79-7

REPORT NO. FA-RD-79-24

PRELIMINARY CONSOLIDATED DISPLAY DESIGNS

Gregory Bishop
M. Stephen Huntley, Jr.
Paul S. Rempfer
Lloyd Stevenson

U.S. DEPARTMENT OF TRANSPORTATION
Research and Special Programs Administration
Transportation Systems Center
Cambridge MA 02142

MARCH 1979

FINAL REPORT

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VIRGINIA 22161

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration
Systems Research and Development Service
Washington DC 20590

Technical Report Documentation Page

1. Report No. FA-RD-79-24	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle PRELIMINARY CONSOLIDATED DISPLAY DESIGNS		5. Report Date March 1979
		6. Performing Organization Code DTS-522
7. Author(s) G. Bishop, M. S. Huntley, Jr., P.S. Rempfer, L. Stevenson		8. Performing Organization Report No. DOT-TSC-FAA-79-7
9. Performing Organization Name and Address U.S. Department of Transportation Research and Special Programs Administration Transportation Systems Center Cambridge, MA 02142		10. Work Unit No. (TRAIS) FA961/R9133
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Aviation Administration Systems Research and Development Service Washington DC 20590		13. Type of Report and Period Covered Final Report Mar. 1978 - Sept. 1978
		14. Sponsoring Agency Code ARD-100

15. Supplementary Notes

16. Abstract

This report is concerned with the possible consolidation of operational information, equipment status information and system control panels within each control position in the control Tower Cab and TRACON at Logan International Airport, Boston, MA. In particular, the report is concerned with the controller interface with such a consolidation system. The consolidated display concept considered in this study is based on a flexible format, face-sensitive, touch-entry display. This type of display is based on advanced, as opposed to proven technology. However, this advanced technology is particularly well suited for consolidated display design; particularly when control panels are to be included. The report presents the operational requirements on such a consolidated display from the viewpoint of Boston Logan controllers, a set of preliminary display format designs based on these requirements, and the reaction of Boston Logan controllers to both the format designs and the concept in general.

17. Key Words Airport Traffic Control, Consolidated Display, Maintenance System, Tower Cab, TRACON, Equipment Status, Operational Information, Touch-Entry Displays		18. Distribution Statement DOCUMENT IS AVAILABLE TO THE PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD VIRGINIA 22161	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 312	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

PREFACE

This report documents the study of an Air Traffic Control system consolidation concept, and how that system concept might be implemented, using advanced technology. The project study was sponsored by the FAA Systems Research and Development Service (SRDS) and conducted at Boston Logan Tower from April through August of 1978.

The work study was completed with the cooperation of the New England Region of the FAA, in particular the Airways Facilities Service (AAF) and the Air Traffic Service (AAT) Divisions. The report was written by Paul Rempfer, Stephen Huntley, Jr., Lloyd Stevenson, and Gregory Bishop, of the Transportation Systems Center of the Research and Special Programs Administration and edited by R. Mahan and R. Tucker of Raytheon Service Company.

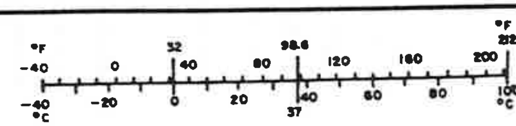
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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ILLUSTRATIONS (CONT'D)

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TABLES (CONT'D)

1. INTRODUCTION

This report documents a study of the equipment and operations at the Airport Traffic Control Tower (ATCT) at Boston Logan Airport. The study objectives are to prepare preliminary designs of new consolidated controller display and control panels for use by the FAA ATCT Consolidated Display and Remote Maintenance System (ACD/RMM) program; and to conduct a general operations analysis of the ATCT operation at Boston Logan to provide the operational requirements for the consolidated display and control panels, and as time permitted, to provide information necessary to analyze the impact of other new/proposed ATCT equipment on the Boston ATCT operation.

The study began with an audit of the equipment at Boston Logan to determine the equipment installed and its use in the Boston ATCT operation. The audit consisted of:

1. photographing each controller position and each piece of equipment at each position,
2. reviewing the standard operating procedures manual,
3. interviewing four controller/supervisors for approximately six hours each to discuss the ATCT operation and equipment usage,
4. reviewing the equipment instruction books and maintenance manuals, and
5. discussing the engineering aspects of the equipment with Airway Facilities Maintenance Sector personnel.

The results of the audit were combined with ACD/RMM program guidelines furnished by the FAA to generate the operational requirements for the consolidated panels. The results of the audit and the operation requirements are summarized in Section 2 (Boston Logan Airport and the Airport Traffic Control Tower Operation), Section 3 (Equipment Characteristics) and, Section 4 (System Requirements).

The second phase of the study consisted of the preliminary design of the new consolidated panels. The design consisted of:

1. a brief survey of currently available displays and flexible format touch-entry devices,
2. the selection of the hardware characteristics upon which to base the system design,
3. the design of panel formats and the system concept for using the formats,
4. a second set of interviews with four controller/supervisors for approximately three hours each to discuss the panel formats and their use, and
5. the revision of the panel formats based upon the controller comments.

The results of the design process are summarized in Section 5 (Hardware Selection) and Section 6 (Preliminary Designs).

The third phase of the study consisted of an operations analysis. In performing the analysis controllers were interviewed on the operation, in particular, the handling of flight progress strips. Observations of the Cab and TRACON were made for two days each week for four weeks, and limited time and motion data was taken. The results of this analysis are given in Appendix C.

The remainder of the Introduction presents the background for the ACD/RMM design study and the study guidelines.

1.1 BACKGROUND OF THE ACD/RMM DESIGN STUDY

In the current Airport Traffic Control Tower (ATCT) operation, the controllers utilize many disparate types of equipment. (See Figure 1-1.) The controllers receive various operational information (e.g., wind speed and direction) from equipment/displays, control various field equipment (e.g., field lighting) from control panels, and receive the status of all relevant equipment (e.g., certified for use or out of commission). Equipment status is

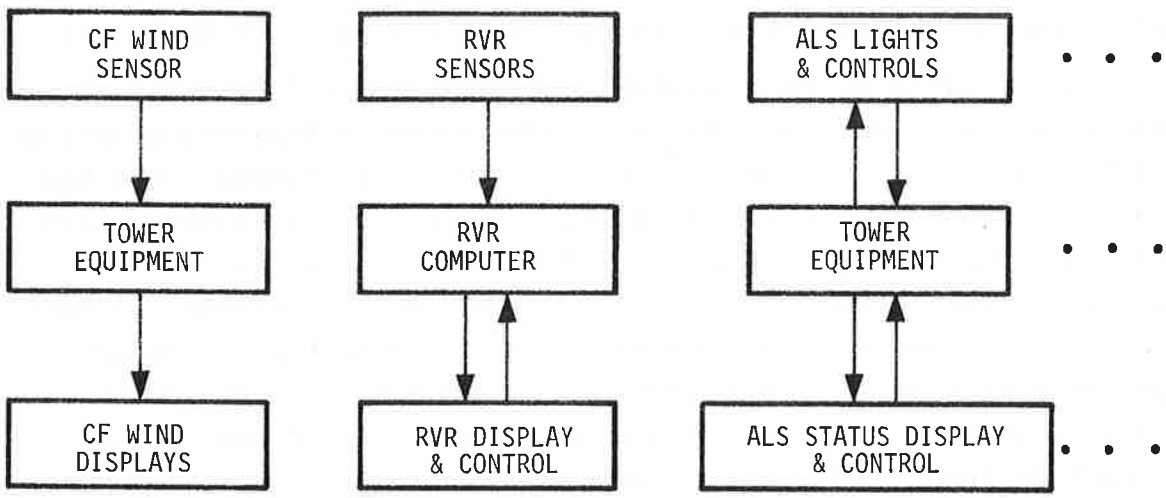


FIGURE 1-1. INDEPENDENT INSTRUMENTATION

primarily a manual system requiring field site visits by technicians who transmit their findings manually to the controllers. The process is manpower intensive and there can be some delay between equipment malfunction and its detection, although some go/no-go status indication is given via control panel lights. As systems have been added to the ATCT, control/status panels and operational displays have multiplied. At some airports, controller positions are becoming jammed and more equipment is forecast for deployment.

In response to these growing problems, the FAA has initiated the ACTC Consolidated Display/Remote Maintenance Monitoring System (ACD/RMM) project. A two part program is being pursued. The Airways Facilities Service is building a prototype consolidation system at two airports - Atlanta Hartsfield and Boston Logan. The Systems Research and Development Service (SRDS) is taking a longer range look at display and control panel consolidation using advanced technology. (See Figure 1-2.) New RMM field equipment will be developed which will permit sensing, and communicate information required for remote status determination back to a central processor at the ATCT. Remote status will not only cover equipment located on-site at the airport, but will include off-site equipments such as VORS. Manual monitoring at the field sites will be eliminated. The remote status information will be displayed on a maintenance status unit.

In addition to status information, the RMM field equipment will transmit operational information to the RMM computer and accept field equipment control commands from the computer. This will permit the consolidation of displays and controls into one or two flexible computer driven units per controller. The units will have full status information available, will be smaller and easier to install than the many existing types of equipment and will provide an easy and inexpensive means for interfacing future equipment with the controller.

The objective of the design study is to recommend to the FAA new consolidated display and control concepts using advanced technology.

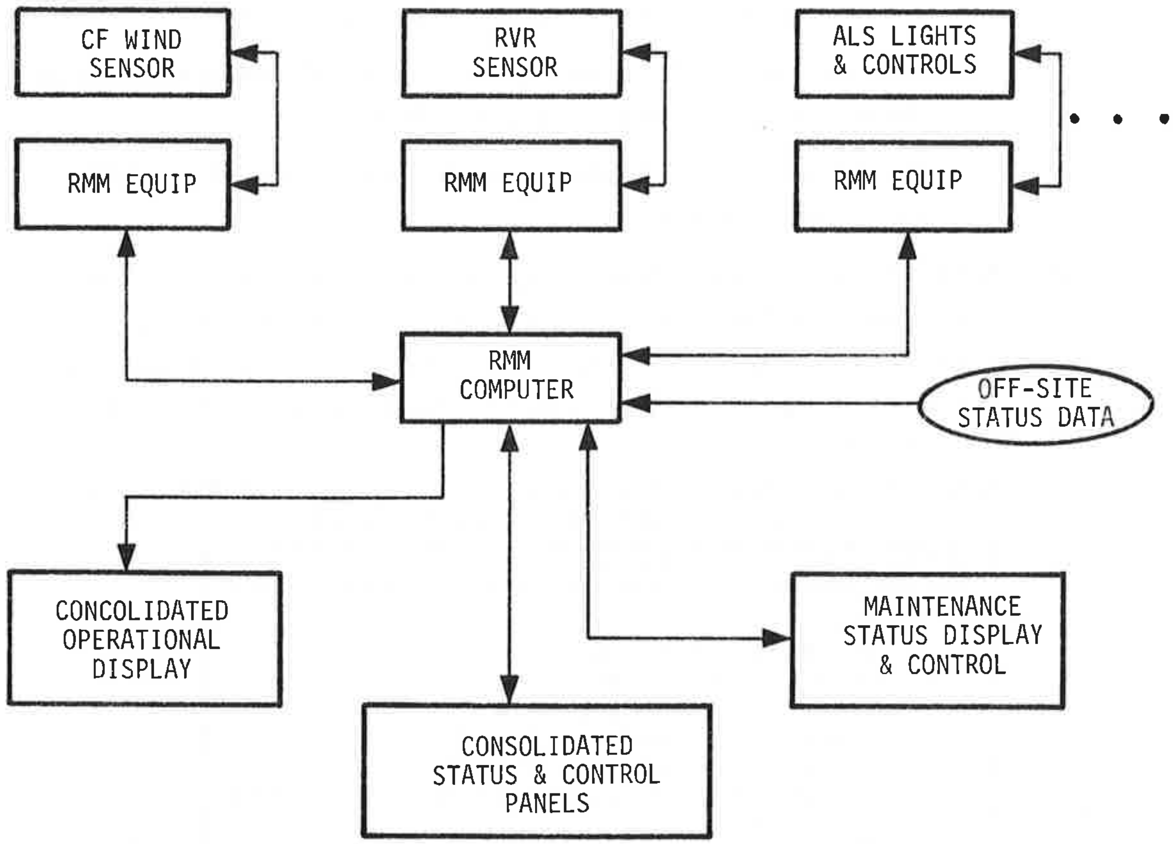


FIGURE 1-2. CONSOLIDATED DISPLAY AND REMOTE MAINTENANCE MONITORING SYSTEM

1.2 DESIGN STUDY GROUND RULES

The following ground rules were adhered to for this study:

a. The designs will be for application at Boston Logan Airport. To the extent that they are general designs, the following guidelines should be adhered to:

   1. The operational format should provide information on three active runways at one time;

   2. The RVR format should provide for up to three RVR units per runway.

b. Some of the operational display data required and the types of equipment considered for consolidation which presently relay this data are listed in Table 1-1. The TELCO system, ARTS, and ASR/ATCRBS equipments should not be considered.

TABLE 1-1. OPERATIONAL DISPLAY DATA AND EQUIPMENT TO BE CONSIDERED FOR CONSOLIDATION

OPERATIONAL DISPLAY DATA
— Digital Clock-Time — Altimeter Setting — Center Field Wind — Runway Visual Range (RVR) — Temperature and Dew Point — Vortex Advisory System (VAS) — Surface Wind Measurement System (SWMS) — ATIS Code
CONTROL/STATUS PANELS
— RVR — VAS — SWMS — ILS Monitor — Approach Lighting System (ALS) — Sequence Flasher Lights (SFL) — Field Lighting — Visual Approach Slope Indicator (VASI)

c. The status information to be displayed via the RMM system should be assumed to be the status information now used by each controller; the current status information used at Boston Logan forms the basis for status-to-be-displayed requirements.

d. A flexible format touch-entry panel should be the primary basis for consolidated equipment designs.

e. Designs should include drawings of the instruments, display/control panel formats, assumed equipment interfaces and, where possible, off-the-shelf equipment which would be satisfactory.

2. BOSTON LOGAN AIRPORT AND THE AIRPORT TRAFFIC CONTROL TOWER OPERATION

The Boston Terminal Area is defined in Figure 2-1. The primary airport, Boston Logan, and the secondary airports associated with the Terminal Area are listed in Table 2-1. A representative daily log of traffic in the Terminal Area is given in Table 2-2. From Table 2-2, it can be seen that about 20 percent of the TRACON traffic is VFR, through TCA requirements, while about 80 percent is IFR. Expanded Radar Service (ERS) represents a very small fraction of the daily traffic (at least on the sample day chosen). From both tables, it is seen that traffic operating into and out of Boston Logan represents by far the most traffic, about 80 percent of all traffic handled by the TRACON.

In sectorizing the terminal airspace, the secondary airports have been divided into two secondary areas as shown in Figure 2-2. The Boston Secondary Area (Figure 2-3A) covers flights below 2000 feet and overlays most of the southern secondary airports. The Bedford Secondary Area is more complex with regard to altitude and is shown in added detail in Figure 2-3B. These areas are used in defining the duties of the TRACON controllers.

The Boston Logan airport is shown in Figure 2-4 along with the Airport Traffic Control Tower (ATCT) location. The most heavily used runway configuration is arrivals on 4R (and alternately 4L) and departures on 9. The Boston Tower Cab is shown in Figure 2-5. The supervisory, flight data, and various control positions for the Cab are listed in Table 2-3 with their respective duties summarized. In the Cab, two Local Control and Local Control (Cab) Coordinator positions are shown. Only one set of positions (North or South) is staffed at one time. Which set is staffed depends upon the runway configuration in use. The positions offering the best line-of-sight to the Local Controller are selected for use.

The Harbor View control position is used to monitor the ship traffic which travels back and forth off the approach ends of runways 4R and 4L, during poor visibility conditions. The position is made up of a BRITE ASDE display set up on the channel with a channel mapper which was added by the local FAA New England Region. It also has a TV monitor from a low-light-level TV camera located on an island at one end of the channel. As long as there are no ships in the channel, the runways can be used during IFR without a displaced threshold. This control position is important during ILS Category II operation at Boston. Category II is an ILS approach procedure which provides for approach to a height above touchdown of not less than 100 feet and with Runway Visual Range (RVR) of not less than 1200 feet.

Table 2-3 lists the complete staffing of the Boston Cab. Boston does combine positions when there is light traffic (e.g., on the 11:00 PM to 7:00 AM shift). The Local Control Coordinator and Local Control are combined, and Flight Data and Clearance Delivery can be combined. Photographs of each position staffed are given in Figures 2-6 through 2-14, and the equipment at each position is identified.

The layout of the Boston TRACON is shown in Figure 2-15. The staffing positions for the TRACON are listed in Table 2-4 with the primary duties summarized. The controller positions listed in Table 2-4 are those used during busy traffic periods. During light traffic, staffing can be reduced to as few as two controllers (e.g., Arrival Radar 1 and a Team Supervisor) such as a light 11:00 PM to 7:00 AM shift. Photographs of each staffing position are given in Figures 2-16 through 2-27 and the equipment at each position is identified.

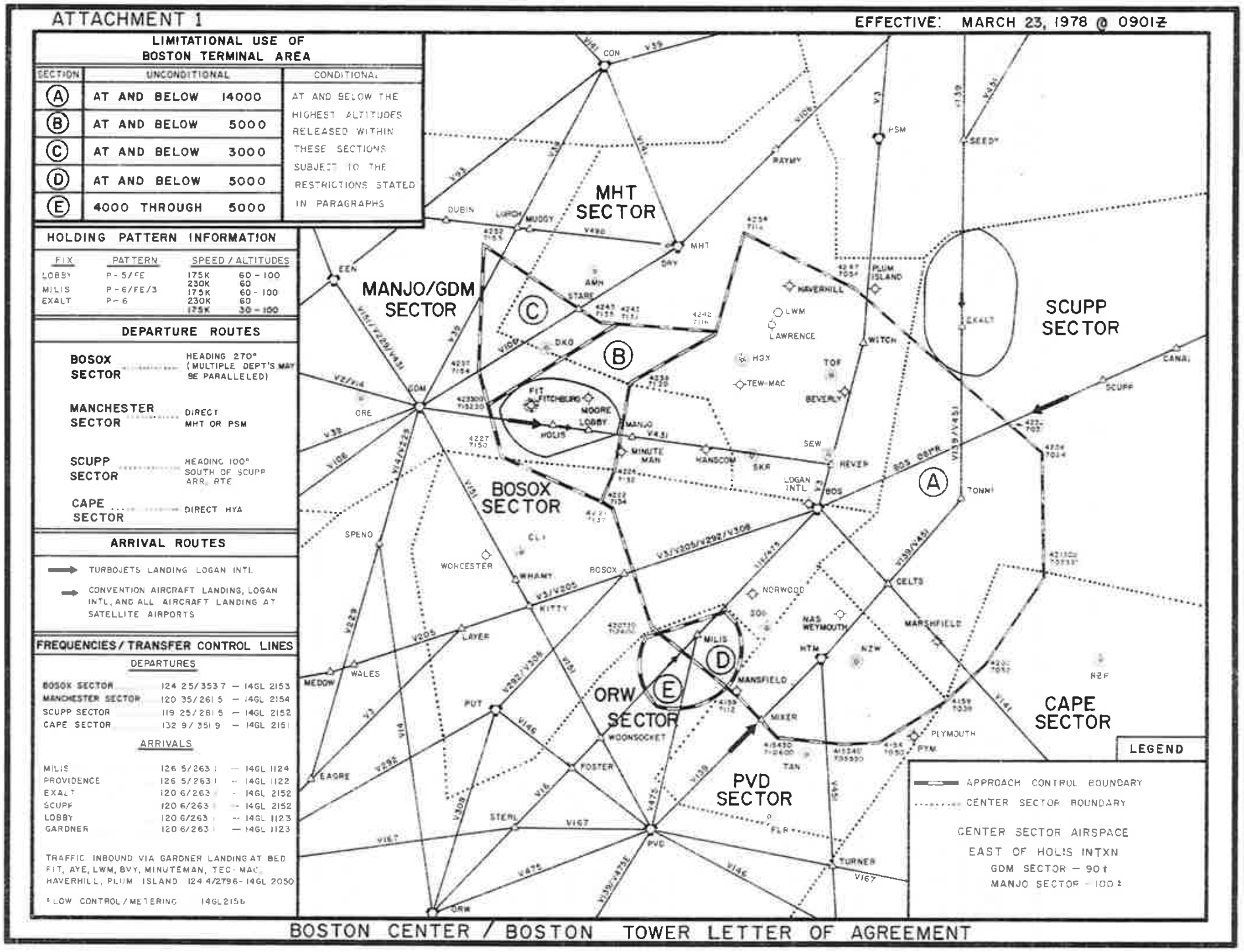


FIGURE 2-1. BOSTON TERMINAL AREA

TABLE 2-1. BOSTON TRACON-CONTROLLED AIRPORTS

BOSTON TERMINAL AREA AIRPORTS	ANNUAL INSTRUMENT OPERATIONS(CY1976)
Primary Airport	
Boston Logan (BOS)	292,475 (84%)
Secondary Towered Airports	
Hanscom Field-Bedford (Bed)	23,754 (7%)
Beverly (BVY)	4,471 (1%)
Norwood (OWD)	6,370 (2%)
Untowered Airports	19,956 (6%)
Marshfield (3B2)	
South Weymouth NAS (NZW)	
Mansfield (1B9)	
Stow-Minute Man (6B6)	
Fitchburg (FIT)	
Tewksbury (B09)	
Lawrence (LWM)	
Haverhill (HAV)	
Plum Island-Newburyport (2B2)	
Moore (AYE)	
Taunton (3B4)*	
Total	347,026 (100%)

*Primarily Quonset controlled.

