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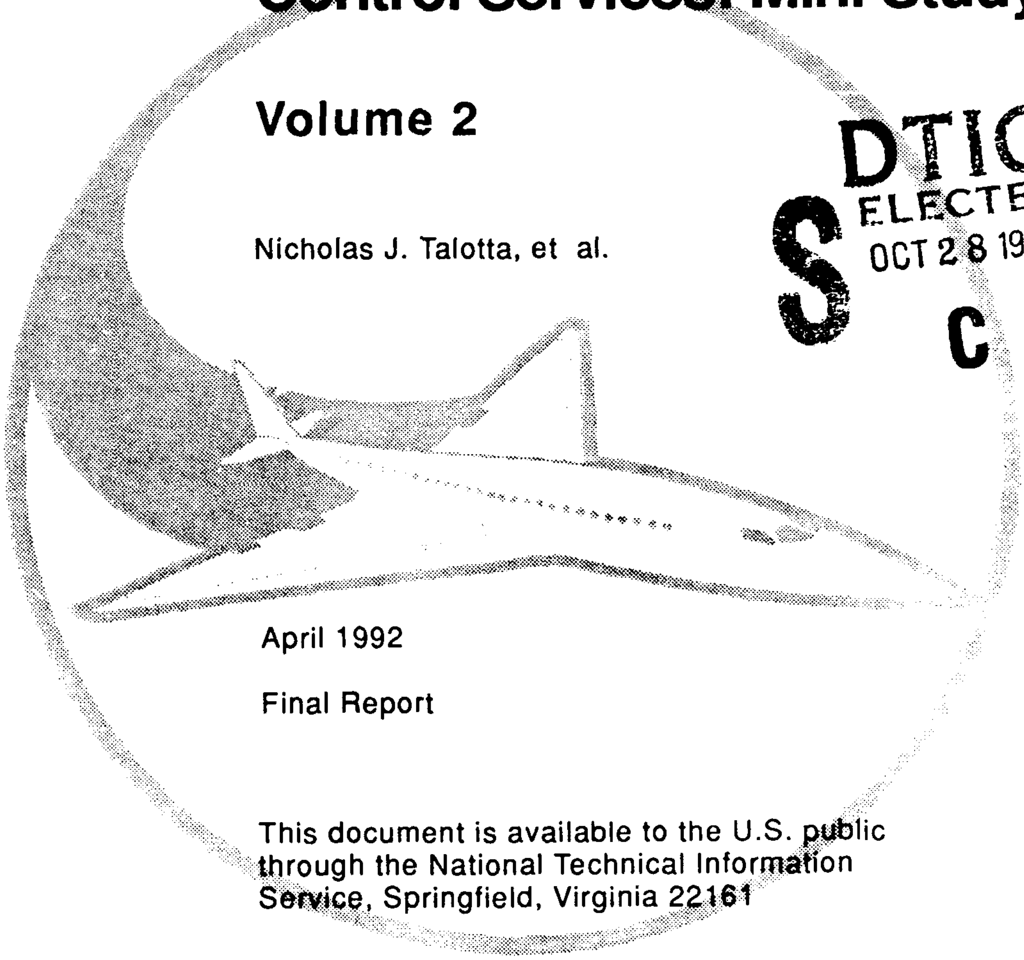
FAA Technical Center
Atlantic City International Airport
N.J. 08405

Controller Evaluation of Initial Data Link Terminal Air Traffic Control Services: Mini Study 2

Volume 2

Nicholas J. Talotta, et al.



April 1992

Final Report

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16. Abstract

This document details the results of the second Mini Study of the Federal Aviation Administration (FAA) Technical Center investigation and development of initial terminal air traffic control (ATC) services for transmission using Data Link technology. Initial Data Link services were evaluated under part task simulation conditions in order to identify service delivery methods which optimize controller acceptance, performance, workload, and to study the effects of various potential Data Link message response delays.

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PREFACE

This report documents the second Federal Aviation Administration (FAA) controller evaluation of an initial group of four terminal air traffic control (ATC) services and functions which are under development for implementation on a Data Link air-ground communications system. The research was conducted at the Federal Aviation Administration (FAA) Technical Center by the Airborne Collision Avoidance and Data Link Systems Branch, ACD-320.

The report is organized in two volumes. Volume 1 contains the main body of the report. It includes a detailed description of the objectives of the study and of the technical approach and testing methods that were used. Volume 1 also presents the results of the research, conclusions, and recommendations for future work.

Volume 2 contains supporting appendixes. These include controller training materials for the test airspace and Data Link procedures, test scenario descriptions, and evaluation forms used for the design review and full scale simulation phases of the study.

ACKNOWLEDGEMENTS

The study reported in this document was conducted at the Federal Aviation Administration (FAA) Technical Center by the Ground Data Link Development Team. The execution of the study was the result of many months of planning and the cooperative efforts of many people.

Mr. Ron Jones was the Data Link Program Manager with overall responsibility for the program.

Mr. Phillip Radzikowski was the Headquarter's Research and Development Associate Program Manager responsible for Technical Center Data Link coordination.

Mr. Nicholas Talotta was the Data Link Technical Program Manager responsible for the overall management and development of the Data Link Services.

Mr. Evan Darby was the test coordinator and provided air traffic control (ATC) system expertise.

Dr. Clark Shingledecker, NTI, provided all human factors research and analysis, and prepared the most significant portion of this report.

Mr. Joseph Lunder and Mr. Michael Headley, both of TMA Inc., designed the ARTS IIIA software.

Dr. Richard Mogford, Mr. David Stahl, and Mr. Terence Fischer of CTA, Inc., provided performance measures analysis and test scenarios.

Mr. George Chandler and Mr. Cuong Le provided test bed engineering and software in the development of these initial services.

Mr. John Van Dongen was technical coordinator.

Mr. Frank Buck, Mr. Preston Cratch, Mr. Dave Sweeney and Mr. Robert Geoghan, all of The MITRE Corporation, provided program support.

Mr. Ephraim Shochet was human factors research coordinator.

Mr. John Evans and Mr. Jim Merel, of UAL, Inc., were ghost controllers.

The Technical Center facility personnel supported this activity during development and testing.

The following members of the Air Traffic Data Link Validation Team (ATDLVT) were active participants in this Mini Study.

Michael Blomquist, Denver ATCT
Michael Bullington, Sacramento TRACON
Joseph D'Alessio, New York TRACON
Harly Jones, Sacramento TRACON
Jerome Karrels, Madison, WI, Tower
David Lister, St. Louis Tower
Jim O'Malley, ATR-320

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EXECUTIVE SUMMARY

The controllers who participated in the study expressed a continued belief that implementation of Data Link air traffic control (ATC) services in the terminal environment will have the potential to significantly improve the quality and effectiveness of air-ground communications. Predicted benefits included reductions in frequency congestion and communication errors and improvements in efficiency made possible by shifting lengthy and repetitive messages from the voice channel to the Data Link system.

The design review phase of the study produced a variety of recommended design changes based on the subject controllers' observations in the Data Link Test Bed. Primary modifications included a change in the design of the initial contact service to reduce the number of Data Link transactions and amount of time required to perform this function, and refinements to the designs of the menu text and terminal information service list displays to enhance the speed and accuracy with which items could be selected for uplink.

The full scale simulation phase of the study confirmed the hypothesis that the viability of Data Link services in the terminal ATC environment will be strongly dependent on the duration of the transaction delay between message dispatch and receipt of an aircrew response. While the results must be tempered by the facts that the subject controllers were not trained to operational proficiency levels on the test airspace or on Data Link procedures, and that the Data Link design was not fully mature, they indicate that total transaction times exceeding 20 seconds may significantly increase controller workload, impair performance, and impede the use of Data Link. The severity of the effects of transaction delay were dependent on the type of airspace sector under control and the time criticality of the message. In addition, the findings suggested that the negative effects were partially mitigated by practice over the course of the study as the controllers developed effective strategies for overcoming time delays.

Several of the experimental performance measures evaluated during the study effectively reflected and complemented the controller evaluation data. In addition, requirements for further metric development and training protocol improvement were identified for incorporation into future operational evaluation study plans.

RECOMMENDATIONS.

The results of this second design development study indicate that the initial Data Link services have significant potential to enhance terminal ATC operations. Therefore, it is recommended that continued design, development, and evaluation efforts be pursued to permit implementation of these services at the earliest possible date. The results support the following recommendations regarding the specific nature of these continued activities:

1. The service design modifications identified during this study should be implemented in the Data Link Test Bed for formal evaluation by the Air Traffic Data Link Validation Team (ATDLVT).

2. In preparation for operational evaluation studies, training protocols should be developed to require extensive pretest controller training in order to approximate the level of airspace familiarity and facility in the use of Data Link that would be expected in the operational environment. Additional effort also should be devoted to the development of improved measures and data collection procedures which will accurately and reliably reflect the impact of Data Link on system performance during operational evaluation research.

3. The observed effects of total transaction times on Data Link effectiveness and usability indicate that technical analyses and flight deck Data Link research should be pursued to define the distribution of terminal transaction times that can be expected at the time of system implementation. Parameters derived from this research should be used in future Data Link ATC simulations, and should serve as a baseline for evaluating modifications to Data Link transmission systems and aircrew interfaces intended to reduce message acknowledgement latency.

4. The results showed that controllers appear to spontaneously develop strategies for overcoming transaction delays and improving ATC operations in a combined voice and Data Link environment. Future research should formally document and define the effectiveness of these strategies in order to support the development of optimal Data Link procedures and training materials that will be needed to complement functional specifications for the Data Link service designs.

APPENDIX A

TEST PLAN AND TRAINING MATERIALS

TRAINING/FAMILIARIZATION PLAN

Primary Objective: Familiarize the participant controllers with the operation of Data Link, Air Traffic Control Simulation Facility, and the airspace geometry which it simulates. Ensure that participants are able to control a moderate level of traffic, using Data Link and the appropriate procedures and techniques.

Enabling Objectives:

1. **Condition:** Given a briefing and documents concerning operational airspace and procedures.

   Task: The participant demonstrates his/her knowledge and acceptance of the airspace and procedures through verbal discussion with the training controller.

   Standard: The training controller verifies that the participant has a working knowledge of airspace and procedures.

2. **Condition:** Given a briefing and documents concerning operational use of Data Link and procedures.

   Task: The participant demonstrates his/her knowledge and acceptance of the Data Link and procedures through verbal discussion with the training controller.

   Standard: The training controller verifies that the participant has a working knowledge of Data Link and procedures.

3. **Condition:** Given a routine air traffic sample (50% of the hourly airport acceptance rate) with voice only aircraft.

   Task: The participant maintains verbal communications with aircraft under his/her control and with adjacent controllers as required for inter-sector coordination.

   Standard: The participant employs standard radio telephone procedures, initiates contact to obtain required information or provide information and directives, accomplishes all necessary land line coordination with adjacent sectors.

4. **Condition:** Given a routine air traffic sample (65% of the hourly airport acceptance rate) with voice and Data Link equipped aircraft.

Task: The participant maintains verbal and/or Data Link communications with aircraft under his/her control and properly coordinates with adjacent controllers as required for inter-sector coordination.

Standard: The participant employs appropriate radio telephone procedures and/or Data Link communications to contact or obtain required information or provide information and directives, accomplishes all necessary land line coordination with adjacent sectors, and demonstrates good working knowledge of airspace and procedures.

5. **Condition:** Given a routine air traffic sample (65% of the hourly airport acceptance rate) with voice and Data Link equipped aircraft.

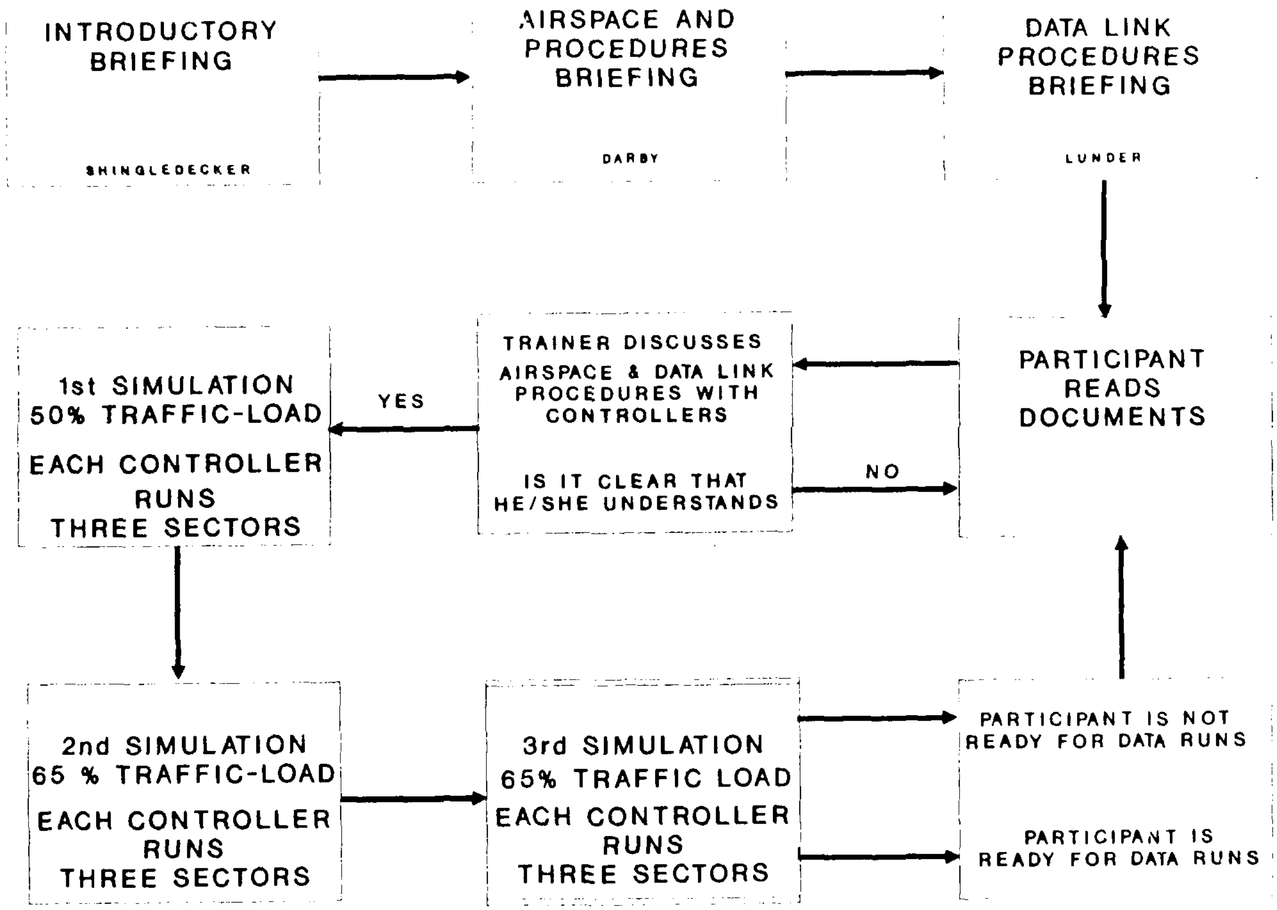
   Task: The participant maintains verbal and/or Data Link communications with aircraft under his/her control and properly coordinates with adjacent controllers as required for inter-sector coordination.

   Standard: The participant is willing to state that he/she is adequately familiar with the simulation and the operation of Data Link so that the simulation/Data Link procedures themselves do not inhibit performance.

6. **Attachments:**

   Attachment A-1 - Raleigh-Durham Airspace/Procedures Briefing
   Attachment A-2 - Data Link Operation and Procedures Briefing

