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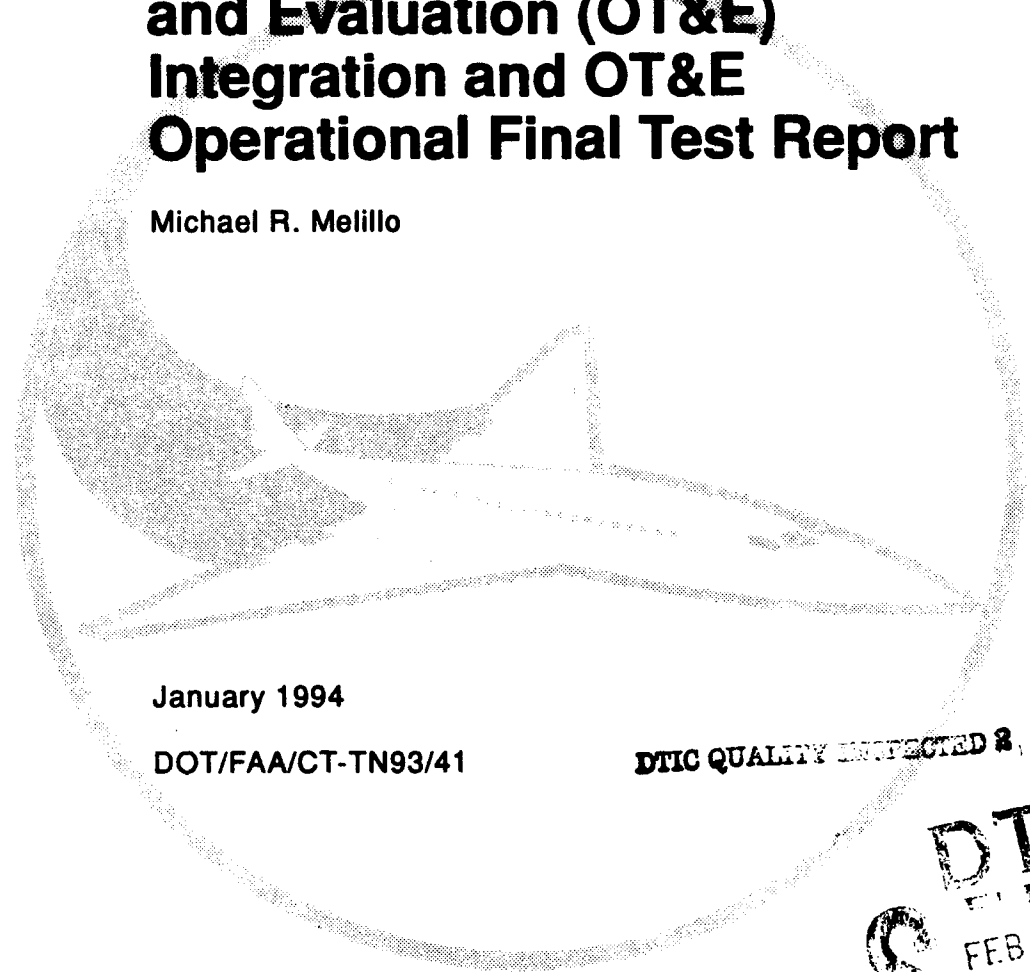
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**1.8 Gigahertz (GHz) Digital Low Density Radio Communications Link (LDRCL) Operational Test and Evaluation (OT&E) Integration and OT&E Operational Final Test Report**

Michael R. Melillo



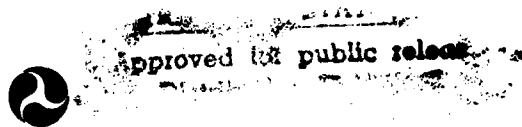
January 1994

DOT/FAA/CT-TN93/41

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16. Abstract  This report contains the results of the Operational Test and Evaluation (OT&E) Integration and OT&E Operational Testing of the Commercial-Off-The-Shelf (COTS) Low Density Radio Communications Link's (LDRCL) 1.8-gigahertz (GHz) digital radio system. The OT&E testing was accomplished by first testing the LDRCL equipment against its equipment specification (FAA-E-2853), and then performing OT&E testing at the key site (Miami, Florida). These tests proved that the 1.8 GHz LDRCL equipment can fulfill its mission in the National Airspace System (NAS) and that it is suitable and effective.  Based on the test results, it is concluded that the 1.8 GHz LDRCL equipment is qualified for operational deployment.			
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## EXECUTIVE SUMMARY

This test report describes the results of the Operational Test and Evaluation (OT&E) Integration and OT&E Operational testing performed on the Low Density Radio Communications Link (LDRCL) 1.8-gigahertz (GHz) digital radio system installed at the Miami, Florida, Air Route Traffic Control Center (ARTCC). The OT&E effort was conducted by Federal Aviation Administration (FAA) Technical Center personnel.

The LDRCL is comprised of nondevelopment items (NDI) from the manufacturers listed below and integrated into the LDRCL system by Alcatel Communications and Government Systems of Richardson, Texas.

<u>Item</u>	<u>Manufacturer</u>
MDR-5302/5202 Radio	Alcatel
Digital Channel Bank	Wescom
Battery/Charger	Power Conversion Products (PCP)
Remote Alarm	Westronic

The test system consisted of two LDRCL terminals at Miami ARTCC and Krome Radar International Flight Service Station (IFSS) International Flight Service Transmitter (IFST) Tower, and two LDRCL repeaters at Miami Air Traffic Control Tower (ATCT) and Tamiami Automated Flight Service Station (AFSS).

All OT&E testing was completed satisfactorily with two noncritical exceptions; the remote control function of the Low Voltage Battery Disconnect (LVBD), and the modem to 4-wire E&M (Ear and Mouth) extended range (E/R) card speed problem. Both problems are described in section 5., Conclusion, of this report.