TABLE 2-2. BOSTON TRACON TRAFFIC - 1 DAY

(May 3, 1978)

TYPES OF TRACON OPERATION				
IFR	OPERATIONS			
Boston Logan				
Air Carrier	632			
Air Taxi	239			
General Aviation	252			
Military	7			
Boston Subtotal	1130	(82%)	(64%)	
Secondary Airports	178	(13%)		
Overflights	27	(2%)		= (79%)
Tower Enroute Control (Boston/Otis)	35	(3%)		
IFR Subtotal	1370	(100%)	(78%)	
TCA (VFR)				
Boston Logan	256		(15%)	
Overflights	130			
TCA Subtotal	386		(22%)	
EXPANDED RADAR SERVICE (VFR)	5		(0%)	
Total	1761		(100%)	

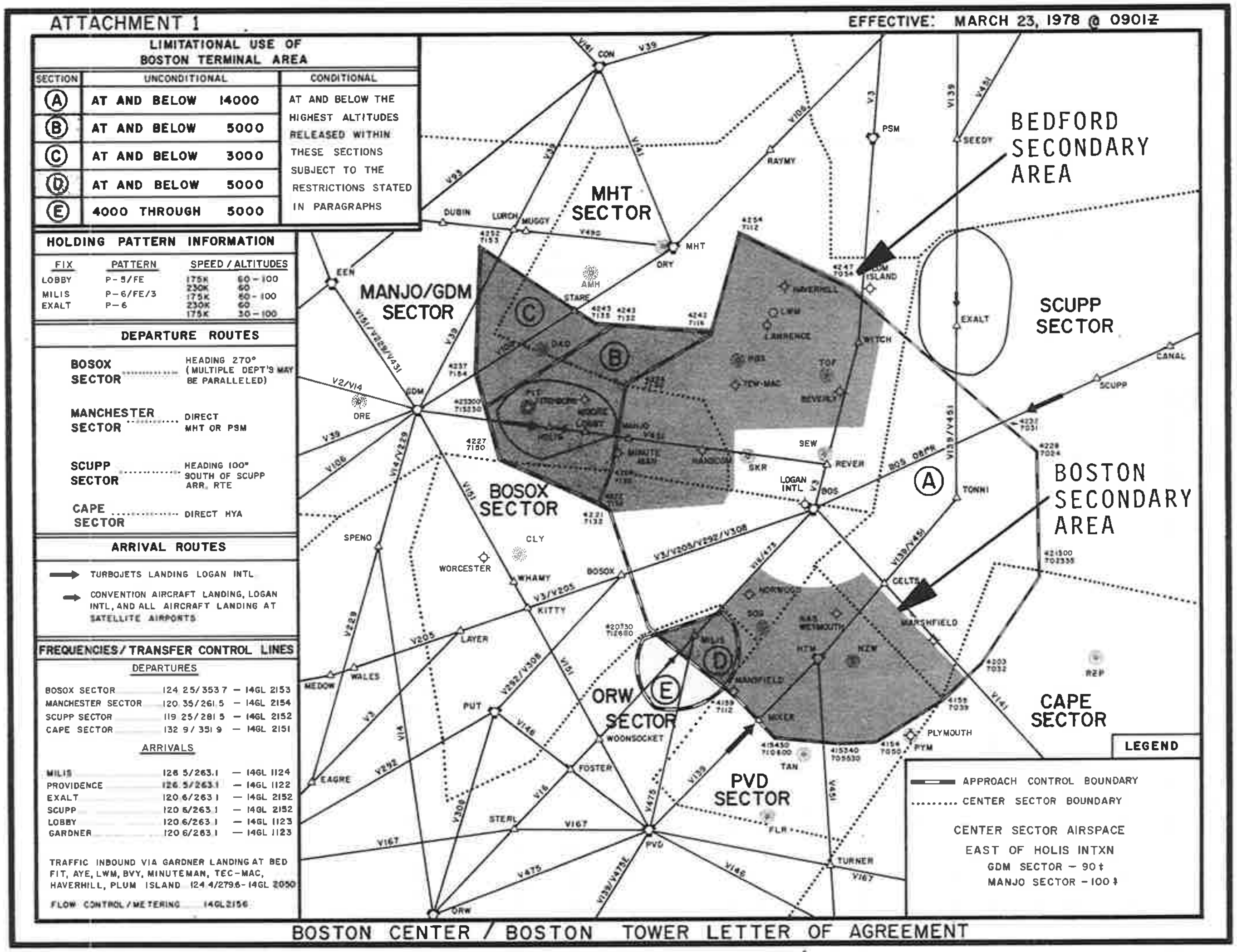
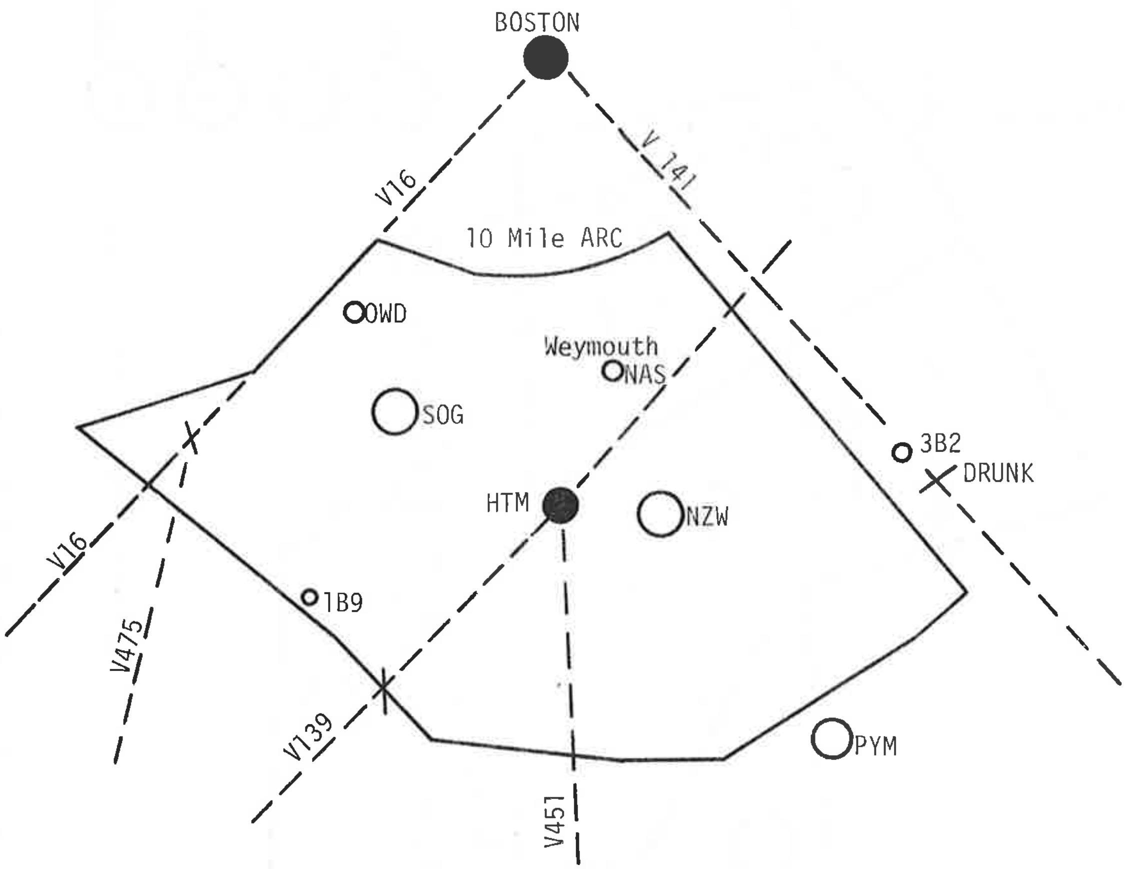


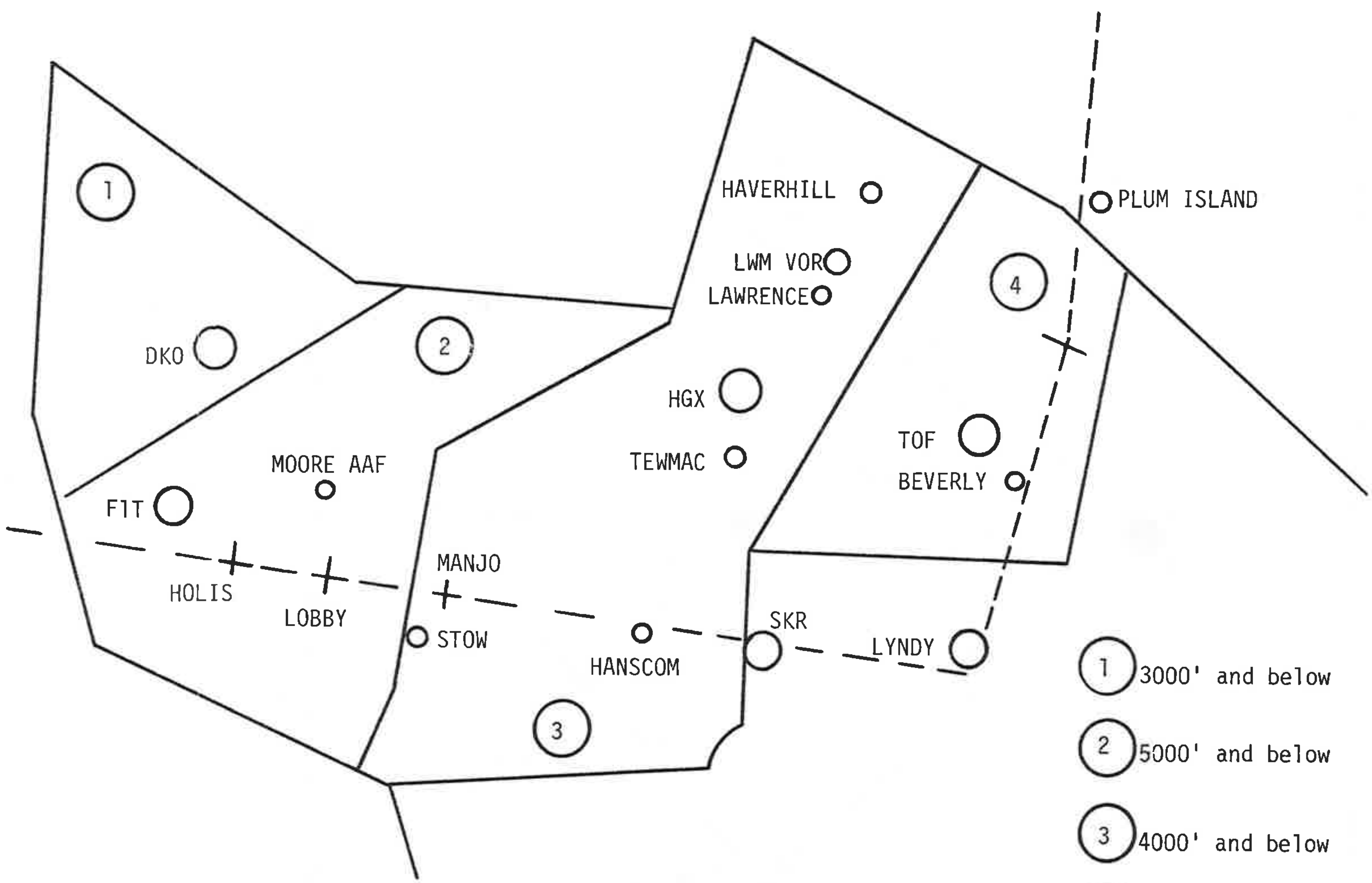
FIGURE 2-2. SECONDARY AREAS

The Secondary Airport Area is defined as that airspace 2000 feet and below beginning at a point on the BOS 158° radial, 10 DME Fix to the TRACON boundary, thence clockwise along the boundary, thence northeast along the west edge of the MILIS HPASA until V-16, thence V-16 to the BOS 10 mile DME Fix, thence counterclockwise via the 10 mile DME Arc to point of beginning.



SOURCE: BOS 7110.35A, CHG. 1, PARA'S 170 AND 179, pp. 60, 61, DATED 3/23/78.

FIGURE 2-3A. BOSTON SECONDARY AREA



SOURCE: BOS 7110. 35A, CHG. 1, PARA. 189, p. 63, dated 3/23/78.

FIGURE 2-3B. BEDFORD SECONDARY AREA

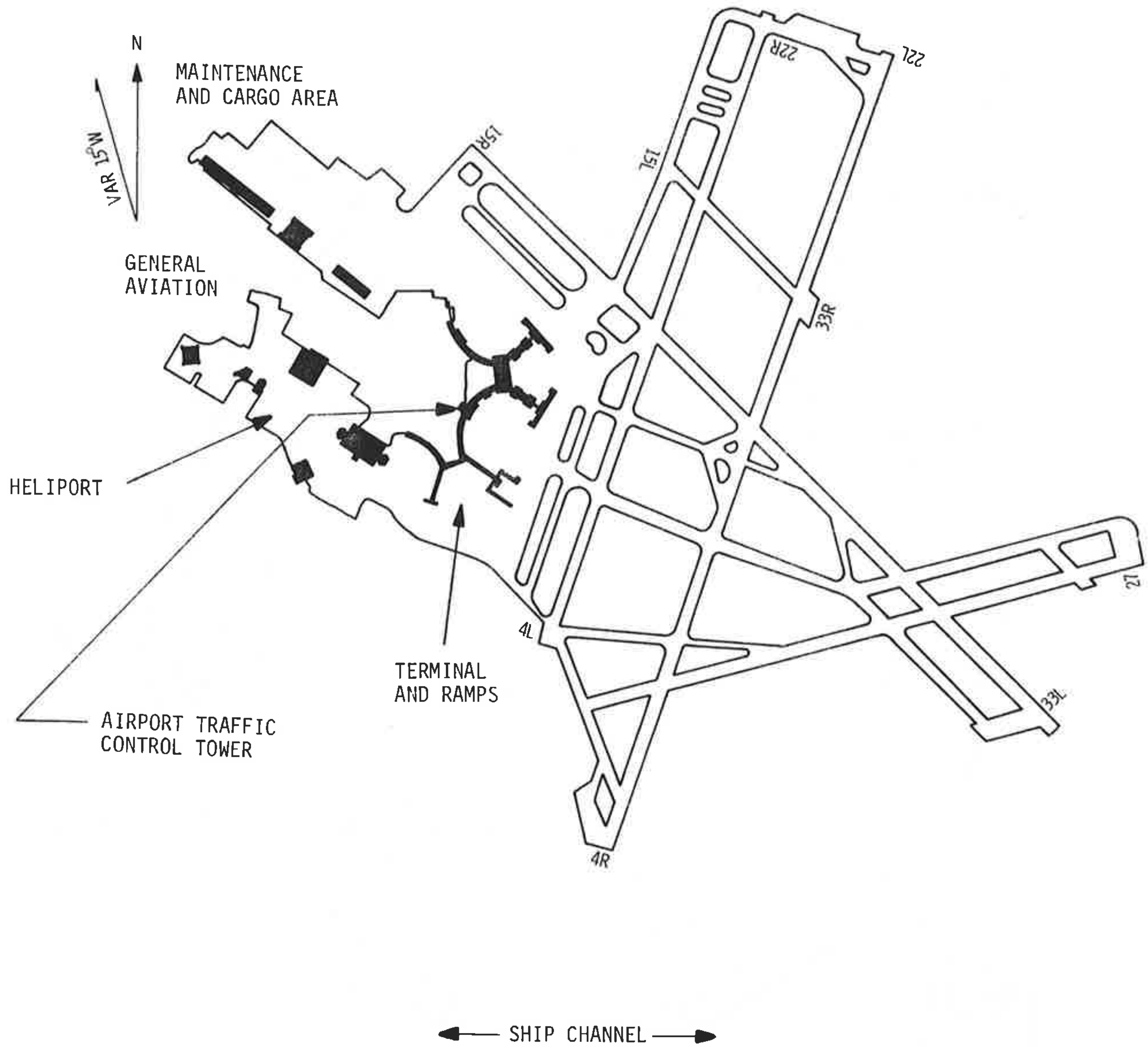


FIGURE 2-4. BOSTON LOGAN AIRPORT RUNWAY AND TERMINAL LAYOUT

TS - TEAM SUPERVISOR
NLCC - NORTH LOCAL CONTROL COORD.
NLC - NORTH LOCAL CONTROL
GC - GROUND CONTROL
SLC - SOUTH LOCAL CONTROL
SLCC - SOUTH LOCAL CONTROL COORD.
HV - HARBOR VIEW
CD - CLEARANCE DELIVERY
FD - FLIGHT DATA

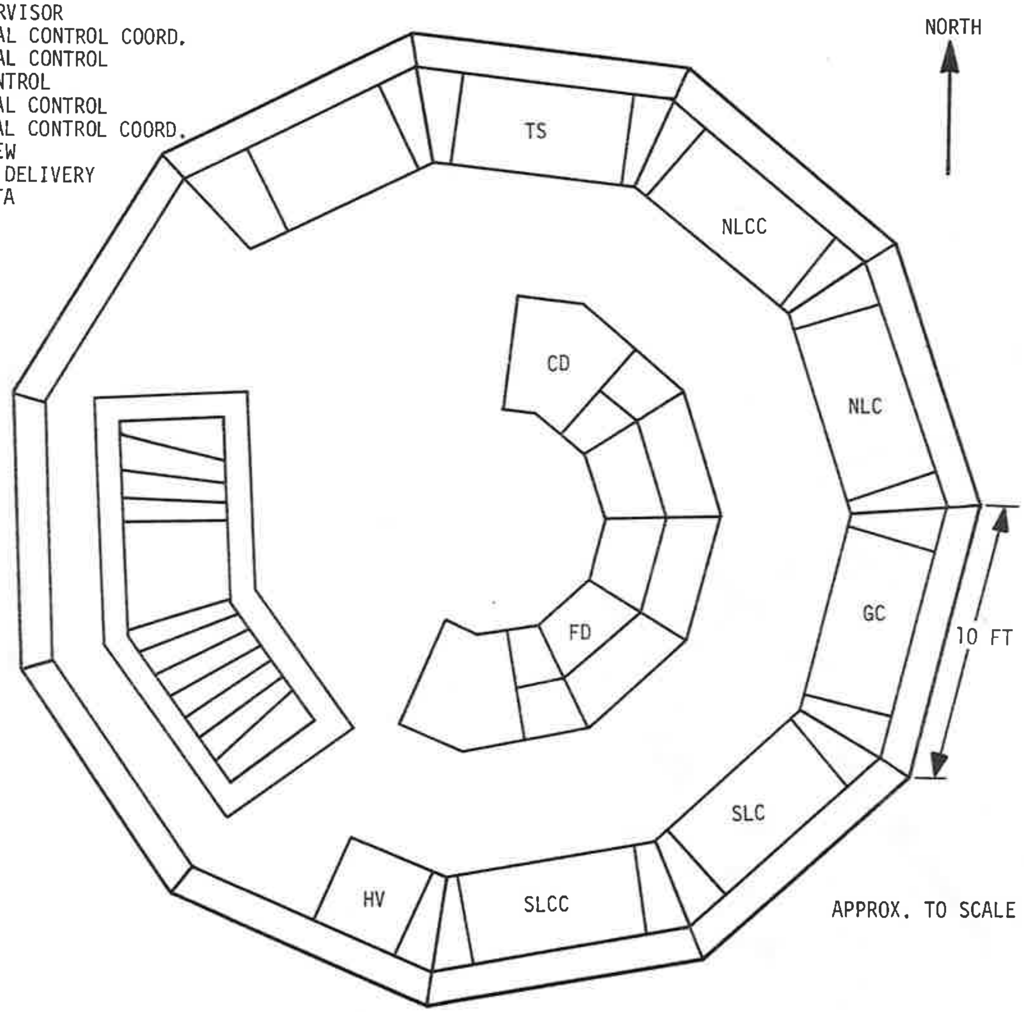
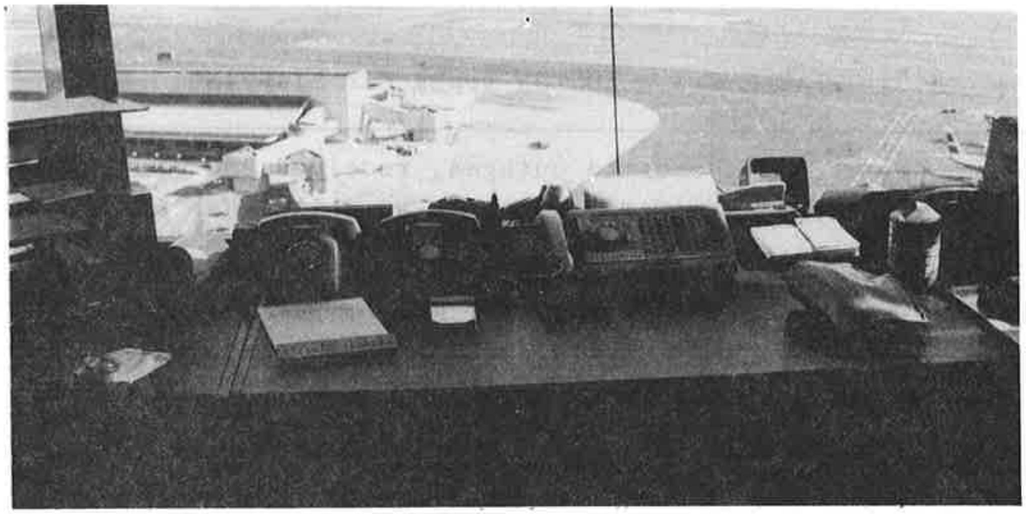
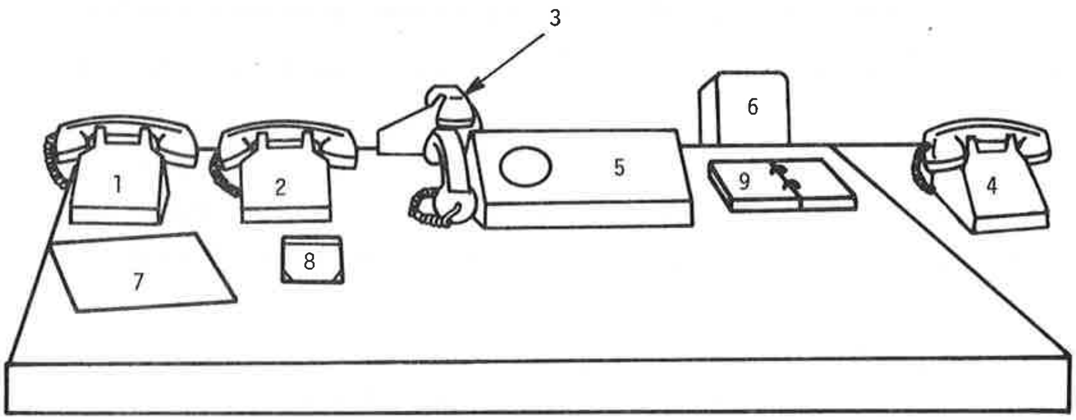


FIGURE 2-5. TOWER CAB LAYOUT

TABLE 2-3. BOSTON TOWER CAB STAFFING

Team Supervisor - Responds to outages, receives and distributes weather, prepares ATIS, and performs out-of-Cab coordination. Supervises Cab operation.
Local Controller - Staffed at either NLC or SLC position depending on runways in use. Controls aircraft in vicinity of the airport and onto and off of the runways.
Cab Coordinator - Staffed at either NLCC or SLCC position depending on runways in use. Coordinates with TRACON for departures and prepares arrival flight progress strips.
Ground Controller - Controls aircraft and ground vehicles on the taxiways.
Sky Watch - Staffed at NCL or SLC, not occupied by Local Control. Operates from 7:00 to 9:00 AM and 4:00 to 6:00 PM. Controls helicopters and fixed-wing aircraft providing Boston road traffic reports.
Flight Data - Processes clearance, operates FDEP, and sets up flight progress strips for Clearance Delivery.
Clearance Delivery - Transmit IFR and TCA departure clearances, and coordinates with Departure Data position in TRACON. Negotiates non-primary runway assignments.





