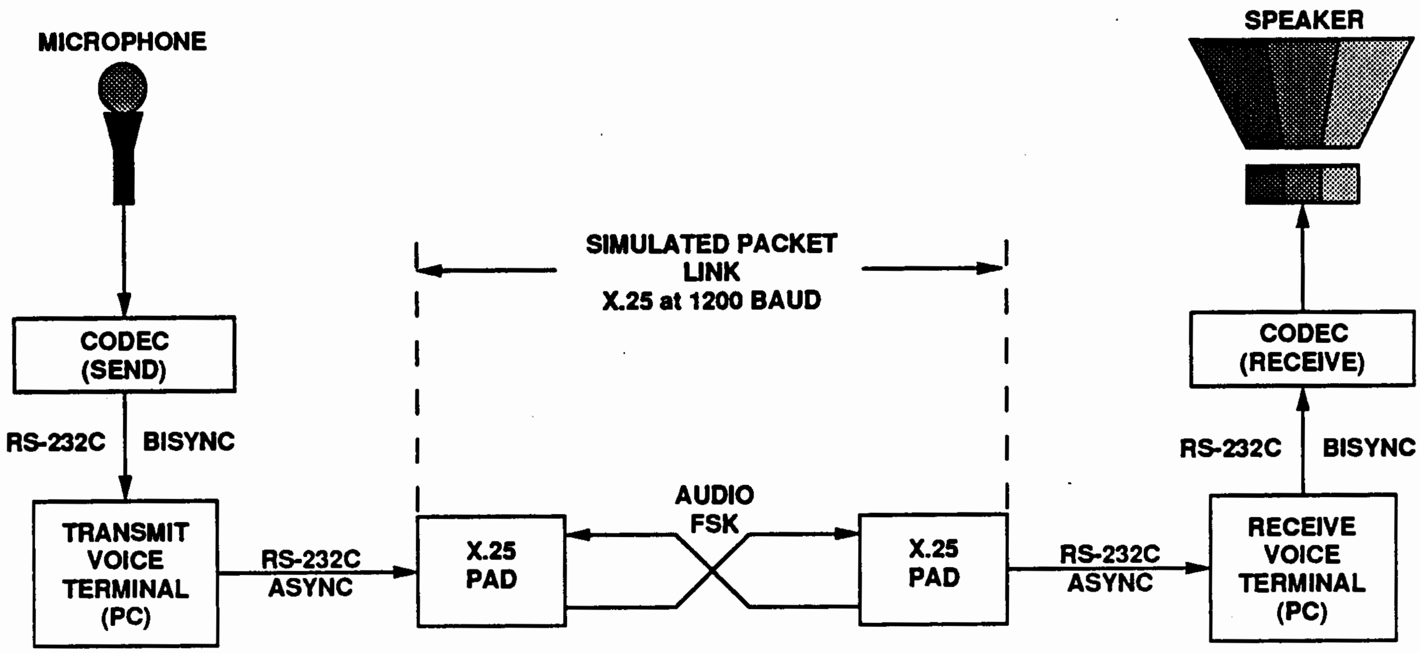


FIGURE 3.6.3. VOICE STORAGE AND PACKET DEMONSTRATION CONFIGURATION

3.7 TEST 7 DTMF and SUPERVISORY SIGNALING.

3.7.1 Purpose.

This test will determine the ability of the voice CODECs to pass dual tone multifrequency (DTMF) signals and single frequency supervisory tones. The purpose of this test is to provide information regarding alternative signaling methods that may be applicable to ICAO SARPS and RTCA MOPS.