ACW-400A recommends the deployment of the 1.8-GHz digital radio system since the two noncritical exceptions mentioned above, coupled with the recommendations in this report, do not affect the operational performance of the system.

## 1. INTRODUCTION.

This report describes the results of the Low Density Radio Communications Link (LDRCL) Operational Test and Evaluation (OT&E) Integration and OT&E Operational testing. The tests were performed in Miami, Florida, during the period of January 21 through January 29 and July 12 through July 20, 1993.

### 1.1 BACKGROUND.

The LDRCL procurement (Specification FAA-E-2853) will provide equipment to replace and upgrade existing links, leased systems, and new requirements for data communications for various NAS plan projects implemented in 1990 and beyond. Some of the current links that will be replaced are the short haul user access links and leased lines remoting circuits which currently provide connections between operational facilities such as Air Traffic Control Towers (ATCT), Terminal Radar Approach Control (TRACON), and remote sites such as Remote Communications Air-to-Ground Facility (RCAG), Air Route Surveillance Radar (ARSR), Airport Surveillance Radar (ASR), etc.

### 1.2 PURPOSE.

The purpose of this report is to describe the OT&E Integration and OT&E Operational testing performed on the 1.8-gigahertz (GHz) digital radio system and ACW-400A's reasons for recommending deployment of the 1.8-GHz digital radio system at this time.

### 1.3 PARTICIPANTS.

<u>Name</u>	<u>Organization</u>
Wayne Bell	FAA Technical Center (APMT)
Michael R. Melillo	FAA Technical Center (Lead LDRCL project engineer) ACW-400A
Tuan Tran	FAA Technical Center, ACW-400A
Son Tran	Program Office, ANC-160
Fritz Chey	Martin Marietta

### 1.4 REFERENCE DOCUMENTS.

#### FAA Specifications

FAA-G-2100E	Electronic Equipment, General Requirements
FAA-E-2853	Low Density Radio Communications Link Specification

FAA Standards

FAA-STD-024A Preparation of Test and Evaluation Documentation  
FAA-STD-028 NAS Training Guidelines  
FAA-STD-013/016/018 Quality Control Program Requirements  
FAA-STD-021 Configuration Management  
FAA-STD-020A Transient Protection, Grounding, Bonding and Shielding Requirements for Equipment

FAA Orders

1810.4B FAA NAS Test and Evaluation Program  
OAP 8200.1 U.S. Standard Flight Inspection Manual  
6000.3 Maintenance of FAA Communications System

NAS Documents

NAS-SS-1000 Vol. I NAS System Specification, Functional and Performance Requirements for the National Airspace System, General  
NAS-SS-1000 Vol. III NAS System Specification, (Ground to Air Element)  
NAS-SS-1000 Vol. I National Airspace System, System Requirements Specification  
NAS-MD-110 NAS Test Terms and Definitions  
NAS-IR-44010001 Digital Interface Requirements  
NAS-IR-44010002 Analog Interface Requirements

Other Documents

ISO-7498 Open Systems Interconnection Standards (Information Processing System)  
EIA RS-195 Electrical and Mechanical Characteristics of Microwave Relay System Antennas and Passive Reflectors  
PUB 62411 Accunet T1.5 Service Description and Interface Specifications  
Bell Labs American Digital Hierarchy

International Radio  
Consultative Committee:  
CCIR REC 283-4  
CCIR REC 275-3

Radio-Frequency Channel Arrangements for  
Radio Relay Systems

Pre-Emphasis Characteristics for Frequency  
Modulation Radio-Relay Systems for  
Telephony using FM Multiplexing

## 2. TEST APPROACH AND CONCEPT.

The test approach and concept was to evaluate the LDRCL equipment against the LDRCL Specification FAA-E-2853, and the NAS-SS-1000 Operational User's Requirements contained in the Master Test Plan and the OT&E Integration and OT&E Operational Test Plan.

The LDRCL system used for the OT&E Integration and OT&E Operational tests was comprised of terminal equipment at Miami Air Route Traffic Control Center (ARTCC) and Krome Radar International Flight Service Transmitter (IFST) Tower, and repeaters at Miami Air Traffic Control Tower (ATCT) and Tamiami Automated Flight Service Station (AFSS). A block diagram of the test configuration is provided in figure 1 and a list of the terminal and repeater equipment in table 1.

