ORDER

6350.22

RML REPLACEMENT AND EXPANSION PROJECT
RADIO COMMUNICATIONS LINK
SYSTEM IMPLEMENTATION PLAN

November 21, 1986

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Distribution: A-W(PM/ES/LG/PT)-2; A-X(AF)-3; A-Y(AY/DE)-3; A-FAF-2/3/7(LTD)

Initiated By: APM-510

FOREWORD

This order provides management direction and technical guidelines for the implementation of a portion of the NAS (National Airspace System) Plan RML (Radar Microwave Link) Replacement and Expansion Project. Effort on this project will be directed toward developing a nationwide microwave transmission system known as the radio communications link (RCL) system. This system will form an interconnecting BACKBONE which will serve the communication needs of the NAS elements as they are developed. This plan covers the implementation of the microwave radios, repeaters, and terminals, including antennas, waveguide, multiplexing equipment, and the Automatic Network Management System (AMMS).

This plan is prepared under the direction of the FAA project manager (APM-510) who will review it frequently and coordinate revisions as necessary.

This plan has been kept broad in scope in order to be a practical working instrument. It is designed to encourage the interactive sharing of information between the FAA headquarters, FAA regions, and all other project participants. This LIVING MANAGEMENT TOOL is intended to be flexible. It permits noncontractural judgements and determinations to be made by all participants as conditions and needs arise.

Em Kelly

for Thomas J. O'Brien
Acting Director, Program Engineering
and Maintenance Service

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CHAPTER 1. GENERAL

1. PURPOSE. This order establishes the tasks and responsibilities required to coordinate and manage all radio communications link (RCL) implementation activities.

2. DISTRIBUTION. This order is distributed to division level in the Program Engineering and Maintenance, Systems Engineering, and the Acquisition and Materiel Services and the Office of Personnel and Technical Training in Washington headquarters; to branch level in the regional Airway Facilities divisions; to branch level in the FAA Academy and FAA depot at the Mike Monroney Aeronautical Center; and to all Airway Facilities sectors, sector field offices, sector field units, and sector field office units.

3. MAINTENANCE AND MODIFICATION OF THE PLAN. This document must be kept up-to-date in order to maintain its accuracy throughout the life of the project. Modifications to the plan in the form of changes, corrections, and/or additions should be submitted to the Program Engineering and Maintenance Service Division, Interfacility Communications Program, APM-510, for review. When these modifications have been approved, the appropriate changes pages and instructions will be expedited to all holders of this radio communications link implementation plan.

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CHAPTER 2. PROJECT OVERVIEW

20. PROJECT SCOPE. This project will direct efforts to convert the existing special-purpose RML system into a general-purpose radio communications link (RCL) microwave backbone system. This system will carry voice, data, and radar information between FAA facilities. Later implementation efforts will complete this new RCL system with Network Management and Control Equipment (NMCE) functions.

21. PRESENT SYSTEM.

a. The FAA is currently using a variety of transmission services and systems to fulfill its communication requirements. This includes 1.6 million miles of leased lines, of which 60 percent carry analog (voice) information, while 40 percent carry digital traffic and 750 FAA-owned RML facilities primarily used for remoting broadband radar information. Independent communication networks have been created for various FAA programs and projects. As new requirements were identified, new networks were created. Thus, the total interfacility communications requirements have been met by many different networks totally separate from each other using owned facilities and leased services.

b. The majority of FAA telecommunications traffic is point-to-point and terminates at a hub facility; e.g., air route traffic control center (ARTCC), terminal, or a flight service station (FSS). A large number of the current transmission circuits carry low-density traffic from remote field sites to a hub facility. Alternate routing is usually not available in the present network. Thus, a transmission outage normally results in an interruption of service. Furthermore, since there is no technical monitoring of the network, the response to outages is purely reactive with no means for avoiding service outages through modern predictive techniques.

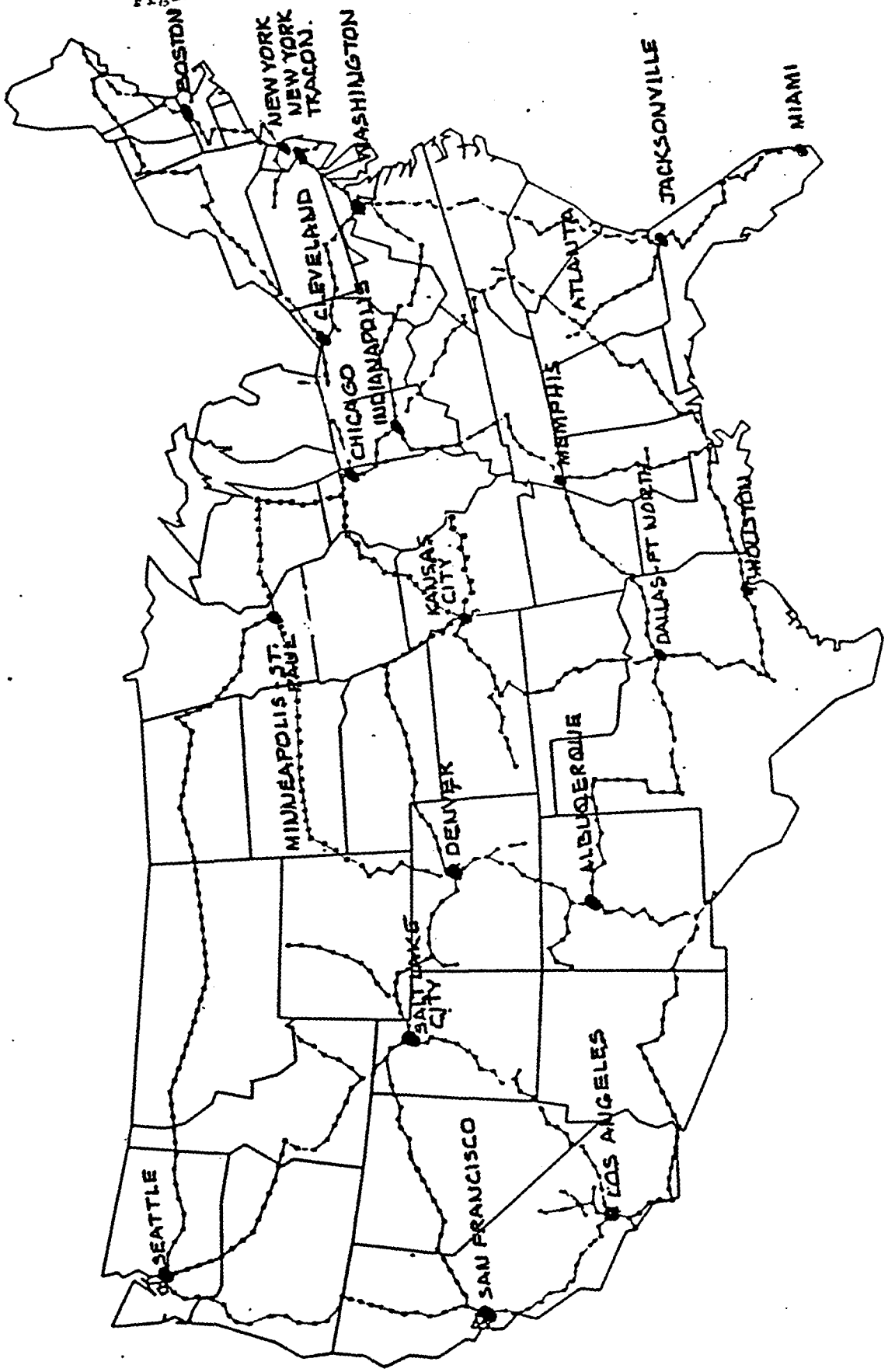
c. Throughout the FAA's history, a variety of specialized and costly communications services has evolved, with each service intended to satisfy an isolated communication need. With the demise of the AT&T TELPAK tariff, which discounted leased transmission service cost, there was a sharp rise in the operating cost of FAA communications. In addition, state-of-the-art telecommunications equipment and techniques have surpassed the technology incorporated into the FAA's present networks. The cost to maintain the current network is growing and is considerably greater than it would be if modern technology were more fully utilized.

d. The present RML system is an important part of the FAA transmission network. However, the RML system was established 25 years ago to primarily route radar data to the ARTCC and is not interconnected as a nationwide network. Its potential use as a general transmission system is therefore limited.

22. FUTURE SYSTEM. The FAA will build an integrated interfacility communication transmission subsystem. This subsystem will be integrated in terms of leased and owned media, variety of transmission media, and the mix of information transmitted. The subsystem will be dynamic and flexible enough to handle not just existing transmission requirements but also future needs of all programs in the NAS Plan. The transmission media and subsystem hardware will be monitored creating a predictive system. Segments of the new network may be leased or owned and will utilize various media (i.e., microwave, satellite, fiber optics) depending on service requirements and cost-effectiveness. In all cases, the equipment will be state of the art, off the shelf, utilizing maintenance on demand with card or chassis level restoration in the event of failure. System topology will consist of alternate routing for restoration with associated monitoring of performance and restoral switching. The RCL microwave equipment will provide the backbone of this future transmission system. The future RCL topology is depicted in Figure 2-1.

23.-29. RESERVED.

Figure 2-1. FUTURE RCL TOPOLOGY



CHAPTER 3. PROJECT MANAGEMENT

30. IMPLEMENTATION.

a. The RCL portion of the RML Replacement and Expansion Project will be implemented utilizing the services of the prime contractor, AT&T Technology Systems, who will provide turnkey installation of state-of-the-art microwave communications equipment. Specification FAA-E-2749a, Radio Communications Link (RCL).

b. This project is in conformance with Order 1000.1A, Policy Statement of the Federal Aviation Administration, which is concerned with ensuring safety, promoting air commerce, supporting national security, and achieving effective airspace utilization. All actions to achieve the objectives of the project are to be based on the policy contained in Order 1000.1A and the following documentation:

(1) NAS Plan - Facilities, Equipment and Associated Development
(2) Order 1100.1A, FAA Organization - Policies and Standards
(3) Order 1100.2B, FAA Organization - FAA Headquarters
(4) Order 1100.5B, FAA Organization - Field
(5) Order 1800.8E, NAS Configuration Management
(6) Order 1810.1D, Major Systems Acquisition
(7) Order 1800.13B, Planning and Resources Allocation

c. The RCL contract began implementation of the project for an initial quantity of 23 segments. The award date for this contract was May 3, 1985, and completion dates for the segments range from 12 to 32 months after contract award.

d. Project participants (see Figure 3-1, Project Communication) are involved in team efforts to analyze poor performing paths on existing hops, to study various network topologies for potential realignment or collocated facilities, to perform preliminary microwave engineering, to develop a multiplex scheme, and to identify the management and coordination activities necessary for project implementation.

31. PROGRAM MANAGEMENT STRUCTURE.

a. The Program Engineering and Maintenance Service (APM) is responsible for the planning, budgeting, funding, engineering, acquisition, and implementation of the RML Replacement and Expansion Project. The Interfacility Communications Program Manager, APM-510, is responsible for the project within the Service. The Program Manager will provide the focal point through which organizations having approved communications services to be provided by the Interfacility Communications Program may get them on an integrated basis.

b. Supporting the Interfacility Communications Program Manager on the RML Replacement/Expansion Project is the project engineer. This individual is responsible for coordination and management of all specification, procurement and deployment activities for RCL implementation into the NAS environment.

c. Spectrum Engineering Division, AES-500, has the responsibility to ensure that the spectrum needs of the FAA and aviation are met. AES-500 develops the guidelines and criteria necessary to accomplish this mission.

32. PROJECT COMMUNICATIONS. Multiple channels of communications will be established to facilitate the efficient interchange of project information. Figure 3-1 illustrates the direction and flow of information between project participants. The RCL Project Engineer will develop, coordinate and modify this information network as communications requirements change during the project.

33. PROJECT COORDINATION. The RCL Project Engineer is the focal point for all internal/external program communications. The Project Engineer must ensure that necessary project information is available to each organization having action responsibility. To this end, the Project Engineer will maintain a file of distribution lists for project information, arranged by functional organization to either the division or branch level, as appropriate. Each responsible organization will designate a key contact for the Project Engineer, identified by name, organization code, and telephone number. Where appropriate, an alternate will be named. The Project Engineer is also responsible for external NAS program communication to ensure that RCL implementation is compatible with implementation of other agency programs.

34. IMPLEMENTATION PROCEDURES.

a. Based on award of the prime contract to AT&T Technology Systems in May 1985, the FAA orders path analyses, option recommendations, and site survey reports. AT&T delivers the path analyses, option recommendations, and survey reports to APM-510. APM-510, in addition to analyzing AT&T's deliverables, also considers regional input in the form of existing and potential route data as well as System Engineering and Integration (SEI) Contractor input. SEI Contractor supports APM-510 by performing microwave engineering analysis on the regions' data and by evaluating and validating equipment options recommended by AT&T. The microwave path statistics provided by AT&T identify specific microwave transmission system parameters for each hop of the segments. Parameters affecting availability are checked by SEI contractors to ensure that the FAA's performance requirements will be achieved. Possibly marginal paths are flagged. Option recommendations are also challenged to determine whether unnecessary options have been recommended and whether costs can be saved while maintaining required availability and performance.

b. After APM-510 concurs with the recommendations from the SEI, a copy of the path analysis and equipment summary table will be submitted to the Spectrum Engineering Division, AES-500. With the information in hand, it will