3.7.2 Introduction.

The method of using audio tones via a telephone push button keypad to send a telephone number is known as DTMF signaling. The standard keypad has 12 keys, which represent the numbers 0 through 9 and the symbols "*" and "#" (some special purpose telephones use an additional column of keys for more signaling combinations as shown in figure 3.7.2). Pressing one of the keys generates two separate tones simultaneously in the voice band. For example, pressing key 6 generates a 770 hertz (Hz) tone and a 1477 Hz tone. The 16 keypad layout uses eight tones. Each is an inband signal within the voice frequency range of 300 to 3,000 Hz. The 16 keypad layout and eight separate frequencies used are international standards, but the frequency tolerances may vary for different countries. The U.S. standards are plus or minus 1.5 percent for the generator and plus or minus 2 percent for the digit receiver (Related Documents, items h and i).

A digit receiver in the central office processes the tones that appear on the line. There are frequency selective filters in the digit receivers that pass only the frequencies used for DTMF. In addition, timing circuits ensure that a certain tone is present for a specified minimum time (50 milliseconds in the U.S.) before a DTMF signal is accepted.

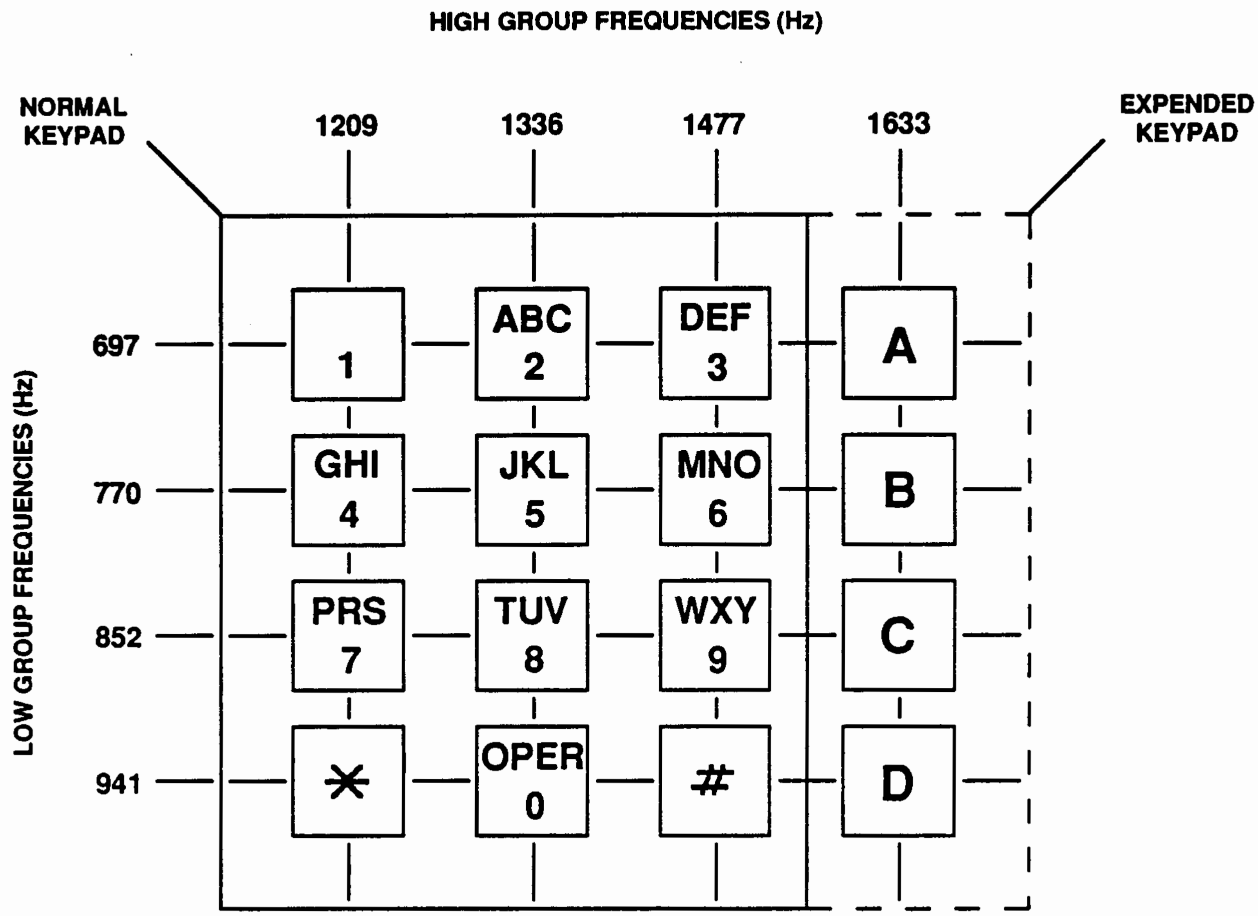


FIGURE 3.7.2. 16 BUTTON KEYPAD CONFIGURATION

The digit receiver is removed from the circuit once the call is connected. This permits DTMF tones to be transmitted over the circuit for use in user communications applications. The FAA wants to verify that voice CODECs can pass inband DTMF signals.

3.7.3 Test Method.

Figure 3.7.3 illustrates the test configuration that will be used to verify the voice CODEC can pass DTMF signals. Two touch tone telephones will be connected to end user CODECs. The CODECs will be connected to the satellite simulator. A pair of modems will convert the digital signals from the satellite simulator to telephone compatible signals for transmission through a PBX. An oscilloscope will be used to measure line levels and durations. Each button on the telephone keypad is depressed once for a duration to exceed 50 milliseconds. The tone frequencies will be measured using DTMF filters and a frequency counter.