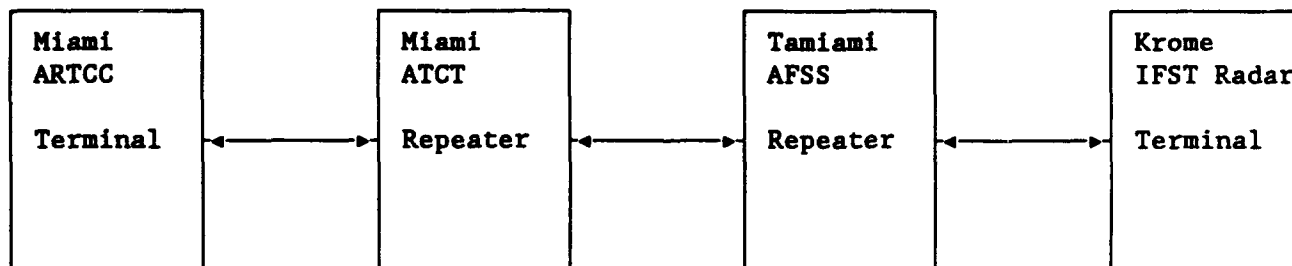


FIGURE 1. LDRCL 1.8-GHz DIGITAL RADIO SYSTEM TEST CONFIGURATION

TABLE 1. 1.8-GHz DIGITAL RADIO SYSTEM EQUIPMENT

Equipment	Terminal 1	Repeater 1	Repeater 2	Terminal 2
MDR-5302 Digital Radio (1 watt)	Qty 1	Qty 2	Qty 2	Qty 1
MDR-5202 Digital Radio (1 watt)	Qty 1	Qty 2	Qty 2	Qty 1
DS1 Crossconnect	Qty 1	Qty 2	Qty 2	Qty 1
Wescom Channel Bank (Redundant)	Qty 3	Qty 2	Qty 2	Qty 1
Westronic Alarm System	Qty 1	Qty 1	Qty 1	Qty 1
202T modem for above	Qty 1	N/A	N/A	N/A
48 channel jackfields	Qty 2	Qty 2	Qty 2	Qty 2
Stand Alone Fault Monitor	Qty 1	N/A	N/A	N/A
Modem for above	Qty 1	N/A	N/A	N/A
Battery Charger System	Qty 1	Qty 1	Qty 1	Qty 1
4 Wire E&M VF cards	Qty 35	Qty 27	Qty 31	Qty 5
4 wire E&M E/R cards	Qty 2	Qty 0	Qty 0	Qty 2

3. TESTS AT FAA TECHNICAL CENTER.

Factory Acceptance Tests (FAT) and Site Acceptance Tests (SAT) performed by the contractor and witnessed by Federal Aviation Administration (FAA) Technical Center personnel served to validate LDRCL specification requirements, since the 1.8-GHz digital system was not available at the FAA Technical Center.

4. OT&E INTEGRATION TESTS AT KEY SITE.

4.1 SYSTEM LEVEL REQUIREMENTS VERIFICATION TESTS.

The key site system level requirements (i.e., integration tests) were conducted in Miami, Florida. These tests were run to evaluate that the LDRCL equipment can suitably and effectively interface with other National Airspace System (NAS) subsystems. Figure 2 is a typical subsystem to subsystem block diagram of the test configuration used.

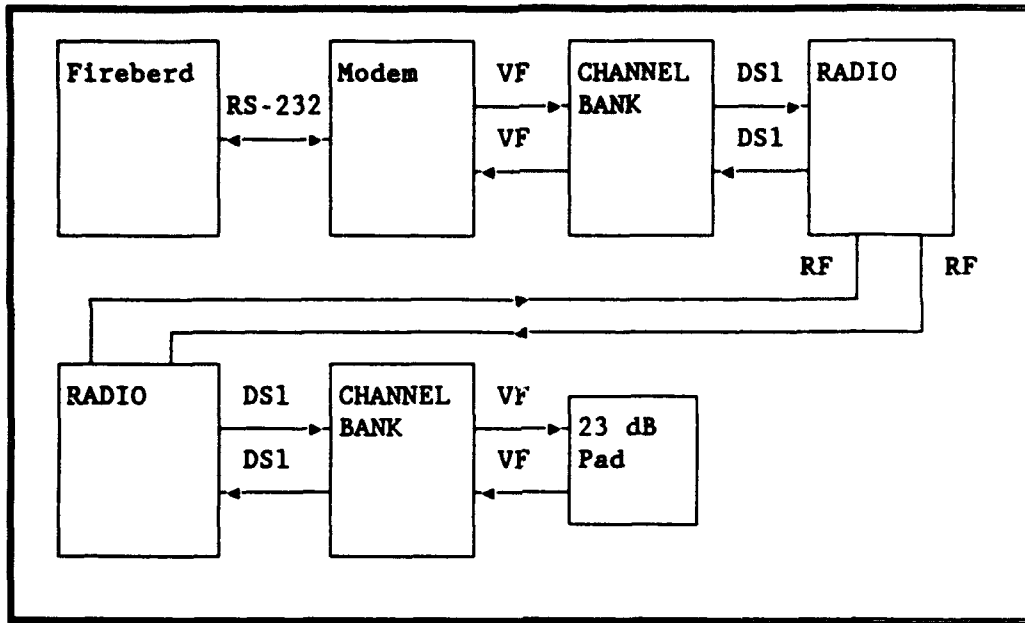


FIGURE 2. SUBSYSTEM TO SUBSYSTEM BLOCK DIAGRAM

4.2 SUBSYSTEM LEVEL REQUIREMENTS VERIFICATION TEST.

The subsystem level verification requirements were conducted in Longview, Texas and Miami, Florida. These tests were run to evaluate that the LDR equipment satisfied the requirements of the LDRCL specification FAA-E-2853. Figure 3 is a typical subsystem block level diagram.

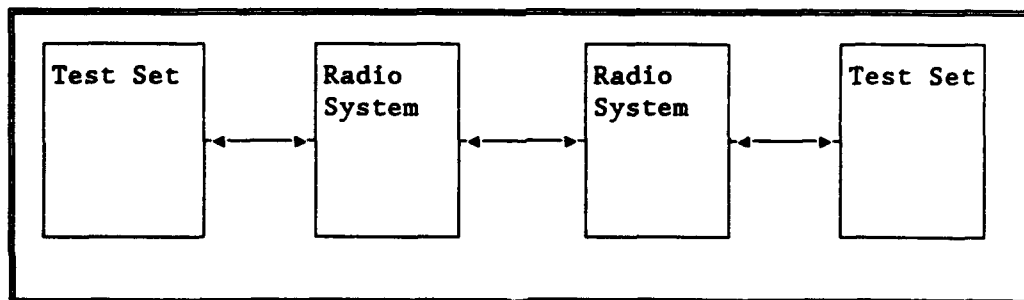


FIGURE 3. SUBSYSTEM BLOCK LEVEL DIAGRAM

## 5. TEST RESULTS.

### 5.1 TEST RESULTS AT TECHNICAL CENTER.

Since no equipment was available at the FAA Technical Center, as mentioned in section 3., FAT and SAT tests conducted by the contractor and witnessed by FAA Technical Center personnel served to satisfy the testing of specification requirements.