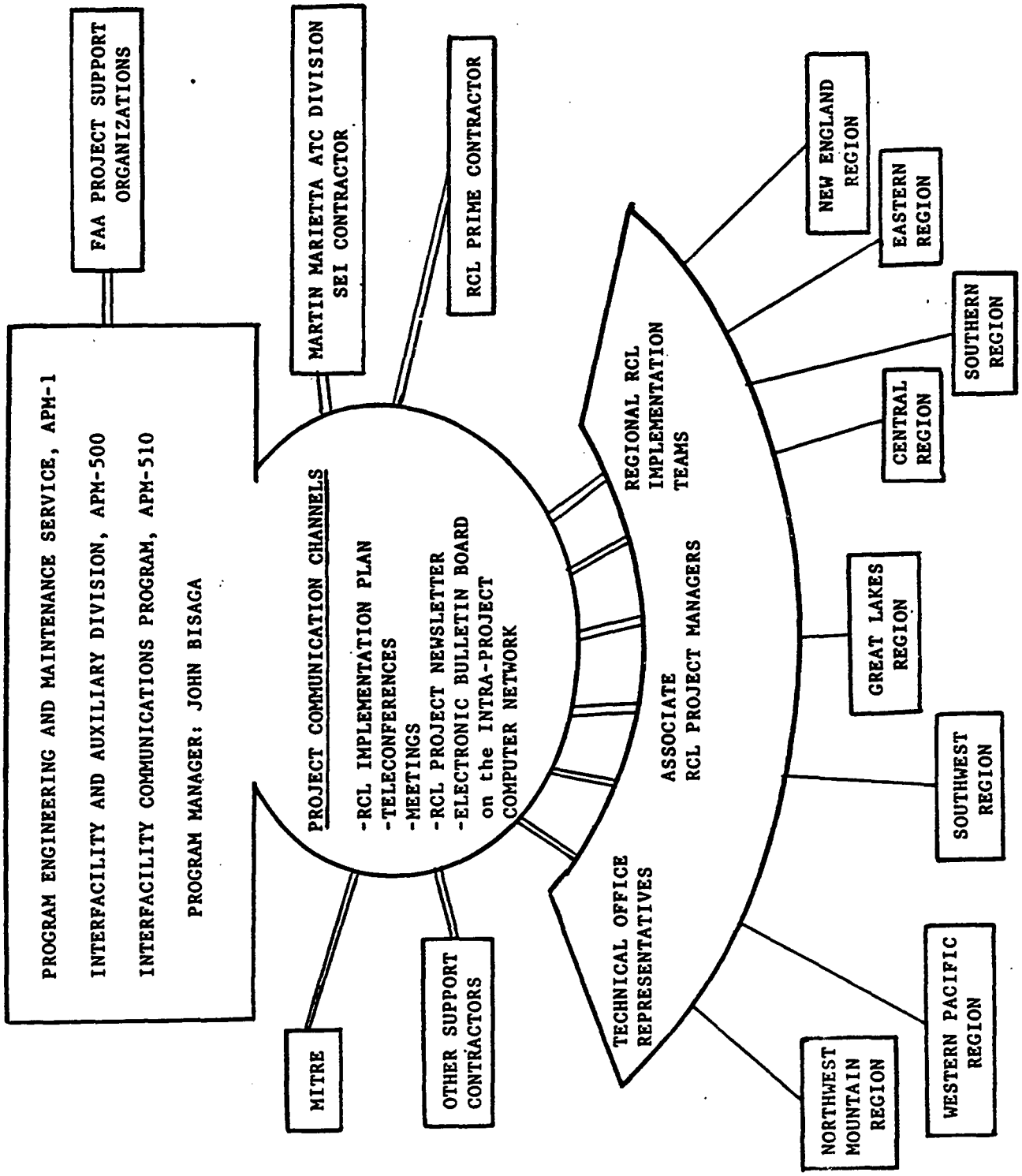
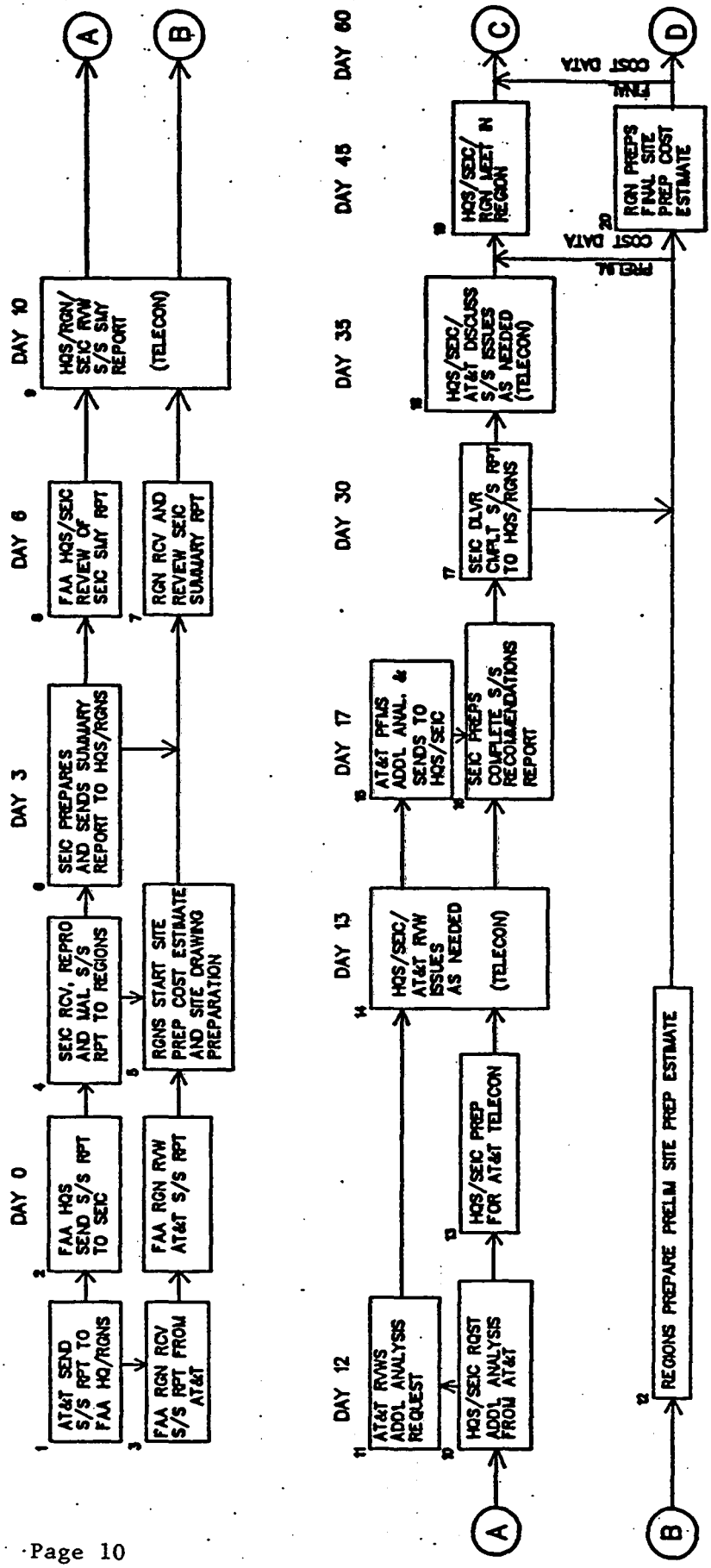

PROGRAM ENGINEERING AND MAINTENANCE SERVICE, APM-1
INTERFACILITY AND AUXILIARY DIVISION, APM-500
INTERFACILITY COMMUNICATIONS PROGRAM, APM-510
PROGRAM MANAGER: JOHN BISAGA
FAA PROJECT SUPPORT ORGANIZATIONS
MARTIN MARIETTA ATC DIVISION SEI CONTRACTOR
RCL PRIME CONTRACTOR
PROJECT COMMUNICATION CHANNELS
-RCL IMPLEMENTATION PLAN
-TELECONFERENCES
-MEETINGS
-RCL PROJECT NEWSLETTER
-ELECTRONIC BULLETIN BOARD on the INTRA-PROJECT COMPUTER NETWORK
MITRE
OTHER SUPPORT CONTRACTORS
TECHNICAL OFFICE REPRESENTATIVES
ASSOCIATE RCL PROJECT MANAGERS
REGIONAL RCL IMPLEMENTATION TEAMS
NEW ENGLAND REGION
EASTERN REGION
SOUTHERN REGION
CENTRAL REGION
GREAT LAKES REGION
SOUTHWEST REGION
WESTERN PACIFIC REGION
NORTHWEST MOUNTAIN REGION

Figure 3-2. RCL IMPLEMENTATION METHODOLOGY



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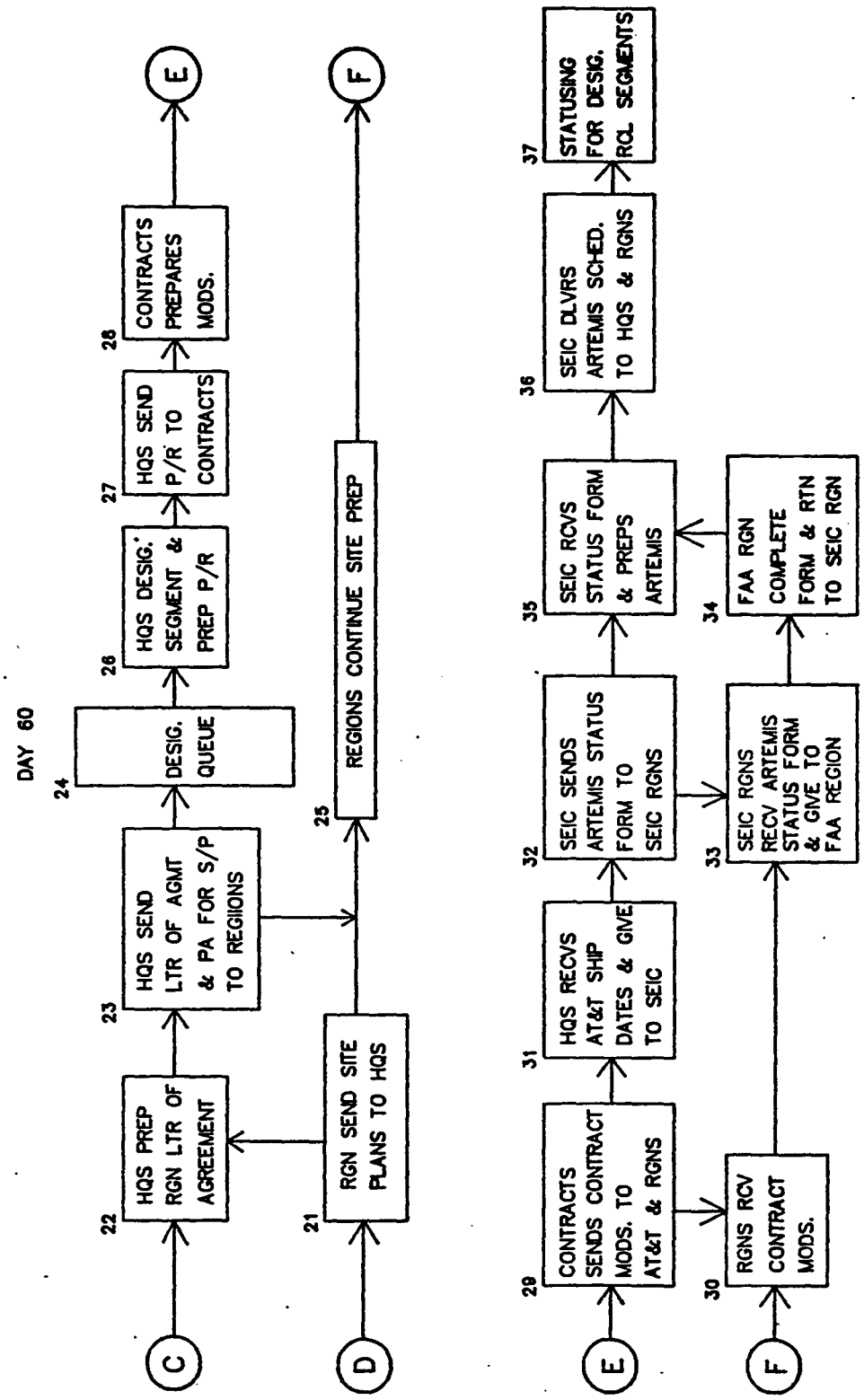


LEGEND

S/S – SITE SURVEY
PA – PURCHASE AUTHORIZATION
P/R – PURCHASE REQUEST
S/P – SITE PREPARATION

be possible to engineer frequencies and submit an application to the National Telecommunications and Information Administration (NTIA) to obtain frequency assignments.

c. The RCL implementation methodology is delineated in block diagram style in figure 3-2. The methodology depicts the flow of events leading to designation of RCL segments beginning with the receipt of AT&T's site survey and path analysis packages. The timing of events is shown. The circled numbers next to each event correspond to the step-by-step description of the RCL implementation methodology as follows:

STEP	ACTION	DAY	DESCRIPTION
1.	AT&T	-	AT&T sends site survey report (with path analysis enclosed) to FAA headquarters and regions.
2.	FAA HQs	-	Receives the site survey report and forwards a copy to the SEIC.
3.	FAA Regions	-	Receive the AT&T site survey report and starts review cycle to highlight pertinent issues (tower raisings, site preparation problems, etc.).
4.	SEIC	0	Receives the AT&T site survey report from FAA headquarters. The SEIC reproduces the AT&T site survey report and delivers the copies to the cognizant FAA regions to ensure these regions have a copy of the report. The SEIC commences generation of a AT&T site survey Summary Report highlighting and summarizing the contents of the site survey report to be followed by a final report on day 30.
5.	FAA Regions	-	After receipt and review of the AT&T site survey report, initiates a preliminary site preparation (site prep) cost estimate, and collection of site drawings.
6.	SEIC	3	The SEIC completes the summary highlighting key issues contained in the AT&T site survey report. The SEIC provides a copy of the summary report to FAA headquarters and sends a copy to cognizant FAA regions by overnight mail in preparation for the day 10 telecon.