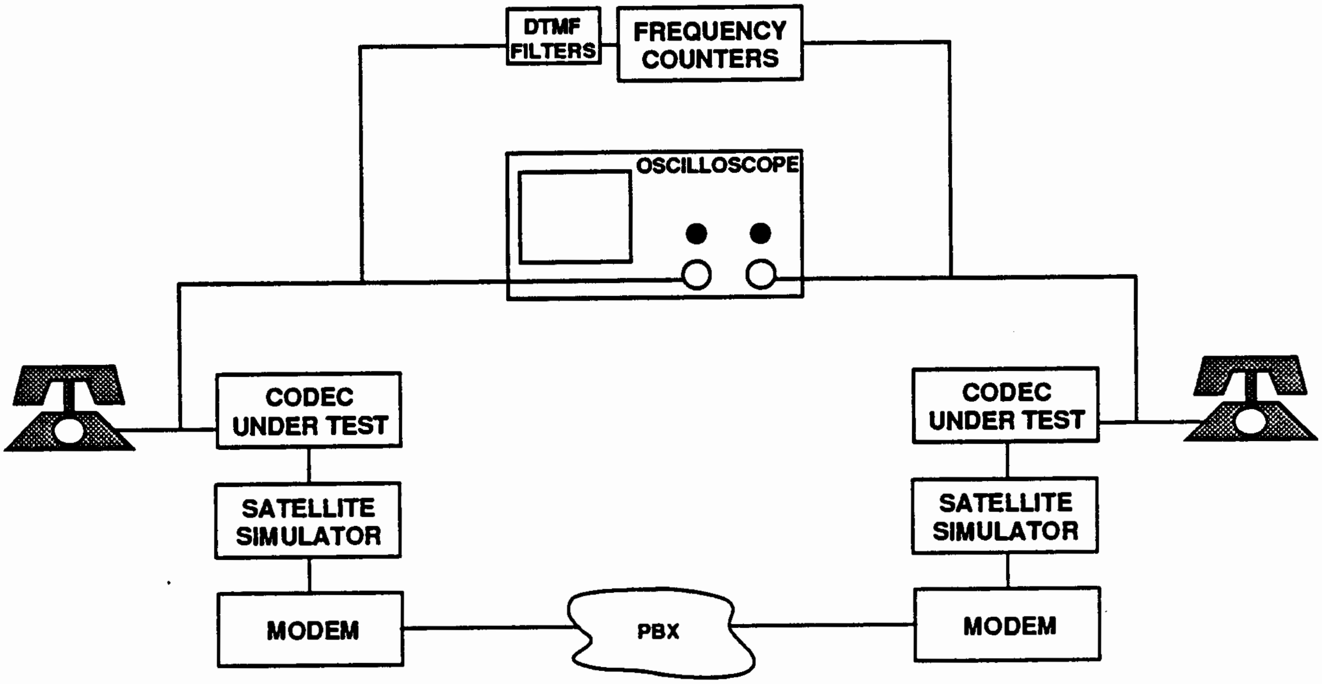


FIGURE 3.7.3. DTMF SIGNALING TEST CONFIGURATION

3.7.4 Data Collection and Analysis.

Figure 3.7.4 shows the test data sheet that will be used to record the measurements. A hardcopy of the oscilloscope displays will be analyzed and appended to the test report.

3.7.5 Test Report.

The results, conclusions, and recommendations of Test 8 will be provided in a separate test report prepared in accordance with FAA Order CT 1710.2B.

3.7.6 Schedule.

Conduct Test	March 1991 - May 1991
Test Report	June 1991

4. FINAL DATA ANALYSIS.

An analysis of Phase III test results will be conducted to evaluate use of low data rate voice CODECs in the satellite aeronautical environment and to support the development of low data rate digitized voice requirements specified in the ICAO AMSS SARPS and the RTCA AMSS MOPS. The results are expected to further substantiate use of 4.8 kbps voice CODECs as a feasible and acceptable alternative to current ATC communications as well as 9.6 kbps voice CODECs. Eventually, the FAA testing results are expected to lead to a

CODEC ALGORITHM ____________________

KEY OR SUPERVISORY SIGNAL	FREQUENCIES (LOW/HIGH)	MEASURED FREQUENCIES (LOW/HIGH) BEFORE CODEC	MEASURED FREQUENCIES (LOW/HIGH) AFTER CODEC	LINE LEVEL	DURATION
1	697/1209				
2	697/1336				
3	697/1477				
4	770/1209				
5	770/1336				
6	770/1477				
7	852/1209				
8	852/1336				
9	852/1477				
*	941/1209				
0	941/1336				
#	941/1477				
A	697/1633				
B	770/1633				
C	852/1633				
D	941/1633				
SEIZE	2250				
SEIZE ACKNOWLEDGE	570				
DIAL TONE	425				
RELEASE ACKNOWLEDGE	2600				
ERROR	425/1050				

FIGURE 3.7.4. DTMF SIGNALING DATA SHEET