### 5.2 OT&E INTEGRATION TEST RESULTS.

Sixty-four subsystem level test requirements are specified for the LDRCL 1.8-GHz digital radio system (appendix A). Forty-five passed, 11 failed, and 8 could not be completely verified. (See the notes associated with the TVRTM.) Those tests that did fail, failed because the equipment selected was nondevelopment items (NDI) equipment which did not entirely meet the LDRCL specifications. The failed tests were considered as noncritical to the actual performance of the radio system and do not effect the operational performance of the radio system.

Those requirements that could not be verified because of equipment availability will be tested by the FAA Technical Center prior to their use in the field. Any problems encountered during this testing will be corrected by Alcatel before this equipment is recommended for deployment.

There were 11 Operational User's Requirements Tests (appendix B) performed on the 1.8-GHz digital radio system. Three requirements were successfully verified, four tests need to be verified at the FAA Technical Center, and four tests will be verified during OT&E Shakedown tests.

There were 10 system level tests (appendix C) performed in Miami on the LDRCL 1.8-GHz digital radio system. Out of the 10 tests only 1 test did not pass completely.

## 6. CONCLUSIONS.

### 6.1 TEST AT TECHNICAL CENTER CONCLUSIONS.

Since there were no tests performed at the FAA Technical Center, there are no real conclusions to report. All subsystem conclusions will follow in section 6.2, OT&E Integration Test Conclusions.

### 6.2 OPERATIONAL TEST AND EVALUATION (OT&E) INTEGRATION TEST CONCLUSIONS.

Based upon the test results obtained, the conclusion for the requirements that failed are as follows:

- a. Specification Paragraph 3.2.1 General. All performance requirements specified shall be met when the equipment is assembled into a system in the configuration that will be installed for field operation.

This requirement was not met. This nondevelopment items (NDI) equipment does not completely meet all the requirements specified. This is still satisfactory as the equipment will accomplish its mission in the National Airspace System (NAS).

b. Specification Paragraph 3.2.3 Equipment Configuration. The threshold level for switching operation shall be adjustable and normally set to operate at a bit error rate (BER) of  $10E-06$ .

The equipment does not have an adjustable threshold level, but switches on the first uncorrected bit error. This is at an approximate BER of  $10E-06$  which is satisfactory.

c. Specification Paragraph 3.2.4 Radio Frequency Coupler. A radio frequency (RF) coupler shall be provided that will present a minimum of 30 decibel (dB) of forward attenuation to the RF signal for testing purposes.

This equipment has a coupler built into the transmitter power amplifier. This coupler is not a precision coupler and sometimes has less than 30 dB of attenuation. This is satisfactory as the coupler is approximately 30 dB and is only used for monitoring purposes. It also does not affect the operational performance of the radio.

d. Specification 3.2.8 Receiver/Combiner Switch. The combiner/switch shall not cause interruptions or transients which may degrade the signal. Level changes due to automatic combiner/switch action shall not cause loss of digital data.

The radio was not designed with hitless switching, therefore during a receiver or transmitter switch the radio will experience a loss of data. If the path analysis is done correctly, this should happen less than 56 minutes per year. This is satisfactory.

e. Specification Paragraph 3.2.9.2 Monitor and Test Capability. Built-in diagnostics shall be incorporated with the digital multiplexing system to include individual DS-1 loopback testing and BER monitoring.

The radio system does not have BER monitoring. This equipment is NDI equipment and was not designed with this function. Since this does not affect the operational performance of the system, it is therefore acceptable.

f. Specification Paragraph 3.6.2.1 Alarm Interfaces With RCL System (TABS). For those Low Density Radio Communications Link (LDRCL) systems which will interface with the existing Radio Communications Link (RCL) Automated Network Monitoring System (ANMS), the contractor shall provide a rack mounted pin or punch block which contains the ACORN interface connectivity point. All blocks will be suitably labeled.

Terminal block was not suitably labeled. The terminal block should be suitably labeled to help the technicians repair the equipment quickly and easily.

g. Specification Paragraph 3.7.1 Reliability. The mean time between maintenance actions (MTBMA) shall not be less than 10,000 hours.

The mean time between actions calculates out to 5,126 hours, not the 10,000 hours required. Being that this is a fully redundant system, this will not affect the operational performance of the system. It does, however, drive up the life cycle cost of the system as now twice as many spare parts will be necessary.

h. Specification Paragraph 3.8.1.1 Battery Protection. A Low Voltage Load Disconnect (LVLD) unit shall be provided that is capable of removing the batteries from the load when a predetermined cell voltage limit has been reached thus preventing damage to the battery bank due to excessive cellular discharge (normally 1.75 volts per cell). The LVLD shall also be equipped for remote control operation that permits control via the LDRCL alarm monitoring and control subsystem. A feature shall be incorporated that allows local and remote override of the switch function. Reset of the switch shall be automatic when the battery compliment recharges to normal operational voltage.

The LVLD has been renamed as a Low Voltage Battery Disconnect (LVBD). The remote control function of the LVBD does not work. This does not affect the operational performance of the radio system, but since it is a specification requirement it should be fixed. Further testing will be required.

The automatic reset of switch after the batteries are charged to normal operating voltages is not incorporated. Switch resets once alternating current (A/C) power is restored to power supplies. This is satisfactory as most NDI radio systems are designed this way.

i. Specification Paragraph 3.8.3 Space Diversity. The digital space diversity receiver shall be switched on BER.