STEP	ACTION	DAY	DESCRIPTION
7.	FAA Regions	5	Receive, review and prepare for day 10 telecon with FAA HQs/SEIC. Points to consider should include: a. Selection of sites (as applicable). b. Tower raisings. c. Equipment locations. d. Power/grounding problems. e. Site prep cost estimates. f. Issues or disagreements w/site survey report. g. Others.
8.	FAA HQ/SEIC	6	FAA HQs/SEIC conduct joint review of the summary report in preparation for the regional telecon on day 10.
9.	FAA HQ/FAA Regions/SEIC	10	Conduct a telecon based on key issues involving all facets of regional site preparation. Action items will be assigned and acted upon as required.
10.	FAA HQ/SEIC	10	HQ/SEIC review issues and send request to AT&T for additional obstruction analysis at alternative centerlines.
11.	AT&T	13	AT&T reviews reanalysis request in preparation for telecon on day 13.
12.	FAA Regions	-	FAA regions continue to prepare preliminary site preparation cost estimates for delivery to FAA HQs.
13.	FAA HQ/SEIC	-	Review key issues in preparation for FAA HQ/SEIC/AT&T telecon on day 13.
14.	FAA HQ/SEIC	13	Conduct telecon to address or readdress key regional implementation issues and concerns related to site preparation.
15.	AT&T	17	Perform obstruction fading analysis and deliver results to HQs/SEIC.
16.	SEIC	-	The SEIC continues preparation of the 30 day final site survey report based on path analysis and site survey data provided by AT&T.
17.	SEIC	30	The SEIC delivers a final site survey report to FAA HQs and FAA regions. The final

STEP	ACTION	DAY	DESCRIPTION
			report makes recommendations as to whether towers should be raised and identifies all key issues contained in the AT&T site survey report. The final site survey report contains analysis of key issues including tower raisings, space diversity, etc.
18.	FAA HQs/SEIC/ AT&T	35	A joint review is held between the FAA HQs/SEIC of the final site survey report and key issues are discussed in a telecon with AT&T. The discussions serve as a baseline for guidance and direction to FAA regions during the 45 day regional meetings, including guidance for tower raisings.
19.	FAA HQs/SEIC	45	Meet with cognizant regions to discuss site preparation and acquisition issues and to provide finite guidance related to tower raisings, equipment installation, RCL implementation issues and discuss overall methodology. FAA regions provide preliminary site prep cost estimates to FAA HQs. A preliminary letter of agreement will be drawn up based on this meeting.
20.	FAA Regions	-	Continue preparation of final cost estimates and site drawings.
21.	FAA Regions	60	Furnish final cost estimates and site drawings showing RCL locations to APM-510.
22.	FAA HQs	60+	FAA HQs prepares a FAA HQs/FAA regional letter of agreement containing all key issues previously discussed.
23.	FAA HQs/ FAA Regions	60+	FAA HQs and region(s) agree on key issues and site preparation dates/methodology.
24.	FAA HQs	60+	FAA HQs places RCL segments in the designation queue as agreed with the FAA region(s) for future designation.
25.	FAA Regions	-	Regions continue with site preparation activities, providing monthly status to FAA HQs.
26.	FAA HQs/ FAA Regions	-	FAA HQs/FAA region(s) coordinate for selection of next segment to be designated to AT&T. (Day 45 and day 60 coordination and agreements provide additional evaluation points for designation decision process.) APM-510 prepares purchase request for designated segment.

STEP	ACTION	DAY	DESCRIPTION
27.	FAA HQs	-	APM-510 sends designated segment P/R to ALG for contract modification to AT&T.
28.	FAA HQs	-	ALG prepares contract modification containing dates and performance requirements.
29.	FAA HQs	-	ALG sends contract modifications to AT&T and FAA region(s) and forwards an information copy to the SEIC.
30.	FAA Region	-	FAA region(s) and AT&T receive the contract modifications. AT&T commences manufacturing process. FAA regions continue site preparation.
31.	FAA HQs	-	ALG receives AT&T equipment ship dates and provides them to the SEIC and regions.
32.	SEIC	-	Upon receipt of the AT&T ship dates, the SEIC sends a program status form to cognizant SEIC regional offices which are in the FAA region(s) to which the AT&T equipment is to be shipped.
33.	SEIC Regions/ FAA Regions	-	The SEIC regional office receives the ARTEMIS status for, prints a copy and provides a copy to the FAA region.
34.	FAA Regions/ SEIC Regions	-	The FAA regions complete the status for which provides status of each regions site preparation activities and returns the completed form to the SEIC regional office. The SEIC regional office transmits the completed form to the SEIC Washington office.
35.	SEIC	-	The SEIC receives the ARTEMIS status form prepared by the FAA region(s) and prepares an ARTEMIS tracking schedule printout for each applicable region.
36.	SEIC/FAA HQs	-	The SEIC delivers printed copies of the ARTEMIS schedule to APM-510. APM-510 transmits the ARTEMIS schedules to FAA regions as applicable.
37.	ALL	-	Continue a monthly status methodology to ensure timely updates and current status of the RCL.

d. Approximately 60 days before the start of installation of a new RCL segment, AT&T Technologies Systems will provide to the FAA, a method of procedures (MOP) for the segment. Each FAA regional Technical Office Representative (TOR) having responsibility for that new segment will receive a copy of AT&T's MOP.

e. AT&T is installing RCL facilities at an average rate of 17 per month. Installation for a given segment begins at one end of the segment and continues to each successive repeater facility to the other end of the segment. AT&T is utilizing a team concept for installation, testing, and cutover from station to station. The installation team will install RCL equipment at both ends of the first hop. Station tests of the equipment will be conducted. Upon completion of the station tests, the team will conduct a hop test. Meanwhile, a leapfrog team will leapfrog to the next facility to perform equipment installation and station testing. After hop testing is completed for the first hop, the second hop will be hop tested. This activity will continue, hop by hop, until all hops of the segment have been tested. An end-to-end test and switching test will then be performed.

f. Installation, testing and activation of each hop of each new RCL system segment requires a minimum of two frequencies in each direction (a total of four frequencies). Before an RCL rf channel can be placed on the air for hop testing, any existing service on the rf frequencies of interest must be previously cutover onto a spare RML channel. This coordination is an FAA responsibility to be managed by the TOR. When the AT&T team places the RCL equipment into service at each end of the hop, hop testing can be conducted.

g. After both RCL frequencies have been tested in each direction of the hop, the RCL equipment will remain operationally on the air on one set of the RCL-designated frequencies and the hop testing process will continue at the next hop in the segment.

h. An end-to-end test will be performed on each RCL channel after all hops have been installed and tested. Circuits can be routed onto the RCL at the completion of a successful end-to-end test. The switching test that follows the end-to-end tests on a segment are conducted by the AT&T team to verify successful protective switching. This test results in system outage time; as a result, circuits routed onto the RCL segment prior to the switching test will experience an outage due to this test.

i. Final acceptance testing will be conducted jointly between the FAA and AT&T. After final acceptance testing has been completed, AT&T will disconnect the old RML equipment and set it aside. The FAA is responsible for disposal of the old RML equipment in accordance with disposal procedures to be published.

j. A detailed sequence of steps describing the in-service cutover has been provided by AT&T in the form of a recommended method of procedures (See appendix 3).

35. PROJECT RESPONSIBILITIES. Project responsibilities are summarized as follows:

a. Washington Office Responsibilities.

(1) General.

(a) Implement the RCL project.
(b) Prepare, coordinate, distribute, and maintain this RCL Implementation Plan.
(c) Determine, coordinate, and announce project reporting requirements.
(d) Amend appropriate tasking documents to this radio communications link implementation plan to reflect changes to the scope of the project.
(e) Review and approve regional annexes to the radio communications link implementation plan.
(f) Review and approve system-engineering specifications.
(g) Review and approve path calculations and test plans for the RCL.
(h) Coordinate the RCL frequency plan.
(i) Develop, review, approve, and implement transition procedures acceptable to the regions.
(j) Provide overall program guidance to all offices, services and regions on the implementation of the RCL system.
(k) Be responsible for providing site preparation standards to the regions.
(l) Be responsible for developing AF certification procedures and have them published prior to the RCL commissioning.
(m) Ensure that all ATC operational aspects of the system implementation are satisfactorily addressed prior to RCL commissioning.

(2) Replacement Program.

(a) Procure equipment.
(b) Establish and adjust delivery schedules.
(c) Select equipment options after SEIC validations of AT&T recommendations.
(d) Submit regional-provided poor-performing hop data to the SEIC for path analysis prior to ordering path.
(e) Obtain frequency assignments.

(3) New Segments.

(a) Provide buildings and towers.
(b) Select equipment options for SEIC validation.
(c) Monitor regional progress and adjust schedules accordingly.
(d) Engineer and obtain frequency authorizations.

(4) Other Washington Office Activities.

(a) Provide funding to the regions.
(b) Perform all negotiations with AT&T.
(c) Keep regions informed of schedules.
(d) APM-150: Coordinate the technical support, and field engineering support in the associated areas.
(e) APM-100: Project operations requirements for staffing, training, and project support equipment.
(f) APM-520: Provide assistance on procuring towers, buildings, and furnishing space.
(g) APM-530: Provide assistance on power, grounding and electrical systems.
(h) APT-300: Analyze project training requirements, develop appropriate materials for training classes and texts, approve proposed training classes by contractor personnel.
(i) ALG-330: Contract administration.
(j) ALG-400: A quality/reliability officer (QRO) will be assigned as the FAA's representative at AT&T's facility. The QRO is directed by agency policy and procedures and by terms and conditions of the contract.
(k) AAC-480: The Supply Management branch will act as the coordinator of logistic support activity.
(l) AAC-900: Conduct FAA training from the 6th year and beyond.
(m) AES-500: Engineer all RCL spectrum requirements.

b. Regional Responsibilities.

(1) Replacement Program.

(a) Identify poor performing hops and provide data to APM-510.
(b) Prepare for installation of RCL equipment.
(c) Investigate topology for the possible collocating with other facilities, re-routing to improve performance or decrease costs or improve efficiency. Use the MITRE configuration analysis tools presented.
(d) Prepare sites. This entails providing space for the new equipment by removing work benches, furniture, etc. Install circuit breakers.
(e) Procure buildings and install towers when required.
(f) Select technical office representatives (TOR).
(g) Remove and dispose of old RML multiplex and designated test equipment after AT&T has cutover service to the new RCL system.

(2) New Segments.

(a) Select alternate sites as necessary for submittal to the prime contractor via APM-510.

1 Considerations.

a Make use of existing FAA facilities, where possible.
b Make use of other facilities where possible.

c When neither of the above items can be accomplished, consideration should be given to ease of access.

(b) Provide pertinent site data to APM-510 for path-analysis by AT&T.

(c) Provide cost estimates to APM-510 for engineering, installation, and cutover activities.

(d) Prepare sites for national building and tower contractors.

(e) Obtain purchase agreements or lease options on selected locations.

(3) Other Regional Activities.

(a) Act as a member of the National Implementation Team with SEIC.

(b) Coordinate and negotiate with other government agencies.

(c) Prepare the Finding of No Significant Impact (FONSI) statements or environmental impact statements as required.

(d) Monitor and update regional progress via inputs to the project control data base.

(e) Using the MITRE configuration analysis tools, identify the most desirable location for drop/insert point repeaters on the microwave backbone.

(f) Final acceptance and circuit cross-connects.

c. System Engineering and Integration Contractor Responsibilities.

(1) Support the Washington office (APM-510) in developing and maintaining this Radio Communications Link Implementation Plan.

(2) Perform microwave engineering analysis to:

(a) Investigate problem microwave hops based on data submitted from the regions.

(b) Validate equipment options recommended by AT&T.

(3) Develop an information data base for project control, logistics, and engineering that facilitates information transfer via APM-510's personal computer.

(4) Perform field audits and site-unique requirements studies as necessary.

(5) Ensure that activities of the RML Replacement and Expansion Project are efficiently integrated into the overall NAS Plan Program.

d. MITRE Corp.

(1) Provide analysis tools and graphic plots to facilitate the development of regional plans for RCL configurations.

(2) Ensure the overall integrity of the national network by coordinating regional plans on a nationwide basis.

(3) Develop a nationwide multiplex planning tool and multiplex plan for the RCL system.

e. AT&T's Responsibilities.

(1) Conduct path analyses and surveys.
(2) Deliver path analyses, option recommendations, and site survey reports.
(3) Recommend alternatives for rejected sites.
(4) Install equipment.
(5) Perform rf cutover.
(6) Demonstrate equipment performance to meet technical sufficiency requirements.
(7) Disconnect old equipment and set aside.

36.-39. RESERVED.

CHAPTER 4. PROJECT CONTROL

40. IMPLEMENTATION MANAGEMENT. The RCL microwave backbone network is to be implemented in accordance with existing agency procedures, as defined in applicable orders.

a. Implementation management is in accordance with Order 1810.1D which requires the preparation of this implementation plan to assure the orderly integration of the RCL network into the National Airspace System.

b. Order 2510.5A, Fiscal Programming and Reporting Procedures for the Facilities and Equipment Appropriations, establishes quarterly review procedures for the reporting and review of the fiscal status of projects included in the program. Monthly reviews cover the overall physical and fiscal status of the program.

c. Logistics support procedures established by Order 5620.3C, Initial Support for New or Modified Equipment Installation will be used for providing initial allowances of spares, supplies, and working equipment required for the operation and maintenance of new FAA facilities and equipment installations. Procedures for the timing and content of project reports: To Be Determined.

41. FISCAL CONSIDERATIONS.

a. This program is F&E funded. It does not require Research and Development work since off-the-shelf equipment will be procured.

b. Funds will be transferred to the regions for performance of their RCL project functions.

c. Funding will be provided out of the leased communications budget for disconnect costs.

d. The F&E costs for this project will be incurred for the following:

(1) System Acquisition.

(2) Site preparation.

(3) Installation.

(4) Site acquisition.

(5) Initial spares.

(6) Test Equipment.

(7) Technical Office Representative.

(8) Engineering for site search of new locations.

(9) Cutover (transition).

(10) Disposal of old equipment.

42. IMPLEMENTATION SCHEDULE. Site surveys and path analyses are being ordered at a rate approximately twice that of segment designation. As a result, a queue of segments from which to designate has been established. The estimated time between designation and the installation dates is about one year for replacement segments. This time should grow to approximately 2-2 1/2 years for replacement segments. A planning schedule providing suggested implementation methodology and dates will be provided in the RCL/IP. The schedules, because the designation process is contingent upon site preparation readiness, are not firm and should be used for planning purposes only. The project schedule is depicted in Appendix 2, RCL Project Schedule.

43. CONTROL TECHNIQUES. The progress of project activities will be communicated, monitored, and controlled using the following techniques:

a. Activity Sequence Listings. These listings will give an informal overview of the general flow of project events.

b. Bar Chart Milestone Summaries. These charts will indicate activity-progress versus time.

c. Activity Sequencing Tool (ARTEMIS).

(1) This tool is designed to accept activity listings and to format them into detailed network diagrams. These diagrams illustrate graphically how the activities must flow over time. They also indicate which activities must occur before others can be started. If a time-slippage occurs in one or more activities, the effect on all other activity dates will be recalculated and a new activity flow diagram will be printed out. This tool is a way to present a diagram of typical sequential and concurrent tasks required for RCL implementation in a given segment. Tasks are broken down into three basic areas:

(a) Segment activities.
(b) Site-oriented activities.
(c) Terminal site activities.

(2) The lines between activities indicate the sequential relationship (or interdependency). For example, route planning, site identification, and site acquisition must occur before the installation of telecommunications equipment at the site. The data contained under each activity block represents:

The earliest start-date of the activity	The activity duration	The earliest finish-date of the activity
The latest start-date of the activity	The duration of allowable activity slip-time	The latest finish-date of the activity

NOTE: All activities which have zero slip-time are on the critical path. This means a slip in one of these activities will affect the completion date of the entire project.

44. CONFIGURATION MANAGEMENT.

a. Configuration Management will follow the policy and procedures established by Order 1800.8E, NAS Configuration Management. The Configuration Management Division is responsible for maintaining the baseline configuration and processing proposed changes through implementation of approved changes.

b. AT&T will provide a configuration management plan. If future enhancements to the RCL (in the form of product improvements) result in revisions or modifications to any boards, modules, or chassis, and if these units will appear in future production runs or be replaceable items for defective units, AT&T will provide documentation explaining the reason for the revisions or modifications.