proposed standard for low data rate voice CODECs for ATC communications. The proposed standard will be selected by the FAA based on criteria similar to the outline in table 3.0.

Upon completion of this test phase, a detailed final test report will be prepared to consolidate the voice CODEC performance capabilities and limitations identified in the Phase III Test Program.

Reports on the final results will be distributed appropriately to the various participating industrial parties, including INMARSAT, Communication Satellite Corporation (COMSAT), American Mobile Satellite Company (AMSC), and Airlines Electronic Engineering Committee (AEEC). Governments specifically interested in the subject of digitized voice for AMSS, such as Australia, Canada, England, France, Japan, and Russia, will also receive the reports.

5. FUTURE TESTS.

The CTB will be available to conduct additional tests, evaluations, or demonstrations of low data rate voice CODECs for interested international organizations related to the AMSS.

Technologies for voice CODECs operating at data rates of 2.4 kbps and lower are maturing. The lower data rates are attractive for bandwidth and power efficiency. CODEC manufacturers are contacted periodically concerning developments of low data rate coding techniques that could possibly improve voice intelligibility. It is apparent that as the lower data rate technologies improve, a series of tests will be required to evaluate the potential benefits to ATC operations.

6. AREAS OF RESPONSIBILITY.

ADS-100 - Responsible for program management and funding for satellite communications projects, which includes the implementation of digitized voice on satellite links. Will provide the U.S. ICAO member to the Aeronautical Mobile Satellite Service Panel (AMSSP) and the representative to the RTCA committees.