The radio system switches on the first uncorrected bit error not the BER. This is acceptable as the switch point is approximately 10E-06.

j. Specification Paragraph 4.3 System Tests. The contractor shall conduct on the first system of each type ordered, factory system end-to-end performance acceptance tests; i.e., the tests required to demonstrate to the Government that the system meets the requirements as specified. The tests shall demonstrate that all equipment is operating within the normal operating tolerances as stated in the equipment documentation.

The equipment does not meet all the requirements as specified because it is NDI equipment. All the specification requirements that are not met will not affect the operational performance of the system.

This equipment does not operate within the normal operating tolerances as stated in the equipment documentation. This happens in the case of the battery chargers. The way Alcatel has engineered the system, the battery chargers do not load share properly. This produces a fault alarm which indicates a battery charger has failed when in reality it has not.

k. Specification Paragraph 4.4 Field System Tests. When site installation of a microwave system is ordered by the Government, the contractor shall conduct field system end-to-end performance acceptance tests, i.e., the tests required to demonstrate to the Government that the system is installed and operating in accordance with the requirements as specified. The tests shall demonstrate that all equipment is operating within the normal operating tolerances as stated in the equipment documentation.

The equipment does not meet all the requirements as specified because it is NDI equipment. All the specification requirements that are not met will not affect the operational performance of the system.

This equipment does not operate within the normal operating tolerances as stated in the equipment documentation. This happens in the case of the battery chargers. The way Alcatel has engineered the system, the battery chargers do not load share properly. This produces a fault alarm which indicates a battery charger has failed when in reality it has not.

1. Modem to LDRCL interface test. The LDRCL system should be capable of interfacing with a modem operating at speeds of up to 19.2 kilobytes per second (Kbps).

When the Codex 3600 was operating at 19.2 Kbps, and connected to an Extended Range 4 wire Ear and Mouth (E&M) voice frequency card, an unacceptable amount of errors were produced over the link. When the rate was dropped to 9.6 Kbps, the errors were reduced to an acceptable amount.

## 7. RECOMMENDATIONS.

Based on all test results, it is recommended that the 1.8-gigahertz (GHz) Low Density Radio Communications Link (LDRCL) digital radio system be deployed under the following criteria:

a. Equipment contained on the LDRCL contract that has not been tested (see notes in appendix A) may not be deployed until successful Operational Test and Evaluation (OT&E) Integration and OT&E Operational testing, and Shakedown testing have been performed.

b. The 4-wire Ear and Mouth (E&M) extended range (E/R) card should only be used at speeds of up to 9600 bits per second (bps) until further testing at the Federal Aviation Administration (FAA) Technical Center indicates it can be used for rates up to 19.2 kilobytes per second (Kbps).

c. All systems should be deployed with Total Harmonic Distortion (THD) Filters.

d. A THD test be run at all sites during Site Acceptance Tests (SAT) to ensure that the THD requirement is met.

e. The FAA use recommended battery charger sizes (appendix D) to order battery chargers for the different configurations.

f. The remote control Low Voltage Battery Disconnect (LVBD) be added to the system within a 3-month period of the first deployed system. All deployed systems at that time be updated with the new circuit.

g. As per previous agreements, Radio Frequency Interface (RFI) testing will be performed at the FAA Technical Center after the deployment recommendation. Any problems that are deemed critical as a result of this testing will result in the suspension of the deployment recommendation until the problems are resolved.

## 8. ACRONYMS AND ABBREVIATIONS.

A/C	alternating current
AFSS	Automated Flight Service Station
ANMS	Automated Network Monitoring System
ARSR	Air Route Surveillance Radar
ARTCC	Air Route Traffic Control Center
ASR	Airport Surveillance Radar
ATCT	Air Traffic Control Tower
BER	bit error rate
bps	bits per second
COTS	Commercial Off-the-Shelf
dB	decibel
E&M	Ear and Mouth
EMI	Electromagnetic Interference
E/R	Extended Range
FAA	Federal Aviation Administration
FAT	Factory Acceptance Tests
GHz	gigahertz
IFSS	International Flight Service Station
IFST	International Flight Service Transmitter
Kbps	Kilobytes per second
LDRCL	Low Density Radio Communications Link
LVBD	Low Voltage Battery Disconnect
LVLDD	Low Voltage Load Disconnect
MTBMA	mean time between maintenance actions
NAS	National Airspace System
NDI	nondevelopment items
OT&E	Operational Test and Evaluation
PCP	Power Conversion Product
RCAG	Remote Communications Air-to-Ground
RCL	Radio Communications Link
RF	Radio Frequency
RFI	Radio Frequency Interference
SAT	Site Acceptance Tests
THD	Total Harmonic Distortion
TRACON	Terminal Radar Approach Control
TVRTM	Test Verification Requirements Matrix

**APPENDIX A**

**FAA-E-2853A**

**TEST VERIFICATION REQUIREMENTS TRACEABILITY MATRIX (TVRTM)**

Paragraph No.	Requirement Description	Verification Method		Test Location		N O T E
		Subsystem Level	System Level	FAT	Key Site	
3.1.2.1	Duty Cycle	A	X	*	N/A	P
3.1.2.2	Ambient Temperature	A	X	*	N/A	P
3.1.2.3	Relative Humidity	A	X	*	N/A	P
3.1.2.4	Power	A	X	*	N/A	P
3.1.2.5	Racks	I	X	*	N/A	N/A
3.1.2.7	Solid State	I	I	*	N/T	P
3.1.2.8	Accessibility	I	I	*	N/T	P
3.1.2.9	Transient Protection	I	I	N/T	*	P
3.1.2.10	Finishes	I	I	*	N/T	P
3.1.2.11	Cooling	I	I	*	N/T	P
3.1.2.12	Interchangeability	A	X	*	N/A	P
3.1.2.13	Special Equipment	I	I	*	N/T	P

Verification Method: T - Test, D - Demonstration, A - Analysis, I - Inspection, X - Not Applicable

Notes:

\* - Verification Method Conducted.