45. PROJECT QUALITY ASSURANCE.

a. Quality assurance will be provided via implementation of a quality control program. AT&T is responsible for implementation of the quality control program, to include delivery of documentation of tests conducted. Tests will be conducted within the time allotted by the contract schedule. The tests will determine whether all provisions called out in the RCL specification have been met.

b. The quality control program will include performance tests, initial acceptance tests, final acceptance tests, and maintainability demonstration tests. The purpose of the performance tests is to verify end-to-end sufficiency, compatibility, interchangeability, and interoperability. Initial acceptance testing verifies that the system tested is ready to accept operating circuits. Final acceptance testing verifies that all equipment is operational under the tolerances prescribed in the equipment documentation. Maintainability demonstration testing verifies the time required to isolate and replace a defective module.

46.-49. RESERVED.

CHAPTER 5. PROJECT ENGINEERING

50. GENERAL. The basic engineering activity required to determine site locations, analyze microwave path performance, and prepare sites for installation will be performed by the combined efforts of the FAA headquarters, the FAA regions, the SEI contractor, and AT&T.

51. MITRE CORP. will assist the engineering work by supplying the guidelines for RCL configuration analysis. These guidelines will assist RCL planners and engineers in their effort to:

a. Determine optimal location of drop/insert points on the microwave backbone in order to reduce tieline access costs.

b. Investigate the cost and benefits of rerouting the backbone system to collocate FAA repeaters and drop/insert points with other existing microwave sites or other FAA facilities.

c. Develop planning charts of alternative tail-circuit connections to drop/insert points on the microwave backbone.

NOTE: Detailed information concerning these guidelines can be obtained from the RCL configuration analysis briefing material provided by MITRE. MITRE has also provided a national multiplex plan and planning tool for the RCL system.

52. SYSTEM ENGINEER AND INTEGRATION CONTRACTOR ENGINEERING SUPPORT.

a. The SEI contractor will use an integrated set of computer-assisted, microwave engineering tools to support the FAA in analyzing and evaluating the following:

(1) Existing problem hops in the RML system and the parameters which can be changed (such as tower heights, transmitter power, diversity schemes, etc.) to improve propagation performance and reliability.

(2) Transmission characteristics of existing microwave hops owned by non-FAA organizations and the feasibility of RCL collocation.

(3) Contractor path analysis reports and equipment option recommendations.

b. SEI contractor microwave engineering support consists of two path analysis tools.

(1) The first satisfies the need for rapid, first-cut feasibility analysis. A regional technical office representative (TOR) or engineer can call Washington headquarters with an analysis request and receive a useful engineering report over the phone within two hours.

(2) The second tool will implement a modified form of the Automated Digital Systems Engineering Model to perform detailed path analysis on the SEI contractor's mainframe computer. This tool utilizes high-resolution terrain data and atmospheric statistical techniques to predict path performance with a high degree of accuracy. The tool will be used to analyze critical parameters on marginal hops and to validate contractor equipment recommendations.

53. TOWER ENGINEERING. The DOT Transportation System Center (TSC) is presently performing a tower analysis to determine if full-scale engineering work is needed to reinforce or replace tower structures to handle the increased waveguide and dish antenna loading.

54. RELATED PROJECTS. In addition to the RCL backbone network, the NAS transmission subsystem has two other elements: the network monitor and control system (NMCS) and the data multiplexing project. Engineering considerations for the interface of these elements into the RCL system will be included in this radio communications link implementation plan as data is made available.

55.-59 RESERVED.

CHAPTER 6. TECHNICAL MANAGEMENT

60. GENERAL. Proper equipment installation involves consideration of equipment sizing and floor space requirements, grounding, power, equipment performance specifications, antennas and towers, new site acquisition, frequency assignments and other related aspects.

61. TECHNICAL AREAS.

a. Floor space arrangements depend to a large degree on the physical dimensions of the equipment and the adjacency requirements of equipment types. Floor space requirements for RCL equipment at each ARTCC also depends on whether the ARTCC will terminate one, two, three or four RCL links under the NAS concept. Diagrams showing proposed floor space requirements for the RCL system are provided in appendix 4. These diagrams are engineering tools only and are intended to assist regions in the floor space planning process.

b. Grounding is to be completed at all sites along a segment before AT&T begins installation of that segment. A policy letter pertaining to grounding has been formulated by APM-500 and it is included as appendix 5 to this plan.

c. If new power panels are required at a site, the responsible TOR will ensure that all required wiring for the power panel is engineered. All power panels are to be completed before AT&T begins equipment installation.

d. A summary of equipment performance specifications is provided in the instruction manuals provided by AT&T to APM-510 for the RCL project. A summarized version is in this plan to facilitate quick references to information frequently needed throughout the RCL implementation process.

(1) AT&T is recommending antenna centerline heights in the path analyses being performed for the FAA. The SEIC then analyzes AT&T's recommendations. In some cases, the SEIC recommends a centerline below AT&T's recommended centerline. In other cases, the SEIC recommends a higher centerline (within the bounds of the existing RML tower) than the AT&T recommended centerline.

(2) The SEIC is also providing antenna and tower "what if" assistance to APM-510. The SEIC performs a "what if" analysis of AT&T's recommendations in order to identify possible sites at which a tower raising has been recommended.

e. Non-government microwave radio site maps have been obtained from the Electromagnetic Compatibility Analysis Center (ECAC) for the purpose of providing assistance to the regions in acquiring new sites. Copies of these maps, and the microfiche data that accompanies them, have been distributed to the regions. The microfiche data will assist the regions in identifying existing non-government microwave facilities, the frequencies in use, the number of systems in operation, and other information such as site

other information such as site latitudes and longitudes, azimuth, and hop distances of the systems listed.

f. Frequencies are assigned by the National Telecommunications and Information Administration (NTIA). APM-510 coordinates with the Spectrum Engineering Division, AES-500, to obtain frequencies for RCL segments to be designated to AT&T.

g. Routing broadband radar on the RCL is required until the CD-2 capability is implemented and certified. Methods to achieve broadband utilization are under current consideration. This paragraph will be expanded to explain broadband utilization of the RCL when an approved method has been selected for implementation.

62.-69. RESERVED.

CHAPTER 7. TRANSITION

70. GENERAL. Transition from the currently operating RML system to the future RCL is to occur smoothly and efficiently. Planning is the key to a successful transition. The transition planning process must consider the configuration constraints of existing facilities, the delivery and installation details of new subsystems, the impact of project changes on facility installations, and all interdependencies of the various subsystems on one another. The transition must be coordinated on a facility-by-facility basis. Detailed facility planning is the responsibility of the regions; planning and schedule guidance is the responsibility of FAA headquarters.

71. TRANSITION SUPPORT. This project is supported by SEI Contractor with tools to assist in the management of the transition from the RML to the RCL. Project activities are being tracked and monitored using the ARTEMIS approach. This automation technique facilitates the evaluation, analysis, and modification of project activities. Durations and interdependencies are maintained precisely by the ARTEMIS system.

72. EQUIPMENT DELIVERY. Upon receipt of AT&T's shipment notice, APM-510 will issue FAA Form 4500-1, Project Materiel Shipping Notice/Receiving Report. When the equipment has been delivered to the site, the region having responsibility for the site will complete the Form 4500 and forward it immediately to APM-510. The FAA will then provide 80 percent payment to AT&T.

73. INITIAL ACCEPTANCE TEST. Upon completion of installation and testing, the regions will prepare FAA Form 256, Inspection Report of Materiel and/or Services with attached AT&T Field Acceptance Test Data, including a list of exceptions. At this point, the equipment is only being initially accepted by the FAA; therefore, FAA Form 256, is considered a modified form to reflect completion of installation and testing but not to reflect final equipment acceptance from AT&T. This form will be used as a contract document to list those items that must be cleared by AT&T within 45 days.

74. 45 DAY CROSS-CONNECT PERIOD. Upon completion of the initial acceptance test, the FAA has 45 days to make all cross-connects of existing RML trunked circuits onto the RCL. Cross-connects will be made at demarcs.

75. RF CUTOVER PERIOD. After the 45 day cross-connect period, AT&T will begin rf cutover. Procedures for rf cutover have been provided by AT&T in the form of a recommended method of procedure (MOP). (See appendix 3).

76. FINAL ACCEPTANCE TEST. After all equipment has been removed and once all drawings have been received and after all punch list discrepancies are cleared, the final acceptance test will be conducted. Upon completion of the final acceptance test, AT&T will receive the 20 percent remaining payment for completion and for the balance of equipment cost.

77. EQUIPMENT DISCONNECT, REMOVAL, AND DISPOSITION. AT&T will make all electrical and mechanical disconnects of the equipment being replaced. This includes removal of unused waveguide, reflectors, and antennas from the towers and buildings. It does not include storage and package of said items after removal. Equipment removal will be conducted immediately after the final acceptance test. Equipment disconnection and removal will be completed within 30 days of completion of the final acceptance test. The FAA is responsible for transporting all government owned excess equipment from the site to a point of disposal.

78.-79 RESERVED.

CHAPTER 8. LOGISTICS SUPPORT

80. GENERAL. All RCL communications equipment will be available as commercial, off-the-shelf equipment. Because the market for interfacility commercial communications equipment is highly competitive and vendor repair and support over the product life cycle is acceptable, the use of commercial equipment is advantageous to the Government (U.S. Air Force study titled, Availability and Quality of Commercially Available Support for New Generation Equipment, July 29, 1981). Restoration will generally be at the card or chassis level in the field. Repair of the cards or chassis will be done by the equipment vendor during the warranty period which starts at initial acceptance and runs for 10,000 hours thereafter. All FAA work centers assigned responsibility for RCL maintenance will maintain a set of RCL spares which will be provided by the contractor. Repair of the line replaceable unit (LRU) after the warranty period will be accomplished by AT&T. This chapter summarizes the logistics support for the RCL project. Details are contained in the RCL integrated logistics support plan (ILSP) and the RCL subsystem training plan (STP).

81. MAINTENANCE PROCEDURES. During installation, AT&T is responsible for maintenance of the RCL equipment. Subsequent to acceptance of a segment by the government, site maintenance will be accomplished by FAA technicians through fault isolation, assisted by ANMS, and LRU removal and replacement. Detailed procedures for maintenance of the system are contained in the appropriate AT&T O&M Manuals and in the FAA Handbook for RCL maintenance. Notification of the appropriate work center will be accomplished by the system engineer at the ARTCC, responsible for monitoring the ANMS, The ANMS terminal will be located in the SMCC. Repair of the unserviceable LRUs will be accomplished by AT&T during the 10,000 hour warranty period. AT&T is also responsible for subsequent LRU repair during the initial 5 year contract period, on a reimbursable basis. Provisions exist for renewal of the repair contract for two subsequent 5 year terms.

82. PERSONNEL STAFFING. Staffing for support of the RCL will be determined by the region, based on the geographic proximity of the facilities to work centers but also giving consideration to the high reliability of the system. For planning purposes, 0.5 manyear per RCL facility is being used in HQ FAA allocation of airway facility resources.

83. TRAINING. A training program is being provided by AT&T. As part of the RCL training program, AT&T has developed two courses to support RCL maintenance. These courses are the RCL course taught at Greensboro, North Carolina, and the ANMS course taught at Dublin, Ohio.

a. The RCL maintenance course will train students to maintain the terminal radios, repeater radios, terminal multiplex equipment, repeater multiplex equipment, and options.

b. The ANMS course will train ARTCC technicians to operate and troubleshoot the ANMS. The first part of the course focuses on the

development and maintenance of the ANMS data base. The second part of the course focuses on the troubleshooting and maintenance of the ANMS system.

c. Training allocations for these courses will be provided by APM-110 to the regions

84. EQUIPMENT DOCUMENTATION. Equipment documentation will be standard commercial texts. Drawings and specifications of the new equipment and facilities will be provided. The AT&T maintenance documentation will be supplemented by the APM-150 maintenance handbook which will contain certification requirements, technical standards and tolerances, and required periodic maintenance.

85. SPARES, REPAIR PARTS, AND CONSUMABLES REQUIREMENTS.

a. The RCL contract specifies purchase of initial spares for the first 308 RCL facilities. This initial sparing will be based on the rate of one spare per lowest replaceable item or 10 percent of lowest replaceable item density, whichever is less, at each site. Requirements for initial sparing for facilities beyond the first 308 facilities will be based upon equipment density and spares usage during the warranty period.

b. Initial spares distribution will be made to the sites of the initial 308 RCL facilities. Subsequently, the spares will be reallocated to the supporting work centers. The number of sets of spares allocated to each work center will be based upon the number of facilities supported by a work center. Spares not distributed to work centers will be maintained by the FAA Depot as back-up stock pending the delivery of subsequent RCL facilities. Distribution of spares procured to support RCL facilities installed after the initial 308 will be at the direction of the FAA Depot.

c. Support procedures for spares, repair parts, and consumables not provided with the initial support package are to be determined.

86. PACKAGING/HANDLING/STORAGE/TRANSPORTATION REQUIREMENTS. To Be Determined. Included will be special requirements for the return of warranteed items to AT&T for repair and return to the FAA. Procedures to be followed during the initial 10,000-hour period will be detailed. Also included will be procedures to be followed during any period of contractor-supplied maintenance beyond the warranty period.

87. TEST EQUIPMENT. Test equipment will be provided by the FAA. To Be Determined.

88. ADDITIONAL CONTRACTOR SUPPORT. Additional contractor support will be determined to ensure that reliable, efficient lowest replaceable item-to-Depot logistics is provided. AT&T will establish a hot line to provide second level support for RCL until APM-150 establishes the capability. Upon establishment, the hot line number will be provided to the RCL work centers.

89. RESERVED.

APPENDIX 1. GLOSSARY

The purpose of this glossary is to provide the definitions of terms and acronyms that will be used in RCL project work.

ACF - Area Control Facility

AF - Airway facilities

ALG - Acquisition and Materiel Service

ANMS - Automatic network management system

APM - Program Engineering and Maintenance Service

ARTCC - Air Route Traffic Control Center

ARTEMIS - A management control system which assists in project planning by generating automated activity sequencing charts using critical path methods. Similar to program review and evaluation technique (PERT) methods.
NOTE: ARTEMIS is not an acronym.

ATC - Air Traffic Control

AT&T - American Telegraph & Telephone

Backbone - A shared telecommunications pathway by which multiple users are served via multiplexing at designated drop and insert points.