ACD-330 - Responsible for all Technical Center activities. Will monitor SARPS tests, Automatic Dependent Surveillance (ADS) tests, and conduct flight tests. Will obtain Federal Communication Commission (FCC) licenses and coordinate the Memoranda of Agreement between the FAA and other organizations, such as Canadian MOT, Japanese Civil Aviation Board, COMSAT, etc.

CTA - Responsible to ACD-330 in low data rate digitized voice testing activities. Will provide test engineering services, develop test plans, implement and operate the CTB, conduct tests, perform data analysis, and provide test reports.

COMSAT - Responsible for obtaining free use of INMARSAT space segment and for providing FAA access to the ground earth station (GES) for CODEC testing.

7. CONSOLIDATED SCHEDULE.

ACTIVITIES	MAY 90	JUN 90	JUL 90	AUG 90	SEP 90	OCT 90	NOV 90	DEC 90	JAN 91	FEB 91	MAR 91	APR 91	MAY 91	JUN 91	JUL 91	AUG 91
1. CODEC BACK-to-BACK PROC DELAY (TEST 1)	▼	▽	◆													
2. PHASE III ACCEPT/INTEL TESTS (TEST 2)			▼					▽	◆							
3. EXTREME BACKGROUND NOISE TESTS (TEST 3)				▼				▽	◆							
4. NETWORK DEMOS (TEST 4)					▼				▽	◆						
5. NON-NATIVE SPEAKER DEMOS (TEST 5)				▼						▽	◆					
6. VOICE STORE & PACKET DEMOS (TEST 6)										▼		▽	◆			
7. DTMF & SIGNALLING TESTS (TEST 7)											▼		▽	◆		
8. PHASE III FINAL TEST REPORT			▼												▽	◆

▼ START
▽ FINISH
◆ REPORT

APPENDIX A

CTB TEST EQUIPMENT LIST

ITEM #	QUANTITY	EQUIPMENT	FUNCTION
1	1	DIGITAL DELAY SIMULATOR (TTC Model 1010B-1) w/ RS-232C, V.35/306, and DSI 1.544 MB/S Interfaces	Simulates a full duplex satellite link by inserting a delay in the transmission path. The amount of delay can be programmed in 1 ms steps from 0 to 999 ms.
2	1	DIGITAL ERROR SIMULATOR (TTC Model 1020B-1) w/ RS-232C, V.35/306, and DSI 1.544 MB/S Interfaces	Introduces Guassian (randomly distributed) and/or burst bit errors into the transmission path to simulate error conditions on a satellite link. The Guassian error rate may be programmed to any value between 1E-11 and 5E-1. The burst error rate may be programmed to any value between 1E-9 and 5E-1, with a burst duration of 5 ms to 9995 ms, and a burst repitation interval of 10 ms to approximately 3 hours.
3	2	DIGITAL DATA ERROR ANALYZERS (TTC Model FIREBIRD MC2000) each w/ RS449-422/423 DTE/DCE Interfaces	Measures errors, error seconds, percent error free seconds, seconds, blocks, block errors, BER (Bit Error Rate), average BER, and count of synchronization losses since beginning of test.
4	1	FUNCTION GENERATOR 12 MHZ (WAVETEK Model 275)	Produces sine, triangle, and square waveforms as well as user-defined arbitrary waveshapes. Any of the waveforms can be generated in the continuous, triggered, gated or burst modes at programmed frequencies between 0.01 mHz and 12 MHz or clock rates between 267 ns to 267 s. Will provide general and delay measurement test signals to the analog input of the CODECs.
5	1	DC DUAL POWER SUPPLY (HP Model 6227B)	Provides two independent outputs, each of which can be set from 0-25 volts at 0-2 amperes. Will provide power to aircraft intercom units.