TRAINING/FAMILIARIZATION FLOW



Attachment A-1

RALEIGH-DURHAM AIRSPACE/PROCEDURES BRIEFING

TERMINAL AIRSPACE

FACILITY - RALIEGH-DURHAM, NC

AIRSPACE - SFC TO 10,000

<u>NORTH</u>

NORTH DEPARTURE
WEST ARRIVAL
WEST FINAL

<u>SOUTH</u>

SOUTH DEPARTURE
EAST ARRIVAL
EAST FINAL

ATDLVT 10/91

CONTROLLER ASSIGNMENTS

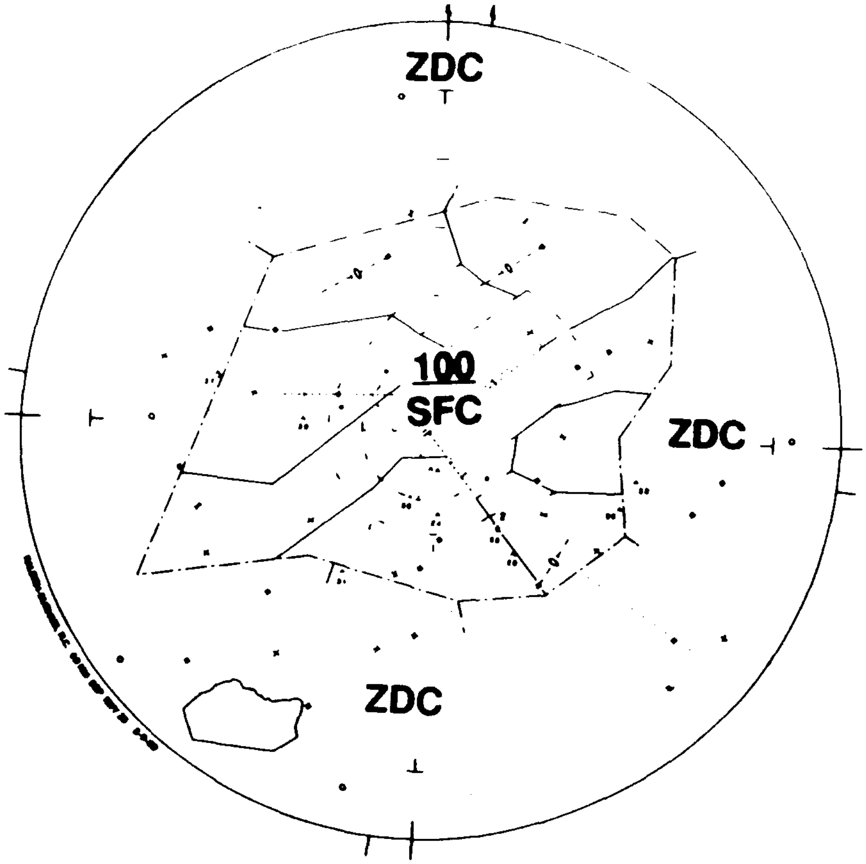
NORTH SECTORS

DAVID LISTER
JEROME KARRELS
JOSEPH D'ALESSIO

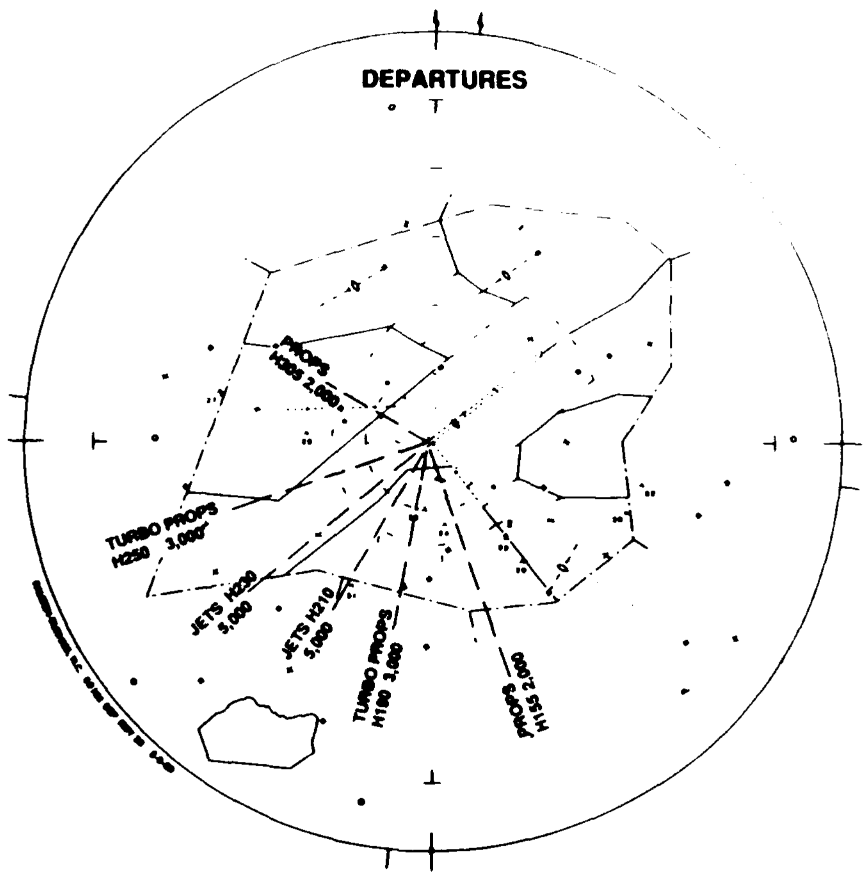
SOUTH SECTORS

MIKE BLOMQUIST
MIKE BULLINGTON
HARLEY JONES

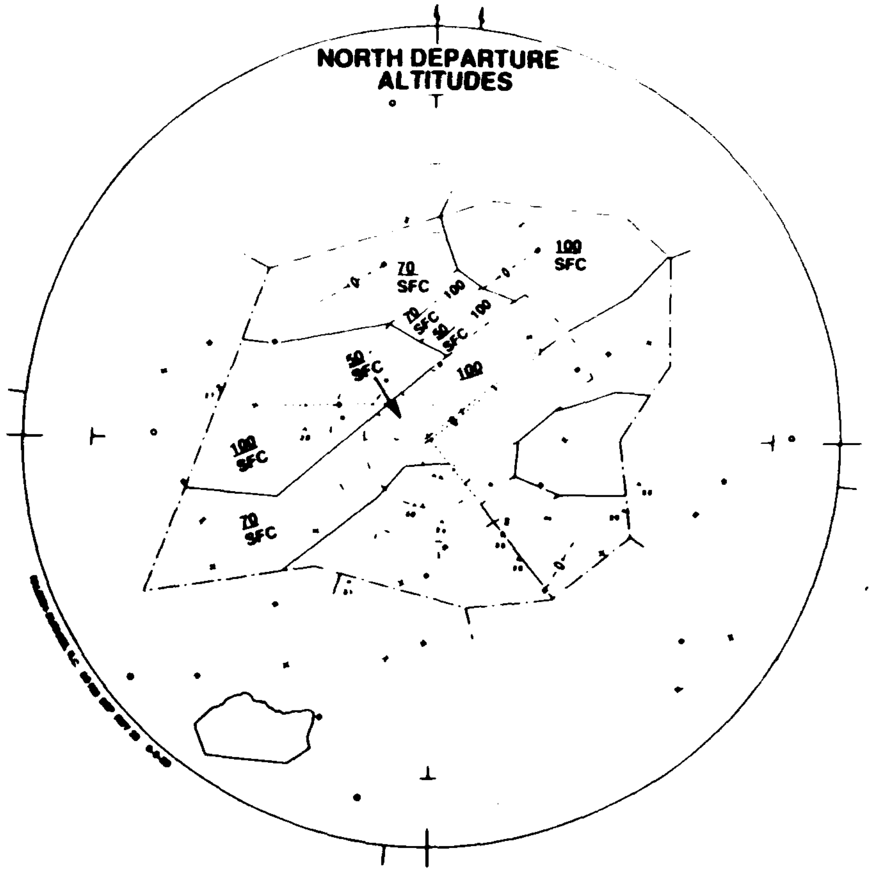
ATDLVT 10/91



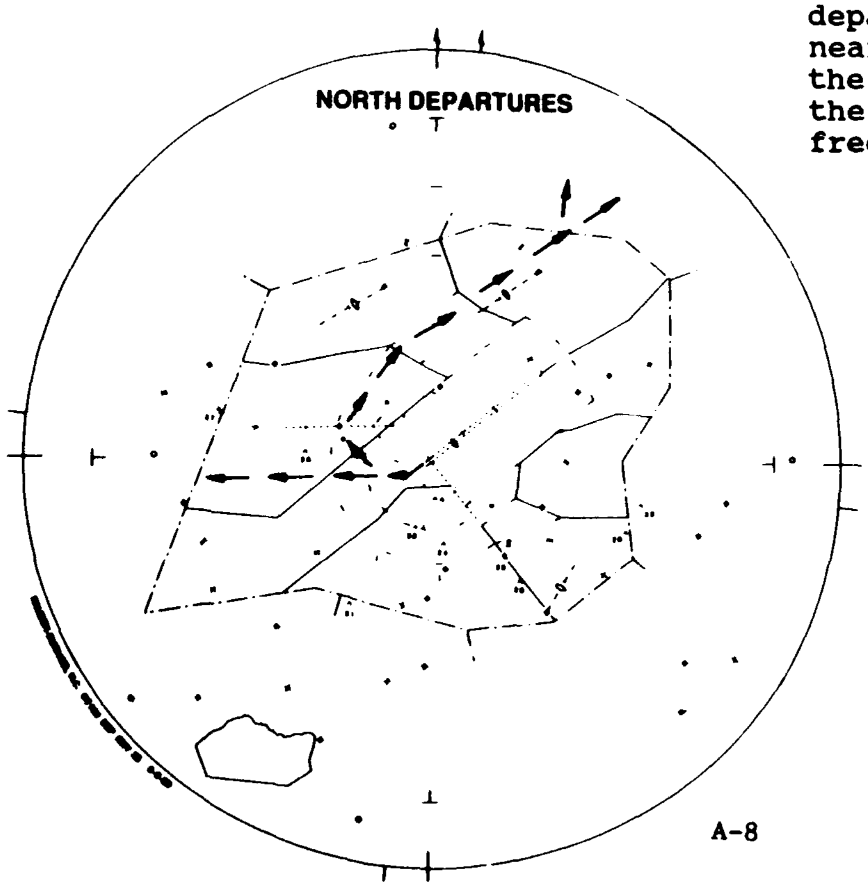
Raleigh-Durham Approach Control is responsible for the outlined airspace surface to 10,000 feet.

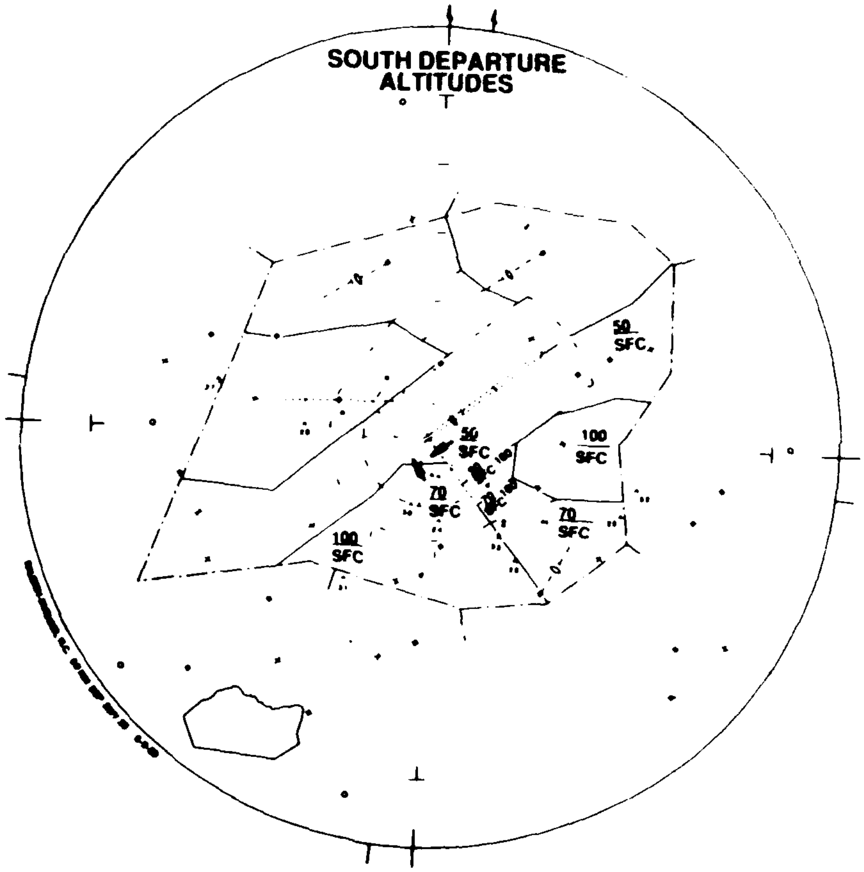


Departure headings assigned to aircraft from Raleigh-Durham Runways 23R and 23L.

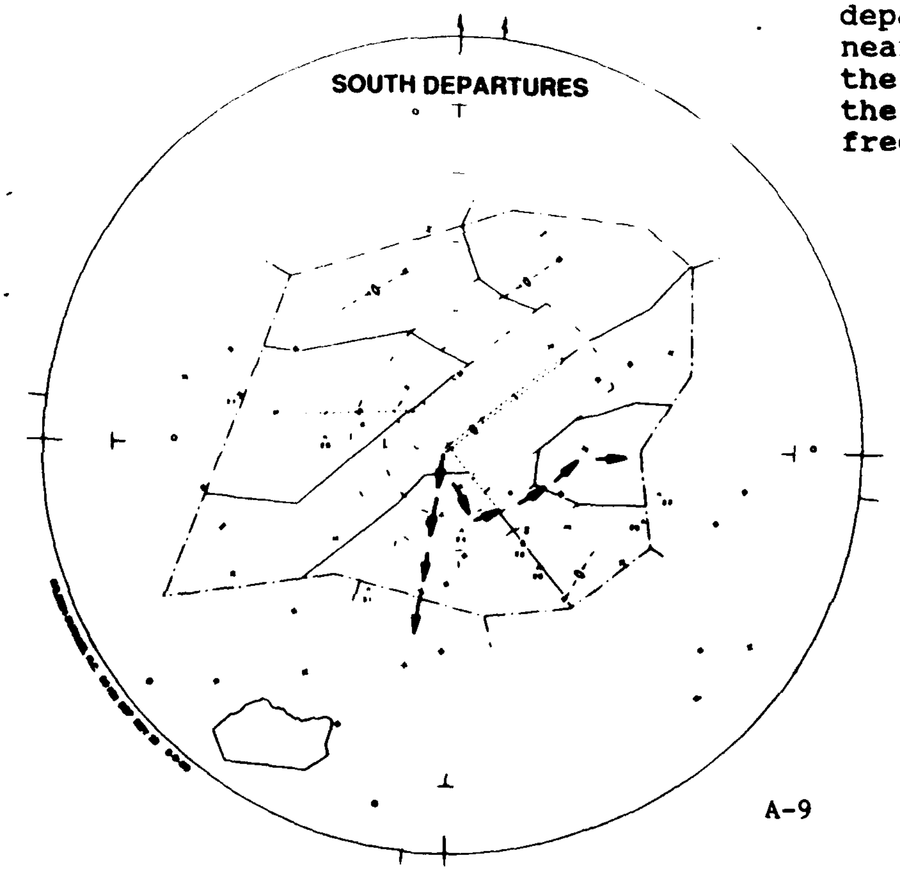


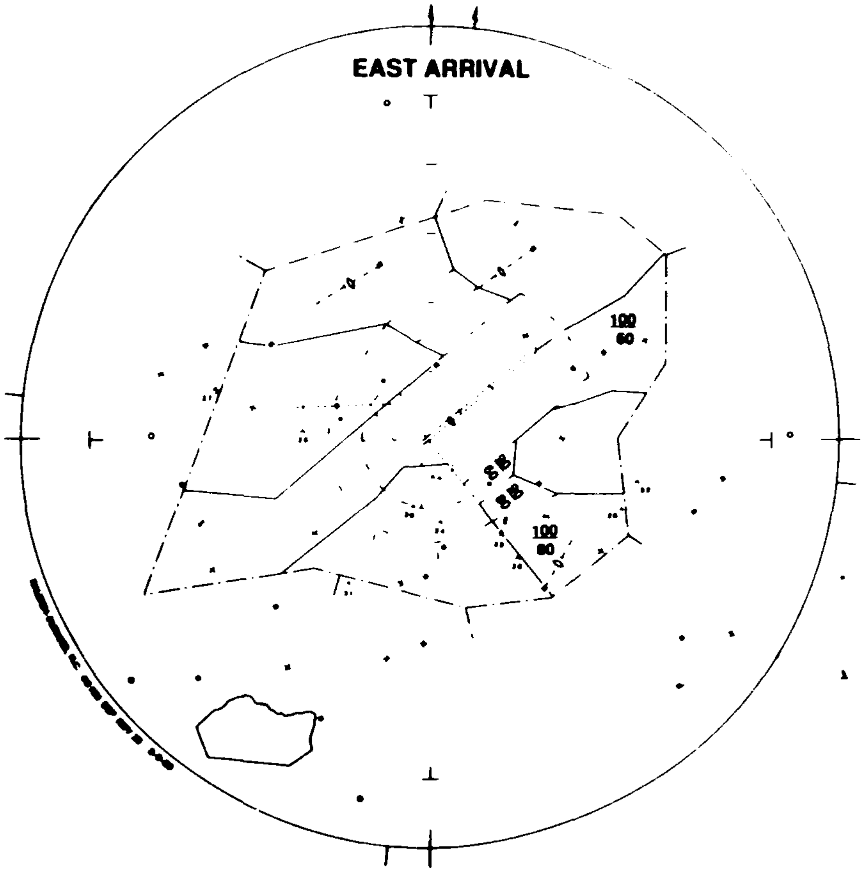
The North Departure Controller radar identifies aircraft immediately after departing from Raleigh-Durham Runway 23R. Then climbs and vectors the aircraft toward one of two departure gates. As the aircraft nears another facilities airspace the controller transfers control of the flight and changes the pilots frequency.



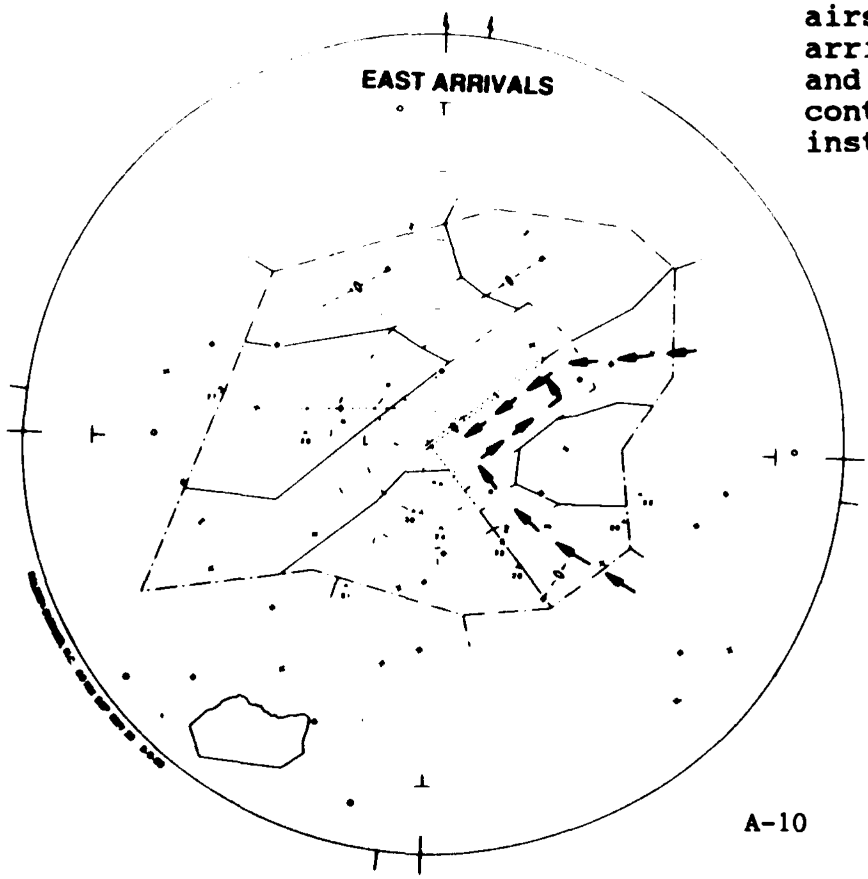


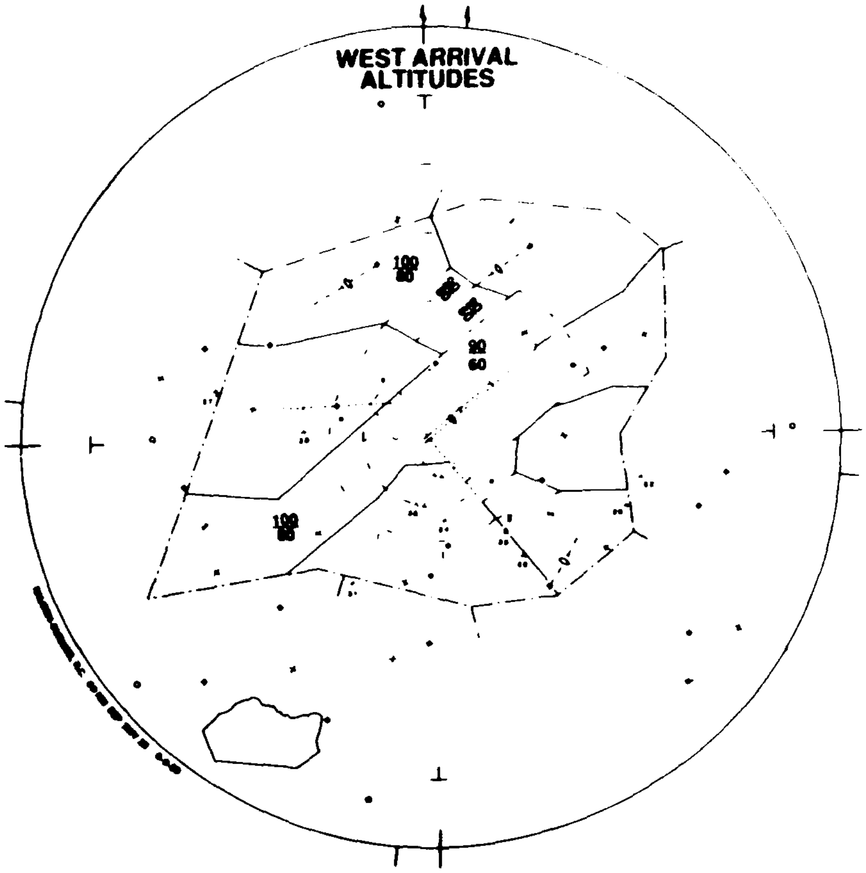
The South Departure Controller radar identifies aircraft immediately after departing from Raleigh-Durham Runway 23L. Then climbs and vectors the aircraft toward one of two departure gates. As the aircraft nears another facilities airspace the controller transfers control of the flight and changes the pilots frequency.