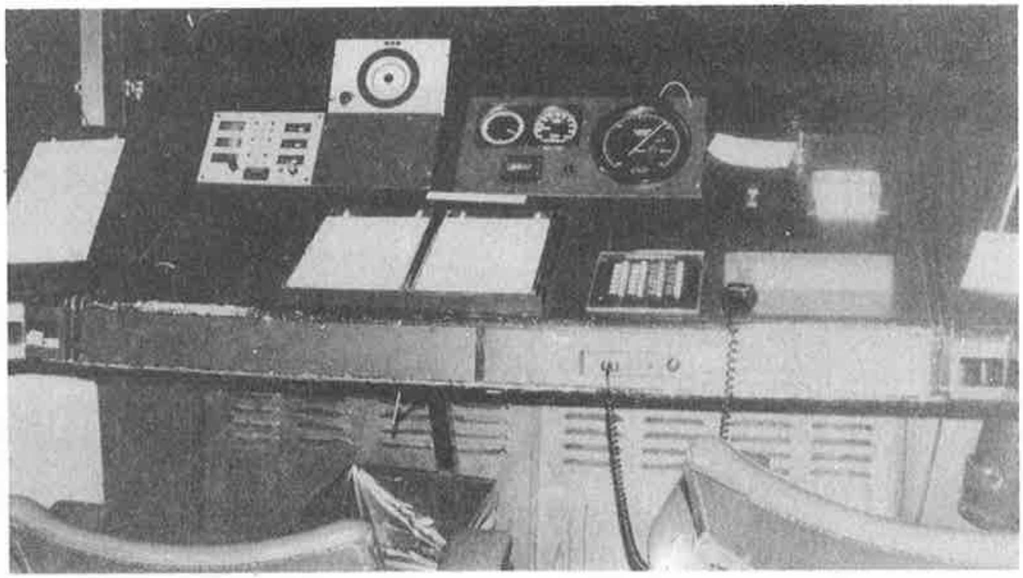
DEVICES

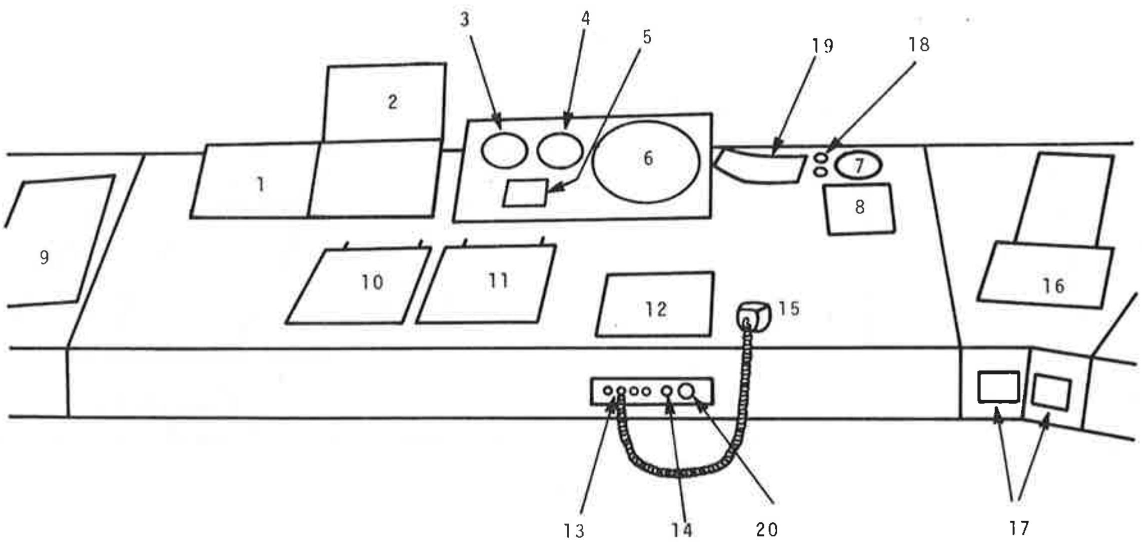
1 TAN TELEPHONE INTERFACILITY
2 BLACK TELEPHONE OUTSIDE LINE
3 BLUE TELEPHONE BOSTON TUG
4 RED TELEPHONE BOSTON FIRE DEPT.
5 TELCO KEYPACK & DIAL BOX
6 TELCO SPEAKER

NOTEBOOKS

7
8
9

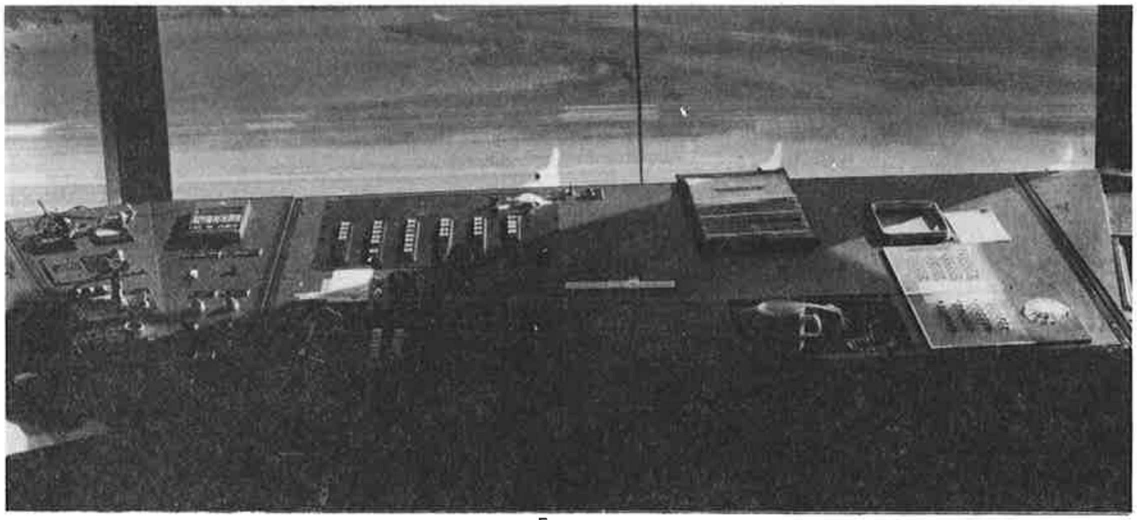
FIGURE 2-6. SUPERVISOR'S DESK

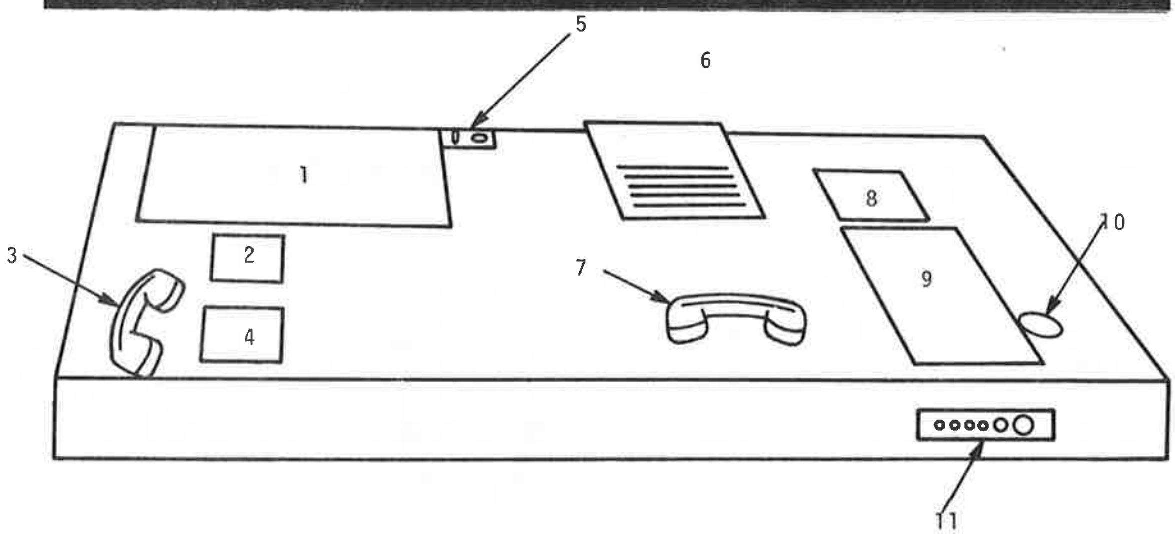




1	RVR DISPLAY	11	FLIGHT STRIP BAY
2	RVV DISPLAY	12	TELCO KEY PACK
3	WIND DIRECT	13	HEADSET JACKS, TELCO
4	WIND SPEED	14	HEADSET/SPEAKER SWITCH
5	DIGITAL CLOCK	15	HAND MIKE
6	ALTIMETER	16	FLIGHT STRIP BAY
7	FAA SPEAKER	17	FLIGHT STRIP BIN
8	TELCO SPEAKER	18	FAA MIKE & HEADSET JACKS
9	FLIGHT STRIP BAY	19	POSITION LOG .
10	FLIGHT STRIP BAY	20	TELCO KEYPACK ILLUMINATION RHEOSTAT

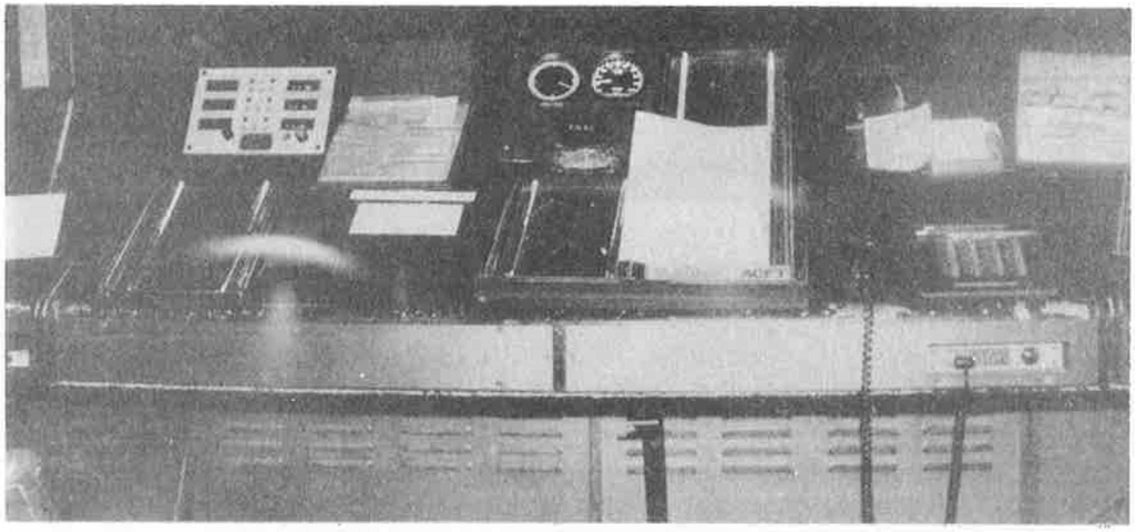
FIGURE 2-7. LOCAL, NORTH

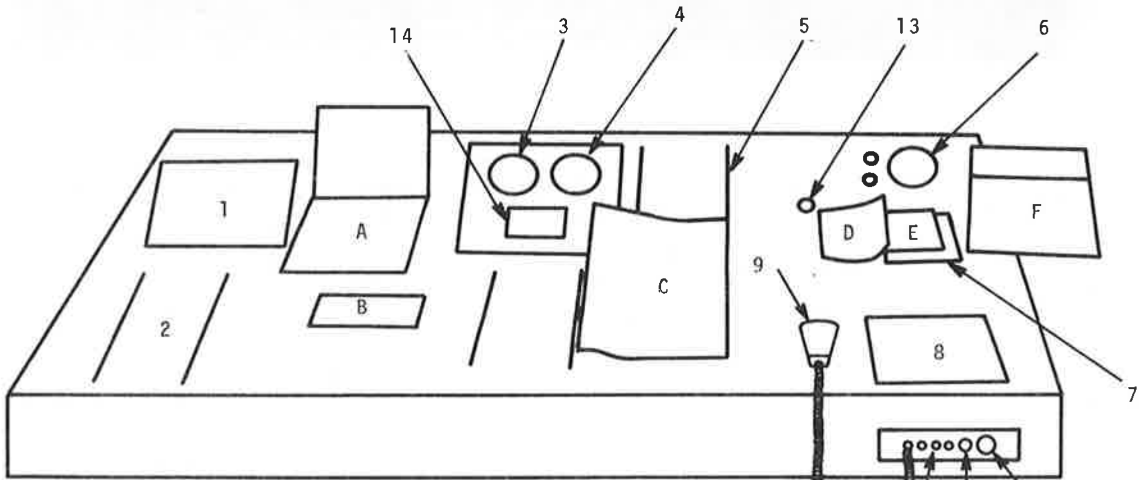




1 ILS PANEL
2 ATIS PANEL (Inactive)
3 NAVAIDS PHONE
4 STANDBY FAA CHANGEOVER PANELS
5 ALS ENGIN LIGHT & SIGNAL SWITCH
6 OP PROCEDURES FLIP CHART
7 TELCO PHONE
8 TELCO SPEAKER
9 TELCO KEY PAK
10 TELCO DIAL BOX
11 TELCO MIKE JACKS, ILLUMINATION & VOLUME RHEOSTATS

FIGURE 2-8. CAB COORDINATOR, NORTH





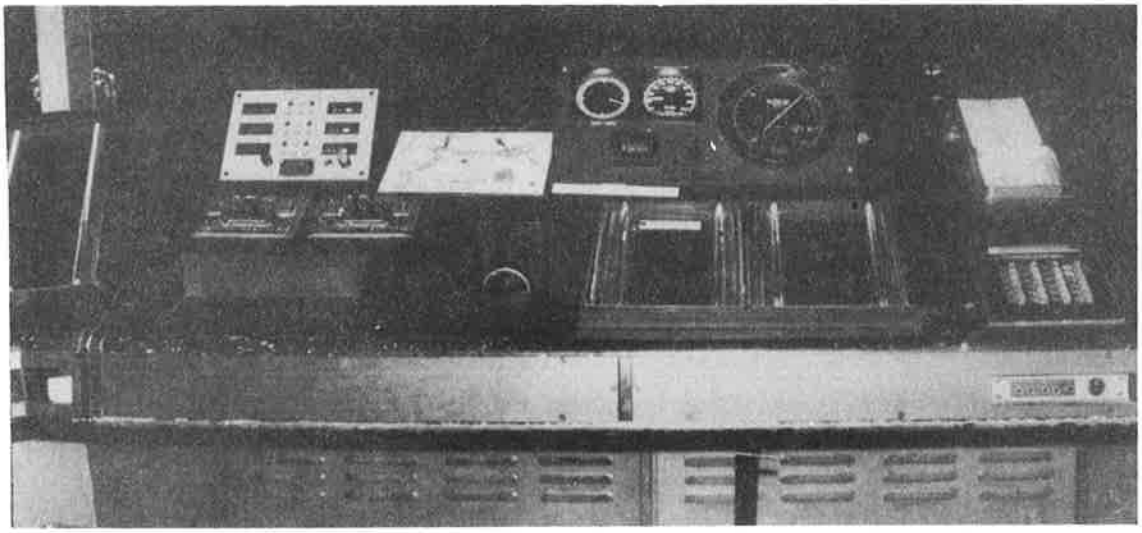
DEVICES

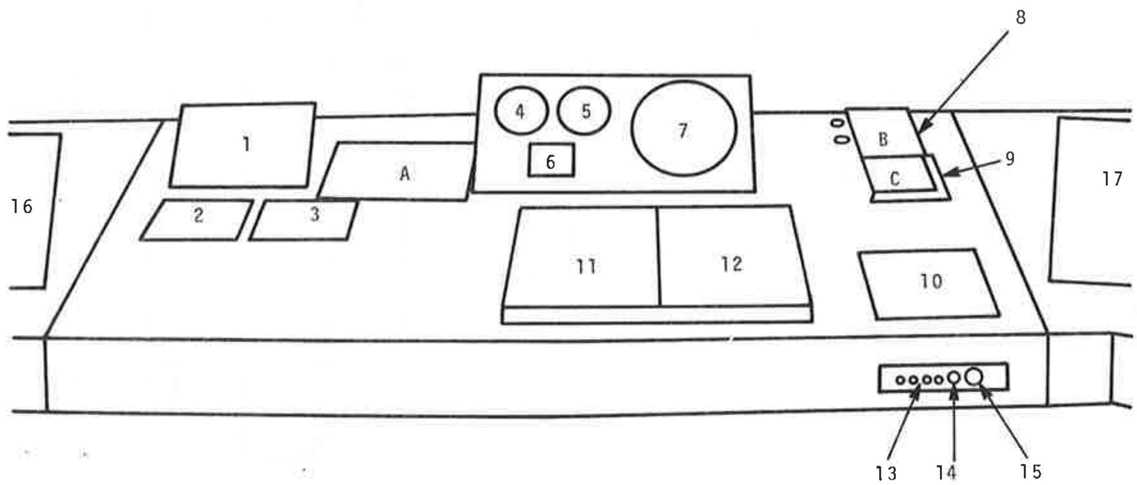
1 RVR
2 STRIP BAY
3 WIND DIRECTION
4 WIND SPEED
5 ALTIMETER (Beneath Stripbay)
6 FAA SPEAKER & JACKS
7 TELCO SPEAKER
8 TELCO KEYPACK
9 HAND MIC
10 HEADSET JACKS
11 HEADSET/SPEAKER SWITCH
12 KEYPACK ILLUMINATION CONTROL
13 VASI CONTROL
14 DIGITAL CLOCK

POSTED PAPER WORK

A. PROCEDURES FLIP CHART
B. LISTS RUNWAY ASSIGNMENTS FOR AIRCRAFT CATEGORIES
C.
D.
E. POSITION LOG
F. PROCEDURES FLIP CHART