Cross-connecting -
1. The removal of circuits from existing equipment and the reconnection of those circuits to new equipment.
2. The act of making connections between terminal blocks on the two sides of a distribution frame.

Cutover - The final transfer of all capabilities from the old system to the new.

DIP - Drop Insert Point - That process wherein a part of the information carried in a transmission system is terminated (dropped) at an intermediate point and different information is entered (inserted) for subsequent transmission in the same position (e.g., time, frequency, or phase) previously occupied by the terminated information.

ECAC - Electromagnetic Compatibility Analysis Center

FAA - Federal Aviation Administration

Facility - Group or groups of equipment located in a common building or site - e.g., a repeater or terminal facility.

F&E - Facilities and equipment

FONSI - Finding of No Significant Impact

FSS - Flight Service Station

Hop - The radio-frequency path between the two adjacent facilities.

ILSP - Integrated Logistics Support Plan

JAI - Joint Acceptance Inspection

LRU - (Lowest Replaceable Unit) - The lowest unit to be replaced within the system during site maintenance. It is a separate, installable, physical package performing a single function or group of closely related functions.

MOP - Method of Procedure

NMCE - Network management and control equipment

NTIA - National Telecommunications and Information Administration

O&M - Operations and maintenance

Path Analysis - A path analysis is everything that the contractor deems necessary to ensure end-to-end technical sufficiency of the system. This could include path surveys, propagation analysis, path profiles, and reliability factors.

P/R - Procurement Request

QRO - Quality/Reliability Officer

Radar Terminal - This facility is the terminal end of a microwave segment, normally located at a long-range radar site. It will use direct-to-line multiplexing.

RCL - Radio communications link

RCL/IP - Radio communications link implementation plan

Repeater (normal) - A facility containing equipment which relays a microwave signal in two or more directions.

RF - Radio frequency

RML - Radar microwave link

Segment - A portion of a system of an undefined number of facilities that will eventually be incorporated into a system by adding more facilities.

SEI Contractor - Systems Engineering and Integration Contractor

STP - Subsystem Training Plan

System - A transmission link composed of repeater and terminal facilities that connect transmission nodes together

TOR (Technical Office Representative) - This term denotes the technical office representative selected as the FAA's official liaison with the contractor's installation crew for a particular RML installation phase.

TSC - Transportation System Center

RCL SCHEDULE 18-Oct-86 *** FOR PLANNING PURPOSES ONLY - PRELIMINARY INFORMATION *** PAGE 1

APPENDIX 2. PART 1. RCL SEGMENTS DESIGNATED TO AT&T

RCL SEGMENTS DESIGNATED TO AT&T TO MANUFACTURER, INSTALL, AND ACTIVATE

LEGEND: RCL PROGRAMMED IMPLEMENTATION SCHEDULE

* = RCL SEGMENT DATE DESIGNATED TO AT&T
S = RCL SEGMENT DELIVERY/INSTALLATION DATE
I = INITIAL ACCEPTANCE DATE
F = FINAL ACCEPTANCE DATE

LEGEND: PROPOSED CD-2 INSTALLATION SCHEDULE

A = CD-2A: ENROUTE INSTALLATION DATE
B = CD-2B: BEACON / MODE 'S' ONLY INSTALLATION DATE
C = CD-2C: FAA / USAF INSTALLATION DATE
D = CD-2D: ASR'S 7 & 8 INSTALLATION DATE

NO.	SEGMENT	REGION	REPLACEMENT/EXPANSION REP.	EXP.	RGN LAT/LON TO HQ	HQ CONTRACTS AT&T	AT&T PATH ANAL TO HQ	PATH ANAL COMPLETE	PRE-1985	1985 QUARTERS 1 2 3 4	1986 QUARTERS 1 2 3 4	1987 QUARTERS 1 2 3 4	1988 QUARTERS 1 2 3 4	1989 QUARTERS 1 2 3 4	1990 QUARTERS 1 2 3 4	HQ CONTRACT DESIGNATE MOD #
1	PATRICK AFB - MIAMI	ASO	14			MAY 85	JUN 85	X		*	SI F C	C				MOD #6
2	AMARILLO - ALBUQUERQUE	ASW	12			MAY 85	JUN 85	X		*	S I F AA					MOD #6
3	ATLANTA - INDIANAPOLIS	ASO AGL	28			JUL 85	AUG 85	X	A	* A A	S I F A					MOD #8
4	LONDON - INDIANAPOLIS	AGL	7			JUL 85	AUG 85	X	AA	*	S I F					MOD #8
5	CEDAR CITY - SALT LAKE CITY	ANM	12			MAY 85	JUN 85	X		* A A	S I F					MOD #8
6	SALT LAKE CITY-DENVER	ANM	19	1		MAY 85	JUN 85	X		* A	S I F A					MOD #8
7	GARDEN CITY - KANSAS CITY	ACE	17			JUN 85	JUL 85	X		* A	S I F A					MOD #12
8	LOS ANGELES - CEDAR CITY	AWP	18			SEP 85	OCT 85	X		* A	S I F B D	F				MOD #15
9	ODESSA - FT WORTH	ASW	14			AUG 85	SEP 85	X		*	SI F A	F CB				MOD #18
10	ATLANTA - BLACK JACK MTN	ASO	5			AUG 85	SEP 85	X		*	SIF					MOD #18
11	DENVER - ALBUQUERQUE	ANM ASW	28			SEP 85	OCT 85	X		A	* S A A	I F				MOD #20
12	OAKLAND - LOS ANGELES	AWP	12			OCT 85	NOV 85	X			* D	SI F DCC				MOD #25
13	JOELTON - MEMPHIS	ASO	9			NOV 85	DEC 85	X			* A A	SI F				MOD #25
14	LA GRANGE - CHICAGO	AGL	9			JAN 86	FEB 86	X			* A	SI F				MOD #32
15	BENTON - NEW YORK CITY	AEA	8			DEC 85	JAN 86	X			* A	S I F				MOD #35
16	OAKDALE - CLEVELAND	AEA AGL	7			DEC 85	JAN 86	X		A A	*	S I F				MOD #38
17	DANSVILLE - CLEVELAND	AEA AGL	11			DEC 85	JAN 86	X		A	* A	SI F				MOD #39
18	ST LOUIS - KANSAS CITY	ACE	10			JAN 86	FEB 86	X			*	S I F A				MOD #43

19	CUMMINGTON - BOSTON	ANE	4			JAN 86	FEB 86	X			A	*		SIF							MOD #43
20	KLAMATH FALLS - SEATTLE	ANM	20			NOV 85	DEC 85	X		A	*- --------*	C		S	I F	C					MOD #49
21								X													

APPENDIX 2. PART 1. RCL SEGMENTS TO BE DESIGNATED FOR AT&T

RCL DELIVERY SCHEDULE 10-Oct-86 *** FOR PLANNING PURPOSES ONLY - PRELIMINARY INFORMATION *** PAGE 1

RCL SEGMENTS TO BE DESIGNATED FOR AT&T TO MANUFACTURER, INSTALL, AND ACTIVATE

LEGEND: RCL PROGRAMMED IMPLEMENTATION SCHEDULE

* = RCL SEGMENT PROPOSED DESIGNATED DATE TO AT&T
$ = RCL SEGMENT DELIVERY/INSTALLATION DATE
I = INITIAL ACCEPTANCE DATE
F = FINAL ACCEPTANCE DATE

LEGEND: PROPOSED CD-2 INSTALLATION SCHEDULE

A = CD-2A: ENROUTE INSTALLATION DATE
B = CD-2B: BEACON / MODE 'S' ONLY INSTALLATION DATE
C = CD-2C: FAA / USAF INSTALLATION DATE
D = CD-2D: ASR'S 7 & 8 INSTALLATION DATE

NO.	SEGMENT	REGION	REPLACEMENT/EXPANSION REP.	EXP.	REG. LAT/LON TO HQ	HQ CONTRACTS AT&T	AT&T PATH ANAL TO HQ	PATH ANAL COMPLETE	PRE-1985	1985 QUARTERS 1 2 3 4	1986 QUARTERS 1 2 3 4	1987 QUARTERS 1 2 3 4	1988 QUARTERS 1 2 3 4	1989 QUARTERS 1 2 3 4	1990 QUARTERS 1 2 3 4	HQ CONTRACT DESIGNATE MOD #
1	MT ASHLAND - OAKLAND	AWP	7	5		OCT 85	NOV 85	X			*---------- AA	DC				
2	BENSON - WASH DC	ASO AEA	12			NOV 85	DEC 85	X			*------ A					
3	SAN ANTONIO - FT WORTH	ASW		11	FEB 86	MAR 86	APR 86	X			*------ A	A				
4	SAN ANTONIO - HOUSTON	ASW	10			JAN 86	FEB 86	X			*------ C	A				
5	BOISE - SALT LAKE CITY	ANW	14		APR 86	MAY 86	JUN 86	X		A	*-- B A					
6	SALT LAKE CITY-BATTLE MTN	ANW AWP	12		APR 86	MAY 86	JUN 86	X		A	*--	A				
7	SEATTLE - SPOKANE	ANW	10		MAR 86	APR 86	MAY 86	X		A	*--	C				
8	PHOENIX - ALBUQUERQUE	ASW	23		JAN 86	FEB 86	MAR 86	X			* A C					
9	OKLAHOMA CITY - FT WORTH	ASW	7		FEB 86	MAR 86	APR 86	X			* A	A				
10	MEMPHIS - NEW PORT	ASO	9		FEB 86	MAR 86	APR 86	X			* A					
11	ATLANTA - MONTGOMERY	ASO	6		FEB 86	MAR 86	APR 86	X			* A	*				
12	FT WORTH - TEXARKANA	ASW	8		MAR 86	APR 86	MAY 86	X		A	A	*				
13	DENVER - LUSK	ANM	8		MAR 86	APR 86	MAY 86	X		A		*				
14	NEW ORLEANS - NEW PORT	ASW ASO		6	OCT 86	NOV 86	DEC 86					*				
15	NEW YORK CITY - CUMMINGTON	ANE		8	JUN 86	JUL 86	AUG 86					*				
16	CHICAGO - HORICON	AGL	5		FEB 86	MAR 86	APR 86	X			A	*				
17	HOUSTON - NEW ORLEANS	ASW		13		FEB 86	MAR 86	X				*				
18	BOSTON - BUCK HARBOR	ANE	9		APR 86	MAY 86	JUN 86	X			C	*				

19	JACKSONVILLE - JEDBURG	ASO	10			JAN 86	FEB 86	X					C	*							
20	JEDBERG - BENSON	ASO		9	JUN 86	JUL 86	AUG 86				A		C	*							
21	WASH DC - OAKDALE	AEA		10	MAY 86	JUN 86	JUL 86			A				*							
22	NEW ORLEANS - MONTGOMERY	ASW ASO		11	NOV 86	DEC 86	JAN 87				AC		C	*							
23	ATLANTA - VALDOSTA	ASO		5	NOV 86	DEC 86	JAN 87			A				*							
24	VALDOSTA - JACKSONVILLE	ASO	5		NOV 86	DEC 86	JAN 87	X						*							
25	MINNEAPOLIS - HORICON	AGL		14	JUL 86	AUG 86	SEP 86				A		B	*							
26	JACKSONVILLE - PATRICK AFB	ASO		12	OCT 86	NOV 86	DEC 86				C			*							
27	BEDFORD - WASH DC	AEA	8		JUL 86	AUG 86	SEP 86	X	A					*							
28	BEDFORD - LONDON	AEA AGL		10	JUL 86	AUG 86	SEP 86							*							
29	WASH DC - NEW YORK CITY	AEA		13	MAY 86	JUN 86	JUL 86			A				*							
30	DETROIT - CLEVELAND	AGL	6		MAR 86	APR 86	MAY 86	X	A					*							
31	INDIANAPOLIS - JOELTON	AGL ASO		9	JUN 86	JUL 86	AUG 86		A					*							
32	LA GRANGE - DETROIT	AGL		9	JUN 86	JUL 86	AUG 86		A		A			*							
33	INDIANAPOLIS - CHICAGO	AGL		6	APR 86	MAY 86	JUN 86		A					*							
34	CHICAGO - WEST BRANCH	AGL	7	18	AUG 86	SEP 86	OCT 86	X						*							
35	KANSAS CITY - WEST BRANCH	AGL ACE		11	AUG 86	SEP 86	OCT 86							*							
36	DENVER - NORTH PLATTE	ANM ACE	11		MAR 86	APR 86	MAY 86	X					A		*						
37	KANSAS CITY - NORTH PLATTE	ACE		17	OCT 86	NOV 86	DEC 86						A		*						
38	SEATTLE - BOISE	ANM		16	AUG 86	SEP 86	OCT 86			A		A			*						
39	OAKLAND - BATTLE MTN	AWP		9	MAY 86	JUN 86	JUL 86				AA		DC	A		*					
40	OKLAHOMA CITY - HUTCHINSON	ASW ACE		9	SEP 86	OCT 86	NOV 86				A			A		*					
41	TEXARKANA - MEMPHIS	ASW ASO		11	AUG 86	SEP 86	OCT 86			A		A				*					

42	PHOENIX - YUMA	AWP		8	JUL 86	AUG 86	SEP 86								*				
43	DANSVILLE - BUCK HARBOR	AEA ANE		27	SEP 86	OCT 86	NOV 86				A		C		B C			*	
44	MINNEAPOLIS - LUSK	AGL ANM		23	DEC 86	JAN 87	FEB 87					A						*	
45	LOS ANGELES - YUMA	AWP		13		OCT 85	NOV 85	X					D					*	
46	SALT LAKE CITY-LOVELL	ANM	13		[---	ON-HOLD	---]					A			A				
47	SALT LAKE CITY-ASHTON	ANM	13		[---	ON-HOLD	---]	X			A	A							
48	LOS ANGELES - SPURS	AWP	11		[---	ON-HOLD	---]						A	D					
49	MINNEAPOLIS - SPOKANE	AGL ANM		72	[---	ON-HOLD	---]												

APPENDIX 3

RECOMMENDED "METHOD OF PROCEDURE" (MOP) FOR IN-SERVICE RML REPLACEMENT AND EXPANSION PROJECTS

This "MOP" is based on a minimal interruption to an existing service. The only downtime would be for end-to-end switching tests.

Before this procedure starts, the following must be installed and tested:

Antenna and Waveguide
Power Plant
Terminal Mux Bays
Center & Remote "ANMS" Equipment
Terminal and Repeater Radio Bay
Terminal and Repeater Auxiliary Bay

Hop tests should start at the terminal on the system or segment and proceed sequentially to each repeater until the other end of the system or segment has been tested.