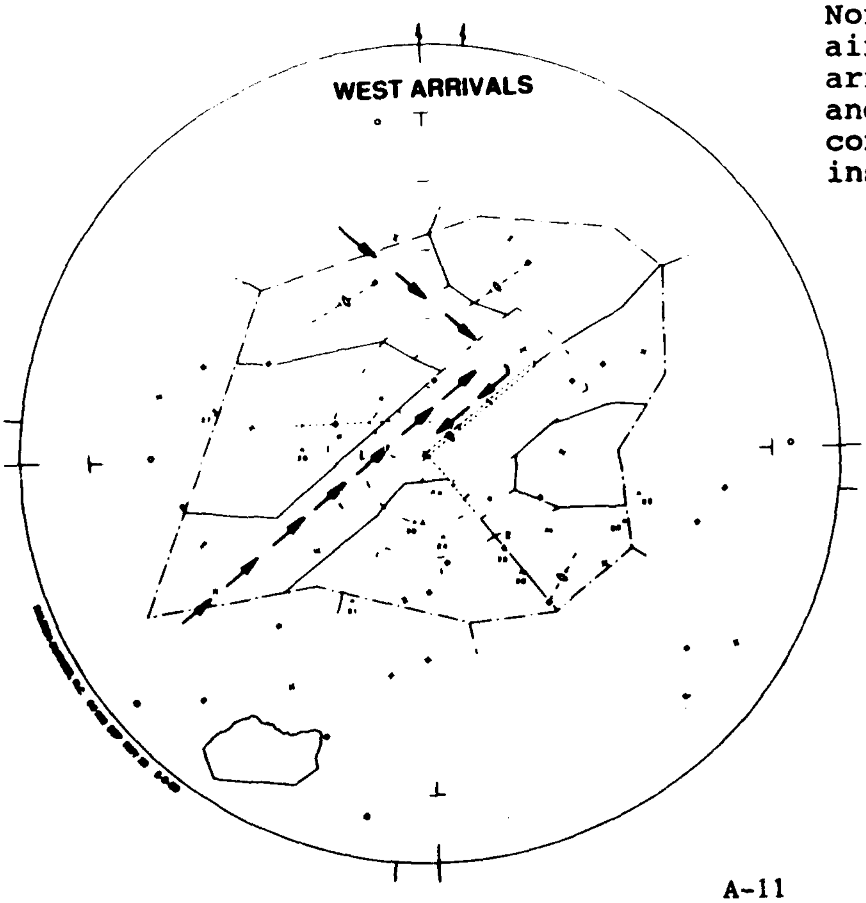


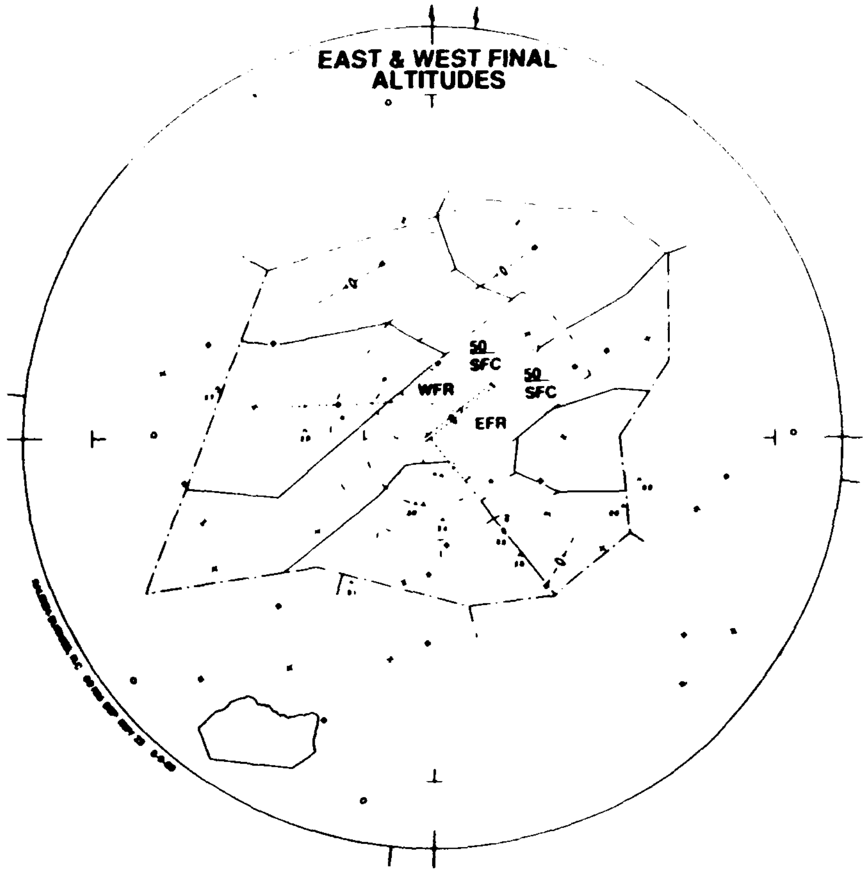
The East Controller accepts arrival and transgressing flights from the South and East of Raleigh-Durham airspace. The flights from two arrival areas are sequenced together and handed off to the East Final controller who provides the flight instructions for landing.





The West Controller accepts arrival and transgressing flights from the North and West of Raleigh-Durham airspace. The flights from two arrival areas are sequenced together and handed off to the West Final controller who provides the flight instructions for landing.





The East and West Final controllers provide sequencing adjustment and approach clearances for multiple aircraft landing at Raleigh-Durham.

DATA LINK OPERATION AND PROCEDURES BRIEFING

TERMINAL DATA LINK
ARTS IIIA

The Arts IIIA Data Link (D/L) program modifies seven subroutines. They are: IFI, IFO, IDAT, PASS, TDOP, COMS, and KOFA.

Changes are also made to the Central Track Store tables (five additional words. Three of these words are used to output the third line of the full data block (FDB), and the others are for storing data and flags.

The third line contains coded information for the controller pertaining to D/L messages sent to or received from the aircraft. These message types or services are Terminal Information (TI), Initial Contact (IC), Menu Text (MT), Transfer of Control (TC), and Free Text (FT).

In order to indicate the D/L status of an aircraft, an additional character has been prefixed to the identification. The character is an asterisk (*) for the aircraft that is D/L equipped and eligible, or a plus (+) for one that is only equipped. These can be changed to a square (■) and a triangle (▲), respectively, via the keyboard entry, **F9,Z,ENTER**.

In the local program we are working with, the tabular lists of the second keyboard are used output the lists required for each controller. The final operational version will have to have new areas identified and the MDBM will have to be modified to handle them.

There are presently three separate lists per D/L controller. They are: (1) TI/MT, (2) History List (HL), (3) Status List (ST). These lists are display oriented.

<u>TI/MT LISTS</u>.

The TI list consists of four lines of data containing pertinent terminal information normally given to the aircraft on initial contact. They are numbered 1 through 4, with the one at the top of the list designated the default message regardless of the number. The remainder of the list will be ordered numerically. The default message is the one which will be sent to the aircraft when the controller does an implied SLEW to a target that has a blinking IC message in the third line of its FDB. The controller has the capability of changing the information in any of the messages, and to designate any one of them as the default message.

The MT list consists of nine lines of specific control instructions. Two are for speeds, three are for altitudes, three are for headings, and one is used to combine two or three of the first eight so that they can be sent to the aircraft with only one keyboard entry by the controller. The controller has the capability to change the specific information (speed-altitude-heading) through keyboard entry.

In addition to the present MT messages, the controller has the ability to send a one time speed, altitude, or heading message. These are being called "Bypass MT" messages at the present.

The keyboard entries to display or inhibit the TI or the MT lists are considered flip/flop entries; that is, if the list is not being displayed when the entry is made, it will be, and visa-versa. The entries are:

For the TI list: **DL, (DL function key),T,ENTER.**
For the MT list: **DL, (DL function key),M,ENTER.**

In the present demonstration program the TI and MT lists are both being displayed in the area reserved for the second keyboard's Coast/Suspend List and, therefore, are not independently moveable. The entry used to move it is **"F&,T,C,SLEW"** from the second keyboard.

<u>HL LIST</u>.

The HL list will display the last **five** messages that the aircraft has **received** via D/L. It consists of six lines. The first line will contain the identification of the aircraft, and the others will show the message sent.

The controller can display the history list for any aircraft under his control by making the following entry: **H, L SLEW.**

The HL list will replace the TI/MT list for a parameter number of seconds (presently set at eight) or until the controller makes the same entry to the aircraft again.

<u>ST LIST</u>.

The ST list consists of up to 16 lines. The first line shows whether the **TC** message will automatically be sent or held after a handoff entry. Remaining lines show the aircraft ID, the message sent, and the status of that message. i.e., AAL123 MT (SNT, DLV, WIL, NAK, UNA, or TIM). When an aircraft sends back a "WILCO," it will be displayed for a parameter number of seconds. If the controller resends a message to an aircraft displaying any of the fail conditions in the third line of its FDB, the old message will be cleared out of the ST list and come up again when the new one is sent.

To display the list, the controller needs to make the following entry: **F9 (DL function key), SL, ENTER.** This is a flip/flop entry, and if made while the ST list is being displayed, t will be turned off.

As is the case with the TI/MT lists, this one also reuses a previously defined ARTS IIIA list for our demonstration program. That list is the Arrival/Departure list for the second controller. The entry to move it is **"F7, T, SLEW"** from the second keyboard.

<u>TERMINAL DATA LINK SERVICES</u>.

Communications Backup Uplink (Free Text) service is the only one of the currently identified services not ready to be demonstrated. The other four are described below.

<u>Initial Contact (IC)</u>.

The IC service is currently designed to be automatically initiated upon completion of the TC message. When the TC is completed, an Altitude Request (AR) message is uplinked to the aircraft. The response expected is an IC message containing the last assigned altitude the aircraft was given.

When the IC is received, it is displayed in the third line of the FDB with the altitude in hundreds of feet flashing.

<u>Terminal Information (TI)</u>.

The TI service is designed to uplink to the aircraft the information that the controller is required to give on initial contact; i.e., expected approach, initial heading-altitude-speed, etc.

Each display has four lines of data available for the TI list. Each line of data can be changed by controller keyboard input. Future additions may include different messages for each configuration which would automatically be displayed when the new configuration entry is made.

The TI message is normally used as a response to the IC sent by the aircraft. The controller has the option to respond in two ways:

1. An implied SLEW entry to an aircraft that has a flashing IC in the third line of the FDB will send the default TI.

2. If the controller wishes to send something other than the default message, he will have to make the following entry: **T, (1-4), SLEW.**

The default message can be any one of the four. The controller can chose the one he wants by the keyboard entry; **F9 (D/L), D, (1-4), ENTER.**

The controller also has the option to send one MT message along with the TI if he wishes.

<u>Menu Text (MT)</u>.

The MT is really a combination of three services as defined by the En Route Data Link documentation. These are altitude, heading, and speed.

Each display has its own MT list. There are nine lines available in the list for control instructions. The first eight lines are dedicated to specific functions: 1 and 2 are for speed control, 3, 4, and 5 are for altitudes, and 6, 7, and 8 are used for headings. Line 9 is for special use. If the controller wants to combine two or three messages from lines 1-8, he may do so. This allows him to send up the combined message with the same entry as any other MT: **M, (1-9), SLEW.**

With the exception of line 9, MT messages may be combined. Up to three messages, one of each category, may be sent at one time. If this option is used, a "space" must be keyed in-between each number.

The messages in the MT list are initially put in with the site adaptation and will always be the same at the start up of the ARTS program. The controller has the option of changing any of them at any time via keyboard entry, and if he wishes, send it to the aircraft at the same time. The new message will stay in the MT list until it is changed or the program is restarted.

In addition to the normal MT message entries, an entry has been provided so that the controller can send a heading, altitude, and/or speed with the use of what has become known as the "MT Bypass" entry. It was designed to send a message to the aircraft without changing the entries in the MT list. The entry will allow for up to three message, one of each category.

<u>Transfer of Communications (TC)</u>.

The TC service sends a message to the aircraft telling the pilot the frequency of the next eligibile controller in case voice communications have to be used because of a Data Link failure.

There are two modes of operation for the TC: automatic or manual. A keyboard entry has been provided so that each controller can select the mode of operation desired. When the ARTS program is first started, all displays will be in the Automatic mode and "AUTO

SEND " will be displayed on the first line of the ST list. If the controller changes to the Manual mode, this will change to "**AUTO HOLD.**"

In the Automatic mode, the TC will be sent when the ARTS handoff has been completed unless an "**H**" is added to the HD entry. If the "H" is added, the TC will beheld.

In the Manual mode, the TC will be held after the handoff unless an "S" (for send) is entered after the controller ID in the handoff entry.

In either mode, if the Transfer of Control message has been held, "**TC H**" will be displayed in the FDB. The eligible D/L controller can continue to send MT messages to the aircraft until he is ready to transfer control.

To send the TC message any time after it has been held, all the controller has to do is an implied **SLEW** to the aircraft when the "**TC H**" is being displayed.

KEYBOARD ENTRIES.

A list of all available keyboard entries is included in this attachment.

INTERFACILITY CHANGES.

The ARTS IIIA has a restricted capability to talk to external devices without adding new hardware. To date no specific D/L/ARTS interface has been identified. For these reasons, and to expedite the Data Link demonstration, we chose to "piggy-back" the D/L messages on the ARTS-HOST Interfacility lines when communicating with the VAX computer.

Formats were established to handle all of the D/L services and new messages used exclusively for transmitting aircraft flight plan information to the VAX.

In an end-to-end demonstration of D/L, we are currently anticipating that all Terminal D/L messages will be sent through the HOST in the same manner that the ARTS-to-ARTS messages are being handled.

LIST OF ALLOWABLE KEYBOARD ENTRIES

F9,T,E	TI DISPLAY LIST ON/OFF TOGGLE.
F9,T,(MSG#1 TO 4), (MSG. CONTENT),E	TI MSG CHANGE ENTRY. THIS ENTRY ALLOWS INPUT OF UP TO 40 CHARACTERS FOR MSG #1 AND UP TO 28 CHARACTERS FOR MSGs #2,3,&4.
F9,D,(TI MSG#),E	THE TI MSG NUMBER ENTERED BECOMES THE NEW DEFAULT TI MSG AND WILL BE MOVED TO THE TOP OF THE LIST. THE REMAINING MSGs WILL BE NUMERICAL ORDER.
F9,M,E	MT DISPLAY LIST ON/OFF TOGGLE.
F9,M,(MSG#1 TO 8), 3DIGITS, E	ALLOWS CHANGE OF ANY MSG IN THE MT LIST. MSG# 1 TO 2 SPEED MSG 3 TO 5 ALTITUDE MSG 6 TO 8 HEADING MSG
F9,M,(MSG#1 TO 8),3DIGITS, SLEW ENTER	ALLOWS CHANGE OF ANY MT MSG AS ABOVE AND SENDS THAT MESSAGE TO THE A/C IDENTIFIED BY THE SLEW ENTRY.
F9,M,9(2 OR 3 MT MSG#), E,OR SLEW	ALLOWS THE OPTION TO COMBINE UP TO 3 MENU TEXT MSGs (1 OF EACH TYPE) IN LINE NINE OF THE MENU TEXT. IF SLEW IS USED, IT WILL ALSO SEND THOSE MSGs TO THE A/C.
F9,(A,H,OR S),3 DIGITS, [(A,H,OR S),3 DIGITS, (A,H,OR S),3 DIGITS], SLEW ENTER ***	ALLOWS CREATION OF A MESSAGE NOT SHOWN IN THE MT LIST AND SENDS IT TO THE A/C IDENTIFIED BY THE SLEW ENTRY AS FOLLOWS: A IS AN ALTITUDE MSG H IS A HEADING MSG S IS A SPEED MSG NOTE: THIS ENTRY WILL NOT MODIFY THE MT LIST.
***	THIS ENTRY WILL ALLOW FOR UP TO THREE MSGs (ONLY ONE OF EACH TYPE). THEY MAY BE ENTERED IN ANY ORDER. EXAMPLE: F9A060H180S150 SLEW F9H230A030 SLEW

F9,SLEW ENTER	CLEARS THE DATA LINK FAIL MESSAGE FROM THE THIRD LINE OF THE FULL DATA BLOCK FOR THE A/C IDENTIFIED BY THE SLEW ENTRY.
F9,OK,SLEW ENTER	STEALS DATA LINK CONTROL OF THE A/C IDENTIFIED BY THE SLEW ENTER AND SENDS A TOC MESSAGE TO THE IDENTIFIED A/C.
F9,SL,E	DISPLAY/INHIBIT THE STATUS LIST.
F9,TH,E	SELECT/INHIBIT AUTO TOC HOLD MODE. IT IS DISPLAY ORIENTED, AND IS A FLIP/FLOP ENTRY. AT START UP, THE MODE IS SET TO AUTO SEND.
F9,Z,E	CHANGE THE EQUIPPED AND ELIGIBLE SYMBOLS FROM (+,*) TO (,). THIS IS A FLIP/FLOP ENTRY AND IS SYSTEM WIDE.
F9,X,SLEW	CANCEL A DATA LINK MSG THAT HAS NOT BEEN WILCOED.

****

THE FOLLOWING ARE THE IMPLIED ENTRIES FOR D/L

****

SLEW(ONLY)	1-WHEN DONE TO AN AIRCRAFT THAT HAS A FLASHING "IC" MSG IN FULL DATA BLOCK, THE DEFAULT TI MSG WILL BE SENT. 2-IF THE A/C HAS "TC H" IN THE DATA BLOCK, A TOC MSG WILL BE SENT. 3-IF THE LAST DL MSG HAS FAILED, IT WILL BE RESENT.
T,(MSG#1 TO 4),SLEW	THE IDENTIFIED TI MSG WILL BE SENT TO THE A/C.
TM,(MT MSG #),SLEW	THE DEFAULT TI MSG AND THE IDENTIFIED MT MSG WILL BE SENT TO THE A/C.
T(MSG#),M(MSG#),SLEW	THE IDENTIFIED TI AND MT MSG WILL BE SENT TO THE A/C.
M(MSG#1-8)[SPACE,(#1-8), SPACE,(#1-8)],SLEW	WILL SEND UP TO 3 MSGs (1 OF EACH TYPE) TO THE A/C. IF MORE THAN ONE #, THEY MUST BE SEPERATED BY A SPACE.

HL,SLEW	DISPLAY THE HISTORY LIST (HL) FOR THE IDENTIFIED A/C. THE HL WILL OVERWRITE THE TI/MT LISTS FOR A PARAMETER (8) NUMBER OF SECONDS - OR UNTIL ANOTHER HL, SLEW TO THE SAME A/C.

** THE HANDOFF ENTRY HAS BEEN MODIFIED TO ALLOW FOR THE HOLDING OR SENDING OF THE TOC MSG.

1	F5,CONTROLLER,H,SLEW/ CONTROLLER,H,SLEW	IN THE AUTO SEND MODE, THIS WILL HOLD THE TOC
2	F5,CONTROLLER,S,SLEW/ CONTROLLER,S,SLEW	IN THE AUTO HOLD MODE, THIS WILL SEND THE TOC

NOTE: E INDICATES THE ENTER KEY ON THE A/N KEYBOARD MODULE.
SLEW ENTER INDICATES THE ENTER KEY ON THE TRACKBALL MODULE.
* DATA INSIDE OF THE BRACKETS [ ] IS OPTIONAL.

****

TERMINAL INFORMATION LIST

TI

1. FLY HDG 120 VTR VISUAL APCH RNWY 23R
2. FLY PRSNT HDG VTR ILS 23R APCH
3. EXP VTRS TO ILS 31 APCH
4. ROGER

TERMINAL INFORMATION LIST

TI

3\. EXP VTRS TO ILS 31 APCH

1\. FLY HDG 120 VTR VISUAL APCH
RNWY 23R

2\. FLY PRSNT HDG VTR ILS 23R APCH

4\. ROGER

MENU TEXT LIST

MT

1. RDC SPD TO 180 KTS
2. RDC SPD TO 150 KTS
3. DTAM 7000 FT
4. DTAM 4000 FT
5. CTAM 12000 FT
6. FLY HDG 220
7. FLY HDG 180
8. FLY HDG 310
9. MT 1/4 (OR 1/4/7)

COMBINED TI/MT LIST

TI

1. FLY HDG 120 VTR VISUAL APCH RNWY 23R
2. FLY PRSNT HDG VTR ILS 23R APCH
3. EXT VTRS TO ILS 31 APCH
4. ROGER

MT

1. RDC SPD TO 180 KTS
2. RDC SPD TO 150 KTS
3. DTAM 7000 FT
4. DTAM 4000 FT
5. CTAM 12000 FT
6. FLY HDG 220
7. FLY HDG 180
8. FLY HDG 310
9. MT 1/4

HISTORY LIST

HL AAL968

EVT ILS/DME RWY 27 APCH

DTAM 9000

H180 S170 A070

EXP VTRS TO RWY 31

•• A050

FLY HDG 310

STATUS LIST

SL

AUTO (HOLD/SEND)