FIGURE 2-9. GROUND CONTROL





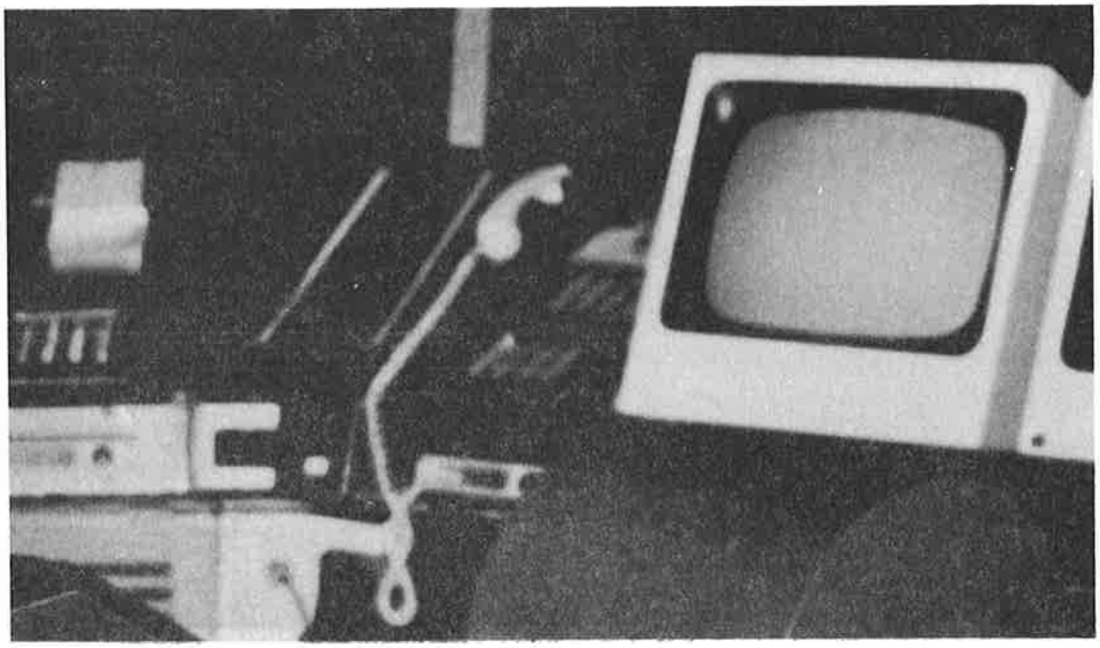
DEVICES

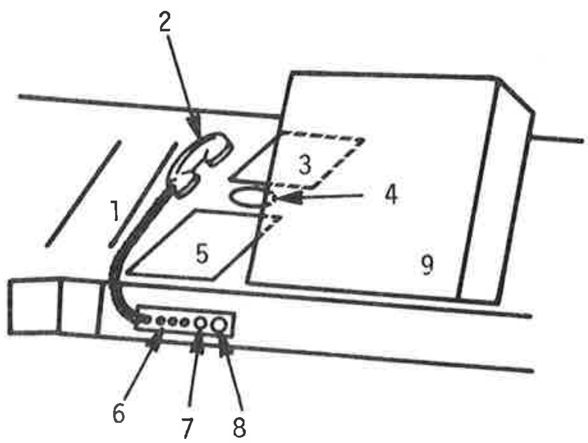
1 RVR
2 ALS, 33L
3 ALS, 4R
4 WIND DIRECTION
5 WIND SPEED
6 DIGITAL CLOCK
7 ALTIMETER
8 FAA SPEAKER & JACKS
9 TELCO SPEAKER
10 TELCO KEYPACK
11 STRIP BAY
12 STRIP BAY
13 HEADSET JACKS
14 HEADSET/SPEAKER SWITCH
15 KEYPACK ILLUMINATION RHEOSTAT
16 STRIP BAY
17 BINOCULAR WELL

POSTED PAPERWORK

A
B
C POSITION LOG

FIGURE 2-10. LOCAL, SOUTH

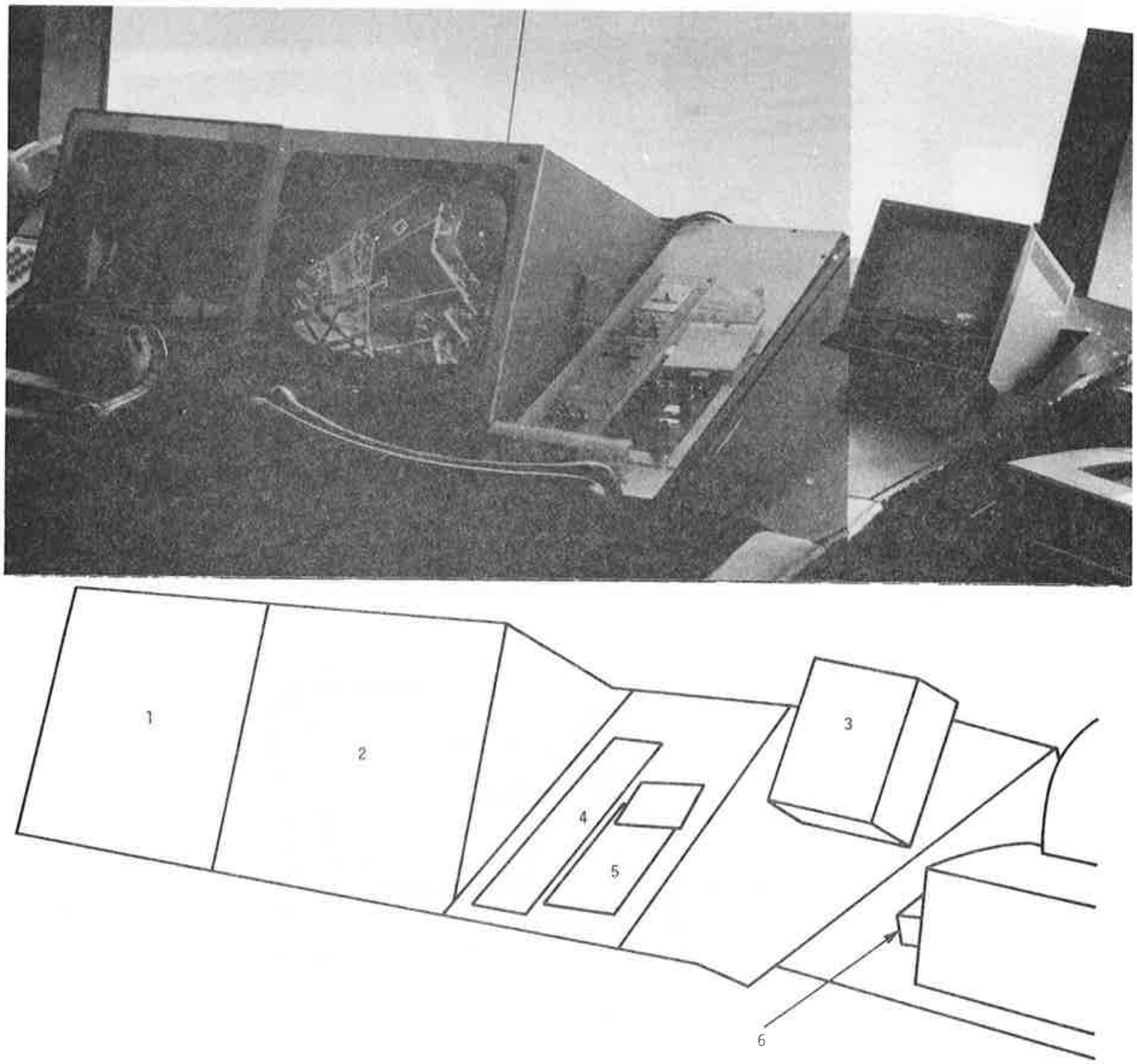




DEVICES

1 STRIP BAY
2 TELCO TELEPHONE
3 TELCO SPEAKER
4 TELCO DIAL BOX
5 TELCO KEYPACK
6 TELPHONE JACKS
7 TELEPHONE/SPEAKER SWITCH
8 KEYPACK ILLUMINATION RHEOSTAT
9 NOT PART OF COORDINATORS POSITION

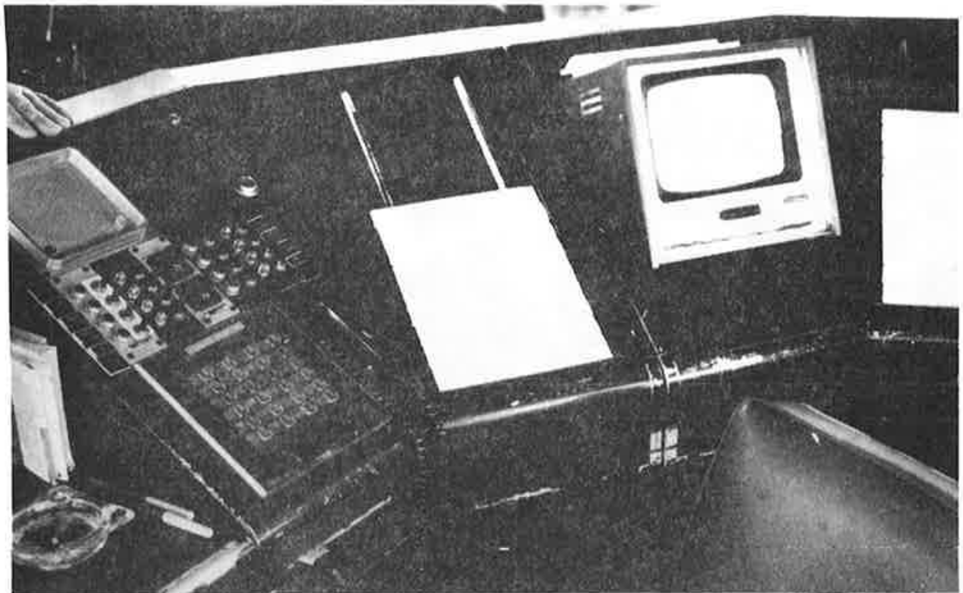
FIGURE 2-11. CAB COORDINATOR, SOUTH

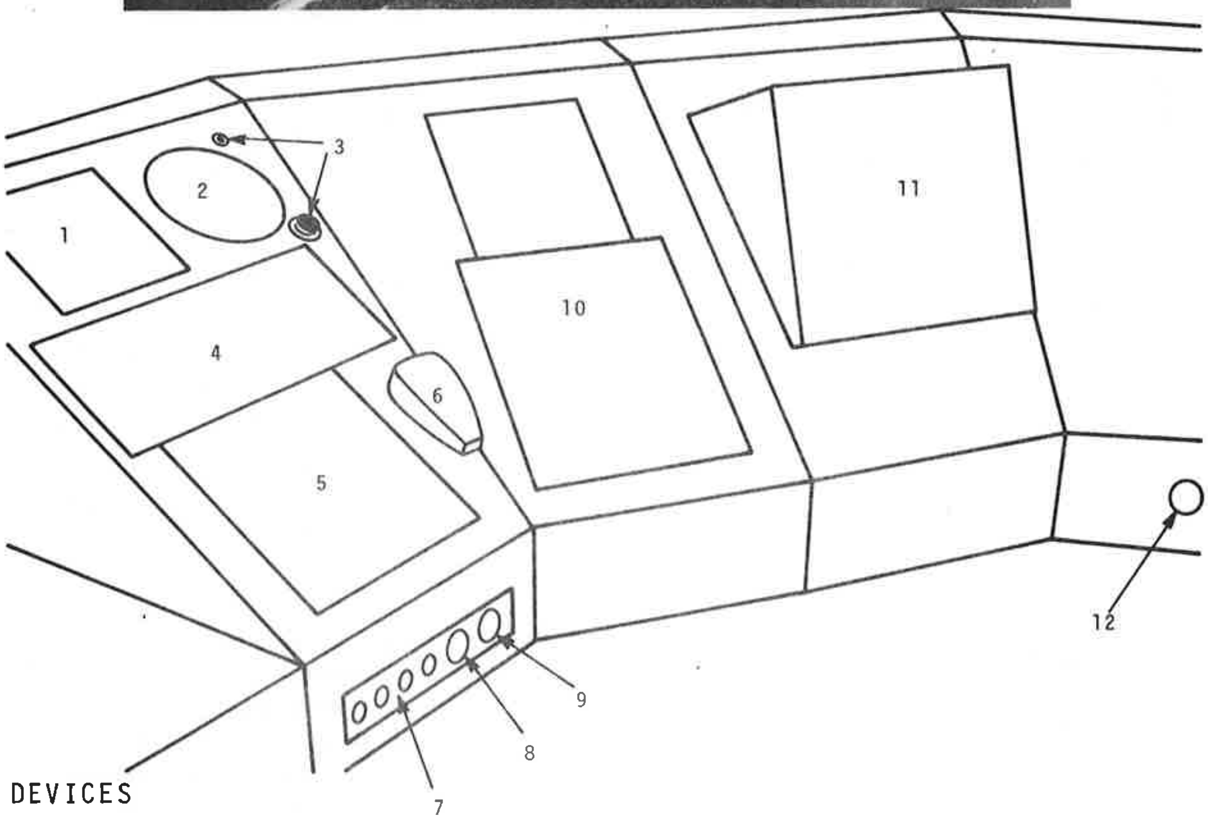


DEVICES

1 HARBOR DISPLAY MONITOR
2 TV MONITOR SHOWING HARBOR PICTURE AS ON ASPE
3 CONRAC, MONITORS SIGNAL BEING VIDEO TAPED
4 VIDEO CAMERA CONTROLS
5 ASDE CONTROL PANEL
6 CONTROL FOR VIDEO TAPE RECORDER

FIGURE 2-12. HARBOR VIEW POSITION

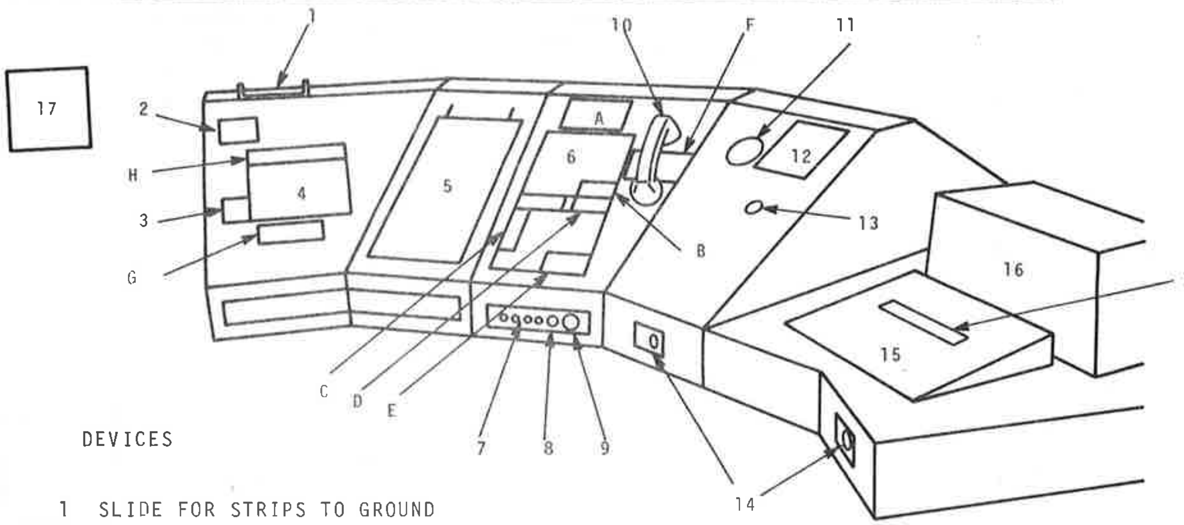




DEVICES

1 TELCO SPEAKER
2 FAA SPEAKER
3 FAA MIKE & EARPHONE JACKS
4 FAA COMMUNICATIONS PANELS
5 TELCO KEY PAK
6 TELCO MIKE
7 MIKE JACKS
8 HEADSET/SPEAKER SELECTOR SWITCH
9 KEYPAK ILLUMINATION RHEOSTAT
10 STRIP RACK
11 ARTS MONITOR
12 OVERHEAD LIGHTS RHEOSTAT

FIGURE 2-13. CLEARANCE DELIVERY



DEVICES

1 SLIDE FOR STRIPS TO GROUND
2 DIGITAL CLOCK
3 ARTS PEM
4 ARTS KEYBOARD
5 STRIP BOARD
6 TELCO KEY PAK
7 HEADSET/TELEPHONE JACKS
8 TELEPHONE/SPEAKER SELECT SWITCH
9 KEY PAK ILLUMINATION CONTROL
10 TELEPHONE
11 TELCO DIAL BOX
12 TELCO SPEAKER
13 SPEAKER VOLUME CONTROL
14 RHEOSTATS FOR CEILING LIGHTS
15 FDEP KEYBOARD
16 FDEP PRINTER
17 ARTS MONITOR

<u>POSTED PAPER</u>

A
B "DSS 02 FLOW 66 FLT DATA 07"
C CARRIER PHONE NUMBERS
D NOTE ON NEW GATE ASSIGNMENT
E PHONE NUMBERS, POLICE, WX, BUTLER, ETC.
F CENTER SECTOR, RADIO FREQ, FOR NORWICH, BOSOX, MANJO, ETC. & TELCO DIAL NOS.
G NOTE TO CALL DD AND TD ABOUT TCA HAND-WRITES & IFR → VRR DEPARTURES FOR SPECIFIED CEILING CONDITIONS
H NOTE ON TC ARTS SYMBOL CHANGE
I SAMPLE FLIGHT STRIP

FIGURE 2-14. FLIGHT DATA

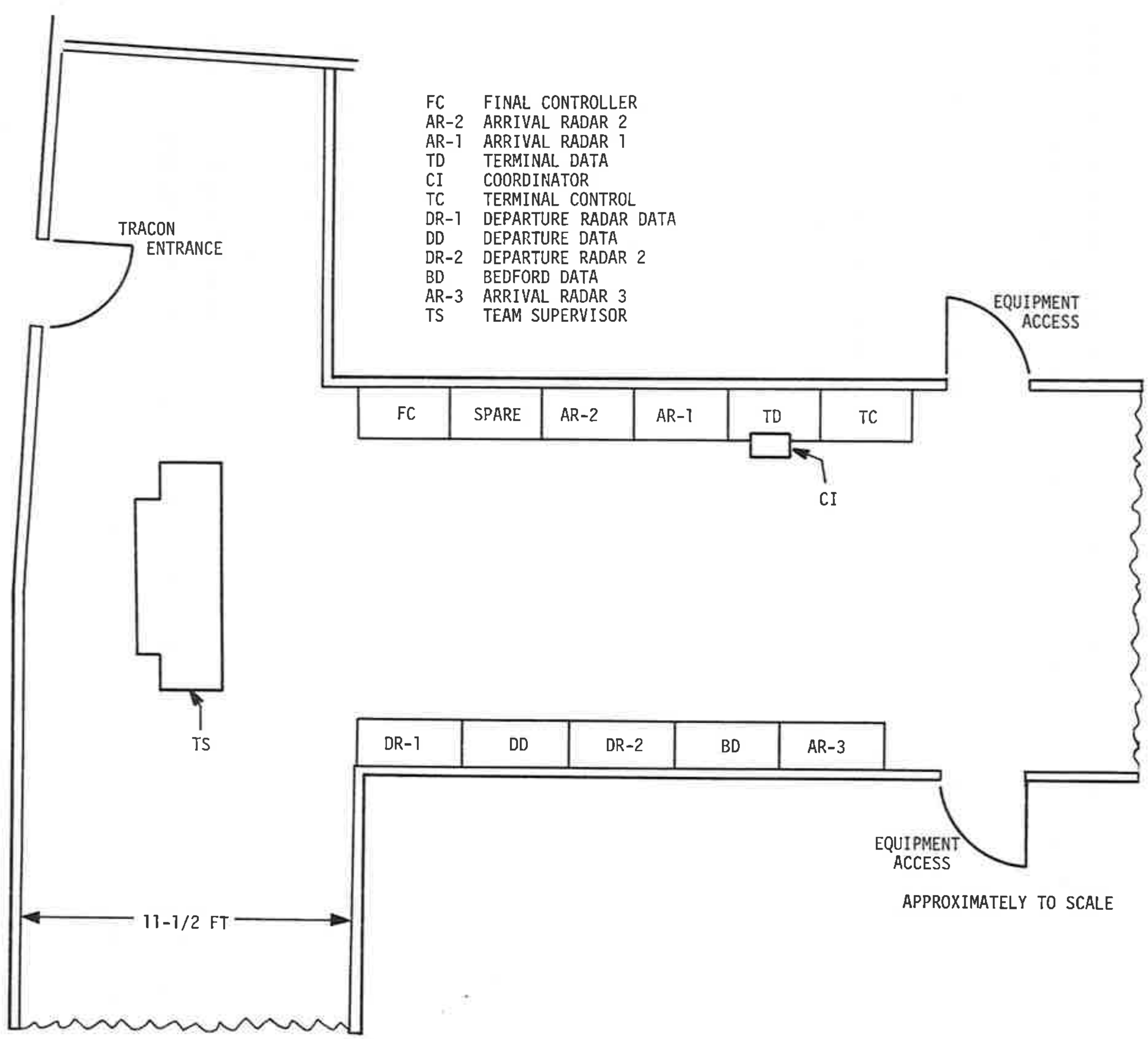
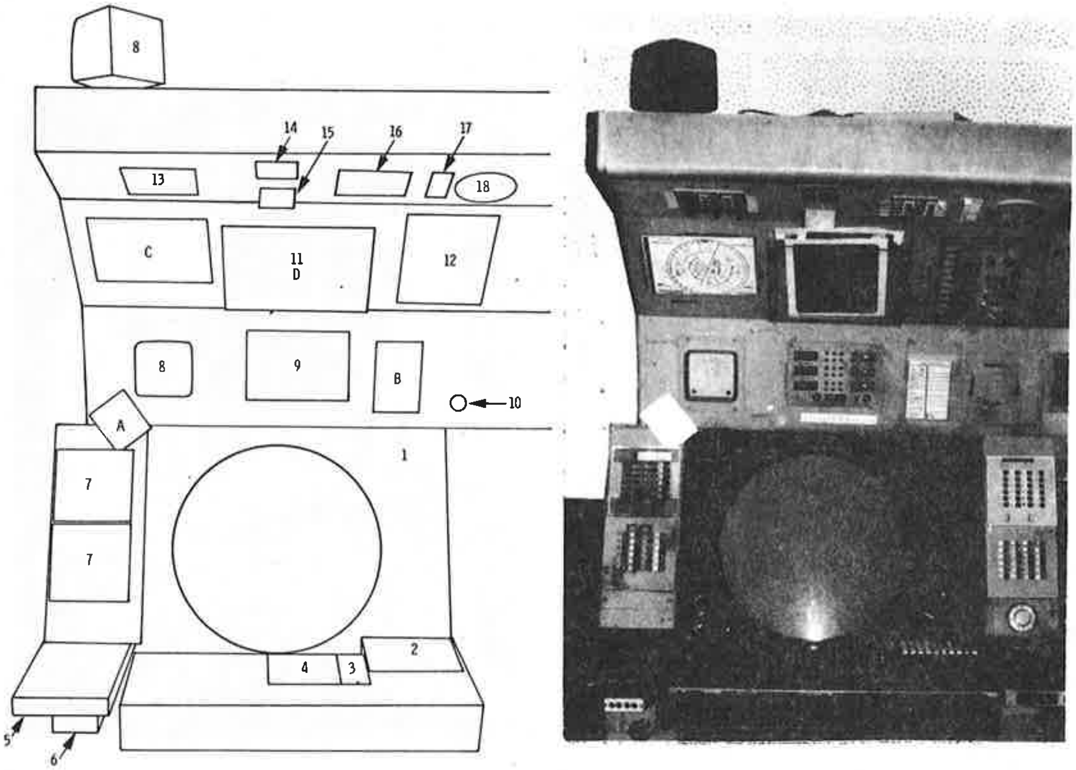