P - Passed, Meets requirement without comment, N/T - Not Tested, N/A - Not Applicable,

N/V - Not Completely Verified.

1 - Paragraph Passed with the exception of the seismic rack which was not available.

Paragraph No.	Requirement Description	Verification Method		Test Location		N O T E
		Subsystem Level	System Level	FAT	Key Site	
3.2.1	General	T	X	*	N/A	F 2
3.2.2.1	Spectrum Design Req'ments	X	I	N/A	N/T	N/A 3
3.2.2.2	Frequency and Antenna Polarization	D	I	*	N/T	P
3.2.3	Equipment Configuration	T	T	N/T	N/T	F 4
3.2.4	Radio Frequency Coupler	I	I	*	N/T	F 5
3.2.5	Radio Freq Connectors	I	I	*	N/T	P
3.2.6	Antennas	X	I	N/A	*	P
3.2.7	Transmission Lines	X	I	N/A	*	P
3.2.8	Receiver/Combiner Switch	T	T	*	N/T	F 6

Verification Method: T - Test, D - Demonstration, A - Analysis, I - Inspection, X - Not Applicable

Notes:

\* - Verification Method Conducted.

P - Passed, Meets requirement without comment, N/T - Not Tested, N/A - Not Applicable,

N/V - Not Completely Verified.

2 - All performance requirements were not met.

3 - Frequencies are ordered by the Program Office under the advice of the FAA Frequency Management section.

4 - Threshold level for switching level is not adjustable. Failure sensing is not initiated by BER.

5 - Coupler does not have a minimum 30-dB Forward attenuation.

6 - During a receiver or transmitter switch, the system produced errors.

Paragraph No.	Requirement Description	Verification Method		Test Location		N O T E
		Subsystem Level	System Level	FAT	Key Site	
3.2.9	Digital Multiplexing Equipment	T	T	*	*	N/A 7
3.2.9.1	Redundant Configuration	T	T	*	N/T	P
3.2.9.2	Monitor and Test Capability	T	T	*	N/T	F 8
3.2.10.1	General	D	D	*	N/T	P
3.2.10.2	Auxiliary Functions	D	D	*	N/T	P
3.2.11	Jackfields	I	I	*	N/T	P
3.2.12	RF Splitter	I	I	*	N/T	P
3.2.13	Line Conditioning Equipment	T	T	N/T	N/T	N/A 9
3.3.1	Frequencies of Operation For the 1.8 GHz Equipment	T	X	*	N/T	P

Verification Method: T - Test, D - Demonstration, A - Analysis, I - Inspection, X - Not Applicable  
Notes:

- \* - Verification Method Conducted.
- P - Passed, Meets requirement without comment, N/T - Not Tested, N/A - Not Applicable, N/V - Not Completely Verified.
- 7 - Paragraph Passed with the exception of the 4-wire E&M/PLR/ER and 4-wire TO/ER which were not available for test.
- 8 - System does not have built-in BER monitoring.
- 9 - Equipment was not available for test.

Paragraph No.	Requirement Description	Verification Method		Test Location			N O T E
		Subsystem Level	System Level	FAT	Key Site	Pass/Fail	
3.3.3	RF Power	T	T	*	*	N/A	10
3.3.4	Transmitter Frequency Stability	T	T	*	*	P	
3.3.5	Channel Capacity	I	I	*	N/T	P	
3.3.6	Transmitter Fault Sensing	T	T	*	N/T	P	
3.3.7	Receiver Fault Sensing	T	T	*	N/T	P	
3.3.13.1	Receiver Squelch	T	T	*	*	P	
3.3.13.3	Receiver Threshold	T	T	*	*	P	
3.3.13.4	System Sensitivity	T	T	*	*	P	
3.3.13.5	Digital Multiplex Equipment	T	T	*	N/T	P	
3.3.13.5.1	Narrow Band Digital Mux Configuration	T	T	N/T	*	P	
3.6	Remote Monitoring/Sensing	I	I	*	N/T	P	

Verification Method: T - Test, D - Demonstration, A - Analysis, I - Inspection, X - Not Applicable  
**Notes:**

\* - Verification Method Conducted.

P - Passed, Meets requirement without comment, N/T - Not Tested, N/A - Not Applicable,

N/V - Not Completely Verified.

10 - 1-watt amplifier passed, the 3-watt and 5-watt amplifiers were not available for test.

Paragraph No.	Requirement Description	Verification Method		Test Location		N O T E
		Subsystem Level	System Level	FAT	Key Site	
3.6.1	Reported Alarms	T	T	*	*	P
3.6.2	Alarm Indication	T	T	*	*	P
3.6.2.1	Alarm Interfaces with RCL system (TABS)	T	T	N/T	*	F 11
3.6.3	Remote Controls	T	T	*	*	P
3.7.1	Reliability	A	X	*	N/A	F 12
3.7.2	Maintainability	A	X	*	N/A	P
3.7.3	Availability	A	X	*	N/A	P
3.8.1	Batteries	X	I	N/A	*	P
3.8.1.1	Battery Protection	T	T	N/T	*	F 13
3.8.2	Battery Charger	T	X	N/T	*	P
3.8.2.1	Optional Battery Charger	X	T	N/A	*	P

Verification Method: T - Test, D - Demonstration, A - Analysis, I - Inspection, X - Not Applicable  
Notes:

\* - Verification Method Conducted.

P - Passed, Meets requirement without comment, N/T - Not Tested, N/A - Not Applicable,

N/V - Not Completely Verified.