AAL968 MT WIL

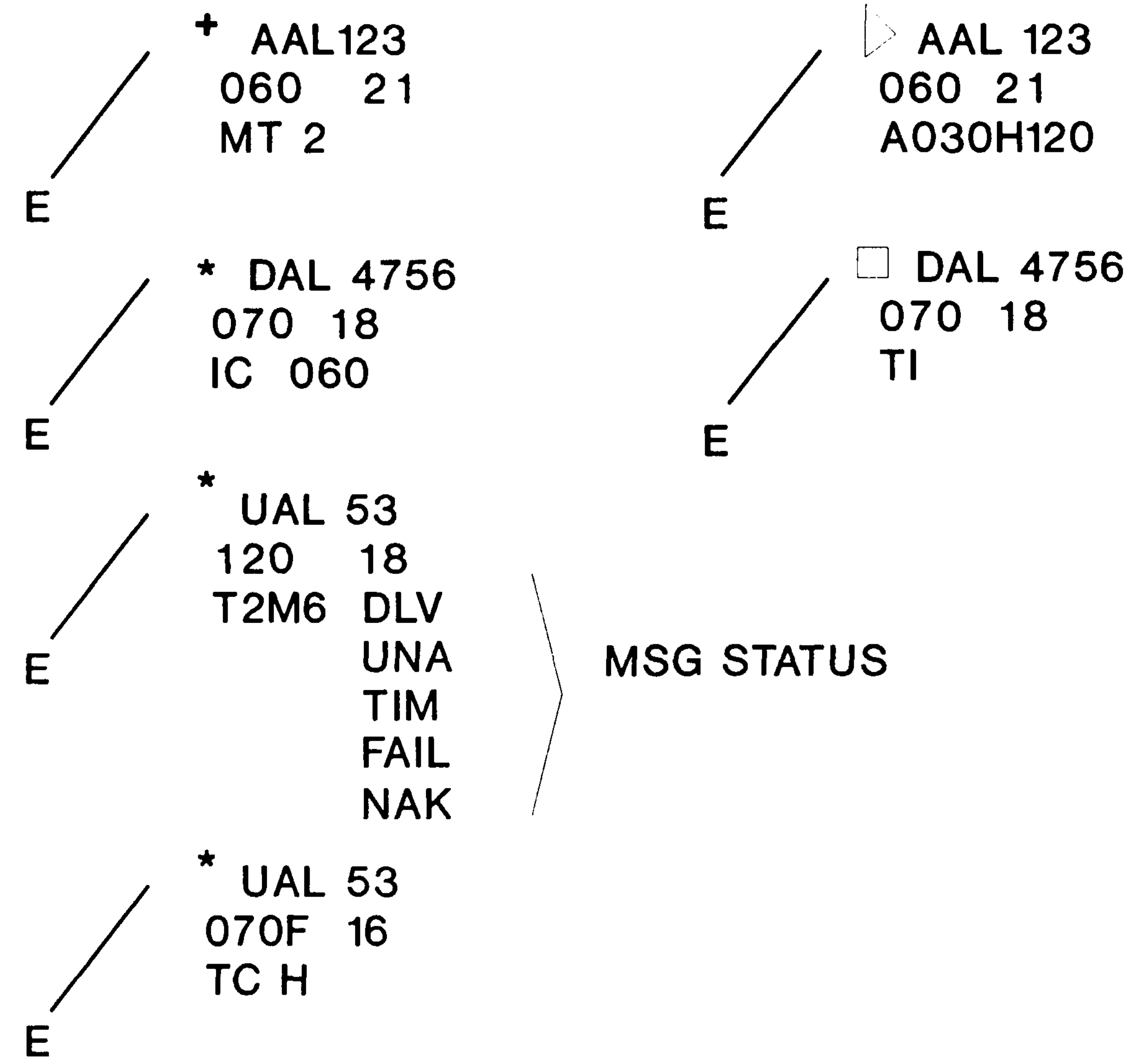
USA743 TI UNA

DAL776 MT NAK

AAL968 TC DLV

N17635 AR SNT

FDB FOR DATA LINK AIRCRAFT



ALTITUDE REQUEST/INITIAL CONTACT

```
    * AAL 968
    070  24
  / AR SNT
W

    * AAL 968
    070  24
  / IC 050
W
```

THIS SERVICE IS INITIATED AUTOMATICALLY BY THE COMPUTER AFTER COMPLETION OF THE TRANSFER OF COMMUNICATIONS

TERMINAL INFORMATION SERVICE

DEFAULT TI

* USA 743
120 24
TI
W

ANY OTHER TI

* USA 743
120 24
TI 2
W

COMBINED TI AND MT

* USA 743
120 24
T2M4
W

MENU TEXT

SINGLE MT MSG

*N1763S
080 15
MT 2
N

COMBINED MT MSGS OR USE OF LINE 9 (M, 9, SLEW)

*N1763S
080 15
MT (27 OR 247)
N

<u>MT BYPASS</u>

SINGLE

*N1763S
080 15
MT H180
N

MULITPLE

*N1763S
080 15
A040H180S120
N

TRANSFER OF COMMUNICATIONS

AUTO SEND

* DAL 611
090 21
TC

E

AUTO HOLD

* DAL 611
090 21
TC H

E

APPENDIX B

ATDLVT
WASHINGTON CENTER/RALEIGH-DURHAM ATCT
LETTER OF AGREEMENT
AND
INTRAFACILITY OPERATING PROCEDURES

LETTER OF AGREEMENT

SUBJECT: Approach Control Service

1. PURPOSE: This agreement describes the Air Traffic procedures and responsibilities to be followed by the En Route and Terminal members of the ATDLVT during separate or combined testing and evaluations in the labs at the FAA Technical Center.

2. SCOPE: The procedures contained herein shall apply unless prior coordination has been affected.

3. PROCEDURES:

a. Arrivals:

(1) All aircraft shall have airport clearance limits, be established on and cleared via the ARGAL, BRADE, BUZZY or SOUTH BOSTON Arrivals (STARS) as depicted on attachment 1.

(2) Aircraft shall be instructed to cross arrival fixes at the altitudes listed below at 250 kts.

(a)	Nonjet:	ARGAL/ALDAN	8,000
		BUZZY/BRADE	11,000
(b)	Jets:	ARGAL/BUZZY/BRADE	11,000
		ALDAN	10,000

(3) The MIT and Flow rates will be determined by the RDU Supervisor and the ZDC TMU. Unless otherwise stated, provide a minimum of 5 MIT to all arrivals, except vertical separation may be applied to Jets vs. Non-Jets via ARGAL/ALDAN.

(4) When arrival delays are anticipated, the RDU Supervisor shall coordinate with ZDC TMU in sufficient time so as to permit ZDC to clear arrivals to the appropriate arrival fix. RDU shall accept any aircraft within 10 nmi of the airspace boundary should holding be instituted.

b. Departures:

(1) All departures shall be issued routings consistent with the DTA's shown on attachment 4.

(2) All aircraft shall be advised to expect requested altitude 10 minutes after departure.

(3) RDU shall ensure a minimum of 5 nmi separation, constant or increasing, exists between successive departures. Vertical separation may be applied with aircraft requesting below 10,000 ft.

(4) RDU shall transfer departures at 10,000 ft or filed lower altitude. Departures filed via DAN/SBV requesting AOB 10,000 ft shall be cleared as filed and transferred at 6,000 ft or lower filed altitude.

c. Overflights:

(1) All overflights shall enter and depart RDU airspace via the ATA's and DTA's in attachments 2 and 4.

Exceptions:

(a) Overflights filed via V39/V136 or direct SBV/DAN may be cleared as filed AOB 7,000 ft.

(b) Overflights departing from RWI/PGV/W03/W55 may be cleared direct RDU then via a DTA or as stated in 3C (1) (a).

d. General:

(1) When both facilities computers and FDIO's are operational, ARTS departure messages shall be used.

(2) In the event of a ZDC or RDU computer or FDIO failure, pass all flight data messages via verbal means as coordinated by the ZDC and RDU Supvs. Forward ammended departure times only when they differ by more than 5 minutes from assumed times.

(3) In the event of an RDU radar outage, ZDC will assume control of the terminal airspace AOA 6,000 ft. The Supervisor will coordinate for appropriate restrictions and routings to minimize delays during the outage.

(4) RDU shall except all aircraft landing Pope AFB, Simmons AAF, RWI and W03 for transition to lower altitudes using the RDU VOR as the TCP.

(5) Each facility has control for turns up to 30 degrees either side of track, for aircraft AOA 7,000 ft or AOB 13,000 ft as appropriate.

<u>ATTACHMENTS</u>:

Attachment 1 - Approach Control Area
Attachment 2 - Arrival/Overflight Procedures
Attachment 3 - Arrival Delay Patterns
Attachment 4 - Departure/Overflight Procedures
Attachment 5 - Center Sector Boundaries
Attachment 6 - Frequency Use and Sector Information
Attachment 7 - Arrival Flow Rate Explanation
Attachment 8 - Runway 23R and 23L Approaches

ARRIVAL PROCEDURES:

1. Unless visual separation is applied or coordination effected, parallel instrument landing system (ILS) approaches shall be conducted as follows:

a. EFR - Ensure aircraft intercept the localizer at 3100 ft inside 10 DME, and 4000 ft outside 10 DME.

b. WFR - Ensure aircraft intercept the localizer at 2100 ft inside 10 DME, and 3000 ft outside 10 DME.

2. EAR/SDR - Instruct arriving aircraft to expect runway 5R/23L unless they state an operational need for 5L/23R. "HEAVY" aircraft will be assigned 5L/23R upon request regardless of whether there is an operational need or not. Inform the pilot of any delays expected to accommodate their requests.

WAR/NDR - Instruct arriving aircraft to expect runway 5L/23R.

3. Ensure arriving turbo-jet aircraft do not descend below 6000 ft until within 20 flying miles of the runway, or below 3000 ft prior to 10 DME.

4. Ensure aircraft below 5500 ft remain at least 10 nautical miles (nmi) from the departure end of the runway.

5. Missed approaches and practice instrument approach climb-outs will be handled as a normal departure based on type.

6. Transfer communications to LC prior to 5 nmi from the runway.

DEPARTURE PROCEDURES:

1. Raleigh-Durham (RDU) Departures shall be assigned the following headings and altitudes based on type:

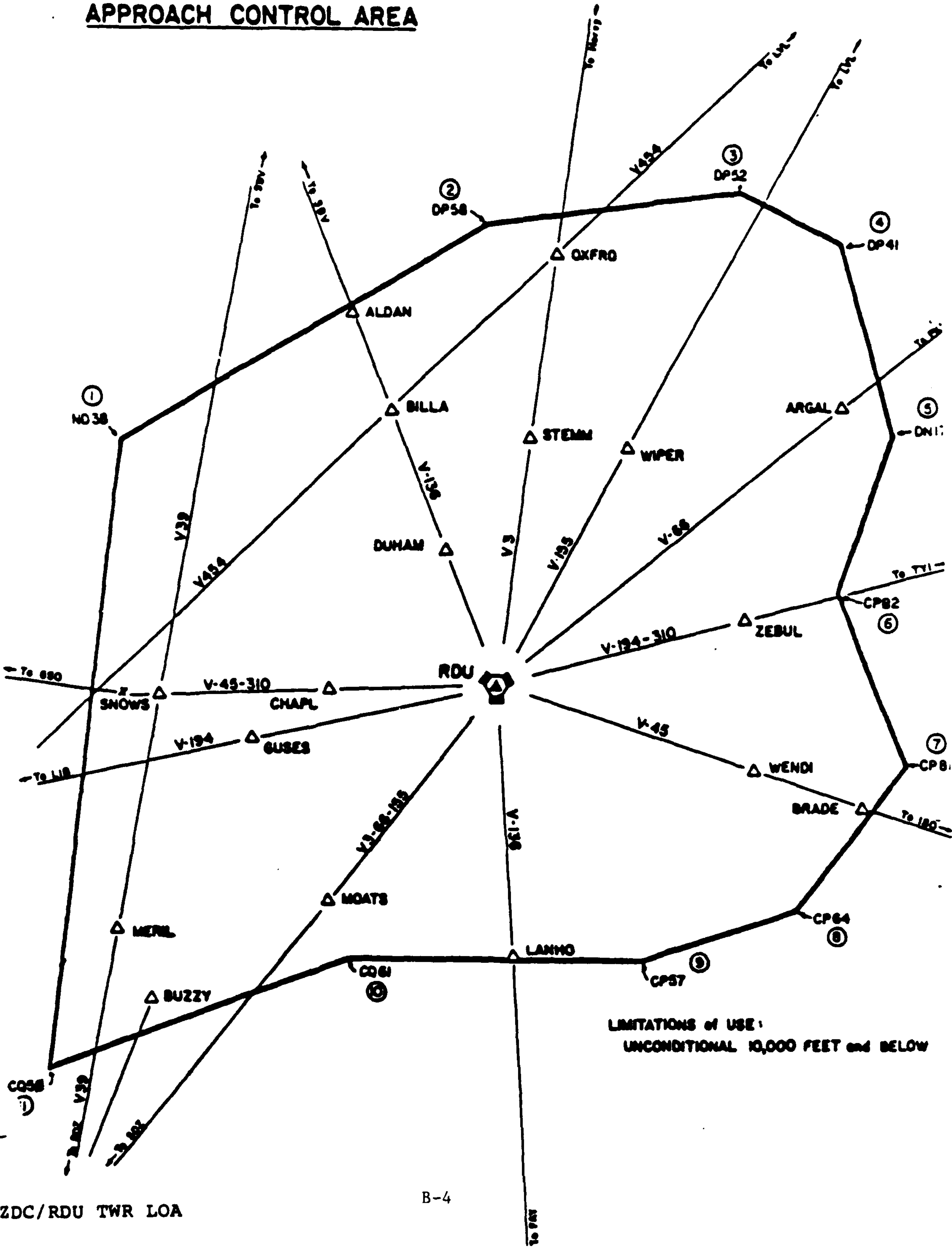
	RWY 23L	ALT	RWY 23R	ALT
Jets	210	5000	230	5000
Turbo-Prop	190	3000	250	3000
Props	155	2000	305	2000