FIGURE 2-15. BOSTON TRACON LAYOUT

TABLE 2-4. BOSTON TRACON STAFFING

Team Supervisor - Responds to outages and performs out-of-TRACON coordination. Supervises TRACON operation.
Arrival Radar 1 - Controls arrivals to Boston Logan primary runway from south and arrivals to airports in Boston Secondary Area. (See Figure 2-2.)
Arrival Radar 2 - Controls arrivals to Boston Logan primary runway from north. (See Figure 2-2.)
Arrival Radar 3 - Controls arrivals and departures to and from airports in the Bedford Secondary Area and fly-throughs below 3500 ft.
Final Controller - Staffed only during heavy arrival traffic into Boston Logan - e.g., 7:00 to 9:00 AM and 2:00 to 7:00 PM. Controls/merges traffic arriving on Boston Logan primary runway(s). Traffic is handed off from AR-1, AR-2 and TC.
Terminal Controller - Controls arrivals to Boston Logan secondary runways during VFR conditions.
Departure Radar 1 - Controls departures from Boston Logan leaving north, and terminal area fly-throughs north of Boston.
Departure Radar 2 - Controls departures from Boston Logan leaving south, departures from Boston Secondary Area and terminal area fly-throughs south of Boston.
Terminal Data - Assists AR-1, AR-2 and TC in posting flight strips, takes TELCO calls, and performs ARTS keyboard functions.
Departure Data - Assists DR-1 and DR-2.
Bedford Data - Assists AR-3.
TRACON Coordinator - Establishes final sequence and coordinates between control positions.



DEVICES

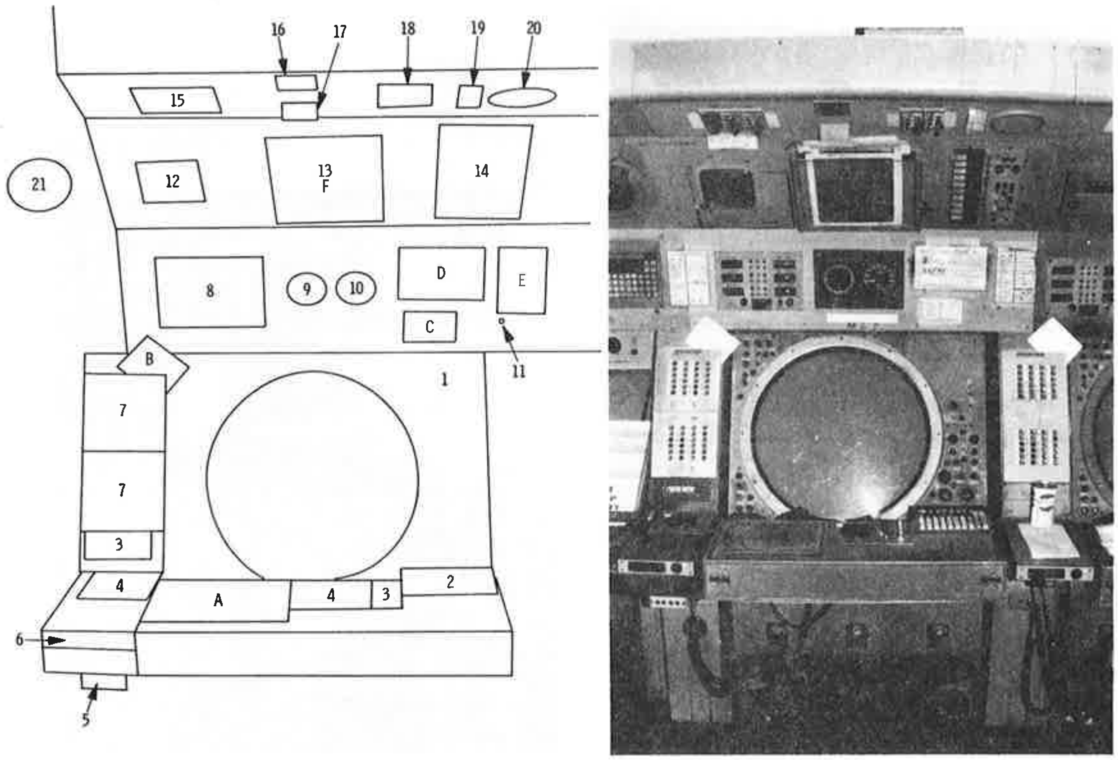
1 PLAN VIEW DISPLAY & ARTS III DISPLAY CONTROLS
2 ARTS KEYBOARD
3 ARTS QUICKLOOK PANEL
4 ARTS TRACKBALL
5 PHONE JACK
6 PHONE JACK*
7 TELCO KEYPACK
8 TELCO SPEAKER
9 RVR PANEL
10 HALO LIGHT SWITCH
11 MAP HOLDER
12 BEACON DECODER
13 REC. FAA COMM. PANEL
14 VIDEO MAP SELECTOR
15 HALO LIGHT
16 XMIT. FAA COMM. PANEL
17 BACKUP FAA COMM. PANEL
18 FAA SPEAKER

POSTED PAPER WORK

A POSITION LOG
B CONTROLLER BRIEFING CHECKLIST
C MIN. VECTOR ALT. CHART
D APPROACH CHART

* For the Logan Controller Station Simulator

FIGURE 2-16. FC POSITION LAYOUT



DEVICES

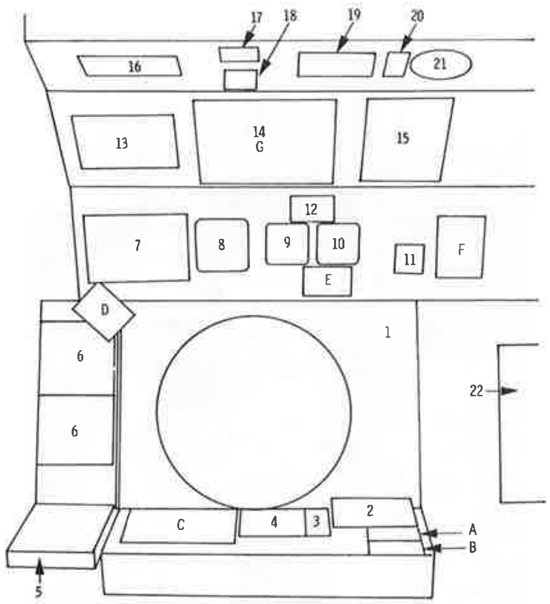
1 PLAN VIEW DISPLAY & ARTS III DISPLAY CONTROLS
2 ARTS KEYBOARD
3 ARTS QUICKLOOK PANEL
4 ARTS TRACKBALL
5 PHONE JACK*
6 PHONE JACK
7 TELCO KEYPACK
8 RVR PANEL
9 WIND DIRECTION IND.
10 WIND SPEED IND.
11 HALO LIGHT SWITCH
12 TELCO SPEAKER
13 MAP HOLDER
14 BEACON DECODER
15 REC. FAA COMM. PANEL
16 VIDEO MAP SELECTOR
17 HALO LIGHT
18 XMIT FAA COMM. PANEL
19 BACKUP FAA COMM. PANEL
20 FAA SPEAKER
21 ALTIMETER

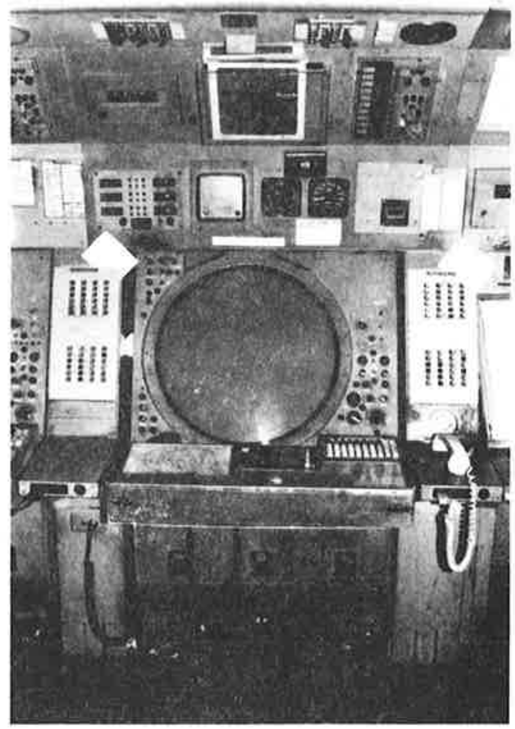
POSTED PAPER WORK

A MIN. VECTOR ALT. CHART
B POSITION LOG
C CENTER SECTOR HANDOFF LIST
D BOSTON WEATHER
E CONTROLLER BRIEFING CHECKLIST
F APPROACH CHART

* For the Logan Controller Station Simulator

FIGURE 2-17. AR-2 POSITION LAYOUT





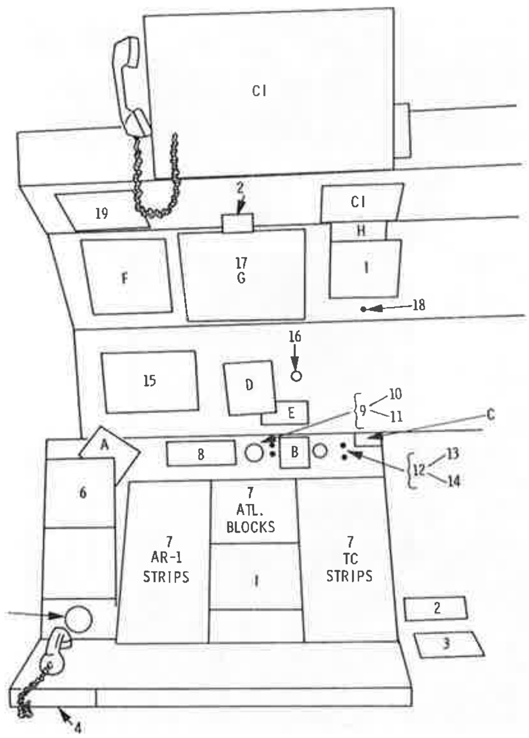
DEVICES

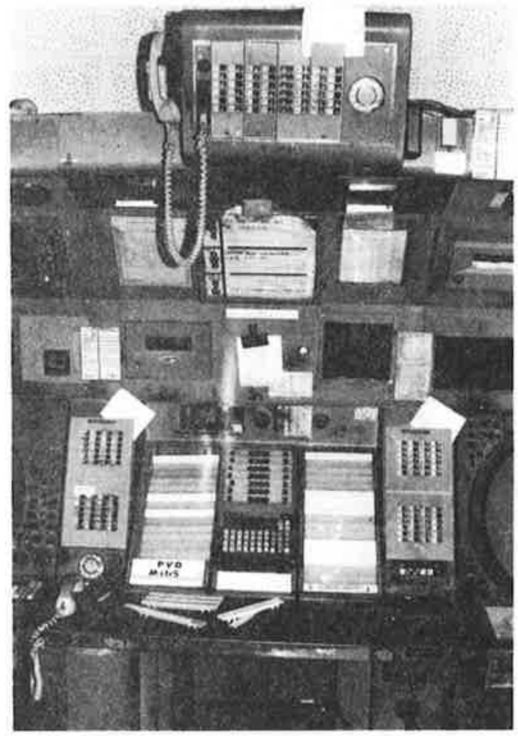
1 PLAN VIEW DISPLAY & ARTS III DISPLAY CONTROLS
2 ARTS KEYBOARD
3 ARTS QUICKLOOK PANEL
4 ARTS TRACKBALL
5 PHONE JACK
6 TELCO KEYPACK
7 RVR PANEL
8 TELCO SPEAKER
9 WIND DIRECTION IND.
10 WIND SPEED IND.
11 DIGITAL ALTIMETER
12 HALO LIGHTSWITCH
13 DIGITAL CLOCK
14 MAP HOLDER
15 BEACON DECODER
16 REC. FAA COMM. PANEL
17 VIDEO MAP SELECTOR
18 HALO LIGHT
19 XMIT FAA COMM. PANEL
20 BACKUP FAA COMM. PANEL
21 FAA SPEAKER
22 FLIGHT STRIP TRAY

POSTED PAPER WORK

A TERM. AREA FIXES/FREQS.
B CENTER SECTOR HANDOFF LIST
C MIN. VECTOR ALT. CHART
D POSITION LOG
E
F CONTROLLER BRIEFING CHECKLIST
G APPROACH CHART

FIGURE 2-18. AR-1 POSITION LAYOUT





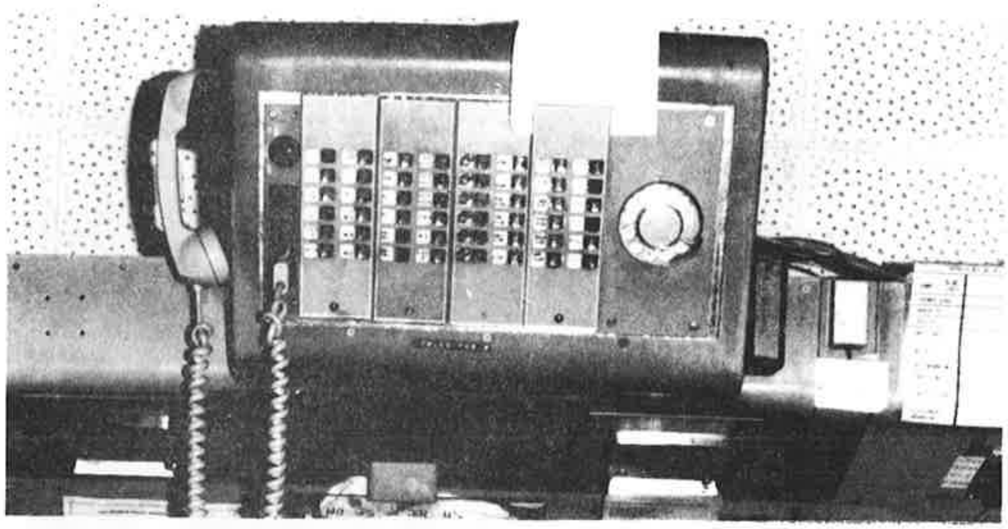
DEVICES

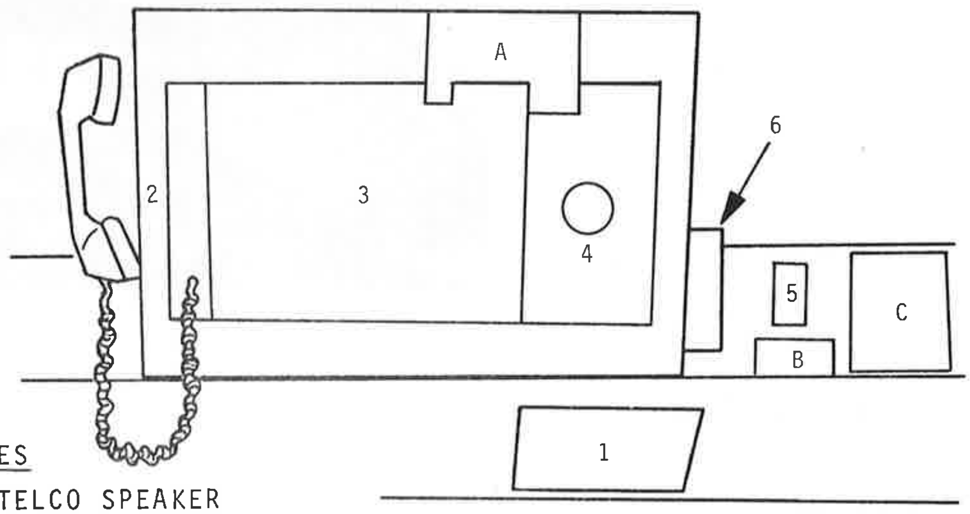
1	ARTS KEYBOARD	12	STRIP TRAY LIGHT-RHEOSTAT CONTROL
2	ARTS QUICKLOOK SWITCH	13	STRIP TRAY LIGHT-ON/OFF SWITCH
3	ARTS TRACKBALL	14	FUSE
4	PHONE JACK	15	DIGITAL CLOCK
5	TELCO DIAL BOX	16	TELAUTOGRAPH CUE LIGHT
6	TELCO KEYPACK	17	MAP HOLDER
7	FLIGHT STRIP TRAY	18	HALO LIGHT SWITCH
8	FLIGHT STRIP STORAGE	19	TELCO SPEAKER
9	"RED" HOLE (FOR TRASH)	20	HALO LIGHT
10	BEDFORD RWY. LIGHT SWITCH	CI	COORDINATOR E'QMT.
11	STATUS LIGHT FOR ITEM 10		

POSTED PAPER WORK

A	POSITION LOG	F	
B	TERM. AREA FIXES/FREQS.	G	BOS/OWD/NZW STATUS
C		H	EMERGENCY ASSISTANCE PROCEDURES
D	TELAUTOGRAPH WEATHER	I	BOS REGS. FOR SIMULTANEOUS INTERSECTION LANDING
E	CENTER SECTOR HANDOFF LIST		