CTB TEST EQUIPMENT LIST (SHEET 1 OF 4)

ITEM #	QUANTITY	EQUIPMENT	FUNCTION
6	1	AUDIO ANALYZER (HP Model 8903B)	Provides audio measurements covering the frequency range of 20 Hz to 100 kHz. It combines a low-distortion signal source with a signal analyzer. The analyzer can perform distortion analysis, frequency count, and ac level, dc level, SINAD, and signal-to-noise ratio measurements.
7	2	COMPUTER (COMPAQ 386/20) w/ multisync monitor (NEC Model NECHE-301) and Printer (EPSON Model LQ-1050)	Provide computer driven ATC and cockpit simulation displays for Phase 3 testing. Also generates reports.
8	3	MULTIMODE DATA CONTROLLER (AEA PAKRATT Model PK-232)	Provides multimode protocol conversion and data control. Operates at half or full duplex packet radio in accordance with AX.25 protocols. Converts AX.25 packet radio to ASCII data for computer interface. Used for voice storage and packet demo.
9	1	PACKET RADIO CONTROLLER (AEA Model PK-90)	Provides packet assembler/disassembler (PAD) or data controller. Converts serial asynchronous ASCII data to internationally accepted packet radio via RS-232 serial port.
10	5	PROFESSIONAL CASSETTE DECK (Yamaha Model C300)	Provides playback and record of CODEC processed audio. Also provides playback of ATC room and cockpit environment background noise.
11	1	OMNI-DIRECTIONAL MICROPHONE (AKG Model C-460B/CK62))	Provides recording source of environmental background noise (ATC room and cockpit) as well as voice recordings.

CTB TEST EQUIPMENT LIST (SHEET 2 OF 4)

ITEM #	QUANTITY	EQUIPMENT	FUNCTION
12	1	MICROPHONE MIXER (SHURE Model 267)	Provides microphone mixer-remote amplification and phantom power for condenser microphone operation.
13	1	METER UNIT (TASCAM Model MU-40)	Provides level readings of any audio source. 4 meter, 8 channel unit. Used for CODEC I/O and cassette deck levels.
14	2	MULTI-HEADPHONE AMPLIFIER (TASCAM Model MH-40B)	Provides 4 pairs headphone jacks from single line-level signal source. Individual headphone control. Used for CODEC listening evaluations.
15	4	MULTI-HEADPHONE AMPLIFIER (TASCAM Model MH-40B)	Headsets used with multi-headphone amplifier for CODEC listening evaluations.
16	2	AIRCRAFT INTERCOM UNITS (TELEX Model TC-200)	Provides hands free voice activated intercom communications between aviation headsets and aircraft transceiver. Used for intermediary between aviation headsets and CODECs.
17	2	AIRCRAFT EXPANSION UNITS (TELEX Model TC-400)	Provides aircraft intercom units with two user remote stations for additional individual listening levels.
18	2	NOISE ATTENUATING AVIATION HEADSETS (David Clark Model H10-40)	Pilot and copilot aviation headsets for CODEC I/O via aircraft intercom unit. 24dB noise reduction rating. M-4 Electret microphone.
19	1	SOUND LEVEL METER (Realistic Model 33-2050)	Provides sound level pressure meter readings for sound intensity measure in all ATC acoustic environments (0dB referenced to 0.0002ubar).

CTB TEST EQUIPMENT LIST (SHEET 3 OF 4)

ITEM #	QUANTITY	EQUIPMENT	FUNCTION
20	2	POWER AMPLIFIER (CROWN Model MA-600)	Provides amplification of environmental background noise via cassette decks (ATC room and cockpit) to isolation rooms.
21	4	STEREO SPEAKERS (Community Light and Sound {CLS} Model CS-35)	Listening source of environmental background noise via power amps. Located in isolation rooms.
22	1	DIGITAL PATCHING UNIT (ADC Model PMSL-16)	Provides RS-232 linked digital patching for voice CODECs, PCs, satellite simulators, and data error analyzers.
23	2	ANALOG PATCHFIELD (ADC Model JB4/24M)	Provides patching between all analog sources, including voice CODECs, and audio and test equipment.
24	1	DIGITAL STORAGE OSCILLOSCOPE (Tektronix Model 2221)	Analyzes all I/O signals to CODECs. Provides timing measurements for CODEC delay tests.
25	2	ATC HEADSETS (AT & T Model Starset)	ATC headsets for CODEC I/O via signal entry panel.
26	2	PREAMPLIFIER/MIXER (TOA Model M900)	Impedance and line level matching for all I/O (ATC headsets, aviation headsets, and cassette decks) between CODECs.
27	1	TELCO EQUIPMENT consisting of (Tellabs Model 6131A & 6131B 2Wire-to-4Wire & 4Wire-to-4Wire Terminal Interface Modules, 6008B FXO-to-E&M Signaling Converter subassembly, 8020 Power Supply, and Rack Mount)	Conversion between facility-side (telephone) signalling formats and terminal-side E&M signaling as required by an associated carrier channel or PBX. This unit will be used as as the interface between CODECs and the user PBX, or simulate a PBX.