2. Assume control of departures passing 2 DME or 3000 ft.

3. Assign altitudes IAW the direction of flight rule unless provided for in the ZDC/RDU LOA.

•RALEIGH - DURHAM TOWER•
APPROACH CONTROL AREA

Attachment 1

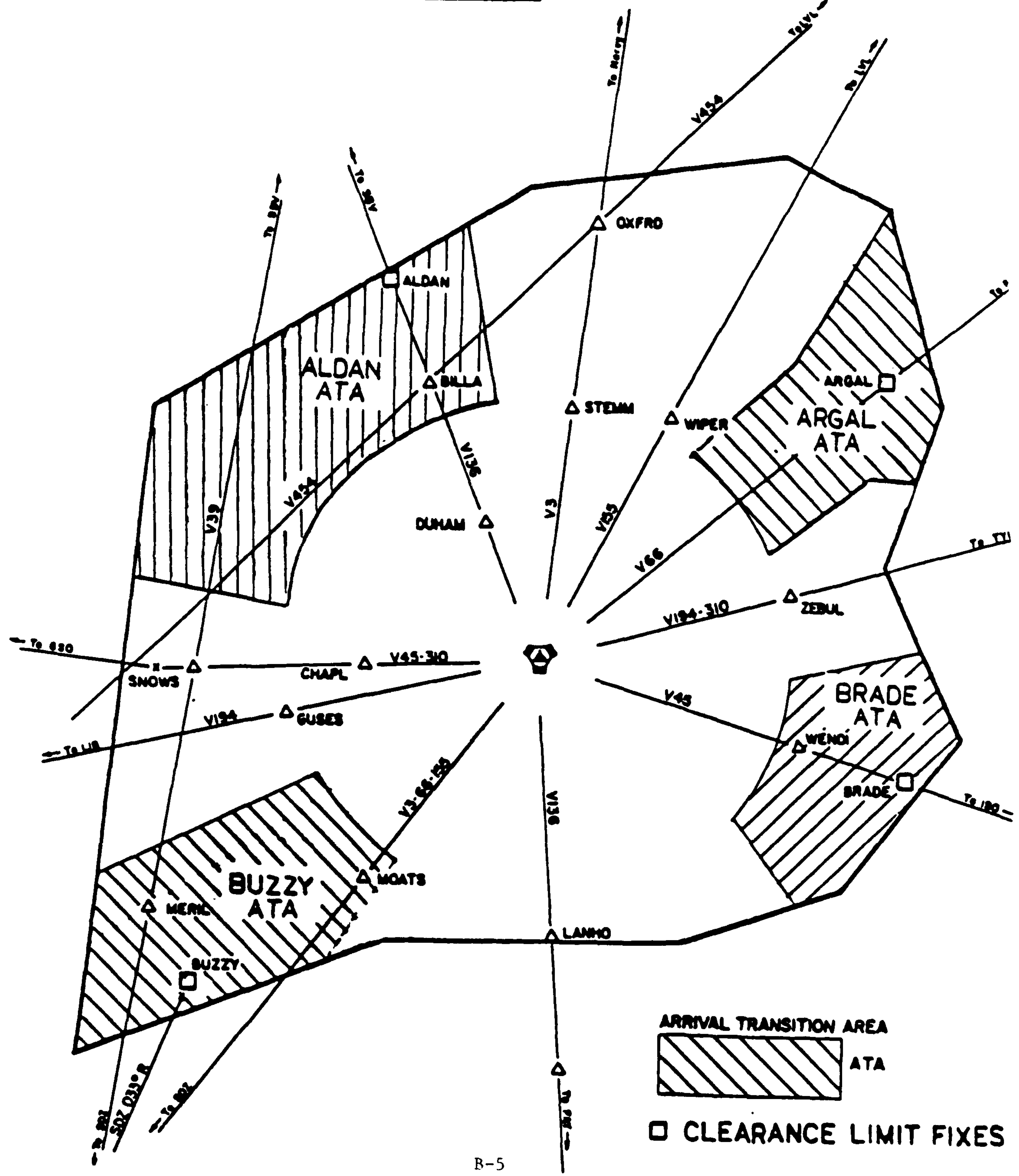


B-4

•RALEIGH- DURHAM TOWER•

ARRIVAL / OVERFLIGHT PROCEDURES

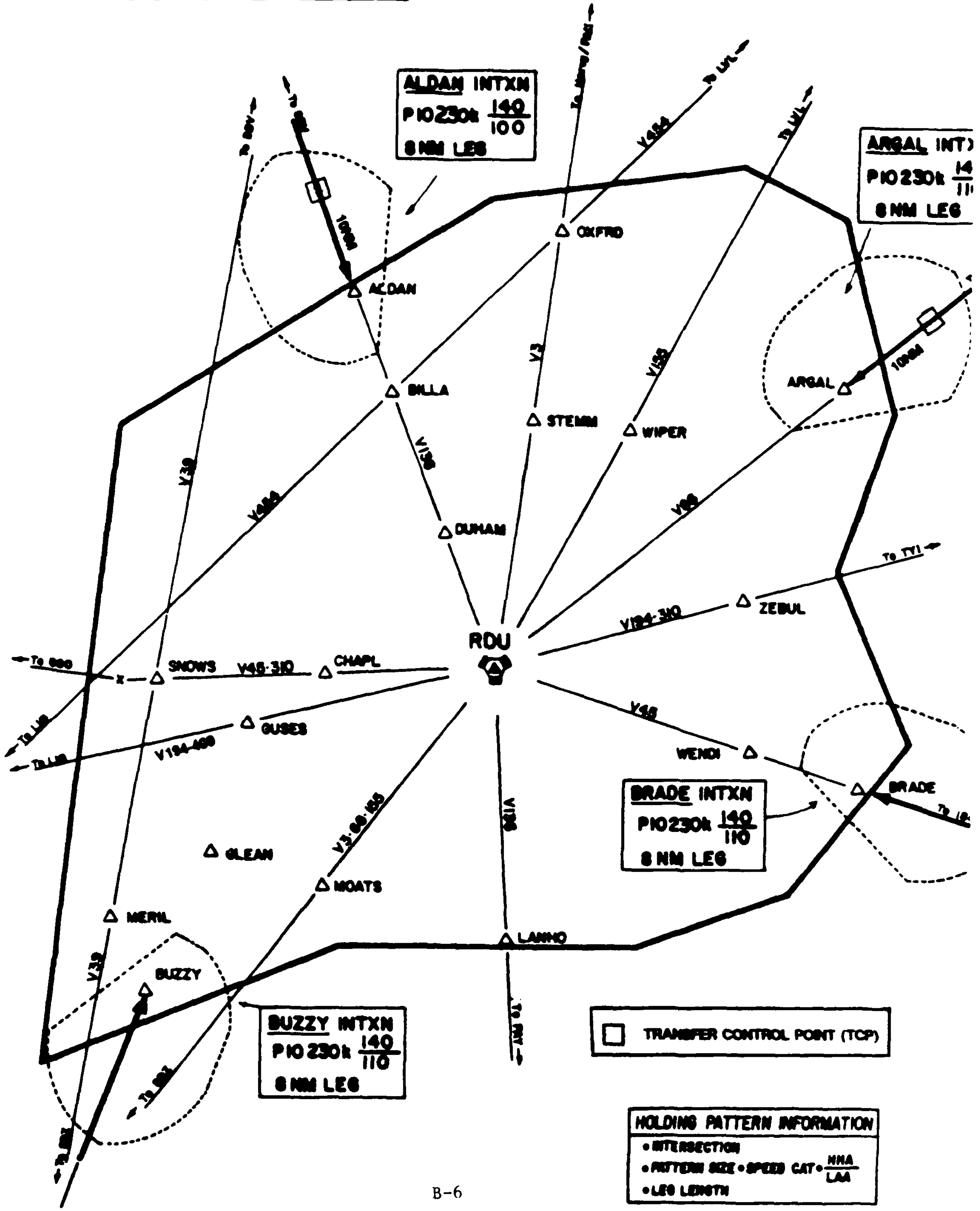
Attachment 2



ZDC/RDU TWR LOA

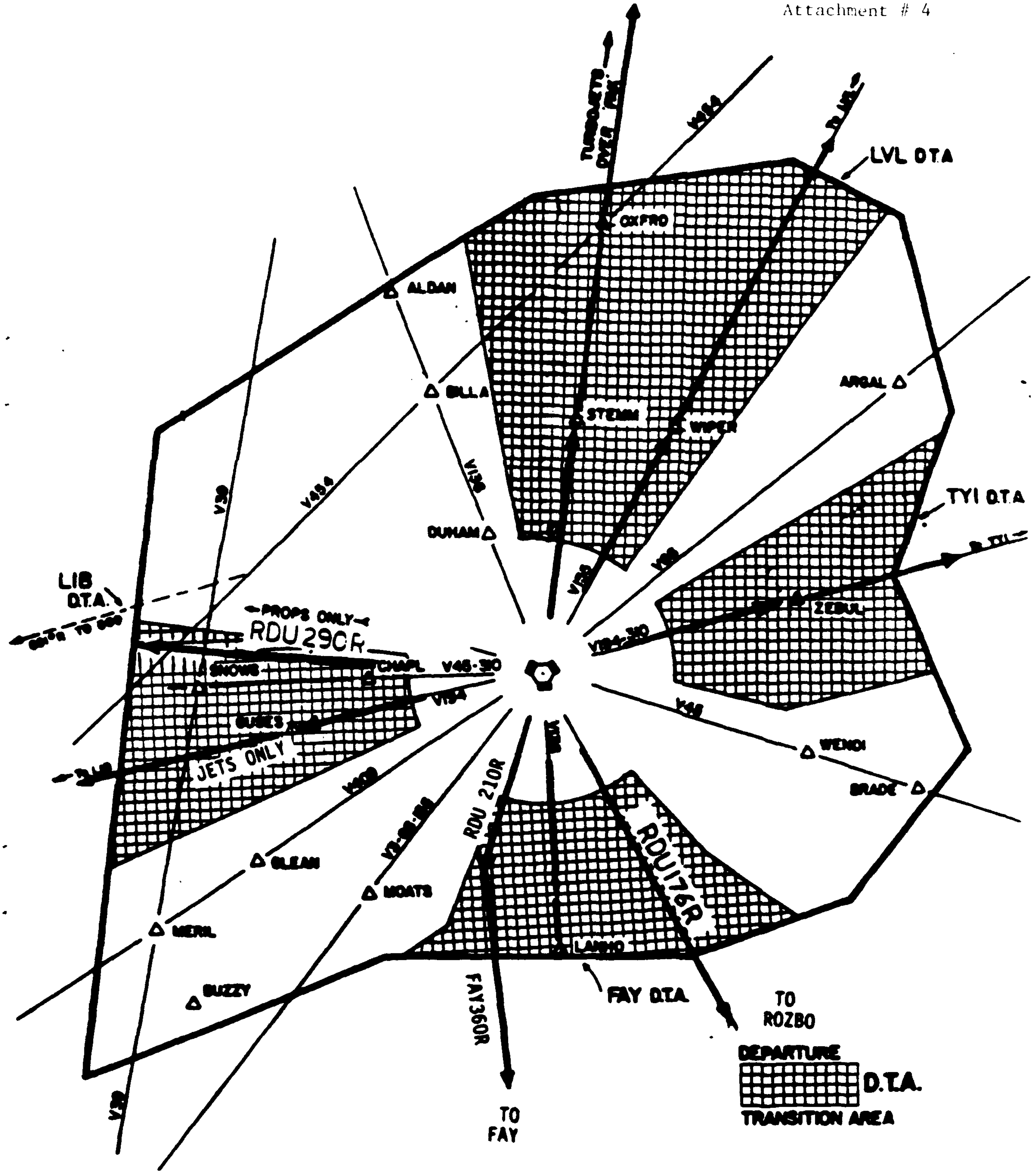
•RALEIGH - DURHAM TOWER•
ARRIVAL DELAY PATTERNS

Attachment 3



DEPARTURE / OVERFLIGHT PROCEDURES

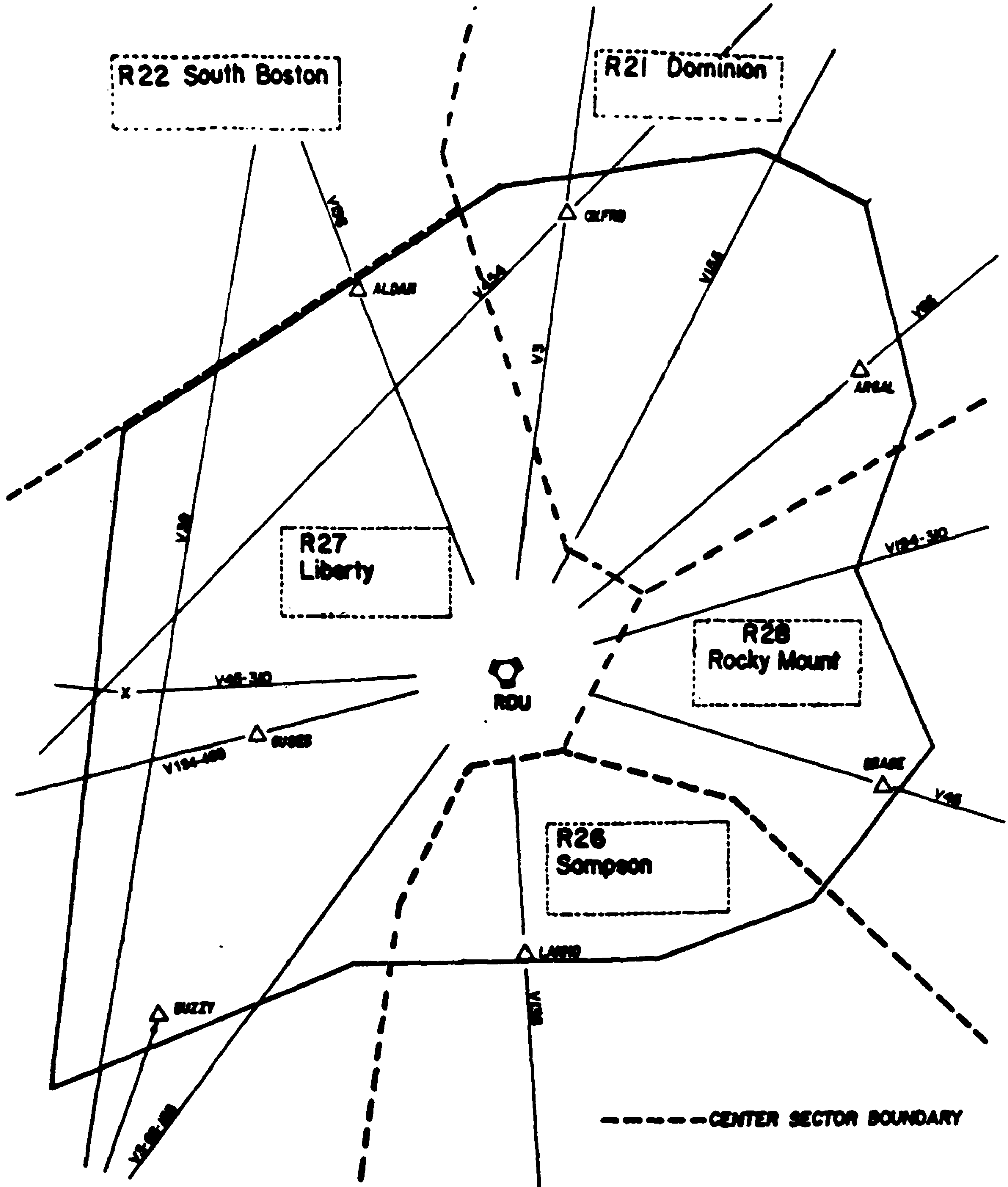
Attachment # 4



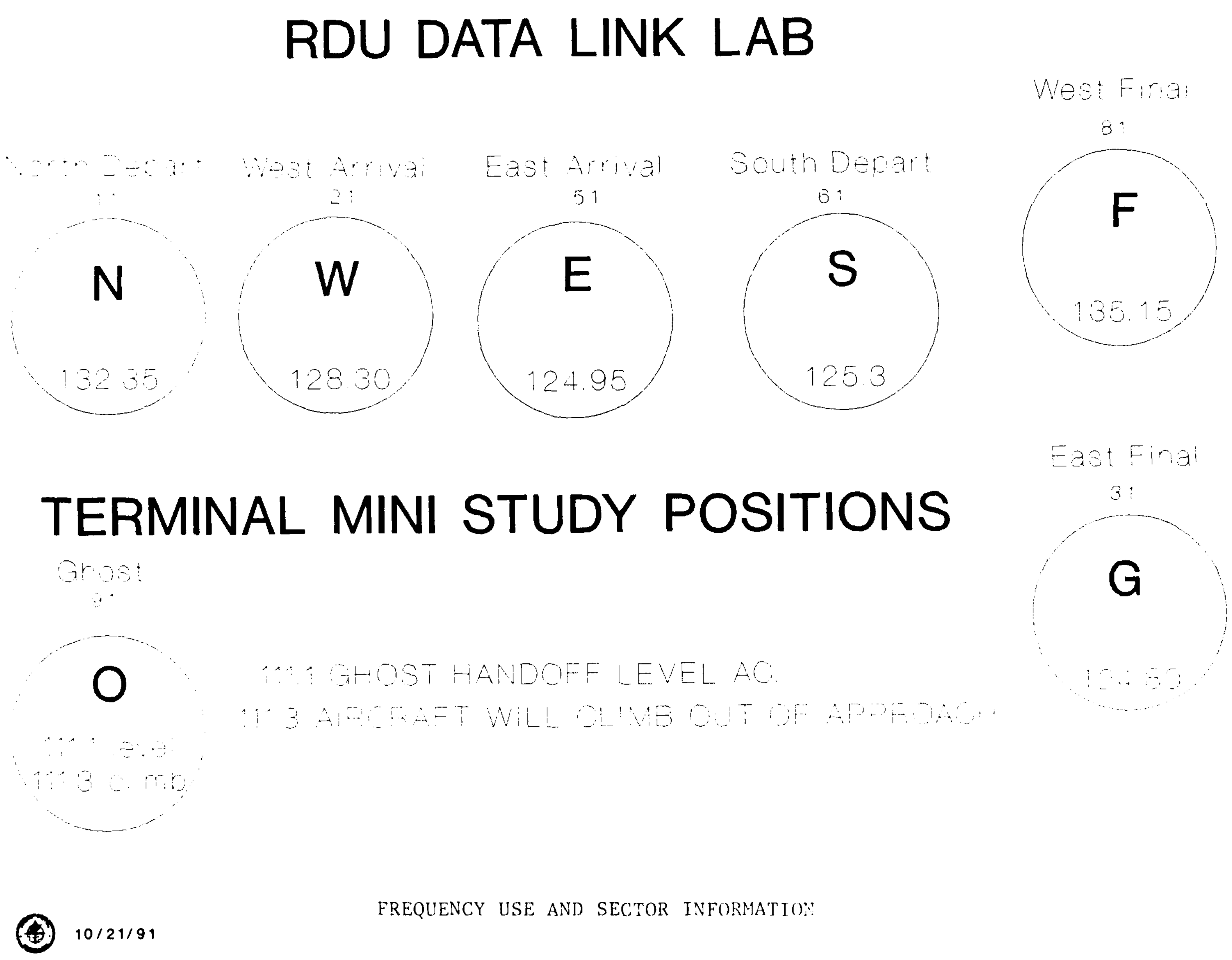
•WASHINGTON ARTCC - LOW ALTITUDE SECTORS•

Attachment 5

OVERLYING RALEIGH APPROACH CONTROL AIRSPACE



Attachment #6



FREQUENCY USE AND SECTOR INFORMATION

ARRIVAL FLOW RATE EXPLANATION

Flow Rate: Number of aircraft per hour--method of balancing the system demand with the system capacity by ensuring maximum efficiency in airspace utilization.

Factor affecting, but not necessarily limited to, the selection of an hourly flow rate should be:

60 aircraft per hour	Weather VFR, very little conflicting traffic. More than one landing runway.
48 aircraft per hour	Weather IFR or marginal. Moderate ARSA or tower en route, nonmetered traffic. Other extenuating circumstances such as changing landing direction.
42 aircraft per hour	Weather IFR or marginal. Heavy influx of ARSA or tower en route, nonmetered traffic. Other extenuating circumstances, such as one landing runway.

Capacity: Number of aircraft per 10 minute period. This figure indicates the maximum number of aircraft inside the outer fixes that can be handled in any 10 minute period without having to extend the downwind leg or vector excessively. These guidelines are designed to provide an aircraft flight plan of between 30 to 38 miles from the outer fixes to the airport.

Compression: Number of aircraft per 10 minute period exceeds capacity. When the compression factor inside the outer fixes exceeds the capacity, additional intrail separation will be necessary. For guidance, use the attached arrival flow rate guide.

Attachment # 7

ARRIVAL FLOW RATE

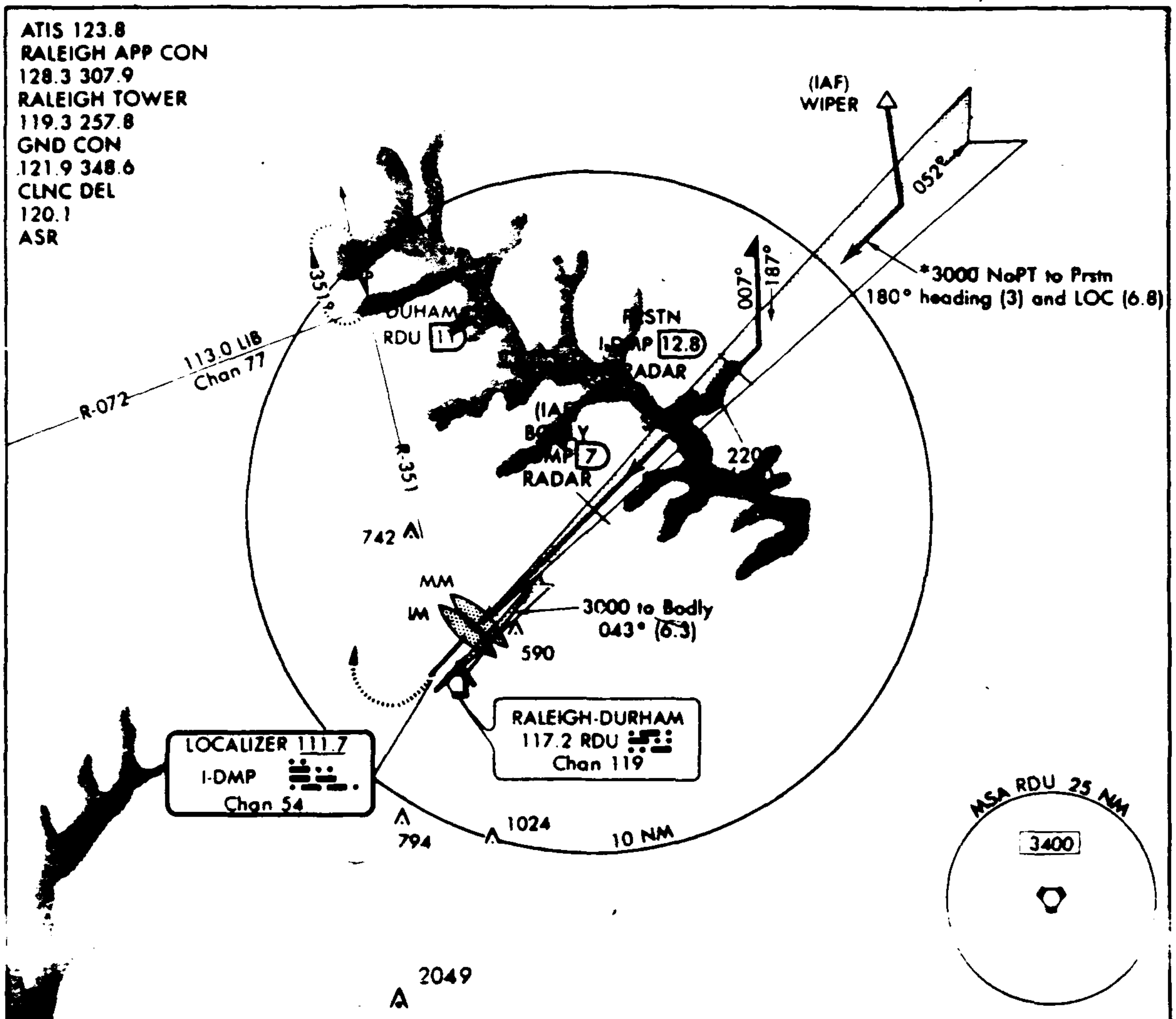
FLOW RATE Number of Aircraft Per Hour	CAPACITY Number of Aircraft Per 10 Min. Period	SEPARATION Minimum Intrail Separation	COMPRESSION No. of Aircraft Per 10 Min. Period Exceeds Capacity	ADJUSTED SEPARATION Minimum Intrail Separation
60	10	10 miles	10th and each Additional Aircraft	15
48	8	10 miles	8th and Each Additional Aircraft	20
42	7	15 miles	7th and Each Additional Aircraft	25

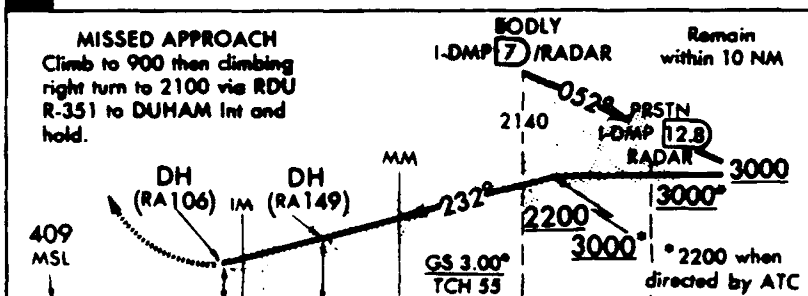
Amdt 6 90347 (CAT II)

ILS RWY 23R

AL-516 (FAA)

RALEIGH-DURHAM INTL (RDU)
RALEIGH/DURHAM, NORTH CAROLINA

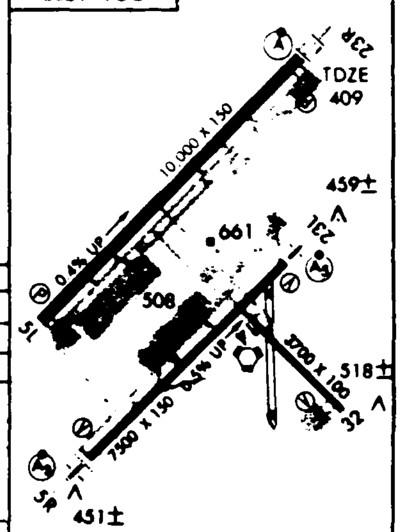




CATEGORY	A	B	C	D
S-ILS 23R	559/16 150 (RA 149)			
S-ILS 23R	509/12 100 (RA 106)			

DME or RADAR required.