FIGURE 2-19. TD POSITION LAYOUT





DEVICES

1 TELCO SPEAKER

2 PHONE JACK

3 TELCO KEYPACK

4 TELCO DIAL BOX

5 SPEAKER/HEADSET CONTROL SWITCH ON TELCO LINE TO METERING POSITION AT BOSTON CENTER

6 PHONE JACK FOR METERING TELCO LINE (ITEM 5)

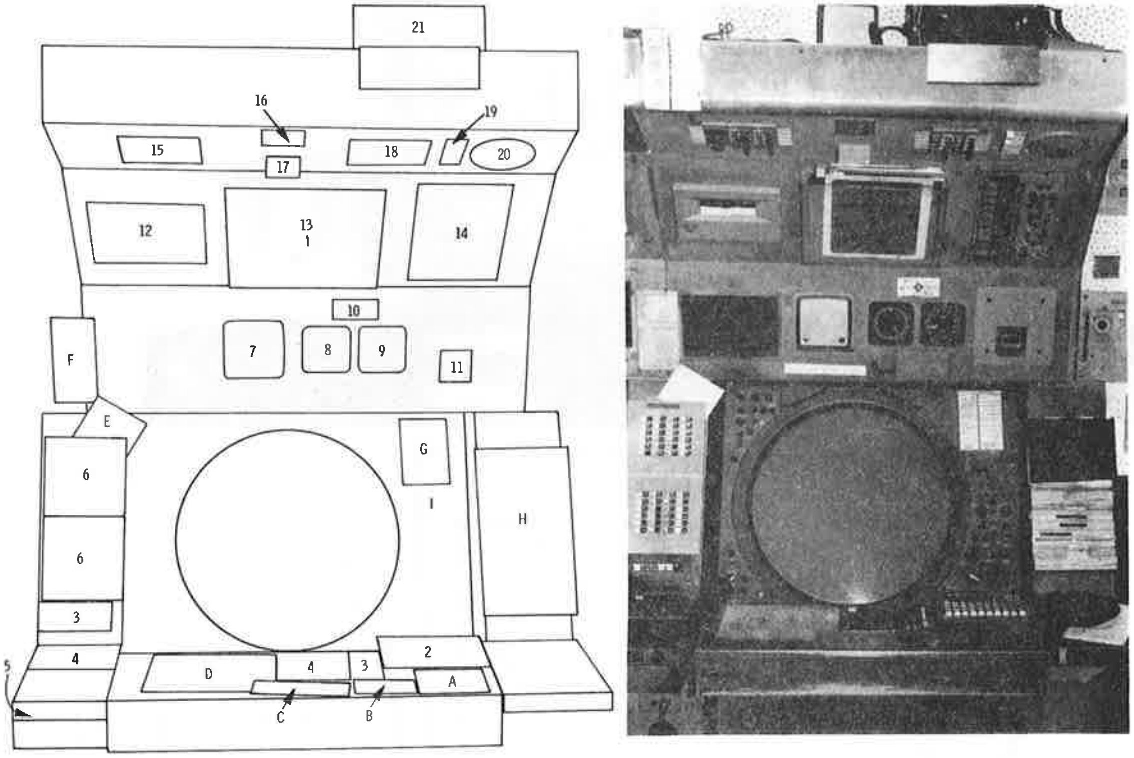
POSTED PAPER WORK

A POSITION LOG

B INSTRUCTIONS ON USE OF ITEMS ABOVE

C CONTROLLER BRIEFING CHECKLIST

FIGURE 2-20. CI POSITION LAYOUT



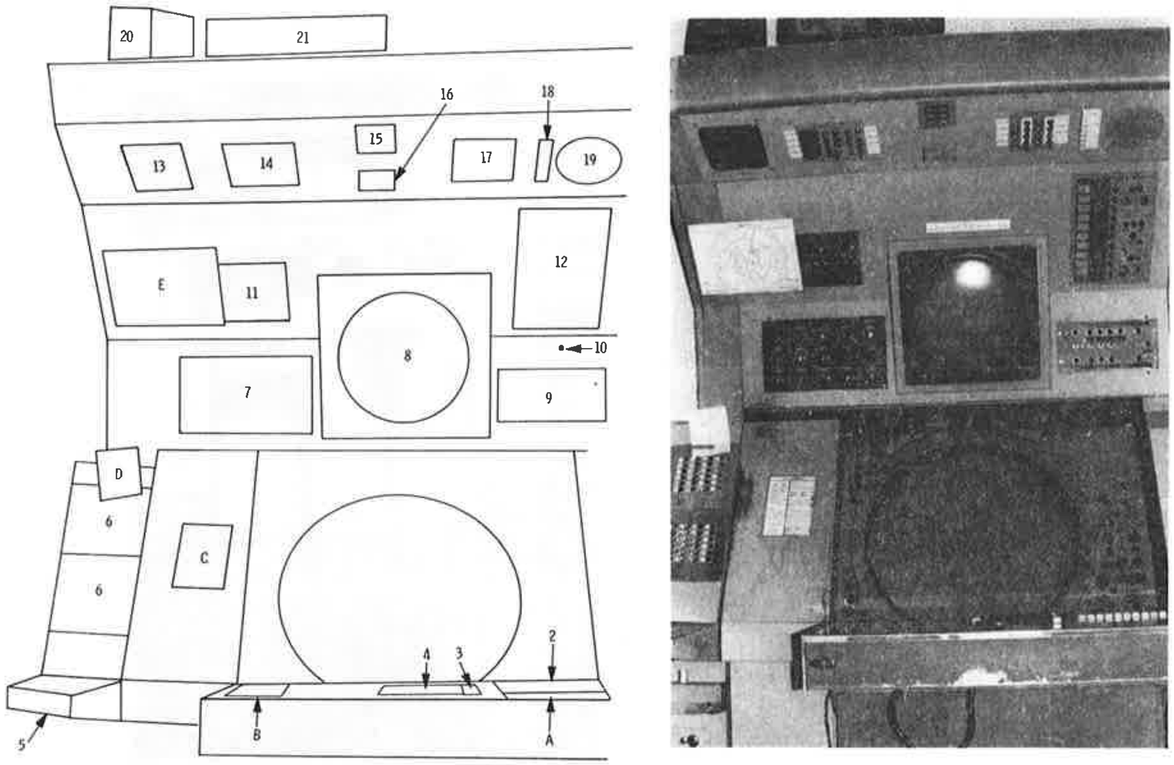
DEVICES

1 PLAN VIEW DISPLAY & ARTS III DISPLAY CONTROLS
2 ARTS KEYBOARD
3 ARTS QUICKLOOK PANEL
4 ARTS TRACKBALL
5 PHONE JACK
6 TELCO KEYPACKS
7 TELCO SPEAKER
8 WIND DIRECTION IND.
9 WIND SPEED IND.
10 HALO LIGHT SWITCH
11 DIGITAL ALTIMETER
12 DIGITAL CLOCK
13 MAP HOLDER
14 BEACON DECODER
15 REC. FAA COMM. PANEL
16 VIDEO MAP SELECTOR
17 HALO LIGHT
18 XMIT FAA COMM. PANEL
19 BACKUP FAA COMM. PANEL
20 FAA SPEAKER
21 BACKUP FAA TRANSCEIVER

POSTED PAPER WORK

A EMERGENCY INFO. REQUIREMTS.
B CENTER SECTOR HANDOFF LIST
C TERMINAL AREA FIXES/FREQS.
D MIN. VECTOR ALT. CHART
E POSITION LOG
F AIRCRAFT GROUP/DIST. MIN. REQ
G CONTROLLER BRIEFING CHECKLIST
H APPROACH PLATES/BOSTON SECTOR
I APPROACH CHART

FIGURE 2-21. TC POSITION LAYOUT



DEVICES

1 PLAN VIEW DIPLAY &
ARTS III DISPLAY CONTROLS

2 ARTS KEYBOARD

3 ARTS QUICKLOOK PANEL

4 ARTS TRACKBALL

5 PHONE JACK

6 TELCO KEYPACK

7 BRITE DISPLAY CONTROLS

8 ARSR (FORT HEATH) BRITE
DISPLAY

9 STAND-BY LINK CONTROL BOX

10 HALO LIGHT SWITCH

11 MAPPER CONTROL

12 BEACON DECODER

13 TELCO SPEAKER

14 REC. FAA COMM. PANEL

15 VIDEO MAP SELECTOR

16 HALO LIGHT

17 XMIT. FAA COMM. PANEL

18 BACKUP FAA COMM. PANEL

19 FAA SPEAKER

20 FREE STANDING TELCO SPEAKER

21 FORT HEATH INTERCOM

POSTED PAPER WORK

A TERMINAL AREA FIXES/FREQ.

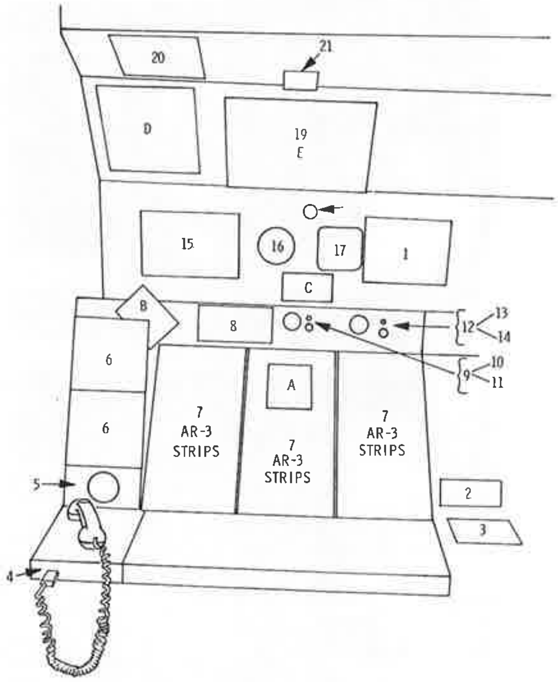
B BOSTON TCA CHART

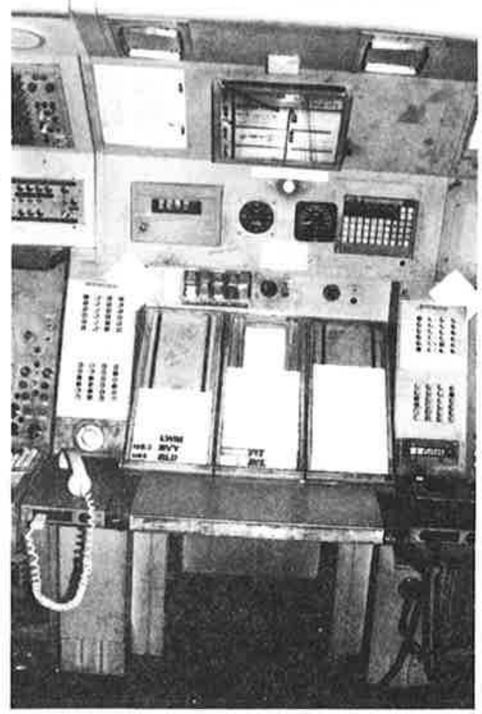
C CONTROLLER BRIEFING
CHECKLIST

D POSITION LOG

E MIN. VECTOR ALTITUDE CHART

FIGURE 2-22. AR-3 POSITION LAYOUT





DEVICES

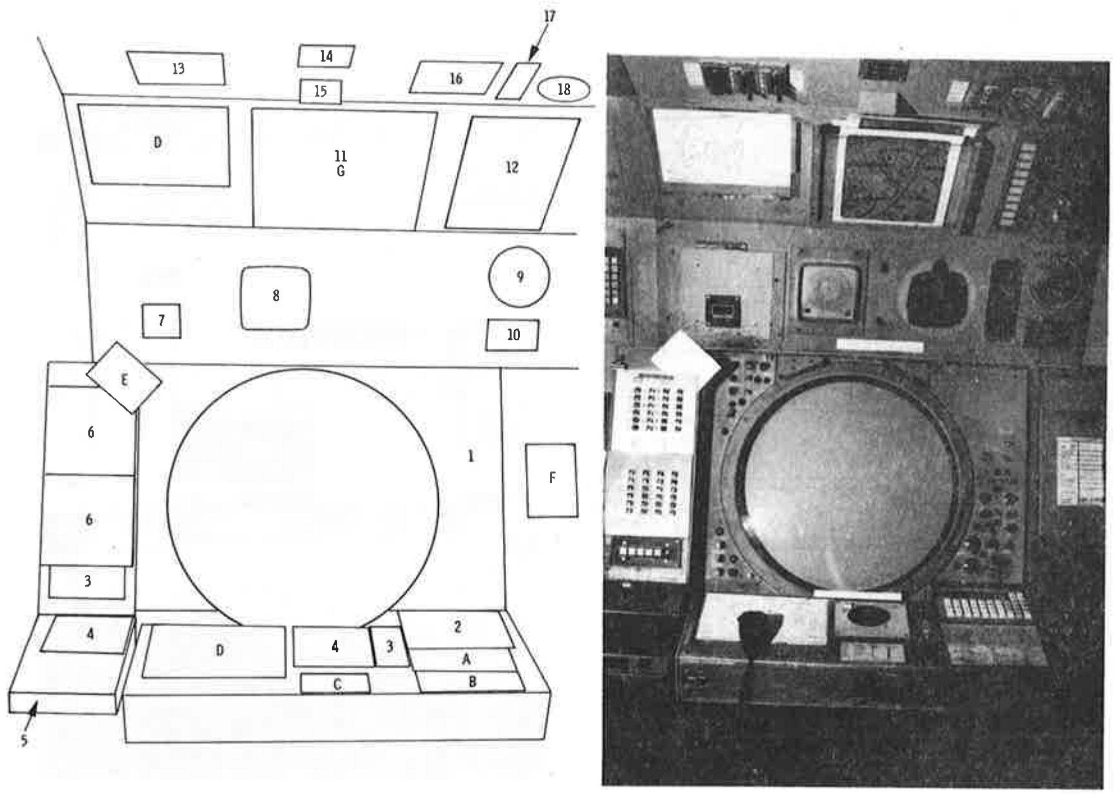
1 ARTS KEYBOARD
2 ARTS QUICKLOOK PANEL
3 ARTS TRACKBALL
4 PHONE JACK
5 TELCO DIAL BOX
6 TELCO KEYPACK
7 FLIGHT STRIP TRAYS
8 FLIGHT STRIP STORAGE
9 "RED" HOLE (FOR TRASH)
10 BEVERLY RWY. LIGHT SWITCH*
11 STATUS LIGHT FOR ITEM 10*
12 STRIP TRAY LIGHT-RHEOSTAT
13 STRIP TRAY LIGH-ON/OFF SWITCH
14 FUSE
15 DIGITAL CLOCK
16 WIND DIRECTION IND.
17 WIND SPEED IND.
18 HALO LIGHT SWITCH
19 MAP HOLDER
20 TELCO SPEAKER
21 HALO LIGHT

POSTED PAPER WORK

A CONT. BRIEFING CHECKLIST
B POSITION LOG
C CENTER SECTOR HANDOFF LIST
D LIST OF VOR/CENTER/APPROACH CONTROL/TOWER FREQUENCIES
E BED/BVY/AYE/FIT/LWM/309 STATUS

*No Longer Operational.

FIGURE 2-23. BD POSITION LAYOUT



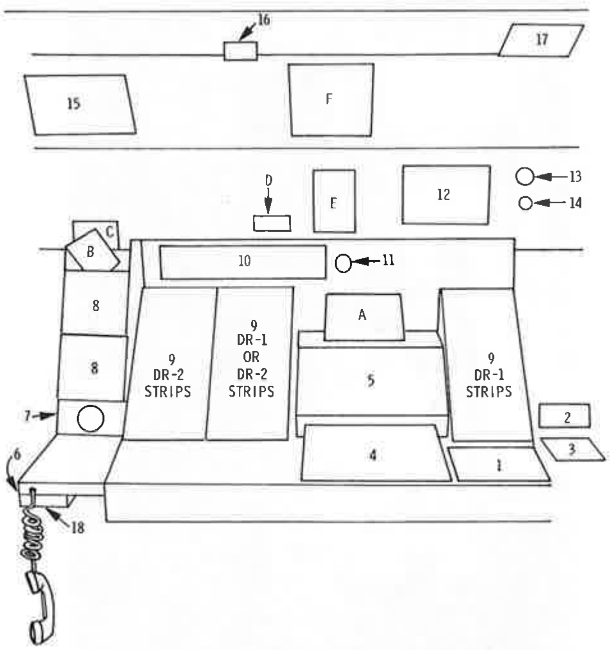
DEVICES

1 PLAN VIEW DISPLAY & ARTS III DISPLAY CONTROLS
2 ARTS KEYBOARD
3 ARTS QUICKLOOK DISPLAY
4 ARTS TRACKBALL
5 PHONE JACK
6 TELCO KEYPACK
7 DIGITAL ALTIMETER
8 TELCO SPEAKER
9 FAA SPEAKER
10 HALO LIGHT SWITCH
11 MAP HOLDER
12 BEACON DECODER
13 REC. FAA COMM. PANEL
14 VIDEO MAP SELECTOR
15 HALO LIGHT
16 XMIT. FAA COMM. PANEL
17 BACKUP FAA COMM. PANEL
18 FAA SPEAKER

POSTED PAPER WORK

A TERMINAL AREA FIXES/FREQS.
B ARTS III HANDOFF SHEET
C CENTER SECTOR HANDOFF LIST
D MIN. VECTOR ALTITUDE CHART
E POSITION LOG
F CONTROLLER BRIEFING CHECKLIST
G APPROACH CHART

FIGURE 2-24. DR-2 POSITION LAYOUT



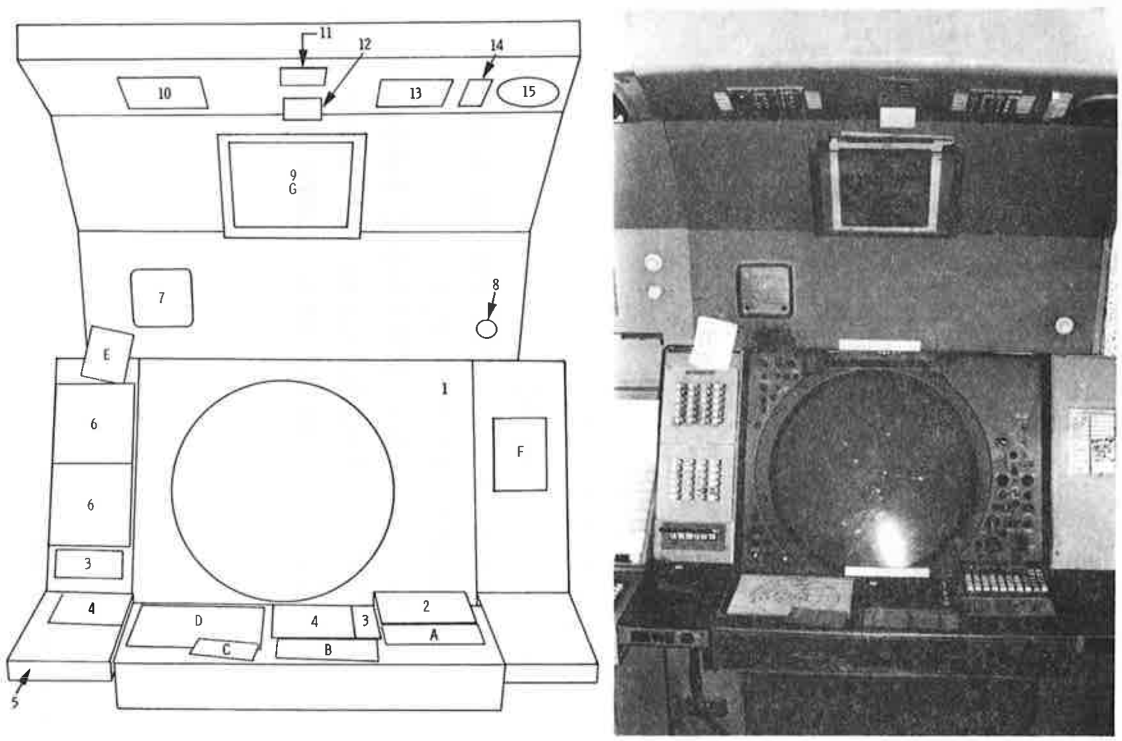
DEVICES

1 ARTS KEYBOARD
2 ARTS QUICKLOOK PANEL
3 ARTS TRACKBALL
4 FDEP TELETYPE
5 FDEP PRINTER
6 PHONE JACK
7 TELCO DIAL BOX
8 TELCO KEYPACKS
9 FLIGHT STRIP TRAYS
10 FLIGHT STRIP STORAGE
11 "RED" HOLE (FOR TRASH)
12 DIGITAL CLOCK
13 HALO LIGHT SWITCH/RHEOSTAT
14 STRIP TRAY LIGHT SWITCH/RHEO.
15 AURAL ALARM CONTROL
16 HALO LIGHT
17 TELCO SPEAKER
18 PHONE JACK (For Logan's Controller Station Simulator)

POSTED PAPER WORK

A FLIGHT STRIPS
B POSITION LOG
C CENTER SECTOR HANDOFF LIST
D DD/TD STRIP RESPONSIBILITY
E CONTROLLER BRIEFING CHECKLIST
F LIST OF VOR/CENTER/APPROACH CONTROL/TOWER FREQUENCIES

FIGURE 2-25. DD POSITION LAYOUT



DEVICES

1 PLAN VIEW DISPLAY & ARTS III DISPLAY CONTROLS

2 ARTS KEYBOARD

3 ARTS QUICKLOOK PANEL

4 ARTS TRACKBALL

5 PHONE JACK

6 TELCO KEYPACKS

7 TELCO SPEAKERS

8 HALO LIGHT SWITCH

9 MAP HOLDER

10 REC. FAA COMM. PANEL

11 VIDEO MAP SELECTOR

12 HALO LIGHT

13 XMIT. FAA COMM. PANEL

14 BACKUP FAA COMM. PANEL

15 FAA SPEAKER

POSTED PAPER WORK

A TERMINAL AREA FIXES/FREQS.