All Hop and end-to-end tests will be done jointly by the FAA and AT&T for "Joint Acceptance Inspection" (JAI). A typical step-by-step procedure for performing Hop tests is given on page 3 of this appendix.

1. At the terminal, the FAA shall remove service from channel frequency (a) toward Repeater Station #1 and turn the transmitter off the air on the existing equipment.

2. At Repeater Station #1, the FAA shall remove service from channel frequency (b) toward the terminal and turn the transmitter off the air on the existing equipment.

3. Between the terminal and Repeater Station #1, the FAA and AT&T will do Hop tests on the new equipment for channel frequencies (a) and (b).

4. The new transmitter frequencies (a) and (b) shall be turned off.

5. At the terminal, the FAA shall restore service to channel frequency (a) and remove service from channel frequency (c) and turn this transmitter off the air on the existing equipment.

6. At the Repeater Station #1, the FAA shall restore service to channel frequency (b) and remove service from channel frequency (d) and turn this transmitter off the air on the existing equipment.

7. Between the terminal and Repeater Station #1, the FAA and AT&T will do Hop tests on the new equipment for channel frequencies (c) and (d). This new equipment will be left on the air. (Note: The channel frequencies picked to be left on the air should be the ones assinged to the same channel on each Hop. Switching tests cannot be completed until both new channels have been established in both directions.

8. Steps 1 through 7 will be done between repeaters in sequence until the last Hop on the system or segment has been tested.

9. The FAA and AT&T will then do end-to-end tests on the new channel established in Steps 1 through 8. (Note: Switching test cannot be completed until both channels have been established in both directions.)

10. The FAA will transfer service from one of the existing channels to the new channel established in Step 9.

11. At the terminal, the FAA shall remove service from channel frequency (a) toward Repeater Station #1 and turn the transmitter off on the existing equipment.

12. At Repeater Station #1, the FAA shall remove service from channel frequency (b) toward the terminal and turn the transmitter off, on the existing equipment.

13. Between the terminal and Repeater STation #1, the FAA and AT&T will establish the new equipment for channel frequencies (a) and (b) on the air and make a cursory check of equipment for failures. This new equipment will be left on the air.

    (Note: Switching tests can only be made from the terminal direction due to missing pilot from the other direction.)

14. Steps, 11, 12, and 13 will be done between repeaters in sequence until the last Hop on the system or segment has been established.

15. The FAA and AT&T will then do end-to-end tests on the new channel established in Step 14.

    Note: End-to-end switching test chan now be performed. Service will be interrupted during these tests when a channel is failed to cause an automatic switch.

16. End of procedure.

Typical "Step-by-Step Procedure"

JAI RADIO REPEATER HOP TESTS

Before this procedure is started, the following equipment must be installed and preliminary tests completed:

Power Bay
Auxiliary Bay
Radio Bay
Antenna and Waveguide

(Preliminary tests include the following:

Antenna alignment, antenna and waveguide performance tests, power bay tests, power supply tests for radio an auxiliary bay and continuity test on installer connected cables.)

Note: No "RF" radio frequency energy should be generated until the FAA has removed service from their equipment. (Power supplies for transmitters should remain turned off.)

1. The FAA shall remove service from channel frequency (a) toward (A) and turn this transmitter off the air.

2. AT&T and FAA will perform Hop tests for frequency (a) toward (A) on the new equipment.

3. The new equipment transmitter frequency (a) toward (A) shall be turned off.

4. The FAA shall restore service to channel frequency (a) toward (A) on the old equipment and remove service from frequency (b) toward (A) and turn this transmitter off the air.

5. AT&T and FAA will perform Hop tests for frequency (b) toward (A) on the new equipment. This equipment will be left on the air.

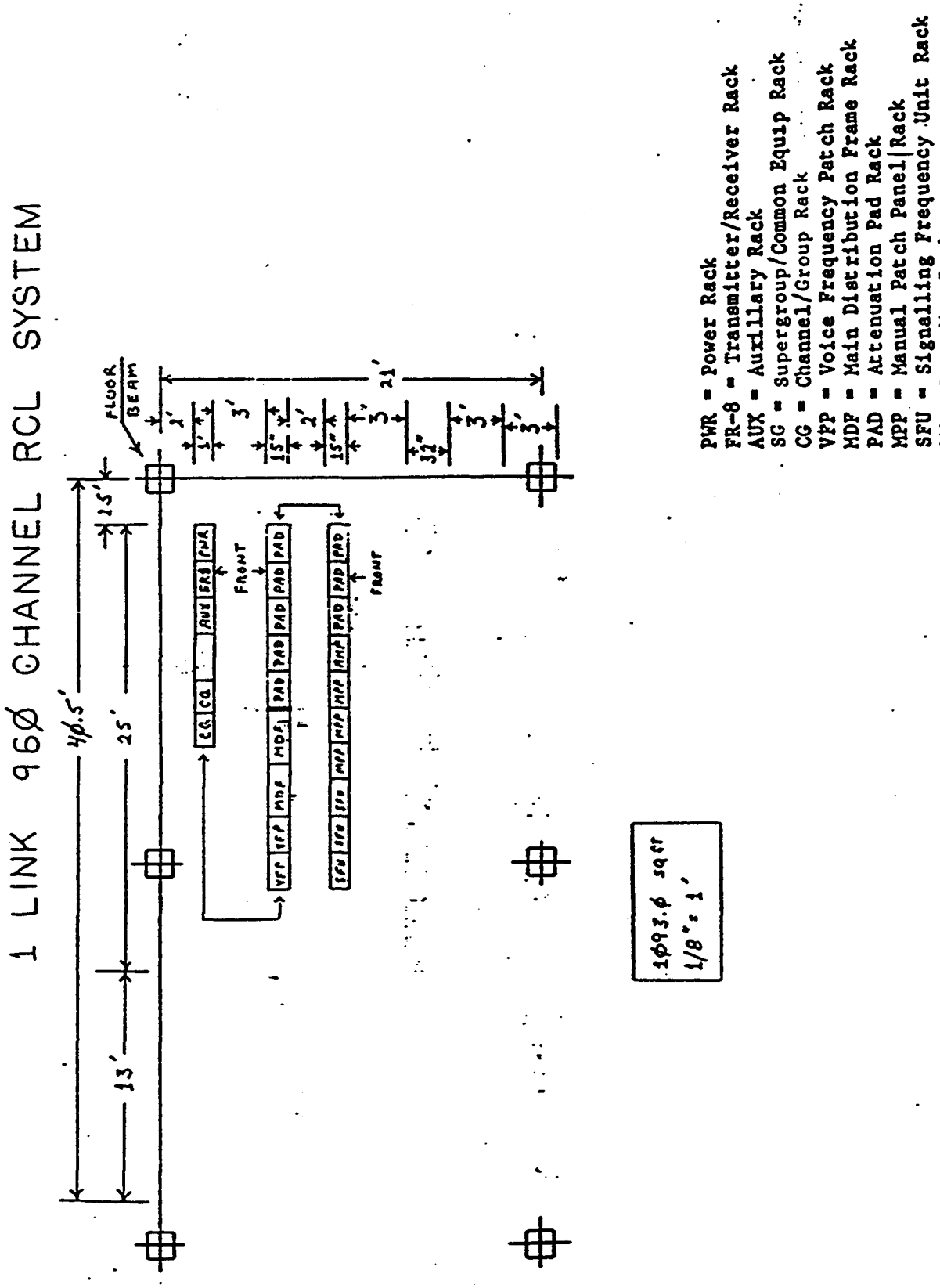
6. Steps 1 through 5 will be done for the other direction(s).

   Note: Step 6 should be expanded to Steps 6 through 10, filling in frequency and site name for (a), (b) and (A) for all steps.

Note: Switching tests cannot be done until both channels have been established for the system or segment.

APPENDIX 4. PROPOSED RCL FLOOR SPACE REQUIREMENTS AT ACF

Figure 1. 1 LINK 960 CHANNEL RCL SYSTEM



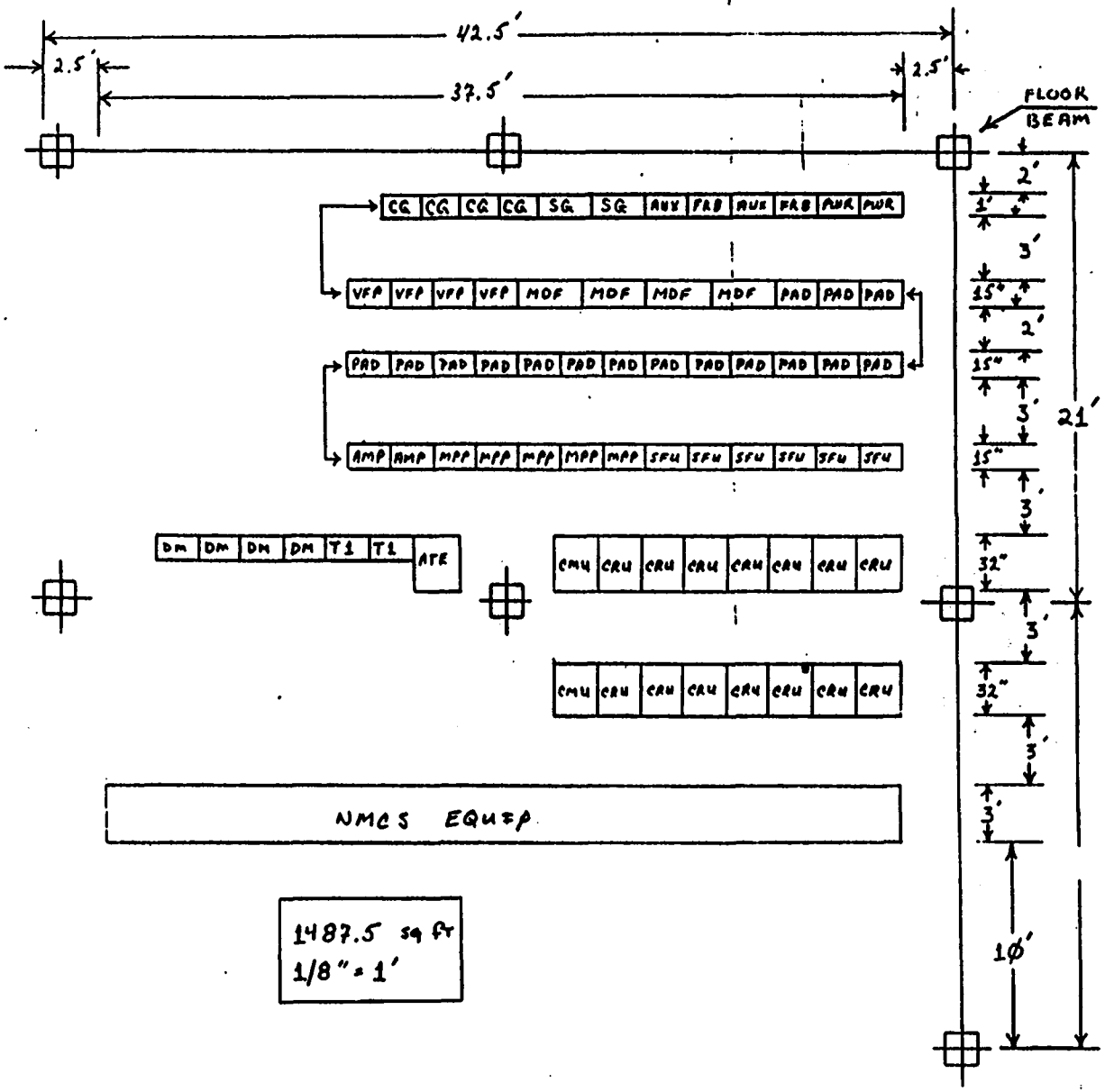


Figure 2. 2 LINK 1920 CHANNEL RCL SYSTEM

PWR = Power Rack
FR-8 = Transmitter/Receiver Rack
AUX = Auxillary Rack
SG = Supergroup/Common Equip Rack
CG = Channel/Group Rack
VFP = Voice Frequency Patch Rack
MDF = Main Distribution Frame Rack
PAD = Attenuation Pad Rack
MPP = Manual Patch Panel Rack
SFU = Signalling Frequency Unit Rack
DM = Data Mux Rack
WPD = Waveguide Pressurization
T1 = T1 Rack