11 - Punch block was not suitably labeled.

12 - Reliability calculates to 5126 hours, not the 10,000 hours required.

13 - Remote control of the LVBD does not work. Auto reset does not work as per specification.

Paragraph No.	Requirement Description	Verification Method		Test Location			N O T E
		Subsystem Level	System Level	FAT	Key Site	Pass/Fail	
3.8.3	Space Diversity	T	T	*	N/T	F	14
3.8.4	Towers	X	D	N/A	N/T	P	
3.8.4.1	Obstruction Lights	A	I	*	N/T	P	
3.8.5	Antenna Mounts	A	I	*	N/T	P	
3.8.6	Grounding System	X	T	N/A	*	P	
3.9.2	Instruction Books	X	I	N/A	N/T	N/V	15
3.10.2.1	Site Spares	X	I	N/A	N/T	N/V	15
3.10.2.2	Depot Parts - Peculiar	X	I	N/A	N/T	N/V	15
4.3	System Tests	T	X	*	N/A	F	16
4.4	Field System Tests	X	T	N/A	*	F	16
5.0	Preparation for Delivery	I	X	*	N/A	P	

Verification Method: T - Test, D - Demonstration, A - Analysis, I - Inspection, X - Not Applicable

**Notes:**

\* - Verification Method Conducted.

P - Passed, Meets requirement without comment, N/T - Not Tested, N/A - Not Applicable,

N/V - Not Completely Verified.

14 - Switches on first uncorrected bit error, not on a BER.

15 - Not tested by ACW, AOS responsibility.

16 - The equipment does not meet all the requirements as specified, and does not operate within the normal operating tolerances as states in the equipment documentation.

Paragraph No.	Requirement Description	Verification Method		Test Location		N O T E
		Subsystem Level	System Level	FAT	Key Site	
6.0	Preparation for Installation	X	I	N/A	*	P

Verification Method: T - Test, D - Demonstration, A - Analysis, I - Inspection, X - Not Applicable  
Notes:

\* - Verification Method Conducted.

P - Passed, Meets requirement without comment, N/T - Not Tested, N/A - Not Applicable,  
N/V - Not Completely Verified.

APPENDIX B

OPERATIONAL USER'S REQUIREMENTS  
TEST VERIFICATION REQUIREMENTS TRACEABILITY MATRIX (TVRTM)

Requirement Description	Verification Method		Test Location		Notes
	Integration Level	Shakedown Level	FAATC	Key Site	
1. Verify that the audio quality of any circuit does not become degraded, and that there is no detectable change in voice quality/level as the LDRCL is accessed by signals to and from the RCL links.	D	X	N/T	N/T	1,2
2. Verify that crosstalk is not detectable under maximum loading of the LDRCL paths.	D	X	N/T	*	P
3. Verify that the alarm indicators function properly under electrical transients caused by commercial power changes.	D	X	N/T	N/T	3
4. Verify that after system failure in LDRCL, the entire path can be restored in 30 minutes. (Maintainability).	D	X	N/T	*	P

Verification Method: T - Test; D - Demonstration, A - Analysis, I - Inspection, X - Not Applicable  
Notes:

\* - Verification Method Conducted

P - Passed, Meets requirement without comment, N/T - Not Tested, N/A - Not Applicable

1 - The LDRCL system at the Key Site does not interface with the RCL voice frequency channels, therefore the requirement cannot be tested.

2 - The FAA Technical Center testbed is not completed, therefore the requirement cannot be tested.

3 - Special test equipment required, can only be done at FAA Technical Center testbed which is not completed.

Requirement Description	Verification Method		Test Location		Notes
	Integration Level	Shakedown Level	FAATC	Key Site	
5. Verify that the removal/replacement of any line replaceable unit (LRU) does not affect the normal operation of the LDRCL.	D	X	N/T	*	P
6. Verify that adequate spare parts exist at each site to support urgent repairs to the LDRCL.	X	D	N/T		4
7. Verify that the LDRCL can be integrated with existing FAA facility power and environmental systems with little or no impact on normal operations.	X	D	N/T		4
8. Verify that the LDRCL can protect itself from the effects of power outages, fluctuations and harmful transients.	X	D	N/T		4

Verification Method: T - Test, D - Demonstration, A - Analysis, I - Inspection, X - Not Applicable

Notes:

\* - Verification Method Conducted

P - Passed, Meets requirement without comment, N/T - Not Tested, N/A - Not Applicable

4 - AOS - 200 responsibility, see Shakedown report

Requirement Description	Verification Method		Test Location		Notes
	Integration Level	Shakedown Level	FAATC	Key Site	
9. Verify that the LDRCL, in the process of accessing the circuits of the RCL paths, will not take down any other specified, critical circuits that would not otherwise have been affected by the problem.	D	X	N/T	N/T	5
10. Verify by random sampling the mechanical and electrical interchangeability among assemblies, subassemblies, and LRU's that are supposed to be identical.	X	D			6
11. Verify that the LDRCL is not affected by electromagnetic radiation and does not affect other FAA systems with EMI	D/T	X	N/T	N/T	7

Verification Method: T - Test, D - Demonstration, A - Analysis, I - Inspection, X - Not Applicable  
Notes:

- \* - Verification Method Conducted
- P - Passed, Meets requirement without comment, N/T - Not Tested, N/A - Not Applicable
- 5 - The LDRCL system at the Key Site does not interface with the RCL voice frequency channels, therefore the requirement cannot be tested.
- 6 - AOS - 200 responsibility, see Shakedown report
- 7 - The FAA Technical Center testbed is not completed, therefore the requirement cannot be tested.