B ARTS HANDOFF LIST

C CENTER SECTOR HANDOFF LIST

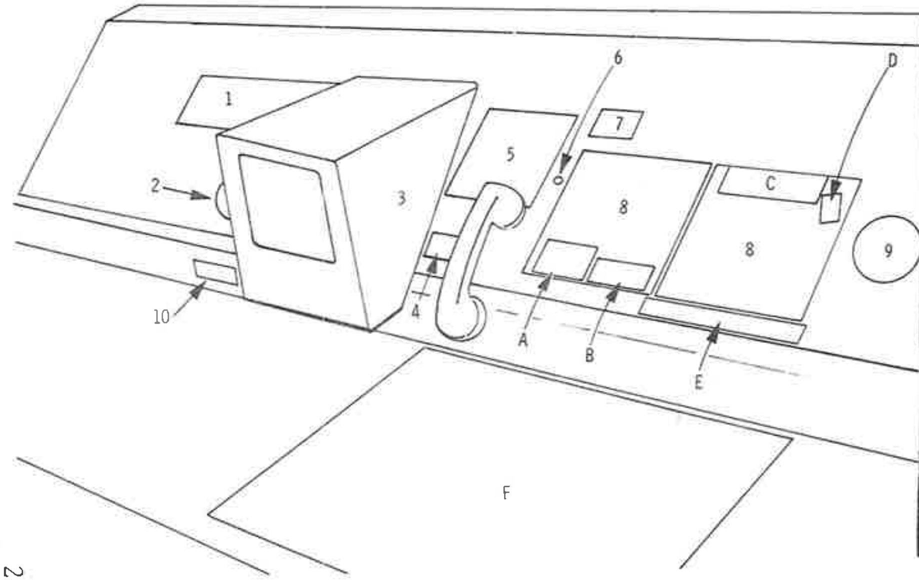
D MIN. VECTOR ALT. CHART

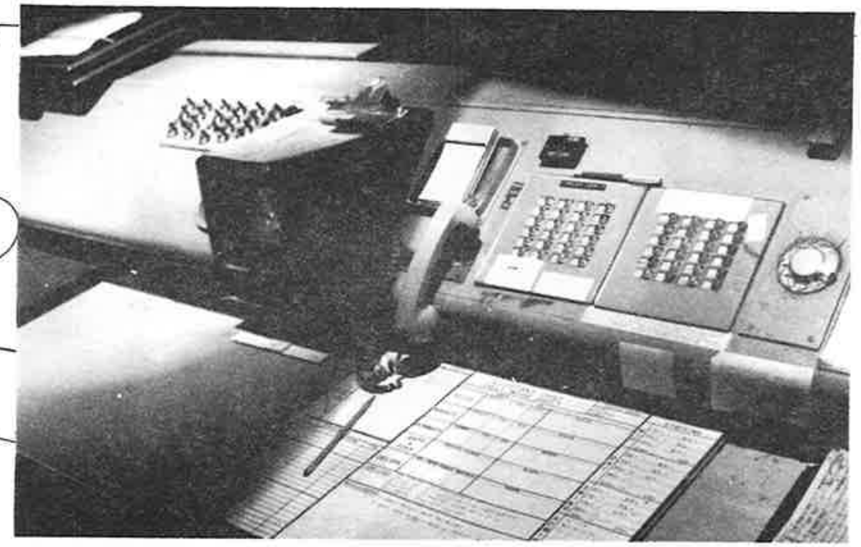
E POSITION LOG

F CONTROLLER

G APPROACH CHART

FIGURE 2-26. DR-1 POSITION LAYOUT





DEVICES

1 FAA COMM. PANELS
2 FAA SPEAKER
3 CONRAC MONITOR-ARTS DISPLAY
4 PHONE JACK
5 TELCO SPEAKER
6 SWITCH TO ACCEPT OUSIDE CALLS TO 19 FLR.
7 PHONE JACK TO CENTER'S METERING POS.
8 TELCO KEYPACKS
9 TELCO DIAL BOX
10 PHONE JACK

POSTED PAPER WORK

A PHONE NUMBERS
B METERING FLOW CONTROLLER NUMBER
C RUNWAY PRIORITY USE
D SINGLE DIGIT INTERPHONE DIRECTORY
E ROUTING INSTRUCTIONS FOR SCUPP ARRIVALS
F ASSISTANT CHIEF DAILY WORK SHEET

FIGURE 2-27. AC/TS POSITION LAYOUT

3. EQUIPMENT CHARACTERISTICS

The following three sections present the characteristics of each of the controller interfaces to be considered as a part of the consolidation program. Descriptions are from a controller's point of view. Presented for each interface are the controller positions at which the controller interface is located, the controllers who use the equipment, a photograph of the controller interface, and the pertinent interface characteristics. Appendix A presents summary descriptions for the systems associated with each interface from an engineering point of view and, in some cases, is referenced in the interface descriptions. These descriptions are used as the basis for the preliminary consolidated system design presented in Section 6.

3.1 OPERATIONAL DISPLAY INFORMATION

(1) Digital Clock-Time

A. In TRACON

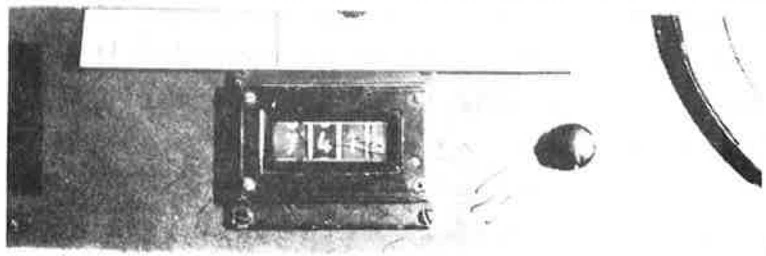
Locations in TRACON:

TC (Terminal Controller)
TD (Terminal Data)
AR-1 (Arrival Radar 1)
BD (Bedford Data)
DD (Departure Data).

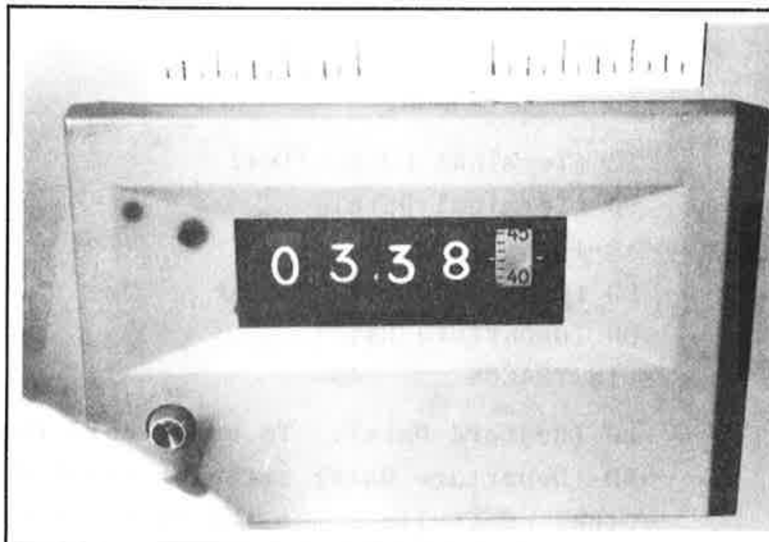
Users in TRACON:

BD (Bedford Data). To enter void time on the DD (Departure Data) strip of filed departures. Other controllers use the ARTS clock when ARTS is in operation.

Figure 3-1 (Photo 156)



TOWER CAB



TRACON

FIGURE 3-1. DIGITAL CLOCK - TIME DISPLAY

Characteristics:

Greenwich Mean Time (Zulu Time)

Hours 00 to 23, two digits

Minutes 00 to 59, two digits

Seconds 00 to 60, on drum

Digits approximately 0.5" high x 0.375" wide

Clock approximately 9.5" wide x 6" high.

B. In Cab:

Locations in Cab:

TS (Team Supervisor)

FD (Flight Data)

NLC (North Local Control)

SLC (South Local Control)

GC (Ground Control).

Users in Cab:

Local controllers record the time of departure (i.e., time airborne) on the departure strips. Ground Control uses during gate-hold procedures. All controllers use for pilot time checks and to reference items for the record (i.e., it's recorded on communication tape).

Figure 3-1 (Photo 252) Unit differs from that in the TRACON.

Characteristics:

Digits approximately 0.3" high.

Clock approximately 3" wide x 2.5" high.

(2) Altimeter

A. In TRACON

Locations in TRACON:

TC (Terminal Controller)
AR-1 (Arrival Radar 1)
DR-2 (Departure Radar 2)
- digital unit used primarily

Users in TRACON:

AR-1 and AR-2 (shared) on initial call-in

TC for arrivals of initial call-in

DR/FC use rarely (DR on fly thru's)

Figure 3-2 (Photo 169) for digital unit

(Photo 215) for analog unit at spare console.

Digital Unit Characteristics:

All displays fed from one altimeter

Inches of Mercury, in hundredths

4 digits with decimal point after first 2

Digits approximately 0.25" high by 0.20" wide

Unit approximately 3" wide by 3" high.

B. In Cab

Locations in Cab:

NLC/SLC (Location North/South)

GC (Ground Control).[1]

---

[1] Unit is covered by flight strip holders and note sheets. Can't be scanned very much by Ground Control.

Users in Cab:

Local Control and Ground Control refer to it infrequently - is on ATIS.

Will scan for rapid changes and give to pilot if not yet on ATIS.[1]

Figure 3-2 (Photo 56) Analog unit in Cab.

Analog Unit Characteristics:

28.00 to 31.00 scale - read in 4 figures

Calibration for each instrument written in white grease pencil on face of display with time of calibration (by Team Supervisor).

(3) Wind Direction and Speed Indicators

A. In TRACON

Locations in TRACON:

TC (Terminal Controller)

AR-1 (Arrival Radar 1)

AR-2 (Arrival Radar 2)

BD (Bedford Data).

Users in TRACON:

On ATIS - rarely used

TS (Team Supervisor) uses for configuration management.

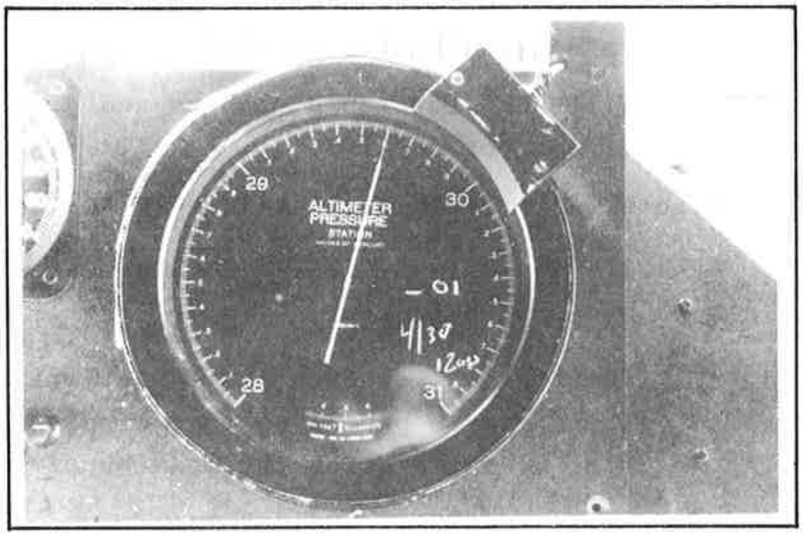
Figure 3-3

Characteristics:

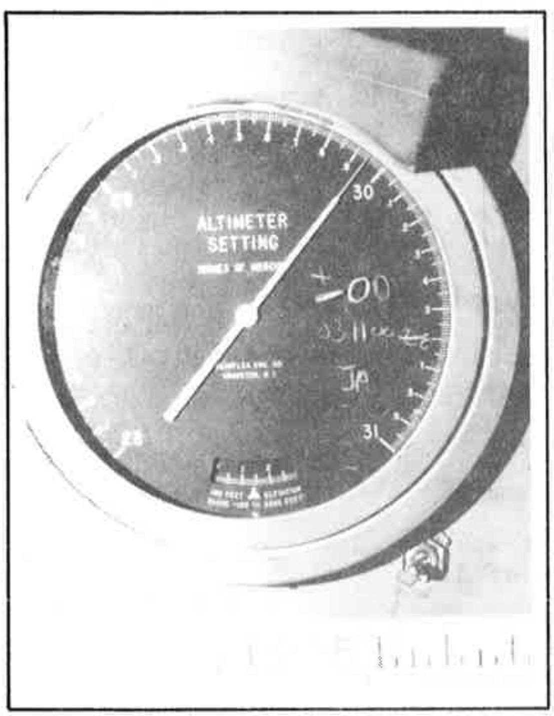
$\left.\begin{array}{l}\text{Degrees in units of 10}\\ \text{Speed in knots}\end{array}\right\}$ circular dials

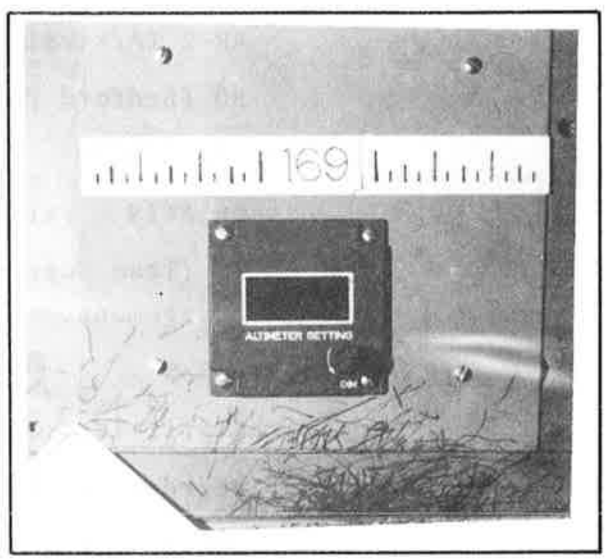
---

1 Unit is covered by flight strip holders and note sheets. Can't be scanned very much by Ground Control.



TOWER CAB





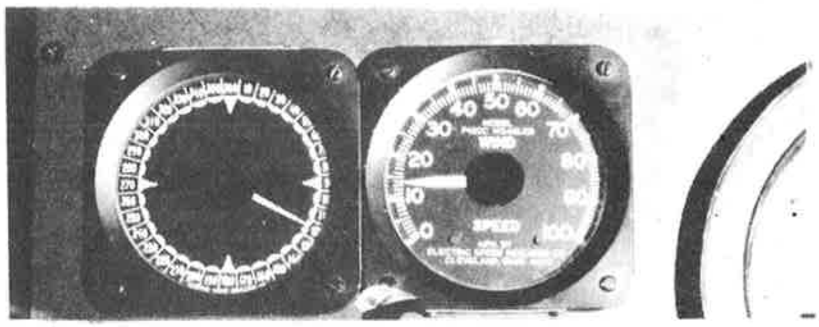
TRACON

FIGURE 3-2. ALTIMETERS

Wind speed lable 0.15" high

Wind speed units 0.25" high

Units approximately 4.5" wide by 4.5" high.



TRACON AND TOWER CAB

FIGURE 3-3. WIND POSITION AND SPEED INDICATORS

B. In Cab

Locations in Cab:

NLC (North Local Control)
SLC (South Local Control)
GC (Ground Control).

Users in Cab:

Local Control always gives winds to arrivals when giving clearance to land.

Ground Control seldom gives out. On ATIS and not so critical to departures. Scans for rapid and sharp changes not on ATIS.

Figure 3-3 - same unit as in TRACON.

(4) RUNWAY VISUAL RANGE (RVR)

A. In TRACON

Locations in TRACON:

AR-1 (Arrival Radar 1)

AR-2 (Arrival Radar 2)

FC (Final Controller).

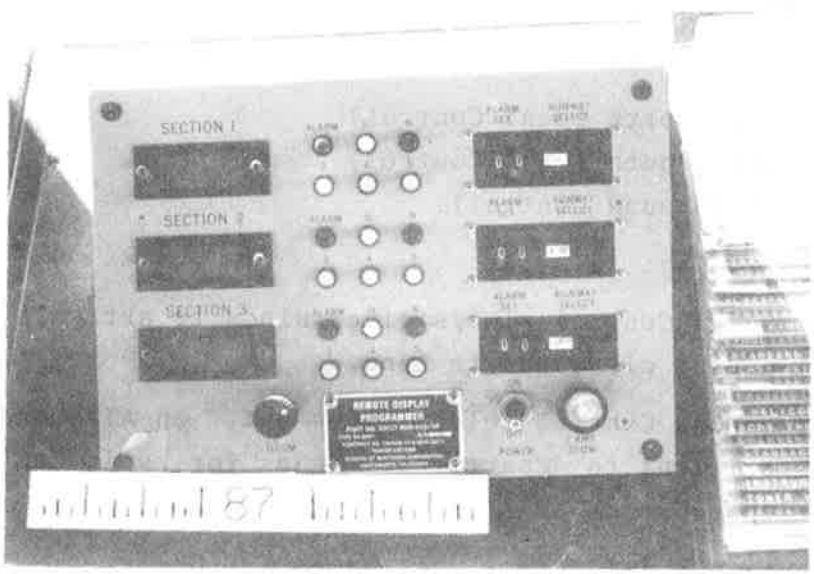
Users in TRACON:

All locations during IFR (<1.5 miles).

Scanned on every operation but relayed only if sharp change takes place since on ATIS.

Touchdown given - mid-range and rollout given if < touchdown and <2000 ft.

Figure 3-4 (Photo 87)



TRACON AND TOWER CAB

FIGURE 3-4. RUNWAY VISUAL RANGE INDICATOR

Characteristics:

Runway (RVR unit) select thumbwheel

Alarm setting is set in by thumbwheel

Alarm light and audible sound when below setting

Labels approximately 0.12" high

Setting digits approximately 0.25" high.

Day/Night declaration (not used) - two lights

Runway lighting setting (useful information, can effect RVR value) - 3 digits

RVR - 3 digits - RVR in hundreds of feet and alphanumeric.

Alphanumeric

E - Error

+ - Over 6,000 ft

. - T or Δ - In test

Digits approximately 0.3" high.

B. In Cab

Locations in Cab:

NLC (North Local Control)

SLC (South Local Control)

GC (Ground Control).

Users in Cab (during IFR):

Local Control uses alarm for arrivals

Ground Control advises departures - particularly if holds or delays

Local Control advises arrivals and departures.

Figure 3-4 (Photo 87). Same units as in the TRACON.

(5) Temperature and Dew Point

A new equipment requirement. No instruments currently furnish this. It comes from Weather Service via telautograph.

Units

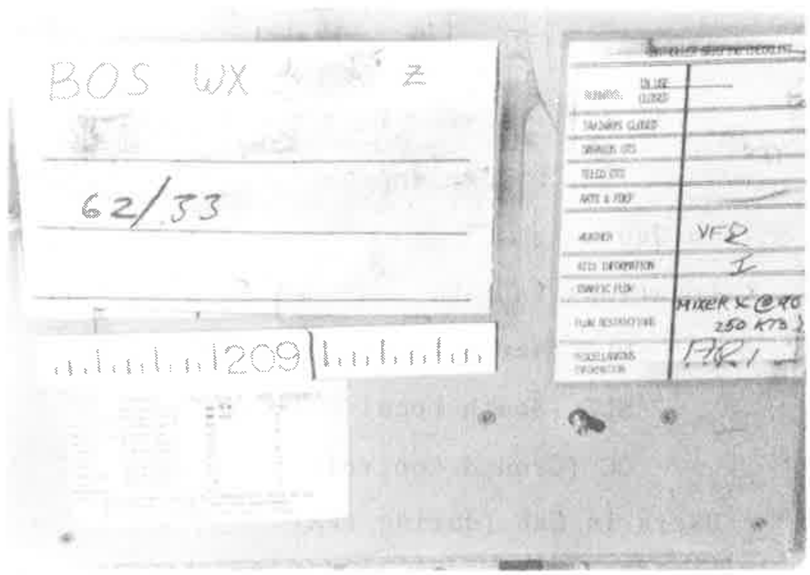
Temperature, degrees Fahrenheit

Dew point, degrees Fahrenheit

Temperature is always on ATIS, dew point is on ATIS occasionally.

A. In TRACON

Both items posted at Arrival Radar 2, available to Arrival Radar 1. Figure 3-5 (Photo 209).



TRACON

FIGURE 3-5. TEMPERATURE AND DEW POINT DISPLAY

B. In Cab

Used by Local Ground Control. Given on pilot request. Mostly temperature when given. Needed rarely. Controller walks over to the tel-autograph if it is needed.

(6) ATIS Code

A. In TRACON

Locations in TRACON:

Plan new displays

All radar control positions.

CONRAC monitor

TS (Team Supervisor).

Users in TRACON:

AR-1, AR-2 and TC confirm that the pilots of Logan arrivals have received the most current ATIS report by means of verifying the ATIS code received by the pilot.

B. In Cab

Locations in Cab:

BRITE displays/ASR presentation (not on the ASDE presentation)

GC (Ground Control)
LC (Local Control).

CONRAC monitor/ASR presentation

CD (Clearance Delivery).

Users in Cab:

CD confirms that the pilots of Logan departures have received the most current ATIS report by means of verifying the ATIS code. The code letter is changed whenever the ATIS report is updated.

3.2 CONTROL/STATUS PANELS

(1) ILS Monitor

A. In TRACON

Located at Team Supervisor position.

Users in TRACON:

Operated by Team Supervisor but visually available to all Boston arrival controllers. The unit is operated frequently during IFR. Alarms can come every 10 minutes.

Figure 3-6 (Photo 223)

Characteristics:

Operation of unit (see Appendix A)

Buttons - 0.72" square

4 window/light capability

Labels 0.1" high (very small, but legible).

Unit approximately 12" wide by 18" high.

B. In Cab

Located at North Local Control Coordinator/Team Supervisor positions.

Users in Cab:

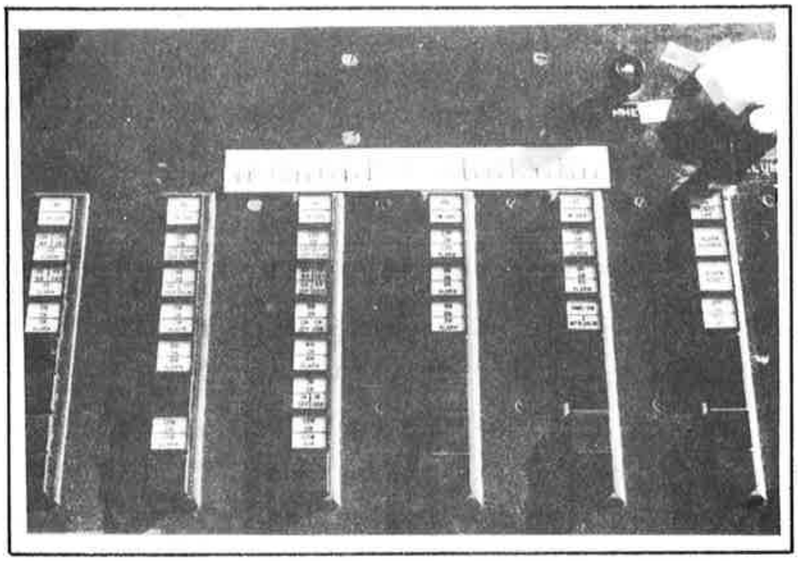
Team Supervisor operated as required.