ELEV 436



CATEGORY II ILS-SPECIAL AIRCREW & AIRCRAFT CERTIFICATION REQUIRED

REIL Rwy 32
MIRL Rwy 14-32
HIRL Rwys 5R-23L and 5L-23R
TDZ/CL Rwys 23R and 5L

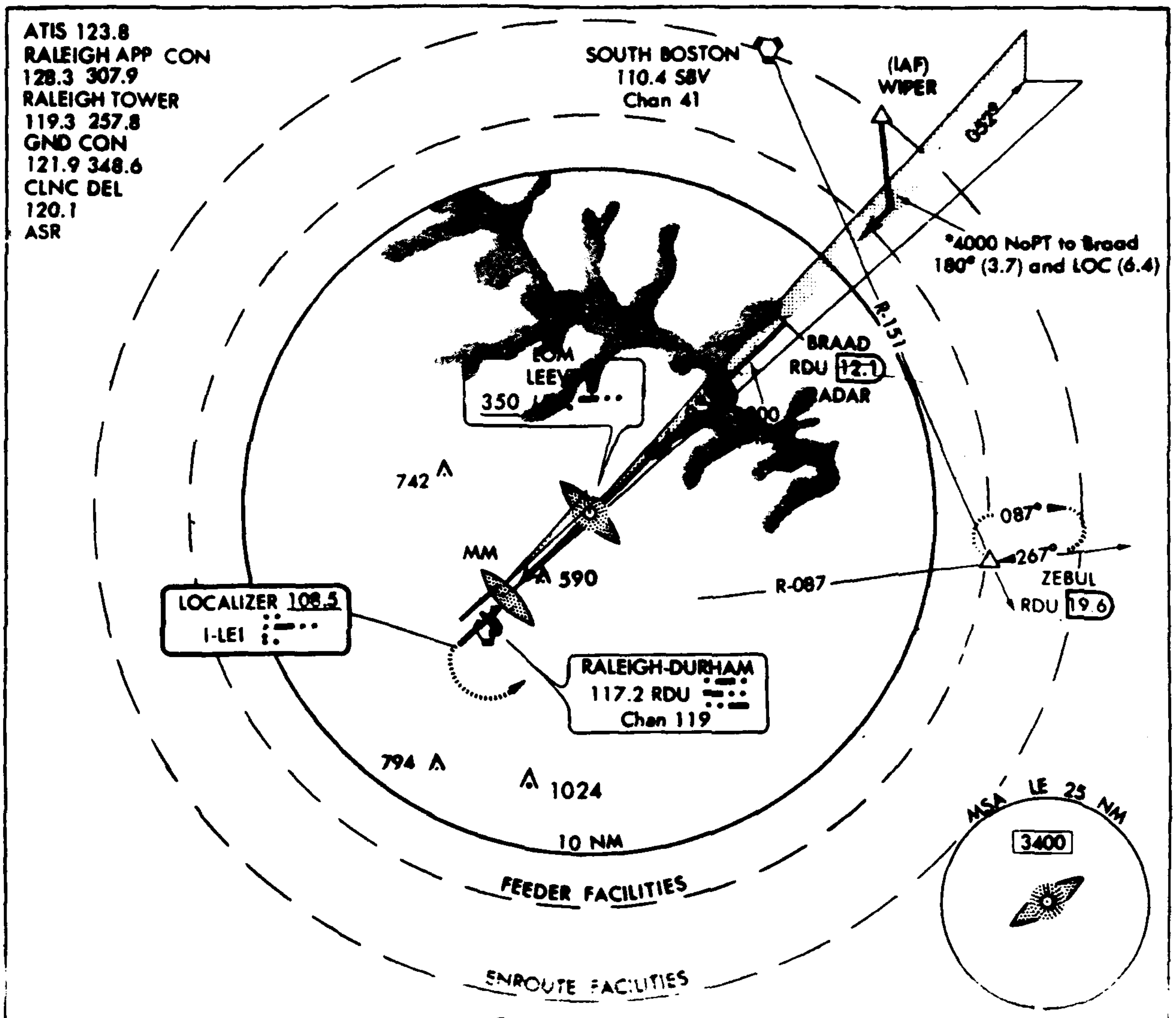
Attachment #8

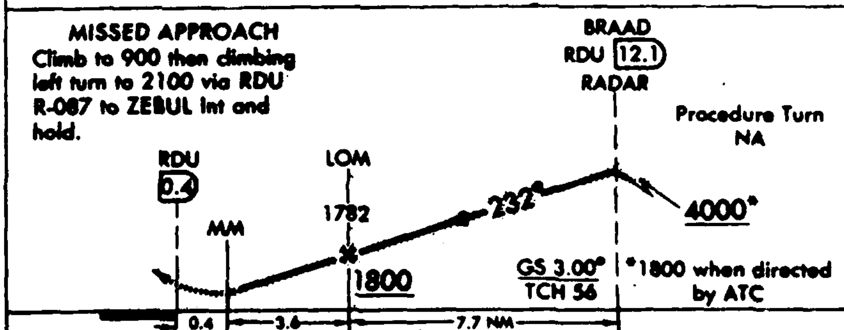
Amdt 4 90347

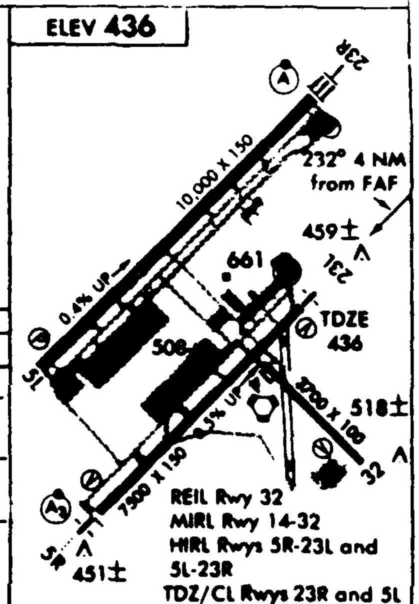
ILS RWY 23L

AL-516 (FAA)

RALEIGH-DURHAM INTL (RDU)
RALEIGH/DURHAM, NORTH CAROLINA







CATEGORY	A	B	C	D
S-ILS 23L	636-½ 200 (200-½)			
S-LOC 23L	920-½ 484 (500-½)		920-¾ 484 (500-¾)	920-1 484 (500-1)
CIRCLING	960-1 523 (600-1)		960-1½ 523 (600-1½)	1000-2 563 (600-2)

DME or RADAR required.

FAF to MAP 4 NM					
Knots	60	90	120	150	180
Min:Sec	4:00	2:40	2:00	1:36	1:20

ILS RWY 23L

35°53'N-78°47'W

RALEIGH/DURHAM, NORTH CAROLINA
RALEIGH-DURHAM INTL (RDU)

APPENDIX C

DESIGN REVIEW AND CONTROLLER EVALUATION MATERIALS

CONTROLLER EVALUATION
INITIAL DATA LINK TERMINAL SERVICES

ARTS IIIA

DESIGN REVIEW BOOKLET
MINI STUDY 2

This booklet contains a series of questions which will permit you to independently review and evaluate the designs of the terminal services as modified according to the results of the first study and currently implemented in the ARTS IIIA portion of the Data Link Test Bed. The goals of this review are to 1) identify those aspects of the designs which are acceptable as presented or which will require further modification and 2) resolve some open design issues.

Please answer all questions in the booklet and carefully record any recommendations for design changes. Explain your reasons for suggesting these changes.

Remember, your main task is to concentrate on completing the booklet. We are doing the review in the Test Bed so that you can examine the service designs and options as you work on the booklet. During this session, it is not important to maintain precise control of the simulated air traffic.

REVIEWER NAME ____________________________________

Part I.

DESIGN EVALUATION

In this section of the review, each of the service designs, as well as the history and status lists, will be described as they have been implemented in the ARTS IIIA Data Link Test Bed. Based on the description and your observations in the test bed, answer the questions that follow each item.

During this session you will be switching control positions between scenarios so that you will be able to evaluate each of the services.

NOTE

In the following service descriptions:

- The D/L key refers to the Data Link Key (F9 or F16)
- The SLEW command should be interpreted as the action sequence of acquiring the target with the trackball and pressing the trackball enter key.
- The ENTER command should be interpreted as pressing the keyboard ENTER key.
- Data as shown in a display or entered on the keyboard are presented in quotation marks. The quotation marks are not part of the display or entry.
- For all services, only one Data Link transaction per aircraft may be in progress at a time -- Except in the case of a "held" TOC, the controller may not uplink a new message until the previous service has been wilcoed or a transaction that has failed has been cleared from the data block display.

STATUS LIST AND DATA BLOCK STATUS DISPLAYS

- Function

The status list contains information on the status of up to 15 ongoing Data Link transactions. The first line of the list indicates whether the TOC service is in the automatic or manual mode. Each of the remaining lines is available to display the status of a single transaction. The display on the third line of the data block also provides status indicators for an ongoing transaction.

- Status Line Content

Each line has three data fields displaying the Aircraft ID, the message sent, and the current status of the transaction (for example, "AAL123 MT SNT"). The abbreviations used for the status messages are "SNT" (message sent), "DLV" (message delivered to aircraft), WIL (pilot wilco received), "NAK" (failure of system to successfully deliver message to aircraft), "UNA" (pilot unable to comply with message), and TIM (pilot failed to respond to a delivered message within 40 seconds).

- Inputs to Display/Suppress Status List

The status list is displayed by pressing the D/L key, typing "SL" and ENTER. When the list is displayed, the identical input sequence will suppress the list.

- Displays on Receipt of Wilco

When an aircraft downlinks a Wilco to a transaction contained in the status list, "WIL" is displayed for 4 seconds, after which all transaction information is deleted from the list.

- Displays on Resend

If the controller resends a message that has failed for any reason, the failed message is cleared from the status list and a new status entry appears when the message is sent.

- Inputs to Move the Status List

The status list can be moved to any position on the display by typing "F7" "T" and SLEW using the second keyboard.

- Coordination Between Status List and Full Data Block

The status list entry and the third line of the full data block for an aircraft display essentially the same information, including the type of message sent and the abbreviation for the current transaction state. However, there are three primary differences: 1) receipt of the WILCO downlink causes WIL to be displayed in the status list for 4 seconds, while in the full data block the WILCO erases the third line immediately after it is received; 2) the full data block displays the identifier number for an MT or TI message being sent while the status list shows the MT or TI, but not the message number; 3) the "SNT" status message is not displayed in the data block.

REVIEW QUESTIONS:

1. Does the description accurately represent the design and operation of the Status List that you examined in the Test Bed?

   ______ YES, THE DESCRIPTION IS CORRECT

   ______ NO, IT DOESN'T MATCH

   Describe those aspects of the description that did not match your Test Bed observations --

2. Do you feel that the Status List will be necessary for operational implementation? Why or why not?

3. Do the abbreviated status messages used in the Status List and Data Block (SNT, DLV, NAK, UNA, TIM, WIL) provide sufficient information? Are they easy to interpret?

4. Is 4 seconds sufficient time for displaying "WIL" in the Status List after the wilco is received?

5. Should the Data Block provide a persistent "WIL" display like that used in the Status List ? Why or why not?

6. The Status List does not display the message identifier numbers for TI and MT uplinks. Are these needed?

7. What should be done to improve the design of the Status List <u>as implemented</u> in the Test Bed ? Include any changes suggested by your answers to questions 2. - 6. above.

_____ THE CURRENT IMPLEMENTATION IS ACCEPTABLE -- NO CHANGES ARE DESIRABLE OR NEEDED

_____ THE CURRENT IMPLEMENTATION IS ACCEPTABLE -- NO CHANGES ARE NEEDED, <u>BUT</u> THE FOLLOWING WOULD BE DESIRABLE: (describe)

_____ THE CURRENT IMPLEMENTATION IS UNACCEPTABLE -- THE FOLLOWING CHANGES <u>MUST</u> BE MADE:

(Use this page for additional comments)

HISTORY LIST

- Function

The history list provides a record of the last 5 Data Link messages received (wilcoed) by an aircraft. The first line of the list contains the ACID of the subject aircraft, while the remaining five lines display the messages received. Messages are sent to the history list when the wilco is received.

- History Line Content

Each line displays the actual content of a completed Data Link transaction rather than the MT or TI message number.

- Message Order

The messages are listed in reverse chronological order of receipt, with the most recently received message appearing at the bottom of the list. The list scrolls up as new messages are received.

- Inputs to Display History List

The history list for an aircraft can be viewed by entering "HL" and SLEW.

- Location of History List

The history list replaces the TI and MT lists. The history list remains in this position for 8 seconds after it is selected and is then automatically replaced by the TI and MT lists. Alternatively, reentering the "HL" SLEW command for the same aircraft will manually remove the history list.

REVIEW QUESTIONS:

1. Does the description accurately represent the design and operation of the History List that you examined in the Test Bed?

   _____ YES, THE DESCRIPTION IS CORRECT

   _____ NO, IT DOESN'T MATCH

   Describe those aspects of the description that did not match your Test Bed observations --

2. Do you feel that the History List will be necessary for operational implementation? Why or why not?

3. Should the History List contain more (or fewer) than 5 past transactions for each aircraft?

4. Is the ordering of messages in the History List and scrolling direction appropriate?

5. Is it acceptable for the History List to share the location of the TI and MT lists ?

6. *Should the History List* be displayed for more (or less) time than the 8 seconds used in the current implementation?

7. What should be done to improve the design of the History List as implemented in the Test Bed ? Include any changes suggested by your answers to questions 2. - 6. above.

_____ THE CURRENT IMPLEMENTATION IS ACCEPTABLE -- NO CHANGES ARE DESIRABLE OR NEEDED

_____ THE CURRENT IMPLEMENTATION IS ACCEPTABLE -- NO CHANGES ARE NEEDED, BUT THE FOLLOWING WOULD BE DESIRABLE: (describe)

_____ THE CURRENT IMPLEMENTATION IS UNACCEPTABLE -- THE FOLLOWING CHANGES MUST BE MADE:

(use next page to complete your answer)

INITIAL CONTACT (IC)

SERVICE DESCRIPTION:

- Initiation of IC

The request for assigned altitude is automatically uplinked to an aircraft when the pilot downlinks a WILCO message to a preceding transfer of communication. The "AR" is displayed in the full data block and in the status list.

- Display on Downlink of Assigned Altitude

When the aircraft downlinks its assigned altitude, the "AR" status list entry is removed and the third line of the data block displays the characters "IC" followed by the altitude value (e.g. "IC 110"). The altitude value flashes to capture the controller's attention and signal a required response.

- Response to an IC Downlink

The controller response may be a TI message, initiation of a transfer of communication, one or more menu text messages, or a combination of a TI message and an MT message. Initiation of the uplink immediately deletes the "IC" display in the third line of the data block.

- Display on Failure to Downlink Assigned Altitude

If the aircraft system fails to technically acknowledge the altitude request, the pilot responds with an Unable or fails to downlink the assigned altitude within 40 seconds of receiving the uplinked request, the third line of the data block and the status list entry displays the characters "NAK", "UNA" or "TIM", as appropriate.

- Inputs to Resend Altitude Request

If a NAK, UNA, or TIM occurs, the controller may resend the altitude request by a SLEW action.

- Inputs to Clear IC Failure Displays

The " NAK", "UNA", and "TIM" displays may be manually deleted from the data block and the status list by pressing the D/L key, followed by a SLEW action. This entry also will cancel any Data Link transaction in progress.

REVIEW QUESTIONS:

1. Does the description accurately represent the design and operation of the IC service that you examined in the Test Bed?

   _____ YES, THE DESCRIPTION IS CORRECT

   _____ NO, IT DOESN'T MATCH

   Describe those aspects of the description that did not match your Test Bed observations --

2. Should the IC service be initiated by the AR as implemented, or should the assigned altitude be downlinked with the Wilco to the Transfer of Communication?

3. Is the flashing data block display adequate to capture the controller's attention when the IC is downlinked by the aircraft?

4. Are the "NAK", "UNA" and "TIM" displays adequate for notifying the controller that the AR message automatically sent by the system will require controller intervention?

5. What should be done to improve the design of the IC service as implemented in the Test Bed ? Include any changes suggested by your answers to questions 2 - 4.

   ______ THE CURRENT IMPLEMENTATION IS ACCEPTABLE -- NO CHANGES ARE DESIRABLE OR NEEDED

   ______ THE CURRENT IMPLEMENTATION IS ACCEPTABLE -- NO CHANGES ARE NEEDED, BUT THE FOLLOWING WOULD BE DESIRABLE:

   ______ THE CURRENT IMPLEMENTATION IS UNACCEPTABLE -- THE FOLLOWING CHANGES MUST BE MADE:

TERMINAL INFORMATION SERVICE (TI)

SERVICE DESCRIPTION:

- Initiation of TI

A message in the TI list can be sent at any time through a controller input action. When used immediately after receiving an initial contact message from an aircraft ("IC" and an altitude value displayed in the third line of the data block) a slew input can be used to send a commonly-used default TI message.

- TI List Display

TI messages are selected from a list display containing four optional messages. Each message is presented on a single line of the list preceded by an identifier digit (1 - 4). The message appearing on the first line (regardless of its identifier digit) is the default message.

- Inputs to Change Default Message

The default message can be changed by pressing the D/L key followed by "D", the identifying digit of the new item number desired (1 to 4), and ENTER. This action will move the selected item to the first line of the list and rearrange the remaining items in numerical order of their identifier digits. Items always retain their original identifier digits regardless of the item designated as the default message.

- Inputs to Reposition TI List

The TI list can be moved (along with the MT list) to any position on the ARTS display by pressing F7, typing "TC" and SLEW to position the list. The second keyboard must be used for these inputs.

- Inputs to Suppress / Retrieve TI List

The TI list can be removed from the ARTS display by pressing the D/L key, typing "T" and ENTER. Repeating this sequence will retrieve the list.

- Inputs to Send Default TI After IC

When a successful initial contact has been completed and the third line of the data block displays "IC" followed by an altitude value, the default TI message may be uplinked by a SLEW action.

- Inputs to Send TI Messages at Any Time

Messages can be uplinked at any time by typing "T", the message identifier number from the TI list (e.g. "3") and SLEW.

- Displays on TI Uplink

If a TI message is sent when "IC" and an altitude value are shown in the third line of the data block, the entry deletes the "IC" and altitude, and replaces it with "TI" followed by the message number selected from the list for uplink. If the default message is sent, no message identifier number is displayed in the data block. In all cases, the status list entry displays "TI" without the message number.

- Displays After Pilot WILCO

Upon receipt of a downlinked WILCO response from the aircraft, the "TI"/message number display in the third line of the data block is deleted. WIL is displayed in the status list entry for 4 seconds before the entry is deleted.

- Displays on Failed Response

If the aircraft does not technically acknowledge the uplink, the pilot responds with an "UNABLE" or fails to respond within 40 seconds after receiving the TI message, "TI" followed by the appropriate abbreviation (NAK, TIM, UNA) appears in the third line of the data block and in the status list entry.

- Inputs to Resend TI

The controller may resend a TI message after any type of response failure by a SLEW action.

- Inputs to Clear TI Display

The TI display can be deleted following a NAK, UNA, or TIM by pressing the D/L key and SLEW. These inputs will also cancel any Data Link transaction in progress.

- Combining TI with an MT Message

Any TI message can be sent together with one MT message by typing "T" and the TI message number desired prior to the Menu Text entry. (see MT description). If sent in response to a flashing IC display, the default TI message can be sent with a Menu Text message without specifying the TI message number.

- Changing the Content of TI Messages

The content of any of the four TI messages can be changed by pressing the D/L key, "T", and the message number to be changed. These entries are followed by the desired text message and ENTER.
Message no. 1 can be up to 40 characters long while message no. 2 - 4 can be up to 28 characters long.

REVIEW QUESTIONS:

1. Does the description accurately represent the design and operation of the TI service that you examined in the Test Bed?

   ______ YES, THE DESCRIPTION IS CORRECT

   ______ NO, IT DOESN'T MATCH

   Describe those aspects of the description that did not match your Test Bed observations --

2. Is the method for changing the designated default message and the resulting reordering of the list acceptable?

3. Does the implemented design offer sufficient flexibility for combining TI and MT messages?

4. What should be done to improve the design of the TI service <u>as implemented</u> in the Test Bed ? Include any changes suggested by your answers to questions 2 and 3.

   ______ THE CURRENT IMPLEMENTATION IS ACCEPTABLE -- NO CHANGES ARE DESIRABLE OR NEEDED

   ______ THE CURRENT IMPLEMENTATION IS ACCEPTABLE -- NO CHANGES ARE NEEDED, <u>BUT</u> THE FOLLOWING WOULD BE DESIRABLE: (describe on next page)

______ THE CURRENT IMPLEMENTATION IS UNACCEPTABLE --
THE FOLLOWING CHANGES MUST BE MADE:

TRANSFER OF COMMUNICATIONS (TOC)

SERVICE DESCRIPTION:

- Initiation of TOC

The TOC message containing a new radio frequency for an aircraft is automatically prepared when the receiving controller accepts a sector hand off.

- Inputs to Set TOC Mode (Auto/Manual)

TOC can be set to operate in either an automatic send or manual send mode. When the ARTS program is started, TOC is in the automatic mode and "AUTO SEND" is displayed on the first line of the status list. Pressing the D/L key, "TH" and ENTER will change TOC to the manual mode and cause the first line of the status list to change to "AUTO HOLD". Repeating the same entry will switch the mode back to "AUTO SEND"

- Inputs to Send TOC - AUTO SEND Mode

If in the AUTO SEND mode, the TOC is automatically uplinked upon acceptance of the hand off when the sending controller completes the normal keyboard sequence for handoff initiation (HANDOFF key (F5), the receiving sector's Controller Symbol, and SLEW). Any other currently acceptable ARTS input sequence normally used to initiate a hand off will result in the same automatic uplink of TOC (e.g. F5-ACID-Controller Symbol- ENTER).

- Display on AUTO SEND TOC Uplink

"TC" is displayed in the third line of the data block and in the status list when the TOC message is uplinked.

- Inputs to Hold a Message When in AUTO SEND Mode

When in the AUTO SEND Mode, the TOC can be held for delayed uplink by adding an "H" prior to the SLEW entry for the Handoff (i.e. F5, Controller Symbol, H, SLEW). The system will revert to the AUTO SEND mode for succeeding TOCs unless the mode is changed or the "H" is added to the handoff entry.