APPENDIX C

SYSTEM LEVEL/INTEGRATION TEST MATRIX

Test Description	Verification Method			Test Location		Notes
	System Level	Integration Level	FAATC	Key Site		
1. Envelope Delay Distortion Test	T	X	N/T	*	P	
2. Frequency Translation and Level Test	T	X	N/T	*	P	
3. Channel Amplitude Frequency Response Test	T	X	N/T	*	P	
4. Phase and Jitter Test	T	X	N/T	*	P	
5. Voice Frequency Performance Test	T	X	N/T	*	P	
6. Modem to LDRCL Test	X	T	N/T	*	1	
7. ANMS to LDRCL interface Test	X	T	N/T	*	P	
8. Backup Radio Channel Test	X	T	N/T	*	P	
9. Degraded Operations Test	X	T	N/T	*	P	
10. Total Harmonic Distortion Test	X	T	N/T	*	2	

Verification Method: T - Test, D - Demonstration, A - Analysis, I - Inspection, X - Not Applicable  
Notes:

\* - Verification Method Conducted

P - Passed, Meets requirement without comment, N/T - Not Tested, N/A - Not Applicable

1 - All testing with the 4-wire E&M card passed. Testing the 4-wire E&M/ER card at a modem speed of 19.2 Kbps failed. 4-wire E&M/ER did pass when the modem speed was lowered to 9.6 Kbps.

2 - Passed LDRCL specification FAA-E-2853. Does not meet critical bus requirements, but as per the DRR checklist, LDRCL will go on the essential bus.

APPENDIX D  
RECOMMENDED BATTERY CHARGER SIZES

1.8 GHz 4 DS1 Radio

Recommended Battery Charger Sizes

# of Channel Banks.	4 DS1 Terminal charger size.	4 DS1 Terminal 30 minute Battery size min.	4 DS1 Terminal 8 hour Battery size min.	4 DS1 Repeater Charger size.	4 DS1 Repeater 30 minute Battery size min.	4 DS1 Repeater 8 hour Battery size min.
Qty 1	16 amp	8 amp hr	128 amp hr	25 amp	8.5 amp hr	136 amp hr
Qty 2	16 amp	8 amp hr	128 amp hr	25 amp	8.5 amp hr	136 amp hr
Qty 3	16 amp	8 amp hr	128 amp hr	25 amp	8.5 amp hr	136 amp hr
Qty 4	16 amp	8 amp hr	128 amp hr	25 amp	8.5 amp hr	136 amp hr
Qty 5	N/A	N/A	N/A	25 amp	17.5 amp hr	272 amp hr
Qty 6	N/A	N/A	N/A	25 amp	17.5 amp hr	272 amp hr
Qty 7	N/A	N/A	N/A	25 amp	17.5 amp hr	272 amp hr
Qty 8	N/A	N/A	N/A	25 amp	17.5 amp hr	272 amp hr

**UHF Radio**

**Recommended Battery Charger Sizes**

# of Channels	UHF Terminal charger size.	UHF Terminal 30 minute Battery size min.	UHF Terminal 8 hour Battery size min.	UHF Repeater Charger size.	UHF Repeater 30 minute Battery size min.	UHF Repeater 8 hour Battery size min.
1 to 12	16 amp	4 amp hrs	64 amp hrs	16 amp	6 amp hrs	96 amp hrs

1.8 GHz 8 DS1 Radio and the 23 GHz Radio

Recommended Battery Charger Sizes

# of Channel Banks.	8 DS1 Terminal charger size.	8 DS1 Terminal 30 minute Battery size min.	8 DS1 Terminal 8 hour Battery size min.	8 DS1 Repeater Charger size.	8 DS1 Repeater 30 minute Battery size min.	8 DS1 Repeater 8 hour Battery size min.
Qty 1	25 amp	12 amp hr	192 amp hr	25 amp	17.5 amp hr	272 amp hr
Qty 2	25 amp	12 amp hr	192 amp hr	25 amp	17.5 amp hr	272 amp hr
Qty 3	25 amp	12 amp hr	192 amp hr	25 amp	17.5 amp hr	272 amp hr
Qty 4	24 amp	12 amp hr	192 amp hr	25 amp	17.5 amp hr	272 amp hr
Qty 5	25 amp	12 amp hr	192 amp hr	25 amp	17.5 amp hr	272 amp hr
Qty 6	25 amp	12 amp hr	192 amp hr	25 amp	17.5 amp hr	272 amp hr
Qty 7	25 amp	12 amp hr	192 amp hr	25 amp	17.5 amp hr	272 amp hr
Qty 8	25 amp	12 amp hr	192 amp hr	25 amp	17.5 amp hr	272 amp hr

1.8 GHz 8 DS1 Radio and the 23 GHz Radio

Recommended Battery Charger Sizes (continued)

# of Channel Banks.	8 DS1 Terminal charger size.	8 DS1 Terminal 30 minute Battery size min.	8 DS1 Terminal 8 hour Battery size min.	8 DS1 Repeater Charger size.	8 DS1 Repeater 30 minute Battery size min.	8 DS1 Repeater 8 hour Battery size min.
Qty 9	N/A	N/A	N/A	50 amp	21 amp hr	336 amp hr
Qty 10	N/A	N/A	N/A	50 amp	21 amp hr	336 amp hr
Qty 11	N/A	N/A	N/A	50 amp	21 amp hr	336 amp hr
Qty 12	N/A	N/A	N/A	50 amp	21 amp hr	336 amp hr
Qty 13	N/A	N/A	N/A	50 amp	21 amp hr	336 amp hr
Qty 14	N/A	N/A	N/A	50 amp	21 amp hr	336 amp hr
Qty 15	N/A	N/A	N/A	50 amp	21 amp hr	336 amp hr
Qty 16	N/A	N/A	N/A	50 amp	21 amp hr	336 amp hr