Figure 3. 3 LINK 2880 CHANNEL RCL SYSTEM

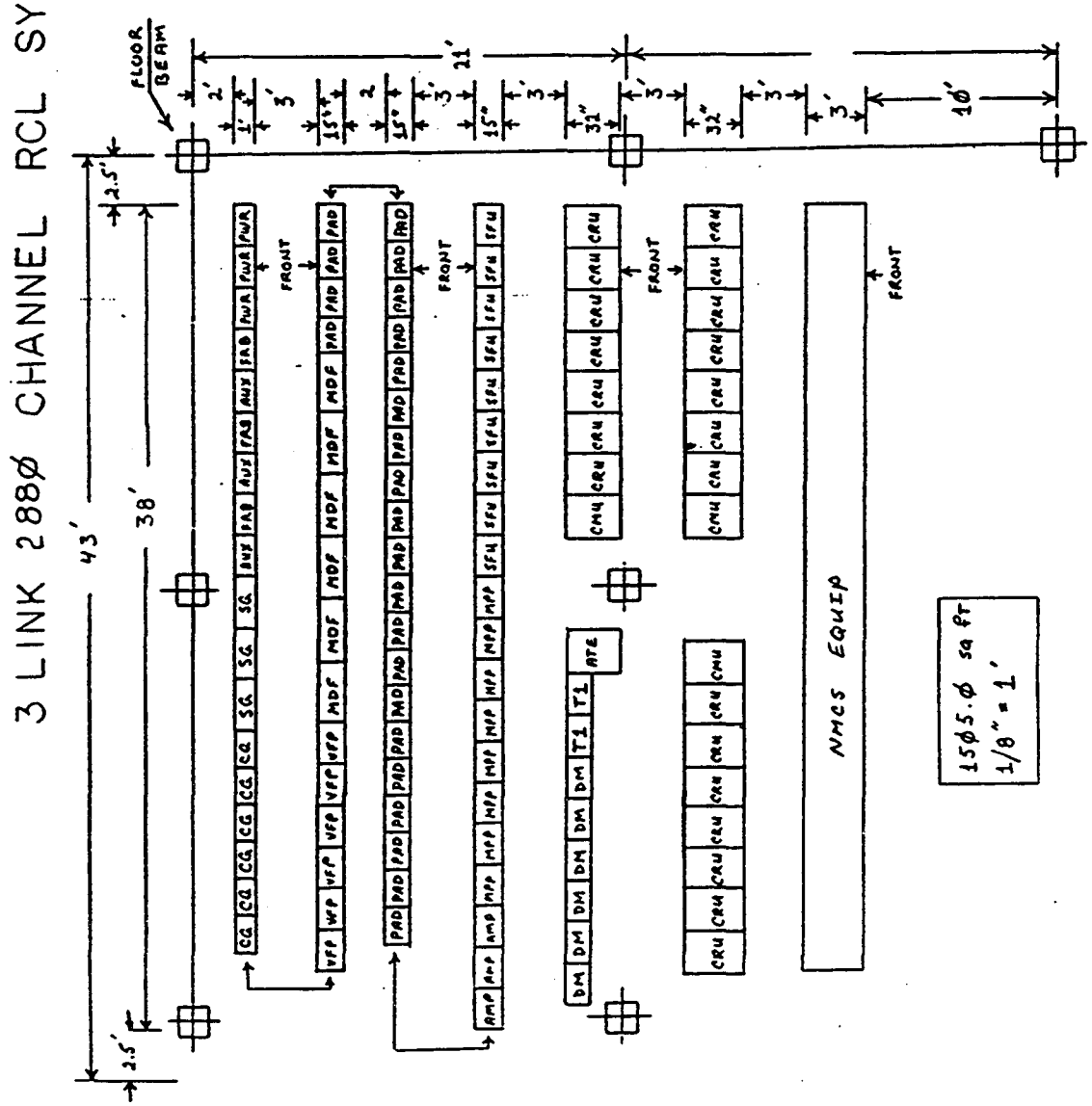
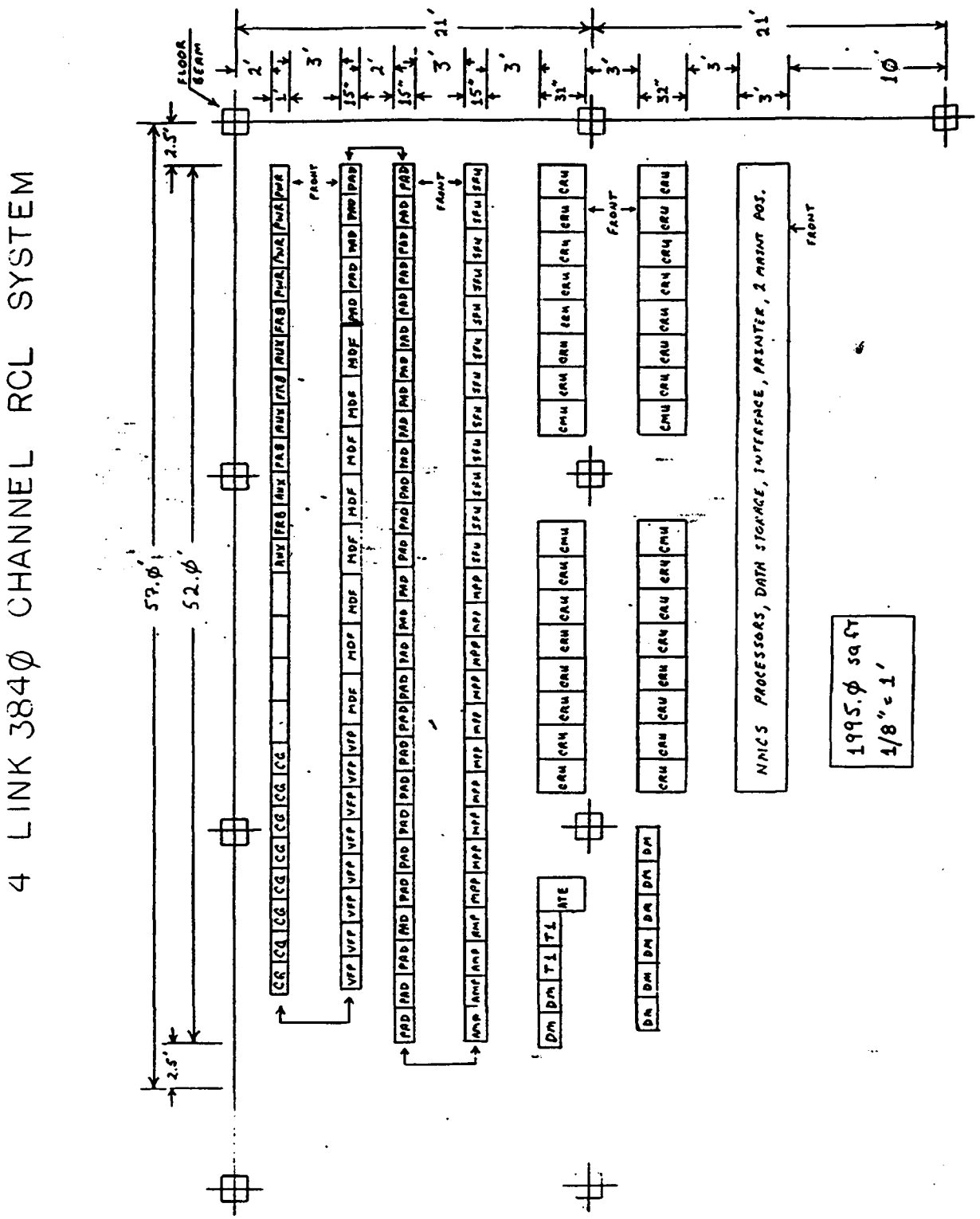


Figure 4. 4 LINK 3840 CHANNEL RCL SYSTEM



APPENDIX 5. POLICY LETTER ON GROUNDING

U.S. Department of Transportation
Federal Aviation Administration

Memorandum

Subject: INFORMATION: RCL Grounding

Date: FEB 21 1986

Reply to Attn. of:

From: Manager, Communications and Facilities, APM-500

Link: FTS 426-3076

To: Regional Airway Facilities Division Managers

This letter is to provide clarification of the guidance on our RCL Grounding letter and its attachment of January 10, 1986. On the first page of the attachment is paragraph 1.a.(1)(d). It should read "...clamp the conductor to the C_2 probe..." and not the C_1 probe. Also, enclosure No. 5 referenced in paragraph 4.a.(5)(a) is the test to determine if the neutral conductor is grounded improperly. Since this test requires an equipment shutdown, it should not be done until just prior to cutover to RCL when power to the RCL has not been activated.

Lawrence Langweil

GROUND SYSTEMS AT RCL FACILITIES

1. Measurement of Earth Ground Systems

a. The method used to measure the resistance to earth of the earth grounding system (counterpoise) is the "62% Fall of Potential." This method is explained in detail in the Biddle Instruments Handbook 25Ta, Titled; "Getting Down to Earth," which comes with the Biddle Instruments Earth Tester that is to be used for these measurements.

(1) In addition to the Earth Tester, the test probes and conductor accessory kit are required. The test kit probes are to be electrically connected to the Biddle earth tester after they are driven into the soil area of the facility. These details are also given in the above referenced handbook. Highlights of these details are as follows:

(a) Locate a ground rod of the existing counterpoise.

(b) Inspect the adequacy of the bonding between the rod and the interconnecting conductors. Correct any and all additional suspect inadequate bonds. Note that exothermic (Cadweld) welding is the preferred method for buried bonds.

(c) Measure and locate a cleared area 100 feet from the uncovered ground rod and drive a test probe into the soil (approximately 12 to 18 inches).

(d) Using the conductors provided with the kit, or a sufficient length of #14 insulated test lead, clamp the conductor to the C1 probe and connect the other end to the C_2 terminal of the tester.

(e) In a straight line with the probe that was installed in step C, measure a distance of 62 feet from the ground rod and install a second probe connect this probe with the same size conductor as used and to the P_2 terminal of the tester.

(f) Using a short piece of conductor, approximately 3 inches, interconnect terminals C_1 and P_1 of the tester.

(g) Attach a conductor to these terminals (C_1 & P_1) and connect it to the counterpoise ground rod.

Resistances will be added at the tester until the galvonmeter bridge meter is balanced. This resistance total value is the resistance to earth for the system being tested.

If the test probes (P_2, C_2) are left in the same original locations then the conductor from the C_1, P_1 terminals may be connected to any other portion of the earth grounding systems. The resistance value should be the same. If there is a difference, the earth grounding system is not continuous and must be repaired or replaced. This test can also be used to determine if there is also continuity between the earth grounding system and that which is supposed to be connected to it, i.e., signal ground plates.

2. Actions After Earth Resistance Readings

a. Measure ground resistance of earth grounding system. If 10 ohms or less, no other action is required.

b. If greater than 10 ohms,

(1) If only slightly exceeded, and there has been record of previous group resistance readings and these readings are constant, no further action is required.

(2) If no previous history exists and readings are above 10 ohms, the earth grounding system should be examined. Ground rods should be existing at the corners of the earth grounding system. Carefully excavate from corner of building on a 45^{o} angle away from building. The top of the ground rod should be about 12 inches below grade and the earth grounding system conductor 24 inches below grade. When either has been found, carefully excavate along conductor. The conductor on the side common to Tower should be the place of excavation in order to ascertain that the tower earth ground system is tied into the building grounding system. For typical Earth Electrode System Configuration for Structures see enclosure #1.

(3) Examine conductor, top ground rods, and connections to ground rods, to be certain that connections are tight and not corroded.

c. If all connections, cables, etc. are found to be in good condition, excavate around a ground rod to ascertain that the lower end of the rod has not corroded.

d. If the ground rod is corroded, replace all ground rods. If ground rods are in good condition, disconnect cables, add sectionalized sections to rods and drive deeper. Reconnect cables and measure ground resistance of earth grounding system.

If resistance measure doesn't change, entire loop of system will need to be checked for any break. If loop is found to be in good condition, the ultimate ground resistance has been found. Improvement may be had by chemical treatment of the ground areas around the rod, but this will be an on-going project into the future.

3. Lightning Protection

a. Tower - All materials, air terminals, conductors, clamps, etc. for the lightning protection system shall be UL approved. These materials shall be of the type noted and installed as shown on FAA-DWGD-6075-131 Sheets 1&2 (Enclosure #2)

1. Air terminal - copper - Height to protect antenna

2. Conductors - Flexible (ROPELAY) Type approved by UL for lightning protection systems. Sized to meet NFPA No. 78 and UL96A standards as indicated in Table IV - "Main Lightning Conductors" of FAA-STD-019a (See Enclosure #3) (Warning - Manufacturer's listing of sizes of lightning cables is not the same as NEC listing for power conductors)

3. Clamps - UL approved for purpose.

4. Down conductors shall have maximum separation and shall not be run down same leg with any other facility cables.

5. All bodies of inductance and/or conductance (such as Wave Guides) shall be connected to the lightning protection system.

b. Building -

(1) If under "45 degree Cone of Protection" of the Tower, No lightning protection is required.

(2) If not under "Cone of Protection", lightning protection system consisting of UL approved materials shall be in accordance with Paragraph 3.9 of FAA-STD-019a. (Paragraph 3.9.1 through 3.9.10.3 - See Enclosure #4)

c. Tall Towers - Lightning protection (air terminals and down conductors) is not required for antennas which are mounted on tall towers and well below the top of the structure. The tower shall have an appropriate Earth Grounding System similar to that described in Paragraph 2 above. Each leg of the Tower and the ladder on the Tower shall be connected to the Buried Earth Grounding System with ropelay (flexible) conductors sized for high structures.

4. Building Grounding System

a. Power - Must meet requirements of National Electrical Code and FAA-STD 019a.

(1) Grounding Electrode Conductor - No. 6 AWG Copper Minimum - Continuous from neutral bar in Main Service Disconnect Means (Fused Disconnect Switch, Enclosed Circuit Breaker, or Distribution Panelboard) to Buried Earth Grounding System.

(2) Equipment Grounding Conductor - Shall be installed in conduit with related phase and neutral conductors from the panelboard to the equipment. This conductor shall be sized in accordance with NEC Article 250 - Table 250-95 and shall be connected to the Ground Bus in the Panelboard and terminated at the equipment with a UL fitting approved for the purpose.

(3) Neutral - Grounded white or gray conductor connected to the ground system only at the Main Service Disconnect Means. This conductor MUST NOT be grounded at any other location.

(4) When any equipment in the facility is removed, all conductors (phase, neutral and equipment grounding) shall be removed in their entirety.

(5) Measurements to show isolation of Neutral and bonding of Equipment Grounding Conductor.

(a) Neutral - Measurements shall be made as noted in Enclosure #5 - TEST TO DETERMINE IF NEUTRAL CONDUCTOR IS GROUNDED IMPROPERLY.

(b) Measure the bonding resistance using a digital low resistance ohmmeter (milliohmmeter). The measurement shall not exceed 2.5 milliohms. The meter shall have a set of calibrated test leads to be used in the bonding resistance measurements. The tests shall be made as directed in the instruction book furnished with the meter to be used.

b. Signal (Electronic) Ground

(1) A Grounding Plate shall be installed on the inside of an exterior wall of the building, located convenient to the electronic equipment and to the Earth Grounding System. This plate shall be isolated from the building wall so that no stray currents or frequencies can be introduced on the ground plate.

(2) A #4/0 insulated copper conductor shall serve as the Main Ground Cable of the Signal Ground System and shall be installed from the Ground Plate (Item 5a above) to the Earth Grounding System. Where mechanical protection is required for this conductor, heavy wall PVC conduct shall be used.

(3) All electronic equipment signal grounds shall be connected to the grounding plate with insulated copper conductors (installed in heavy wall PVC conduct - Sch. 40 where required for protection or support). These cables will be sized in accordance with Table V - Size of Equipment Ground Cables - of FAA-STD-019a (See Enclosure 6).

(4) Measure the resistance of the Ground Plate to any building steel, power ground systems, etc. to ascertain then the plate is indeed isolated. This measurement shall be similar to that used for the neutral conductor (See Paragraph 4.5(a)).

NOTE: The following items are mandatory for these installations.

1. Integrety of lightning protection system. This includes air terminals and down conductors which are properly bonded to each other and adjacent metal (within 6 feet)

2. Integrity of earth grounding system.

3. Absence of neutral to ground connections at all power panels except the Main Entrance Service Disconnect Switch and the feeder transformer.

4. Installation of a signal reference ground plate.

5. Integrity of the equipment grounding conductors which must run in the same raceways/conducts as the related power conductors for the RCL Equipment.