- Inputs to Send TOC - AUTO HOLD Mode

When in the AUTO HOLD mode, the controller may initiate the sector hand off but reserve communications eligibility until a later time by completing the normal keyboard sequence for handoff initiation (HANDOFF key (F5), the receiving sector's Controller Symbol, and SLEW). Any other currently acceptable ARTS input sequence normally used to initiate a hand off will result in the same held status of TOC (e.g. F5-ACID-Controller Symbol- ENTER). The TOC can then be sent manually by a SLEW action.

- Display on Manual TOC Uplink

"TC H" is displayed in the third line of the data block and the status list when a handoff has been completed in the hold mode. "SNT" is displayed in the status list when the SLEW is completed to manually send the TOC.

- Inputs to Automatically Send TOC When in AUTO HOLD mode

When in the AUTO HOLD Mode, the TOC can be sent automatically upon handoff acceptance by adding an "S" prior to the SLEW entry for the Handoff (i.e. F5, Controller Symbol, S, SLEW). The system will revert to the AUTO HOLD mode for succeeding TOCs unless the mode is changed or the "S" is added to the handoff entry.

- Display After Pilot WILCO

In both automatic and manual procedures the "TC" display in the third line of the data block is deleted when the aircraft downlinks a WILCO response. The status list entry will display "WIL" for 4 seconds after receipt of the wilco, and then will be deleted.

- Sending Other Messages When a TOC is in Held Status

An MT or TI message can be sent to the aircraft while a TOC is in the held status. Sending the new message will replace the "TC H" display in the data block with the type, number and status of the TI or MT message. When the message is wilcoed, the "TC H" reappears in the data block.

- Display on Failed Response

If the aircraft fails to technically acknowledge the TOC or if the pilot sends an UNABLE response or fails to WILCO the message within 40 seconds of receipt, "TC NAK", "TC UNA", or "TC TIM" appears in the third line of the data block and in the status list.

- Inputs to Resend TOC

The controller may resend any type of non-wilcoed TOC message by a SLEW action.

- Inputs to Clear TOC Display

The controller may delete any type of non-wilcoed display by pressing the D/L key and a SLEW action. The same inputs will delete any Data Link transaction in progress.

- Inputs to Acquire Data Link Eligibility

The controller may acquire ("steal") eligibility for Data Link communications by pressing the D/L key, typing the letters "OK" and a SLEW action. This action also sends a TOC message to the aircraft.

REVIEW QUESTIONS:

1. Does the description accurately represent the design and operation of the TOC service that you examined in the Test Bed?

   _____ YES, THE DESCRIPTION IS CORRECT

   _____ NO, IT DOESN'T MATCH

   Describe those aspects of the description that did not match your Test Bed observations --

2. Will all four options for initiating the TOC be needed in an operational implementation? Why or why not?

3. Is the Status List display of the active TOC mode (AUTO SEND/AUTO HOLD) appropriate and effective?

4. What should be done to improve the design of the TOC service <u>as implemented</u> in the Test Bed ? Include any changes suggested by your answers to questions 2 and 3.

   _____ THE CURRENT IMPLEMENTATION IS ACCEPTABLE -- NO CHANGES ARE DESIRABLE OR NEEDED

(see next page)

_____ THE CURRENT IMPLEMENTATION IS ACCEPTABLE -- NO CHANGES ARE NEEDED, BUT THE FOLLOWING WOULD BE DESIRABLE: (describe)

_____ THE CURRENT IMPLEMENTATION IS UNACCEPTABLE -- THE FOLLOWING CHANGES MUST BE MADE:

MENU TEXT (MT)

SERVICE DESCRIPTION:

- Function

The MT service permits the controller to uplink speed, heading and altitude clearances list by selecting the required messages from a predefined menu or by composing clearances not contained in the menu.

- MT List Display

Available MT clearances are displayed in a list containing 9 lines. Each menu item (up to 29 characters) is displayed on a single line preceded by an identifier number (1-9). Messages are selected using the identifier numbers.

The first 8 lines are dedicated to specific clearance types. Lines 1 and 2 are for speed control, lines 3, 4 and 5 are for altitudes, and lines 6, 7 and 8 are for headings. Line 9 is used for a combination entry composed of any two or three items contained in lines 1 to 8. Only one of each clearance type may be entered on line 9.

- Inputs to Reposition MT List

The position of the MT list (and the TI list) on the ARTS display can be altered from the second keyboard by pressing the MULTIFUNCTION key (F7), typing TC, and completing a SLEW action to move the list.

- Inputs to Suppress / Retrieve MT List

The MT list can be removed from the display by pressing the D/L key and typing "M" and ENTER. The list is retrieved using the same sequence of key strokes.

- Inputs to Send a MT Message

A single MT item can be uplinked by typing "M" followed by the menu item identifier number, and a SLEW action.

- Inputs to Send Multiple MT Messages

Up to three MT menu items can be sent in a single uplink by inserting spaces between the item numbers (e.g. M1 3 8 SLEW would send menu items 1, 3 and 8). Item 9 cannot be combined with other items. The software will not permit attempts to send more than one of each clearance type (altitude, heading or speed) in a multiple menu uplink.

- Bypassing the Menu

A heading (H), altitude (A) or speed (S) not contained in the menu can be uplinked by pressing the D/L key, typing "H", "A" or "S" followed by the three digit numeric value of the clearance and SLEW. One of each clearance type also can be combined in a single uplink in any order (e.g. F9 H230A030). The third line of the data block displays "MT", the clearance letters, and the three digit numerical values entered (e.g. MT A 110) until the message is wilcoed.

- Inputs to Send an MT Message Combined with TI

A TI message can be sent in combination with one MT item by adding "T" and the desired TI message number prior to the first MT input (e.g. T2M3 SLEW would send TI message no. 2 and menu item 3). If the IC is flashing in the data block, the default TI message can be combined with an MT message without specifying the default's identifier number (e.g. TM3 SLEW).

- Displays on MT Uplink

When an MT uplink is initiated "MT" appears in the third line of the data block followed by the identifier numbers of the messages sent.

- Displays After Pilot WILCO

A downlinked WILCO to an MT message or group of messages deletes the data in the third line of the data block and causes "WIL" to be displayed in the status list for 4 seconds.

- Displays on Failed Response

If the aircraft fails to technically acknowledge an MT uplink, the pilot responds with an UNABLE or fails to downlink a WILCO response within 40 seconds of its receipt, "MT NAK", "MT UNA", or "MT TIM" appears in the third line of the data block and in the status list entry.

- Inputs to Resend MT

Upon a failed response to a MT uplink, the controller may resend the message with a SLEW action.

- Inputs to Clear MT Display

The data block and status list displays can be manually deleted for any non-wilcoed transaction by pressing the D/L key and making a SLEW action. The same inputs will cancel any Data Link transaction in progress.

- Modifying Numeric Values in Menu Items

The numeric value of a heading, speed or altitude clearance can be changed by pressing the D/L key, typing M and the one-digit identifier number of the menu item to be changed, typing the new numeric value (three digits) and pressing the ENTER key.

If a SLEW action is substituted for the keyboard ENTER, the menu item will be changed AND the message will be uplinked to the slewed aircraft.

The modified values will stay in the MT list entries until the program is restarted.

- Creating/Modifying Line 9 Combination Clearance

Line 9 permits the combination of up to three clearances shown in lines 1 to 8. This entry is created or modified by pressing the D/L key, typing "M9", the identifier numbers for two or three of entries 1 to 8 and ENTER. If a SLEW action is substituted for ENTER, the combined clearance will be entered in the list and simultaneously sent to the designated aircraft.

REVIEW QUESTIONS:

1. Does the description accurately represent the design and operation of the MT service that you examined in the Test Bed?

    ______ YES, THE DESCRIPTION IS CORRECT

    ______ NO, IT DOESN'T MATCH

    Describe those aspects of the description that did not match your Test Bed observations --

2. MT now offers three ways to send multiple clearance uplinks (line 9, combining items from the menu, and multiple by-pass methods). Are all of these methods needed for an operational system?

3. Unlike other menu items, line 9 displays the identifier numbers of the lines that represent the combined clearance rather than the clearances themselves. Is this acceptable?

4. What should be done to improve the design of the MT service as implemented in the Test Bed ? Include any changes suggested by your answers to questions 2 and 3.

    ______ THE CURRENT IMPLEMENTATION IS ACCEPTABLE -- NO CHANGES ARE DESIRABLE OR NEEDED

(continued on next page)

_____ THE CURRENT IMPLEMENTATION IS ACCEPTABLE -- NO CHANGES ARE NEEDED, BUT THE FOLLOWING WOULD BE DESIRABLE: (describe)

_____ THE CURRENT IMPLEMENTATION IS UNACCEPTABLE -- THE FOLLOWING CHANGES MUST BE MADE:

PART II.
OPEN DESIGN ISSUES

A few issues relating to the service designs and procedures have not been fully resolved during prior team meetings. Some of these issues are presented on the next pages of the booklet. Please consider each issue and answer the questions that follow.

DATA LINK EQUIPAGE/ELIGIBILITY SYMBOLS

The current implementation offers two choices for the symbol set indicating the Data Link status of each aircraft. In both sets, no symbology on the first line of the data block identifies an aircraft that does not have Data Link capability. In one of the sets, a plus (+) denotes that the aircraft is equipped, but the control position is not eligible to communicate with it. An asterisk (✱) indicates that the aircraft is equipped and that the position is eligible to communicate. In the other set, a diamond (△) is used to indicate equipage and a square (□) indicates equipage with eligibility.

Which of the following best describes your preferences?

_____ EITHER SET IS ACCEPTABLE

_____ I PREFER THE PLUS/ASTERISK SET

_____ I PREFER THE DIAMOND/SQUARE SET

_____ SOME OTHER SYMBOL SET SHOULD BE USED (DESCRIBE BELOW)

DATA LINK KEY LOCATION

In response to suggestions from the first study, two alternatives for the location of the Data Link key have been implemented. Both are active on the keyboard for this test. Either F9 or F16 may be used.

Assuming that only one key position will be available in an operational implementation, which of the following best describes your preferences?

______ EITHER POSITION IS ACCEPTABLE

______ THE F9 KEY SHOULD BE USED

______ THE F16 KEY SHOULD BE USED

______ SOME OTHER OPTION (DESCRIBE BELOW)

ORGANIZATION OF MENU LISTS

At the last ATDLVT meeting, the team discussed redesigning the TI and MT lists which permit controllers to select items from menus for uplink. The motivation for this discussion was that: 1) there should be a consistent logic for assigning messages to menus, and 2) improved menu design may help controllers to select messages more rapidly and with fewer errors. Your answers to the following questions will be used to direct further consideration of these issues.

1. Do you feel that the MT and TI names for the two menus clearly indicate their possible applications? If not, what alternatives would be more appropriate?

2. Should the two menus include spacing or labels to separate different classes of messages to aid in the location of desired items?

3. Do you feel that extended practice with menus will overcome any speed or error problems that may be experienced with menu usage?

4. Should guidelines be developed to limit maximum menu length? If so, how many messages do you feel should be the maximum number of items per menu?

5. At this point in testing, do you feel that it is <u>operationally</u> feasible to uplink final approach clearances using the menu?

6. Can the two menus continue to be linked as in the current implementation, or must they be independently movable and suppressible?

THIS IS THE LAST PAGE
OF THE REVIEW BOOKLET

SWAT WORKLOAD RATINGS

After each test run that you complete, you will be asked to complete a rating of the workload that you actually experienced while controlling traffic. The scale that you will use to make these estimates is known as SWAT (Subjective Workload Assessment Technique). SWAT was developed as a method for collecting quantified subjective data on how hard a person feels he or she had to work when performing different tasks or when using different procedures and equipment to perform duties.

If you examine the SWAT rating scale, you will notice that SWAT defines workload in terms of a combination of three different dimensions that contribute to the subjective feeling of "working hard". A workload rating in SWAT is accomplished by selecting a "1", "2" or "3" on EACH of the three scales representing the dimensions of TIME LOAD, MENTAL EFFORT, and PSYCHOLOGICAL STRESS.

Each of these dimensions and their levels are described below:

TIME LOAD

Time Load refers to the fraction of the total time that you are busy. When Time Load is low, sufficient time is available to complete all of your mental work with some time to spare. As Time Load increases, spare time drops out and some aspects of performance overlap and interrupt one another. This overlap and interruption can come from performing more than one task or from different aspects of performing the same task. At high levels of Time Load, several aspects of performance often occur simultaneously, you are busy, and interruptions are very frequent.

Time Load is rated on the three point scale below:

(1) Often have spare time. Interruptions or overlap among activities occur infrequently or not at all.

(2) Occasionally have spare time. Interruptions or overlap among activities occur frequently.

(3) Almost never have spare time. Interruptions or overlap among activities are very frequent, or occur all the time.

MENTAL EFFORT LOAD

As described above, Time Load refers to the amount of time one has available to perform a task or tasks. In contrast, Mental Effort Load is an index of the amount of attention or mental effort required by a task regardless of the number of tasks to be performed or any time limitations. When Mental Effort Load is low, the concentration and attention required by a task is minimal and performance is nearly automatic. As the demand for mental effort increases due to task complexity or the amount of information which must be dealt with in order to perform adequately, the degree of concentration and attention required increases. High Mental Effort Load demands total attention or concentration due to task complexity or the amount of information that must be processed.

Mental Effort Load is rated using the three point scale below:

(1) Very little conscious mental effort or concentration required. Activity is almost automatic, requiring little or no attention.

(2) Moderate conscious mental effort or concentration required. Complexity of activity is moderately high due to uncertainty, unpredictability, or unfamiliarity. Considerable attention required.

(3) Extensive mental effort and concentration are necessary. Very complex activity requiring total attention.

PSYCHOLOGICAL STRESS LOAD

Psychological Stress Load refers to the contribution to total workload of any conditions that produce anxiety, frustration, or confusion while performing a task or tasks. At low levels of stress, one feels relatively relaxed. As stress increases, confusion, anxiety, or frustration increase and greater concentration and determination are required to maintain control of the situation.

Psychological Stress Load may be rated on the three point scale below:

(1) Little confusion, risk, frustration, or anxiety exists and can be easily accommodated.

(2) Moderate stress due to confusion, frustration, or anxiety noticeably adds to workload. Significant compensation is required to maintain adequate performance.

(3) High to very intense stress due to confusion, frustration, or anxiety. High to extreme determination and self-control required.

Each of the three dimensions just described contribute to workload during performance of a task or group of tasks. Note that although all three factors may be correlated, they need not be. For example, one can have many tasks to perform in the time available (high Time Load) but the tasks may require little concentration (low Mental Effort Load). Likewise, one can be anxious and frustrated (high Stress Load) and have plenty of spare time between relatively simple tasks. Since the three dimensions contributing to workload are not necessarily correlated, please treat each dimension individually and give independent assessments of the Time Load, Mental Effort Load, and Psychological Stress Load that you experienced during each test run.

The form that you will be using to make your SWAT ratings during the Data Link test session is shown on an attached page. Note that the descriptions for each level of time, effort and stress load have been removed to save space. Should you need to review these descriptions during testing, a copy of the full scale will be available at all times.

SWAT SCALE DEVELOPMENT CARD SORT

Now that you are familiar with the SWAT rating scale, there is one last procedure that must be completed before testing can begin. This procedure is a card sorting task that will allow us to interpret your SWAT workload ratings.

One of the most important features of SWAT is its unique scoring system. The developers of SWAT recognized that different people have different conceptions of how the time, effort and stress dimensions combine to produce an overall impression of low and high workload. Because of these differences, a special card sorting procedure is used in SWAT to define a distinctive workload scale for each person. This individualized scale greatly improves our ability to accurately interpret the actual workload ratings that you will be making during the test sessions.

In order to develop your individual scale, we need information from you regarding the amount of workload that you feel is produced by various combinations of the three levels on the time, effort and stress dimensions. We get this information by having a person rank order a set of cards. Each card contains a different combination of the levels of time load, mental effort load, and stress load. Since there are three dimensions, and each dimension has three levels, there are 27 cards in the deck that you will be sorting. Your job will be to sort the cards so that they are ranked according to the level of workload represented by each card. Thus, the first card in the deck will represent the lowest workload and the last card will represent the highest workload.

In completing your card sorts, please consider the workload imposed on a person by the combination represented in each card. Arrange the cards from the lowest workload condition through the highest condition. You may use any strategy you choose in rank ordering the cards. One strategy that proves useful is to arrange the cards into a number of preliminary stacks representing "High", "Moderate", and "Low" workload. Individual cards can be exchanged between stacks, if necessary, and then rank ordered within stacks. Stacks can then be recombined and checked to be sure that they represent your ranking of lowest to highest workload. However, the choice of strategy is up to you and you should choose the one that works best for you.

There is no "school solution" to this problem. There is no correct order. The correct order is what, in your judgment best describes the progression of workload from lowest to highest for a general case rather than any specific event. That judgment differs for each of us. The letters you see on the back of the cards are to allow us to arrange the cards in a previously randomized sequence so that everyone gets the same order. If you examine your deck you will see the order on the back runs from A through Z and then ZZ.

Please remember:

(1) The card sort is being done so that a workload scale may be developed for you. This scale will have a distinct workload value for each possible combination of Time Load, Mental Effort Load, and Psychological Stress Load. The following example demonstrates the relationship between the card sort and the resulting workload scale:

TIME	EFFORT	STRESS		WORKLOAD SCALE
1	1	1	------------	0.0
.	.	.		.
.	.	.		.
.	.	.		.
.	.	.		.
3	3	3	-----------	100.0

Note that other than the fact that a 1-1-1 will always represent the lowest workload and that a 3-3-3 will always represent the highest workload, the remaining cards could occur in a number of orders. Your order will depend on how you weight the importance of Time, Effort and Stress dimensions.

(2) When performing the card sorts, use the descriptors printed on the cards. Please remember not to sort the cards based on one particular task. Sort the cards according to your general view of workload and how important you consider the dimensions of Time, Mental Effort, and Psychological Stress Load to be when you think of high and low workload experiences.

(3) A SWAT rating for any situation consists of one number from

SWAT RATING SCALE

TIME LOAD

1. Often have spare time. Interruptions or overlap among activities occur infrequently or not at all.
2. Occasionally have spare time. Interruptions or overlap among activities occur frequently.
3. Almost never have spare time. Interruptions or overlap among activities are very frequent or occur all the time.

MENTAL EFFORT

1. Very little conscious mental effort or concentration required. Activity is almost automatic, requiring little or no attention.
2. Moderate conscious mental effort or concentration required. Complexity of activity is moderately high due to uncertainty, unpredictability or unfamiliarity. Considerable attention is required.
3. Extensive mental effort and concentration are necessary. Very complex activity requiring total attention.

PSYCHOLOGICAL STRESS

1. Little confusion, risk, frustration or anxiety and can be easily accommodated.
2. Moderate stress due to confusion, frustration or anxiety noticeably adds to workload. Significant compensation is required to maintain adequate performance.
3. High to very intense stress due to confusion, frustration or anxiety. High to extreme determination and self

each of the three dimensions. For example, a possible SWAT rating is 1-2-2. This represents a 1 for Time Load, a 2 for Mental Effort Load, and a 2 for Psychological Stress Load.

(4) We are not asking for your preference concerning Time, Mental Effort, and Psychological Stress Load. Some people may prefer to be "busy" rather than "idle" in either Time Load, Mental Effort Load, or Psychological Stress Load dimension. We are not concerned with this preference. We need information on how the three dimensions and the three levels of each one will affect the level of workload as you see it. You may prefer a 2-1-1 situation instead of a 1-1-1 situation. However, you should still realize that the 1-1-1 situation imposes less workload on you and leaves a greater reserve capacity.

The sorting will probably take 30 minutes to an hour. Please feel free to ask questions at any time.

FULL SCALE SIMULATION TESTING

CONTROLLER NAME ______________________________

INSTRUCTIONS

The next twelve test runs will be used to compare voice and Data Link communications under conditions that are as realistic as possible. Traffic loads in all 12 runs will be similar, and slightly heavier than those you worked with during training and the design review. Three of the runs will be voice-only tests, while for the remaining nine you will have Data Link as well as voice available. The Data Link runs will differ from one another in the average turn around delay between initiation of an uplink and your receipt of the pilot's response.

During all of these test runs we will be automatically recording data on voice and Data Link usage, system safety, and the overall efficiency with which the air traffic is handled. Because of this, it is very important that you treat all of the test runs as though they were real work periods at an ATC facility. Just as if we were operating in the real world, you should use the Data Link services to the extent that they improve your workload and help to maintain the safe and expeditious flow of air traffic.