CTB TEST EQUIPMENT LIST (SHEET 4 OF 4)

APPENDIX B

PHASE III ACCEPTABILITY/INTELLIGIBILITY TEST MATERIAL AND EVALUATION FORMS

ATC : " Delta 705 turn 10 degrees left, intercept J48 on the southwest side of Montebello."
PILOT: " 10 left, intercept the airway on the other side of Montebello, Delta 705."
PILOT: " Any ride reports at 35 southbound?"
ATC : " I had, uh, reports of, uh, light chop with 31."
ATC : " Delta 705, say the mach."
PILOT: " Well, let me see! 75 right now, sir."
ATC : " Delta 705, can you bring the mach up any?"
PILOT: " Yes sir, yeah, do it right now."
ATC : " 705, what will it be when you get it up sir?"
PILOT: " Uh, 78."
ATC : " Delta 705 Roger 78."

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•
•

TBS

PHASE III ATC DIALOGUE (EXAMPLES)

SET 1

1) The girl lost the foot race.
2) Card games are fun to play.
3) Happy hour is over.
4) Let's talk after his show.
5) Cross this road and turn left.
6) They sat in the cool park.
7) Tom left home in disgust.
8) We watched the new program.
9) The blue dress is not wet.
10) I read the news today.
11) Wrap the bones in tin foil.
12) He stole all of her hats.
13) I hated the poems.
14) You are the biggest man.
15) We all ate fresh mushrooms.

SET 2

1) Toms' birthday is in June.
2) Franks' neighbor mowed his lawn.
3) Clip the pens on the books.
4) That is the oldest wine.
5) Line up at the screen door.
6) They took the crosstown bus.
7) I use ketchup on fish.
8) Toss that dish over here.
9) He sprayed our house for bugs.
10) We saw a bad movie.
11) That hose can wash her feet.
12) The goose laid an odd egg.
13) That quiz was much to hard.
14) Those are pudgy old men.
15) We cracked all those pecans.

SET 3

1) We lost the golden chain.
2) Those boxes were not full.
3) All the boys have cold feet.
4) That frog jumped through the weeds.
5) He was placed to far back.
6) Don't install that sewer.
7) She saved about eight cents.
8) His clothes have some false cuffs.
9) They enjoy loud concerts.
10) The glass pane is clear now.
11) That flower is in bloom.
12) Please excuse the bald man.
13) The fish was not to bad.
14) This book was on the shelf.
15) He chops their wood at dawn.

SET 4

1) He has the bluest eyes.
2) Don met me first today.
3) These shoes were black and brown.
4) They are to loud in church.
5) The rabbits and dogs drowned.
6) I suggest you leave now.
7) Music can calm the nerves.
8) They sure do take long walks.
9) I munch those candy bars.
10) Those boys planned the picnic.
11) I had toast for breakfast.
12) Cloudy days can be fun.
13) The man took Petes' snapshot.
14) The cat is in our home.
15) Stop at the oldest street.