6. Proper bonding of ground connections to achieve a resistence of 2.5 milliohms or less.

ENC. NO. 1

FAA-STD-019a
September 26, 1985

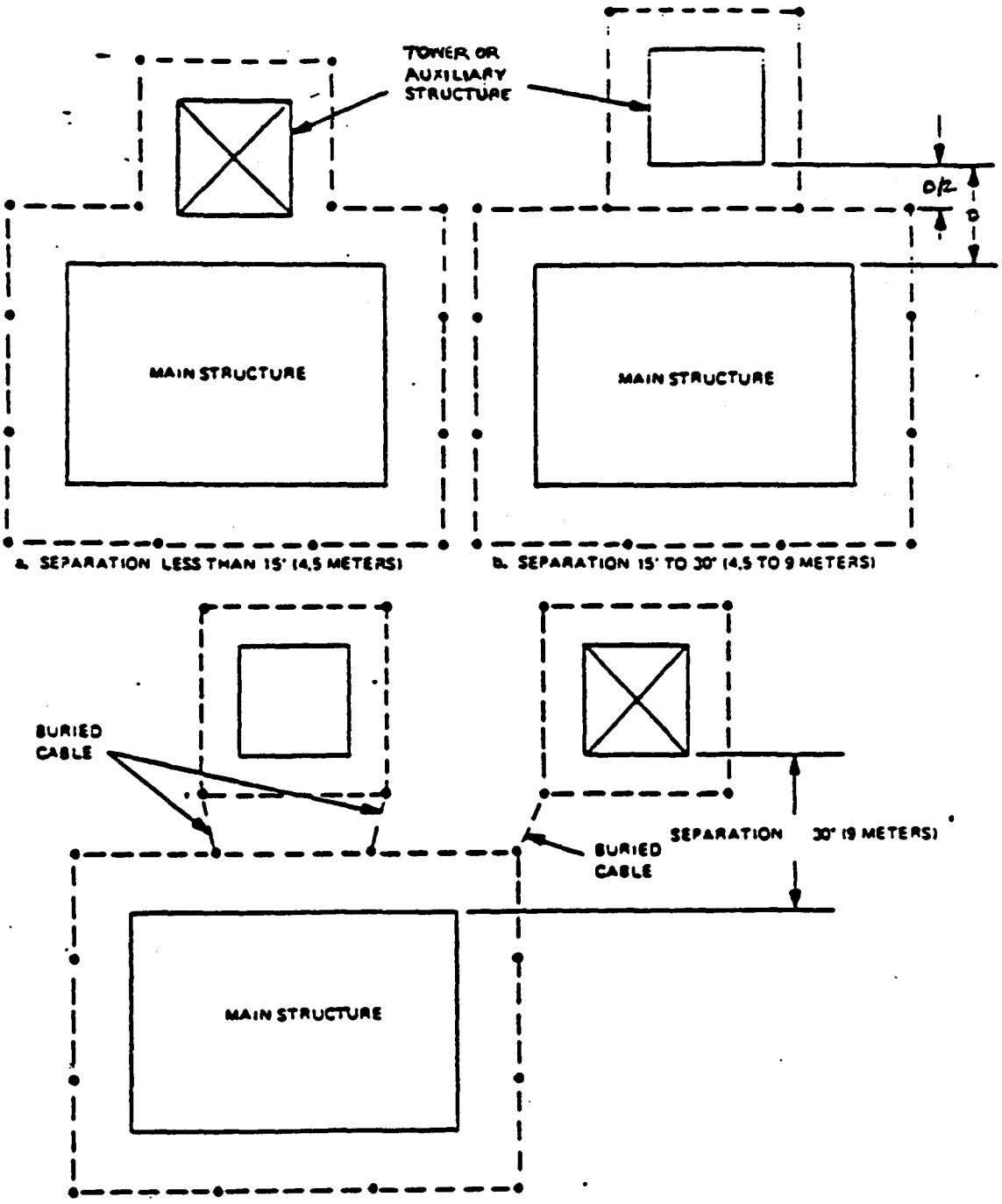


Figure 4 Earth Electrode System Configurations for Structures

ENC.NO.3

TABLE IV

MAIN LIGHTNING CONDUCTORS

Material	Structures Less Than 75 Feet			Structures over 75 feet		
	Min. Strand Size*	Weight Per 1000 ft	Area in circ mils (sq cm)**	Min Strand Size*	Weight Per 1000 ft	Area in circ mils (sq cm)**
Copper	17 AWG (1.15mm)	187.0 lbs (85 kg)	57,400 (0.30 sq cm)	15 AWG (1.45 mm)	375 lbs (170 kg)	115,000 (.583 sq cm)
Aluminum	14 AWG (1.63 mm)	95 lbs (43 kg)	98,600 (05. sq cm)	13 AWG (1.83 mm)	190 lbs (86 kg)	192,000 (.999 sq cm)

* This is the minimum size of <u>each</u> strand within the stranded conductor.

** This is the minimum circular area for each stranded conductor.

3.9 Lightning protection system requirements.

3.9.1 General. The intended purpose of the lightning protection system is to provide preferred paths for lightning discharges to enter or leave the earth and to provide personnel protection. The essential components of a lightning protection system are air terminals, roof and down conductors and connections to the earth electrode system to dissipate lightning currents. The lightning protection system shall meet the requirements of the Lightning Protection Code, National Fire Protection Association (NFPA 78), Underwriters' Laboratories (UL) Master Labeled System (UL 96A) and as specified herein.

3.9.2 Materials. All equipment used shall be UL approved and labeled in accordance with UL procedures with each air terminal bearing a "B" label and all main conductors bearing an "A" label. All equipment shall be new and of a design and construction to suit the application in accordance with NFPA 78 and UL 96A requirements. The prefered material shall be copper. Aluminum, bronze and stainless steel may be used for some components. Copper materials shall not be used on aluminum roofs, aluminum siding or other aluminum surfaces. Aluminum materials shall not be used on surfaces coated with alkaline-base paint, on or embedded in masonry or cement, on copper roofing, in contact with copper materials, or underground. Bimetallic connectors shall be used for interconnecting copper and aluminum conductors. Dissimilar materials shall conform to the bonding requirements of paragraph 3.14.12.

3.9.3 Main conductors. Roof and down conductors shall be stranded conductors and shall meet or exceed the minimum requirements given in Table IV.

3.9.4 Hardware. Hardware shall meet the following requirements.

3.9.4.1 Fasteners. Roof and down conductors shall be fastened in place at intervals not exceeding 3 feet (0.9 meter (m)). Fasteners shall be of the same material as the conductor, base or bracket being fastened or other equally corrosion resistant material. Galvanized or plated nails, screws or bolts shall not be used.

3.9.4.2 Fittings. Bonding devices, cable splicers, and miscellaneous connectors shall be of cast bronze or aluminum with bolt pressure connections to cable. Cast or stamped crimp fitting shall not be used.

3.9.5 Guards. Guards shall be provided for down conductors located in or next to driveways, walkways or other areas where they may be subject to displacement or damage. Guards shall extend at least 6 feet (1.8 m) above and 1 foot (0.3 m) below grade level. Guards shall be metal or polyvinyl chloride (PVC), schedule 40 plastic. Metal guards shall be bonded to the down conductor at both ends. Bonding jumpers shall be of the same size as the down conductor. PVC guards do not require bonding. Crimp fittings shall not be used.

3.9.6 Bonds. All exterior or interior metallic objects, including structural steel and the sheet metal of metal clad buildings, that are within 6 feet (1.8m) of roof or down conductors, shall be bonded to the lightning protection system in accordance with the requirements of NFPA 78 and UL 96A. Any metallic body of inductance within 6 feet of another bonded metallic object shall be bonded either to the adjacent metallic object or to the roof or down conductors. Metal bodies of inductance include gutters, downspouts, metal wall vents, door and window frames, metal balcony railings, interior piping, ductwork, and machinery. Bonding jumpers shall be not less than No. 6 AWG. Non-metallic conduit or other objects of non-conductive material shall not require bonding.

3.9.7 Conductor and conduit routing. Roof conductors shall maintain a horizontal or downward course. Roof and down conductors and guards shall be routed such that the bend radius is not less than 8 inches (203 millimeters (mm)) and the angle at any turn shall not be less than 90 degrees. Conductors shall be routed external to buildings and not within 6 feet (1.8 m) of power or signal conductors.

3.9.8 Down conductor terminations. Down conductors (used to ground air terminals and roof conductors) shall terminate on ground rods 1 foot (0.3 m) to 2 feet (0.6 m) vertically below ground level and from 2 feet to 6 feet (1.8 m) outside the foundation or exterior footing of the building. Down conductors shall be connected to the ground rods by exothermic welding or equivalent or by the use of double bolted ground clamps which shall make contact with the ground rod for a distance of 1.5 inches, measured parallel to the axis of the rod and with the cable itself for a distance of a least 1.5 inches. Clamps shall only be used where accessible for inspection.

3.9.9 Disconnectors. All down conductors except one may be provided with a screw type disconnect as described in NFPA-78 so that the resistance of the ground rods can be measured independent of any other path. This is not a requirement.

3.9.10 Buildings. Lightning protection shall be provided for all buildings, or parts thereof, not within a 45-degree cone of protection provided by an antenna or tower. Buildings which exceed 50 feet (15.2m) above ground have special requirements which are identified in NFPA 78.

3.9.10.1 Air terminals. Air terminals shall be solid copper, bronze or aluminum. Copper air terminals may be nickel plated. Air terminals shall be a minimum of 24 inches (610 mm) in height and at least 1/2 inch (12.7 mm) in diameter and have a rounded or "bullet" point. Air terminals shall be located in accordance with the requirements of NFPA 78 and UL 96A. The distance between air terminals shall not exceed 25 feet (7.6 m). Flat roofs that exceed 50 feet (15.2 m) in width shall have an additional row(s) of air terminals installed as required by NFPA 78 and UL 96A. Air terminals shall extend at least 10 inches (254 mm) and not more than 36 inches above the object to be protected and located so as to provide a 45° cone of protection as described in NFPA-78. A ball tip not exceeding 5 inches diameter may be used on air terminals at communication sites to reduce electromagnetic noise.

3.9.10.2 Number of down conductors. Not less than two down conductors shall be provided for buildings with a perimeter of 250 feet (76 m) or less. The down conductors shall be as widely separated as possible such as at diagonally opposite corners on square or rectangular buildings. Buildings with a perimeter in excess of 250 feet (76 m) shall have one down conductor for each 100 feet (30.5 m) of perimeter distance or part thereof.

3.9.10.3 Metal parts of buildings. Metal roofing and siding, eave troughs, down spouts, metal ladders and ducts and similar metal parts shall not be used as substitutes for roof or down conductors. A lightning conductor system shall be applied to the metal roof and to the metal siding of a metal clad building in the same manner as on a building without metal covering. Building metal parts shall be bonded in accordance with 3.9.6.

ENC. NO.5

TEST TO DETERMINE IF NEUTRAL CONDUCTORS ARE GROUNDED IMPROPERLY (GROUNDED ON THE LOAD SIDE OF THE SERVICE ENTRANCE DISCONNECT.)

EQUIPMENT NEEDED
Volt-OHM meter. Flash lights, allen wrenches, screw drivers, socket set, wire markers.

NOTE 1: Resistance test
Readings<about 20K OHMS indicate "bad"
Readings>= about 20K OHMS indicate "good"

NOTE 2: Be aware of capacitors on the neutral line and their effect on Readings. The reading may show short, but then slowly go to open. Use the steady state reading.

NOTE 3: The difficult part is Step 21. Because the load side neutral conductors are usually not identified it may be difficult to locate the end of the conductor that is not at the disconnect. Given sufficient time it can be located.

STEPS:

1. Schedule a shutdown of all facilities using power at the site.
2. Review one line power diagram.
3. Identify service entrance device.
4. Lock out all standby power sources.
5. Remove power by opening service entrance conductors.
6. CAUTION: Voltage is present at the line side.
7. Verify that no voltage is present at the load side by using the voltmeter.
8. Disconnect the line side neutral from the neutral bar.
9. Disconnect the grounding electrode conductor from the neutral bar.
10. Disconnect the main bonding jumper from the neutral bar. (May be a screw).
11. Disconnect all grounding conductors from the neutral bar.
12. If a lightning arrestor is present, remove its neutral and ground conductor from the neutral bar.
13. Only load side neutral conductors are now connected to the neutral bar.
14. Measure the resistance between the neutral bar and the case.
15. If the test is good, reconnect all conductors and restore the system: END OF TEST.
16. If the test is bad remove a load side neutral conductor from the neutral bar.
17. Measure the resistance between the removed load side neutral conductor and the case.
18. If the test is good reconnect this conductor to the neutral bar.
19. If the test is bad "tag" the conductor and leave it off the neutral bar.
20. Go to step 14 and repeat until the test is good.
21. Determine the circuit of each "tag" conductor.
22. This "tag" conductor is grounded somewhere within the load. Unground this conductor at the load.
23. Reconnect to the neutral bar all conductors after they have been c leared.
24. Go to step 14.

ENC. NO. 6

FAA-STD-019a
September 26, 1985

TABLE V

SIZE OF EQUIPMENT GROUND CABLES

Cable Size	Maximum Path Length ft (m)
750 MCM[1]	375 (114.3 m)
600 MCM[1]	300 (91.4 m)
500 MCM	250 (76.2 m)
350 MCM	175 (53.3 m)
300 MCM	150 (45.7 m)
250 MCM	125 (38.1 m)
4/0 AWG	105 (32.0 m)
3/0 AWG	84 (25.6 m)
2/0 AWG	66 (20.1 m)
1/0 AWG	53 (16.2 m)
1 AWG	41 (12.5 m)
2 AWG	33 (10.1 m)
4 AWG	21 (6.4 m)
6 AWG	13 (4.0 m)
8 AWG	8 (2.4 m)

Busbar Size inch (mm)	
4 x 1/4 (100 x 6.4 mm)	636 (193.9 m)
4 x 1/8 (100 x 2.3 mm)	318 (96.9 m)
3 x 1/4 (75 x 6.4 mm)	476 (145.1 m)
3 x 1/8 (75 x 2.3 mm)	238 (72.5 m)
2 x 1/4 (50 x 6.4 mm)	318 (96.9 m)
2 x 1/8 (50 x 2.3 mm)	159 (48.5 m)
2 x 1/16 (50 x 1.6 mm)	79 (24.1 m)
1 x 1/4 (25 x 6.4 mm)	159 (48.5 m)
1 x 1/8 (25 x 2.3 mm)	79 (24.1 m)
1 x 1/16 (25 x 1.6 mm)	39 (11.9 m)

NOTE: [1]Where these cables are not available, paralleling of smaller cables may be used i.e., three-250 MCM cables may be used in lieu of one-750 MCM cable or two-300 MCM cables may be used in lieu of one-600 MCM cable.