EVALUATIONS BETWEEN RUNS

This booklet contains a set of rating forms and questionnaires that you should fill out as soon as you have completed each of the 12 test runs that will be conducted during the full scale simulation phase of this study. Following every test run (both voice-only and Data Link runs), you will complete a SWAT rating of the workload level that you experienced during the run. On Data Link runs, you will also complete a questionnaire designed to record your perceptions of the effects of Data Link turn around delays that were experienced during the test run.

Please be sure to complete these forms before moving to a new sector. When moving between control positions, follow the schedule on the next page.

FINAL RATINGS

After you have finished all 12 test runs, complete the final ratings section at the end of this booklet.

SWAT WORKLOAD

TEST RUN ________ POSITION ________

DL / VOICE ________

Rate the workload that you *actually experienced* while controlling traffic during the test run just completed. For each of the SWAT dimensions of TIME LOAD, EFFORT and STRESS, place an "X" on the appropriate line to indicate the level that you experienced ranging from 1 (low) to 3 (high)

	1	2	3
TIME LOAD	______	______	______
MENTAL EFFORT	______	______	______
STRESS	______	______	______

Please describe any events or experiences that may have affected your workload during this test run:

DATA LINK QUESTIONNAIRE

TEST RUN ___________ **POSITION** ___________

Place an "X" on the rating scale above the number that best describes your answer to questions 1 - 3:

1. To what extent did the Data Link turn-around delays that you experienced during this run impair your ability to control traffic?

____	____	____	____	____	____	____
1	2	3	4	5	6	7
^						^
Delays Had No Effect On ATC Abilities						Extremely Impaired ATC Abilities

2. How did the Data Link turn-around delays that you experienced during this run affect your use of the Data Link services?

____	____	____	____	____	____	____
1	2	3	4	5	6	7
^						^
No Delay Effect- Used Data Link at Every Opportunity						Delays Prevented Any Use of Data Link

3. How often did you use voice instead of Data Link during this run in order to avoid turn-around delays?

____	____	____	____	____	____	____
1	2	3	4	5	6	7
^						^
Never Used Voice When I Could Data Link						Had to Switch to Voice All of the Time

4. In what ways did turn-around delays affect you or the way in which you controlled traffic during this run?

(Check all that apply)

_____ Data Link delays did not affect me in any way.

_____ I compensated by sending Data Link messages and clearances sooner than I would normally.

_____ I used voice instead of Data Link.

_____ I "got behind the power curve" and found it difficult to keep up with the air traffic.

_____ I increased aircraft separation.

_____ I made minor control errors.

_____ I made major control errors.

_____ I sometimes forgot (temporarily) about an ongoing transaction or its status.

_____ Because of the length of delays, I didn't use Data Link for (when): (describe services and situations)

_____ Other effects of the delays (Describe):

5. Overall, if average Data Link turn-around delays in my facility were as long as those I experienced during this test run (and in this type of scenario and control position):

_____ I would use Data Link at every possible opportunity.

_____ I would use Data Link slightly less often than if the delays were shorter.

_____ I would use Data Link much less often than if the delays were shorter.

_____ I would not use Data Link at all

DATA LINK SERVICE

Use the scales below to rate the terminal service indicated above. On the first scale, check the box if this service is unsuitable for operational use. If the service can meet some, or all operational requirements, check the space below the number that best describes its effectiveness.

OPERATIONAL EFFECTIVENESS / SUITABILITY

Highly Effective			Meets Most Operational Requirements			Minimally Effective	
↓			↓			↓	☐
1	2	3	4	5	6	7	↑
___	___	___	___	___	___	___	Not Operationally Suitable

On this scale, regardless of the service's effectiveness, check the box if the way in which the service is designed would be completely unacceptable to controllers. If the service design is acceptable, check the space below the number that best describes your preference for the design.

CONTROLLER ACCEPTANCE / PREFERENCE

Highly Preferred			Moderately Preferred			Acceptable, But Not Preferred	
↓			↓			↓	☐
1	2	3	4	5	6	7	↑
___	___	___	___	___	___	___	Completely Unacceptable

Please use the following page to comment on your ratings.

APPENDIX D

RALEIGH-DURHAM SCENARIO LOAD FACTORS
AND
TRAFFIC DISTRIBUTION

SCENARIO 1

Load Factors

- 50% traffic (66 aircraft)
- No Data Link

Traffic Distribution

- East Arrival and Final Sectors
  - 15 aircraft to primary airport
  - 1 aircraft to secondary airport
  - 1 overflight
- West Arrival and Final Sectors
  - 15 aircraft to primary airport
  - 1 aircraft to secondary airport
  - 1 overflight
- North Departure Sector
  - 15 aircraft from primary airport
  - 1 aircraft from secondary airport
- South Departure Sector
  - 15 aircraft from primary airport
  - 1 aircraft from secondary airport

SCENARIO 1
(Continued)

Traffic Interval

- East Arrival and Final Sectors
  - One aircraft not more than every 3 minutes and 32 seconds
- West Arrival and Final Sectors
  - One aircraft not more than every 3 minutes and 32 seconds
- North Departure Sector
  - One aircraft not more than every 3 minutes and 45 seconds
- South Departure Sector
  - One aircraft not more than every 3 minutes and 45 seconds

SCENARIO 2

Load Factors

- 65% traffic load (84 aircraft)
- 75% Data Link equipped (63 aircraft)

Traffic Distribution

- East Arrival and Final Sectors
  - 19 aircraft to primary airport
    - -- 15 aircraft Data Link equipped
    - -- 4 aircraft not Data Link equipped
  - 1 aircraft to secondary airport
    - -- Not Data Link equipped
  - 1 overflight
    - -- Data Link equipped
- West Arrival and Final Sectors
  - 20 aircraft to primary airport
    - -- 15 aircraft Data Link equipped
    - -- 5 aircraft not Data Link equipped
  - 1 aircraft to secondary airport
    - -- Data Link equipped
  - 1 overflight
    - -- Not Data Link equipped
- North Departure Sector
  - 19 aircraft from primary airport
    - -- 15 aircraft Data Link equipped
    - -- 4 aircraft not Data Link equipped
  - 1 aircraft from secondary airport
    - -- Data Link equipped

SCENARIO 2
(Continued)

- South Departure Sector
  - 20 aircraft from primary airport
    - -- 15 aircraft Data Link equipped
    - -- 5 aircraft not Data Link equipped
  - 1 aircraft from secondary airport
    - -- Not Data Link equipped

Traffic Interval

- East Arrival and Final Sectors
  - One aircraft not more than every 2 minutes and 51 seconds
- West Arrival and Final Sectors
  - One aircraft not more than every 2 minutes and 44 seconds
- North Departure Sector
  - One aircraft not more than every 3 minutes
- South Departure Sector
  - One aircraft not more than every 2 minutes and 51 seconds

SCENARIO 3

Load Factors

- 65% traffic load (84 aircraft)
- All Data Link equipped (84 aircraft)

Traffic Distribution

- East Arrival and Final Sectors
  - 19 aircraft to primary airport
  - 1 aircraft to secondary airport
  - 1 overflight
- West Arrival and Final Sectors
  - 20 aircraft to primary airport
  - 1 aircraft to secondary airport
  - 1 overflight
- North Departure Sector
  - 19 aircraft from primary airport
  - 1 aircraft from secondary airport
- South Departure Sector
  - 20 aircraft from primary airport
  - 1 aircraft from secondary airport

SCENARIO 3
(Continued)

Traffic Interval

- East Arrival and Final Sectors
  - One aircraft not more than every 2 minutes and 51 seconds
- West Arrival and Final Sectors
  - One aircraft not more than every 2 minutes and 44 seconds
- North Departure Sector
  - One aircraft not more than every 3 minutes
- South Departure Sector
  - One aircraft not more than every 2 minutes and 51 seconds

SCENARIO 4D

Load Factors

- 85% traffic load (109 aircraft)
- 76% Data Link equipped (83 aircraft)

Traffic Distribution

- East Arrival and Final Sectors
  - 25 aircraft to primary airport
    - -- 19 aircraft Data Link equipped
    - -- 6 aircraft not Data Link equipped
  - 2 aircraft to secondary airport
    - -- 1 aircraft Data Link equipped
    - -- 1 aircraft not Data Link equipped
  - 1 overflight
    - -- Data Link equipped
- West Arrival and Final Sectors
  - 26 aircraft to primary airport
    - -- 20 aircraft Data Link equipped
    - -- 6 aircraft not Data Link equipped
  - 1 aircraft to secondary airport
    - -- Data Link equipped
  - 1 overflight
    - -- Data Link equipped
- North Departure Sector
  - 25 aircraft from primary airport
    - -- 20 aircraft Data Link equipped
    - -- 5 aircraft not Data Link equipped
  - 1 aircraft from secondary airport
    - -- Data Link equipped

SCENARIO 4D
(Continued)

- South Departure Sector
  - 26 aircraft from primary airport
    - -- 19 aircraft Data Link equipped
    - -- 7 aircraft not Data Link equipped
  - 1 aircraft from secondary airport
    - -- Data Link equipped

Traffic Interval

- East Arrival and Final Sectors
  - One aircraft not more than every 2 minutes and 24 seconds
- West Arrival and Final Sectors
  - One aircraft not more than every 2 minutes and 24 seconds
- North Departure Sector
  - One aircraft not more than every 2 minutes and 37 seconds
- South Departure Sector
  - One aircraft not more than every 2 minutes and 30 seconds

SCENARIO 4V

Load Factors

- 85% traffic (109 aircraft)
- No Data Link

Traffic Distribution

- East Arrival and Final Sectors
  - 25 aircraft to primary airport
  - 2 aircraft to secondary airport
  - 1 overflight
- West Arrival and Final Sectors
  - 26 aircraft to primary airport
  - 1 aircraft to secondary airport
  - 1 overflight
- North Departure Sector
  - 25 aircraft from primary airport
  - 1 aircraft from secondary airport
- South Departure Sector
  - 26 aircraft from primary airport
  - 1 aircraft from secondary airport

SCENARIO 4V
(Continued)

Traffic Interval

- East Arrival and Final Sectors
  - One aircraft not more than every 2 minutes and 24 seconds
- West Arrival and Final Sectors
  - One aircraft not more than every 2 minutes and 24 seconds
- North Departure Sector
  - One aircraft not more than every 2 minutes and 37 seconds
- South Departure Sector
  - One aircraft not more than every 2 minutes and 30 seconds

SCENARIO 5

Load Factors

- 85% traffic load (109 aircraft)
- 76% Data Link equipped (83 aircraft)

Traffic Distribution

- East Arrival and Final Sectors
  - 25 aircraft to primary airport
    - -- 18 aircraft Data Link equipped
    - -- 7 aircraft not Data Link equipped
  - 2 aircraft to secondary airport
    - -- 1 aircraft Data Link equipped
    - -- 1 aircraft not Data Link equipped
  - 1 overflight
    - -- Data Link equipped
- West Arrival and Final Sectors
  - 26 aircraft to primary airport
    - -- 20 aircraft Data Link equipped
    - -- 6 aircraft not Data Link equipped
  - 1 aircraft to secondary airport
    - -- Data Link equipped
  - 1 overflight
    - -- Data Link equipped
- North Departure Sector
  - 25 aircraft from primary airport
    - -- 20 aircraft Data Link equipped
    - -- 5 aircraft not Data Link equipped
  - 1 aircraft from secondary airport
    - -- Data Link equipped

- South Departure Sector
  - 26 aircraft from primary airport
    - -- 19 aircraft Data Link equipped
    - -- 7 aircraft not Data Link equipped
  - 1 aircraft from secondary airport
    - -- Data Link equipped

Traffic Interval

- East Arrival and Final Sectors
  - One aircraft not more than every 2 minutes and 24 seconds
- West Arrival and Final Sectors
  - One aircraft not more than every 2 minutes and 24 seconds
- North Departure Sector
  - One aircraft not more than every 2 minutes and 37 seconds
- South Departure Sector
  - One aircraft not more than every 2 minutes and 30 seconds

SCENARIO 6

Load Factors

- 85% traffic load (109 aircraft)
- 76% Data Link equipped (83 aircraft)

Traffic Distribution

- East Arrival and Final Sectors
  - 25 aircraft to primary airport
    - -- 18 aircraft Data Link equipped
    - -- 7 aircraft not Data Link equipped
  - 2 aircraft to secondary airport
    - -- 1 aircraft Data Link equipped
    - -- 1 aircraft not Data Link equipped
  - 1 overflight
    - -- Data Link equipped
- West Arrival and Final Sectors
  - 26 aircraft to primary airport
    - -- 20 aircraft Data Link equipped
    - -- 6 aircraft not Data Link equipped
  - 1 aircraft to secondary airport
    - -- Data Link equipped
  - 1 overflight
    - -- Data Link equipped
- North Departure Sector
  - 25 aircraft from primary airport
    - -- 20 aircraft Data Link equipped
    - -- 5 aircraft not Data Link equipped
  - 1 aircraft from secondary airport
    - -- Data Link equipped

SCENARIO 6
(Continued)

- South Departure Sector
  - 26 aircraft from primary airport
    - -- 19 aircraft Data Link equipped
    - -- 7 aircraft not Data Link equipped
  - 1 aircraft from secondary airport
    - -- Data Link equipped

Traffic Interval

- East Arrival and Final Sectors
  - One aircraft not more than every 2 minutes and 24 seconds
- West Arrival and Final Sectors
  - One aircraft not more than every 2 minutes and 24 seconds
- North Departure Sector
  - One aircraft not more than every 2 minutes and 37 seconds
- South Departure Sector
  - One aircraft not more than every 2 minutes and 30 seconds

SCENARIO 7

Load Factors

- 85% traffic load (109 aircraft)
- 76% Data Link equipped (83 aircraft)

Traffic Distribution

- East Arrival and Final Sectors
  - 25 aircraft to primary airport
    - -- 18 aircraft Data Link equipped
    - -- 7 aircraft not Data Link equipped
  - 2 aircraft to secondary airport
    - -- 1 aircraft Data Link equipped
    - -- 1 aircraft not Data Link equipped
  - 1 overflight
    - -- Data Link equipped
- West Arrival and Final Sectors
  - 26 aircraft to primary airport
    - -- 20 aircraft Data Link equipped
    - -- 6 aircraft not Data Link equipped
  - 1 aircraft to secondary airport
    - -- Data Link equipped
  - 1 overflight
    - -- Data Link equipped
- North Departure Sector
  - 25 aircraft from primary airport
    - -- 20 aircraft Data Link equipped
    - -- 5 aircraft not Data Link equipped
  - 1 aircraft from secondary airport
    - -- Data Link equipped

SCENARIO 7
(Continued)

- South Departure Sector
  - 26 aircraft from primary airport
    - -- 19 aircraft Data Link equipped
    - -- 7 aircraft not Data Link equipped
  - 1 aircraft from secondary airport
    - -- Data Link equipped

Traffic Interval

- East Arrival and Final Sectors
  - One aircraft not more than every 2 minutes and 24 seconds
- West Arrival and Final Sectors
  - One aircraft not more than every 2 minutes and 24 seconds
- North Departure Sector
  - One aircraft not more than every 2 minutes and 37 seconds
- South Departure Sector
  - One aircraft not more than every 2 minutes and 30 seconds

SCENARIO 9D

Load Factors

- 85% traffic load (109 aircraft)
- 76% Data Link equipped (83 aircraft)

Traffic Distribution

- East Arrival and Final Sectors
  - 25 aircraft to primary airport
    - -- 18 aircraft Data Link equipped
    - -- 7 aircraft not Data Link equipped
  - 2 aircraft to secondary airport
    - -- 1 aircraft Data Link equipped
    - -- 1 aircraft not Data Link equipped
  - 1 overflight
    - -- Data Link equipped
- West Arrival and Final Sectors
  - 26 aircraft to primary airport
    - -- 20 aircraft Data Link equipped
    - -- 6 aircraft not Data Link equipped
  - 1 aircraft to secondary airport
    - -- Data Link equipped
  - 1 overflight
    - -- Data Link equipped
- North Departure Sector
  - 25 aircraft from primary airport
    - -- 20 aircraft Data Link equipped
    - -- 5 aircraft not Data Link equipped
  - 1 aircraft from secondary airport
    - -- Data Link equipped

SCENARIO 9D
(Continued)

- South Departure Sector
  - 26 aircraft from primary airport
    - -- 19 aircraft Data Link equipped
    - -- 7 aircraft not Data Link equipped
  - 1 aircraft from secondary airport
    - -- Data Link equipped

Traffic Interval

- East Arrival and Final Sectors
  - One aircraft not more than every 2 minutes and 24 seconds
- West Arrival and Final Sectors
  - One aircraft not more than every 2 minutes and 24 seconds
- North Departure Sector
  - One aircraft not more than every 2 minutes and 37 seconds
- South Departure Sector
  - One aircraft not more than every 2 minutes and 30 seconds

SCENARIO 9V

Load Factors

- 85% traffic load (109 aircraft)
- No Data Link

Traffic Distribution

- East Arrival and Final Sectors
  - 25 aircraft to primary airport
  - 2 aircraft to secondary airport
  - 1 overflight
- West Arrival and Final Sectors
  - 26 aircraft to primary airport
  - 1 aircraft to secondary airport
  - 1 overflight
- North Departure Sector
  - 25 aircraft from primary airport
  - 1 aircraft from secondary airport

SCENARIO 9V
(Continued)

- South Departure Sector
  - 26 aircraft from primary airport
  - 1 aircraft from secondary airport

Traffic Interval

- East Arrival and Final Sectors
  - One aircraft not more than every 2 minutes and 24 seconds
- West Arrival and Final Sectors
  - One aircraft not more than every 2 minutes and 24 seconds
- North Departure Sector
  - One aircraft not more than every 2 minutes and 37 seconds
- South Departure Sector
  - One aircraft not more than every 2 minutes and 30 seconds

SCENARIO 10D

Load Factors

- 85% traffic load (109 aircraft)
- 76% Data Link equipped (83 aircraft)

Traffic Distribution

- East Arrival and Final Sectors
  - 25 aircraft to primary airport
    - -- 18 aircraft Data Link equipped
    - -- 7 aircraft not Data Link equipped
  - 2 aircraft to secondary airport
    - -- 1 aircraft Data Link equipped
    - -- 1 aircraft not Data Link equipped
  - 1 overflight
    - -- Data Link equipped
- West Arrival and Final Sectors
  - 26 aircraft to primary airport
    - -- 20 aircraft Data Link equipped
    - -- 6 aircraft not Data Link equipped
  - 1 aircraft to secondary airport
    - -- Data Link equipped
  - 1 overflight
    - -- Data Link equipped
- North Departure Sector
  - 25 aircraft from primary airport
    - -- 20 aircraft Data Link equipped
    - -- 5 aircraft not Data Link equipped
  - 1 aircraft from secondary airport
    - -- Data Link equipped

SCENARIO 10D
(Continued)

- South Departure Sector
  - 26 aircraft from primary airport
    - -- 19 aircraft Data Link equipped
    - -- 7 aircraft not Data Link equipped
  - 1 aircraft from secondary airport
    - -- Data Link equipped

Traffic Interval

- East Arrival and Final Sectors
  - One aircraft not more than every 2 minutes and 24 seconds
- West Arrival and Final Sectors
  - One aircraft not more than every 2 minutes and 24 seconds
- North Departure Sector
  - One aircraft not more than every 2 minutes and 37 seconds
- South Departure Sector
  - One aircraft not more than every 2 minutes and 30 seconds

SCENARIO 10V

Load Factors

- 85% traffic load (109 aircraft)
- No Data Link

Traffic Distribution

- East Arrival and Final Sectors

  - 25 aircraft to primary airport
  - 2 aircraft to secondary airport
  - 1 overflight

- West Arrival and Final Sectors

  - 26 aircraft to primary airport
  - 1 aircraft to secondary airport
  - 1 overflight

- North Departure Sector

  - 25 aircraft from primary airport
  - 1 aircraft from secondary airport

SCENARIO 10V
(Continued)

- South Departure Sector
  - 26 aircraft from primary airport
  - 1 aircraft from secondary airport

Traffic Interval

- East Arrival and Final Sectors
  - One aircraft not more than every 2 minutes and 24 seconds
- West Arrival and Final Sectors
  - One aircraft not more than every 2 minutes and 24 seconds
- North Departure Sector
  - One aircraft not more than every 2 minutes and 37 seconds
- South Departure Sector
  - One aircraft not more than every 2 minutes and 30 seconds

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