SET 5

1) My razor gives close shaves.
2) The convicts had no hope.
3) I jumped on the new bed.
4) The lathe machine broke down.
5) We like that cold sherbert.
6) Sue was fast on her feet.
7) That blue copy is hers.
8) Floods destroyed your attic.
9) They borrowed antique junk.
10) He had such a brown face.
11) Some dipthongs have no sound.
12) The book was green and white.
13) Open the olive jar.
14) He brushed those cobwebs off.
15) They took the light outside.

SET 6

1) You should call the taxi.
2) Her food license expired.
3) Daves' best pillows were gone.
4) Every tool was stocked there.
5) Use the clipboard for that.
6) Don't throw trash on the street.
7) They want two red apples.
8) Their cooking was not great.
9) We danced by the full moon.
10) Do not drink the coke fast.
11) Please rent the car to him.
12) Invest your money now.
13) Take all the chalk with you.
14) They don't have the right change.
15) This man was knocked out cold.

PHASE III ACCEPTABILITY TEST (EXAMPLES OF DAM SENTENCES)

SECTOR	NINE	END	INTERCEPT	ZULU
VECTOR	WINE	SEND	INCORRECT	LULU
SIX	ALTITUDE	CLIMB	RAIN	OCEAN
MIX	ATTITUDE	RHYME	MAINE	MOTION
SEVEN	SOUTH	EIGHT	MACH	LEFT
HEAVEN	MOUTH	LATE	CLOCK	LEAF
REPORT	ZERO	HELL	TWO	LEVEL
RESORT	HERO	HAIL	THROUGH	DEVIL
FLIGHT	TURN	DANGER	NORTH	PACIFIC
HEIGHT	BURN	RANGER	FOURTH	TERRIFIC
FOUR	CENTER	DROP	EAST	SIDE
FIVE	ENTER	STOP	BEAST	RIDE
ONE	TREE	FIRE	FIVE	CHARLEY
FUN	THREE	HIGHER	DIVE	BARLEY
RIGHT	RUNWAY	DAMPER	AIRWAY	ALPHA
LIGHT	MONDAY	DANDER	STAIRWAY	APPROACH
TWO	CLEAR	SLOW	BOSTON	PILOT
THREE	LEAR	FLOW	HOUSTON	PIRATE
WEST	MILES	CLOUDS	NINER	DESCEND
TEST	DIALS	CROWDS	MINER	DEPEND

PHASE III INTELLIGIBILITY TEST (EXAMPLES OF DRT WORD PAIRS)

1. Describe your present form of Air Traffic Control Communications (Oceanic, En route,etc.)

2. Overall, would you say that what you just listened to is (Circle One)

   a. much better than
   b. slightly better than
   c. about the same as
   d. slightly worse than
   e. much worse than

   your present form of communications.

3. Overall, would this form of communications be acceptable to you in your present environment? (Circle One)

   a. YES
   b. NO OPINION
   c. NO

4. Comment on the similarities and/or differences between what you have just heard and your present form of communications.

5. You have just listened to a comparison of typical HF communications and CODEC processed speech. Would you say that the CODEC processed speech is (Circle One)

   a. much better than
   b. slightly better than
   c. about the same as
   d. slightly worse than
   e. much worse than

   the HF communications.

6. You have just listened to a comparison of typical VHF communications and CODEC processed speech. Would you say that the CODEC processed speech is (Circle One)

   a. much better than
   b. slightly better than
   c. about the same as
   d. slightly worse than
   e. much worse than

   the VHF communications.

PHASE III ACCEPTABILITY TEST EVALUATION FORM (EXAMPLE)

SECTION 1 - FILL IN THE BLANK

1. Delta ________ turn 10 degrees left, intercept J48 on the southwest side of Montebello.

2. ________ left, intercept the airway on the other side of Montebello, Delta 705.

•
•
•

TBS

SECTION 1 - WORD PAIRS

1. SECTOR ________
   VECTOR ________

2. SIX ________
   MIX ________

3. SEVEN ________
   HEAVEN ________

•
•
•

ETC

PHASE III INTELLIGIBILITY TEST EVALUATION FORM (EXAMPLE)