Resets alarm if required.

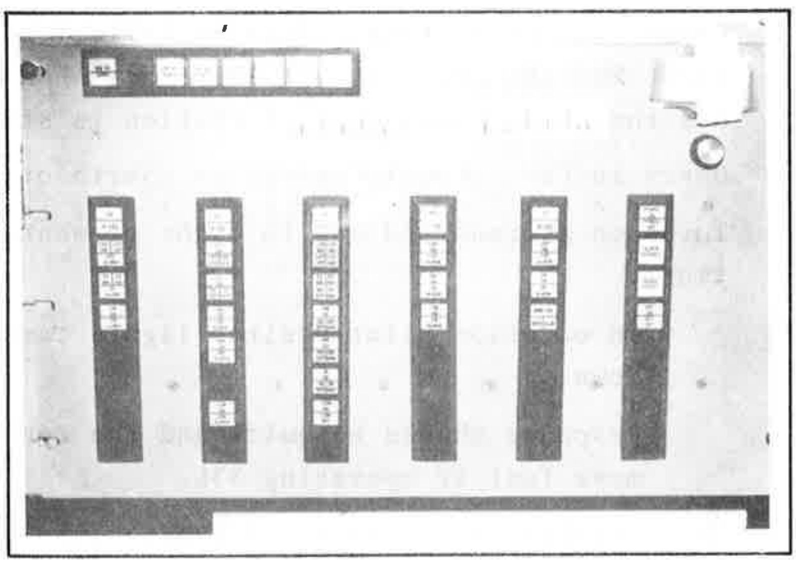
Coordinates with TRACON (prime operators).

Normally does not silence the alarm from the Cab. It is done in the TRACON. If he does silence it, he must coordinate with the TRACON.

No controls as in TRACON (except reset).



TOWER CAB



TRACON

FIGURE 3-6. INSTRUMENT LANDING SYSTEM PANEL

Local Control monitors from both positions.

Location poor for SLC.

Controller comment, "All positions should have status presented." Many alarms in bad weather.

Figure 3-6 (Photo 51) Unit is different than TRACON unit.

Row for control of 33L is not included.

(2) Approach Lighting System/Sequence Flasher Lights (ALS/SFL) - Located only in Tower Cab

Boston has ALSF2 on runway 4R and ALSF1 on runway 33L. Both units are standard 2400'/3000' high intensity approach lighting systems with sequence flasher lights. The sequence flasher lights are in Cat II configuration on 4R and Cat. I configuration on 33L. (See Figure 3-7.)

The controls for both units are located at the South Local Control station. This installation is inconvient for the operation of 33L since when 33L is in use the North Local Control station is staffed.

Users in Cab: Local Controller (North or South).

Turns on as required due to light or weather conditions.

On occasion pilot desires lights turned up or down.

Response should be quick and the controller must move fast if operating 33L.

Characteristics: Figure 3-8 (Photo 90)

Controls, Indicators, Alarms are described in Appendix A

Label characters approximately 0.15"

Unit dimensions approximately 7" wide by 5" high.

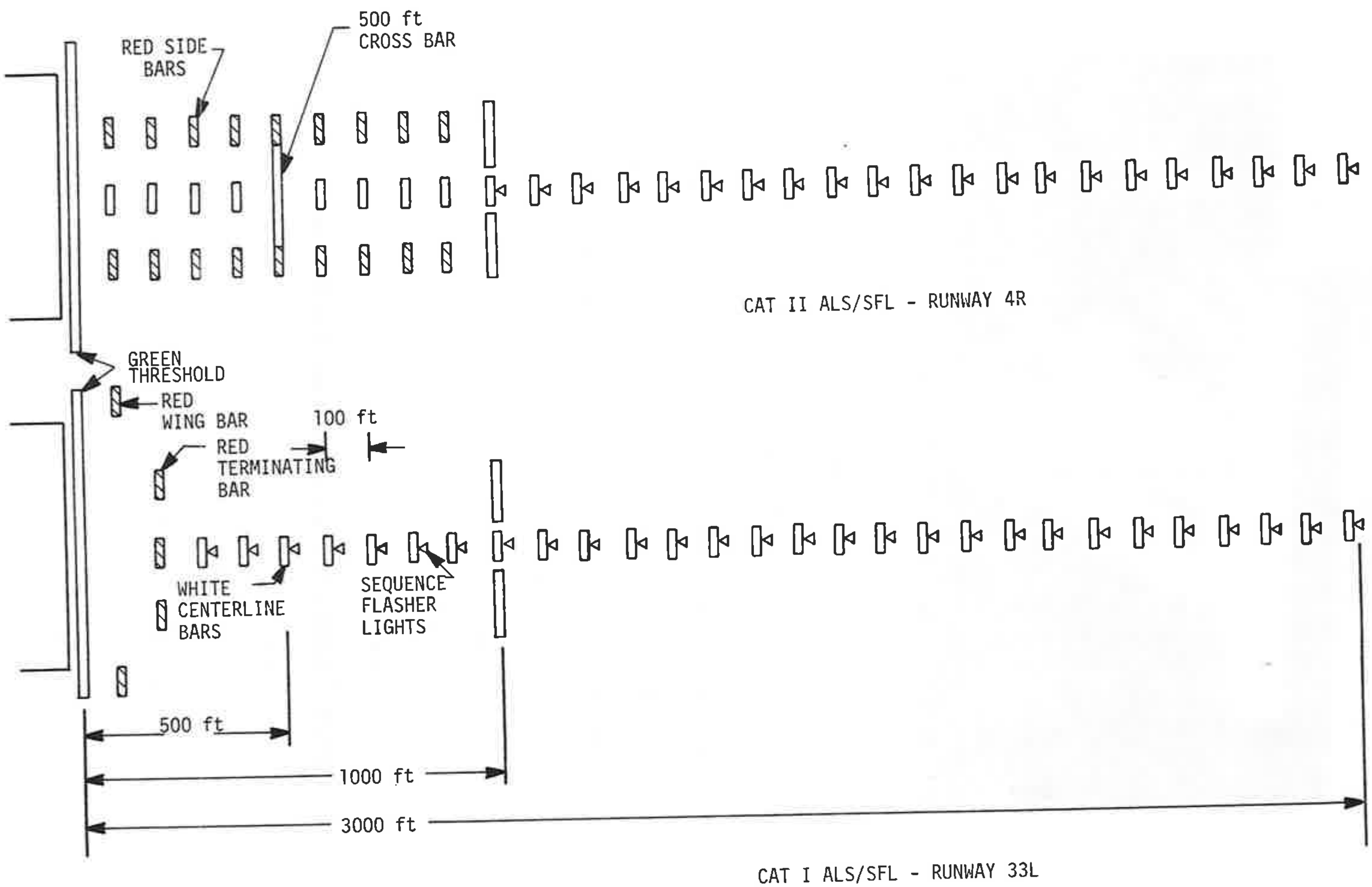
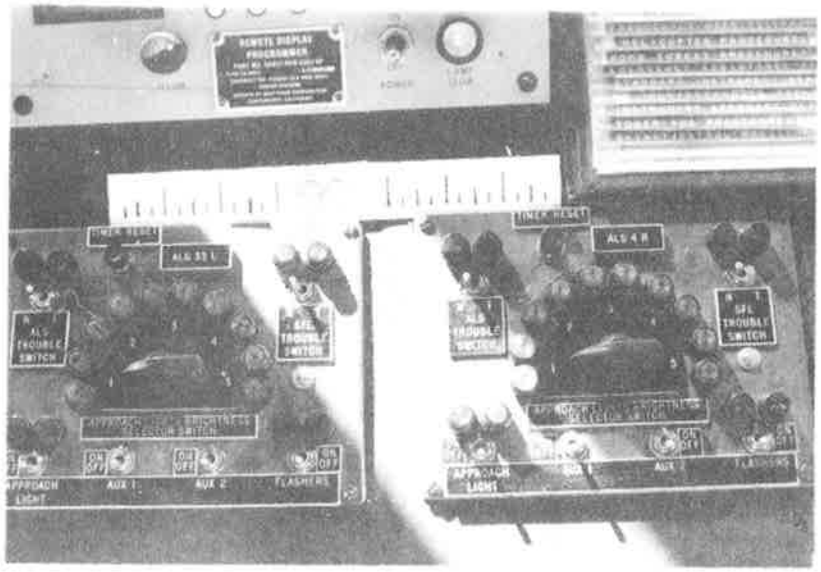


FIGURE 3-7. ALS/SFL DIAGRAM



TOWER CAB

FIGURE 3-8. ALS/SFL PANEL

(3) Field Lighting Panel - Located only in Tower Cab

Runway lighting

High intensity runway edge lights on

4L/22R

4R/22L

9/27

15R/33L

High intensity certerline lights on

4R/22L

15R/33L

Runway end identifier lights (REIL)

4L

22L

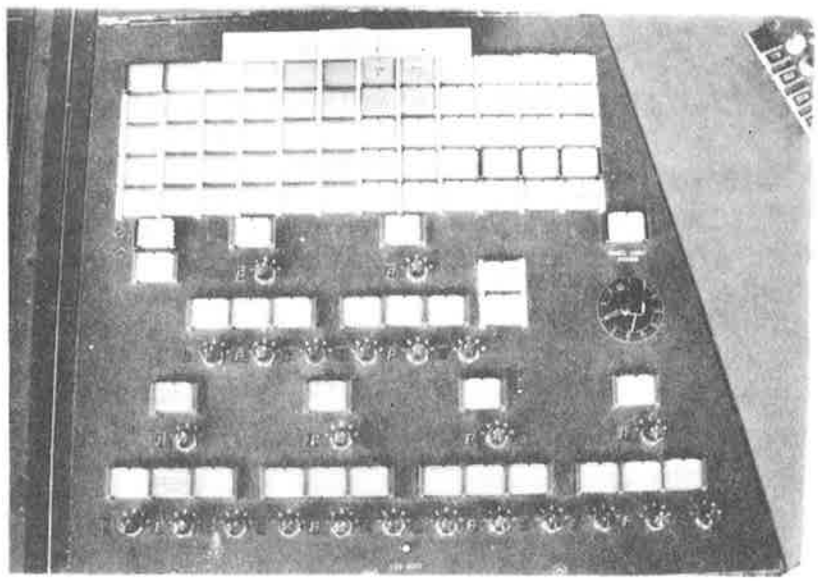
4R

Medium intensity runway edge lights

15L/33R

Touchdown zone lights on 4R.

These systems are controlled from the field lighting panel shown in Figure 3-9 (Photo 126) except that only the REIL on 4L is included. The other REIL are controlled by Massport via telephone. However, the controllers desired they be on the control panel.



TOWER CAB

FIGURE 3-9. FIELD LIGHTING PANEL

Taxiway lighting - segmented with the following segments:

Column 1 - T/W N

Column 2 - Outer No. 1

Outer No. 2

Column 3 - Main Inner T&L
Inner No. 1 & T
Inner No. 2 & 4L
Column 4 - Main J, F, H, G
Column 5 - T/W F, G, H, J
Main Allegheny & E
Main Outer & K
Column 7 - T/W D
Column 8 - Main C1, C2, C3, D
T/WC2
T/WC1
Column 9 - T/WC3
Column 10 - T/W S1 & E
South Apron Inner
Column 11 - South Apron Main
Column 12 - South Apron Outer.

The unit is located in the center island behind Ground Control, between the two Local Control positions. The systems are turned on by whomever is near the panel and free. On occasion, Local Control changes the runway light intensity at pilot request. Sometimes, Local Control turns up the edge lights if a pilot is unfamiliar with the airport to help him locate the prescribed runway. Also, on a rare occasion, Ground Control will turn a segment of taxiways on/off to cue a pilot which direction to travel.

Characteristics:

No status/alarms come to this panel. Field lighting status/alarms come from Massport via telephone.

The lights are turned on/off by pushbuttons, which are back lit and covered by a hinged plastic cover which must be opened to press the button. The cover guards against accidental switching of lights. When on, the button light intensity is increased to indicate the associated lights have been selected. It does not indicate the field lights are actually on.

There are 60 switches available for taxiway segments with 19 used.

Switches are approximately 1 inch square.

Label characters are approximately 0.13" high.

There are twenty-four runway lighting system controls available for runway lights with eight used.

Each control consists of an on/off button and a 5-position rotary switch for intensity selection. The selected intensity is displayed beside the rotary switch.

Other switches on the panel are:

Panel LTS CKT BRKR - turns the lighting panel on and off.

Rotary switch below Panel LTS -- controls the panel light intensity.

CKT BRKR Off/On - resets the panel circuit breaker if it trips - this rarely happens.

LTG Vault Con Power On - purpose unknown to controllers.

Unit dimensions are approximately 16.5" wide at the top, 23" wide at the bottom, and 17" high.

(4) Visual Approach Slope Indicator (VASI) located only in the Cab

Boston has VASI on

22L

27

15R

33L

The units on 33L and 22L are automatically controlled by photo optic cells. The 15R unit simply has an on/off switch and is shown in Figure 3-10 (Photo 124). The 27 unit has intensity levels (low and high, medium is not operational) and is shown in Figure 3-10 (Photo 123). There is no automatic status feedback. Status is normally provided by pilot reports.

The units (15R, 27) are located at the center island behind North Local Control.

Users are Local Control or Team Supervisor. Settings for 27 are normally

High 30 min before sunrise

Low at sunrise

High at sundown

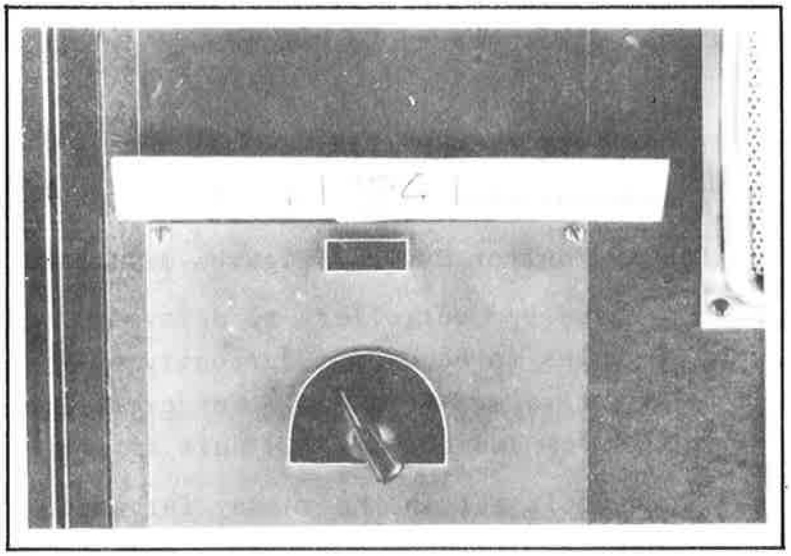
Low at 30 min after sundown.

Pilots rarely request intensity change.

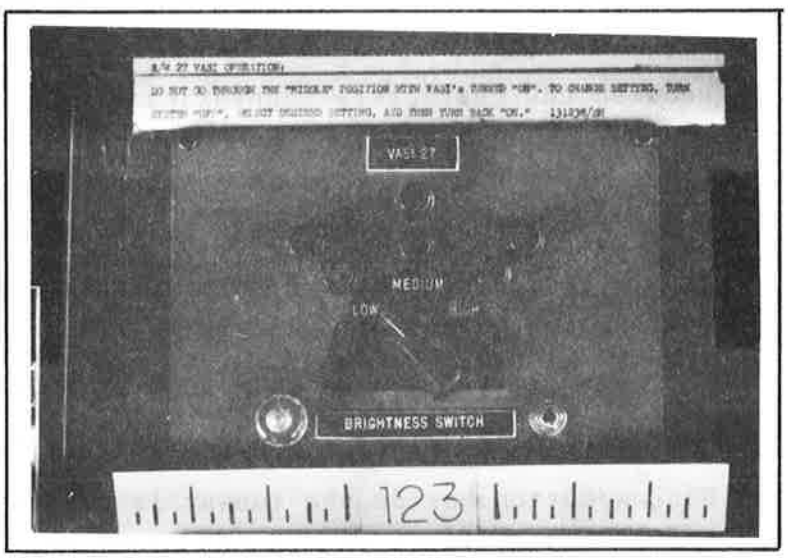
Characteristics:

Label characters approx. 0.15" high

Unit dimensions approx. 6.5" wide x 4.5" high.



TOWER CAB



TOWER CAB

FIGURE 3-10. VASI PANEL

3.3 NEW EQUIPMENT

The following two systems are planned for Boston but are not currently installed. They are to be considered in the consolidation program.

(1) Vortex Advisory System (VAS)

Characteristics:

Runway Monitor System (Figures 3-11 and 3-12)

Used by controllers to determine separation rules to be used. Currently only used for arrivals. Plans call for extension to departures, and the display unit is set up for this.

Thumbwheels set in the runway for which information is desired.

4 characters - A/D (Arrival Use/Departure Use) and runway designation.

Approximately 0.2" high labels on runway characters.

Reddish LED characters (approximately 1.4" high) indicate wind direction, speed and gusts (3 characters, 2 characters, 2 characters, respectively) on the sensor associated with the selected runway.

Window beside wind data gives separation rules (either 3-6 in red or 3 in green).

Window is approximately 0.72" x 0.72"

Label characters are approximately 0.1" high.

Window/button beside the runway is pushed to turn the display unit on or off (to standby). In the event of a VAS sensor unit failure on the selected runway, the fail light (above on) is lit (red).

Unit dimensions approximately 6.5" wide by 3.5" high.

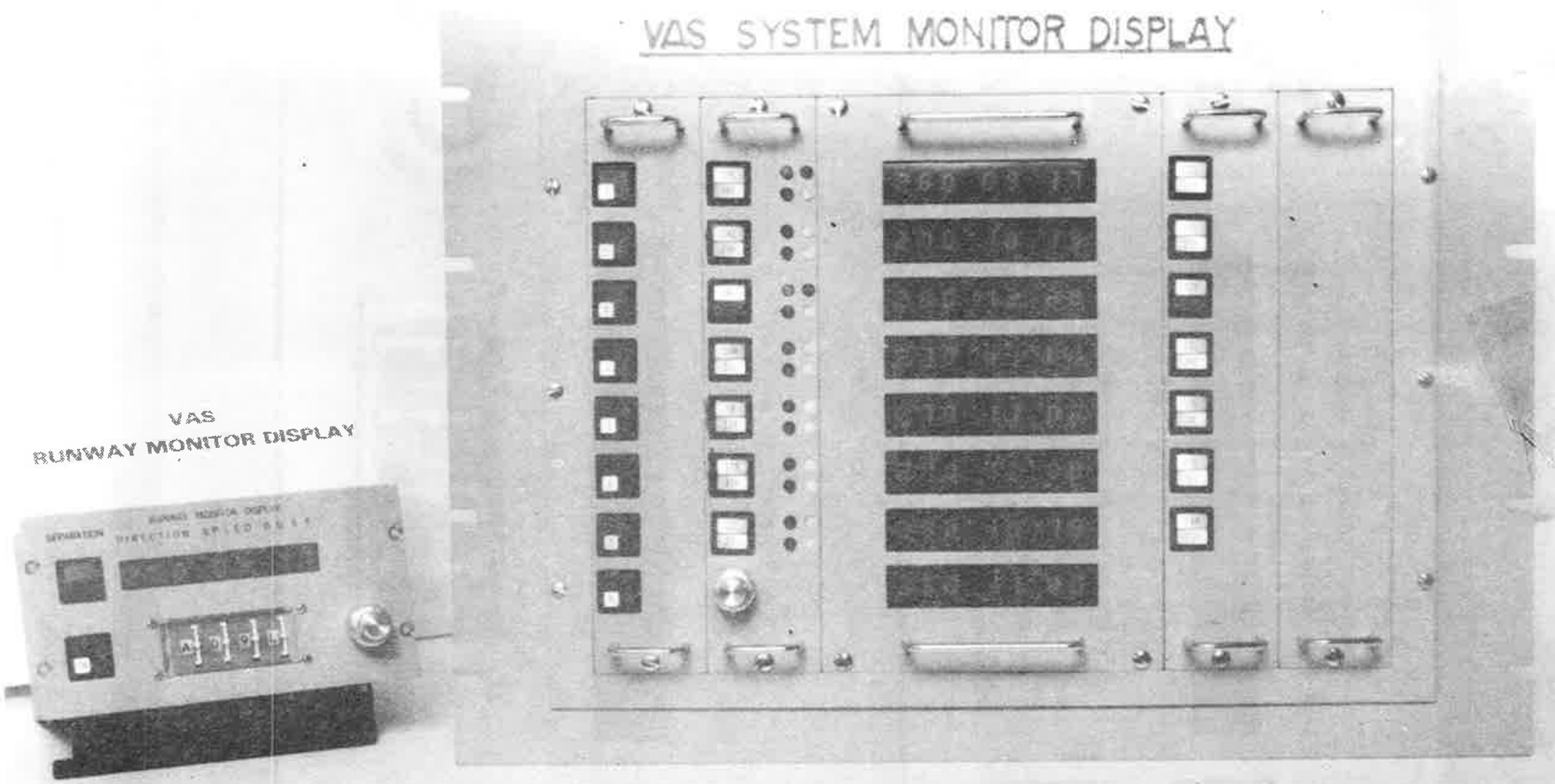


FIGURE 3-11. VAS MONITOR DISPLAY

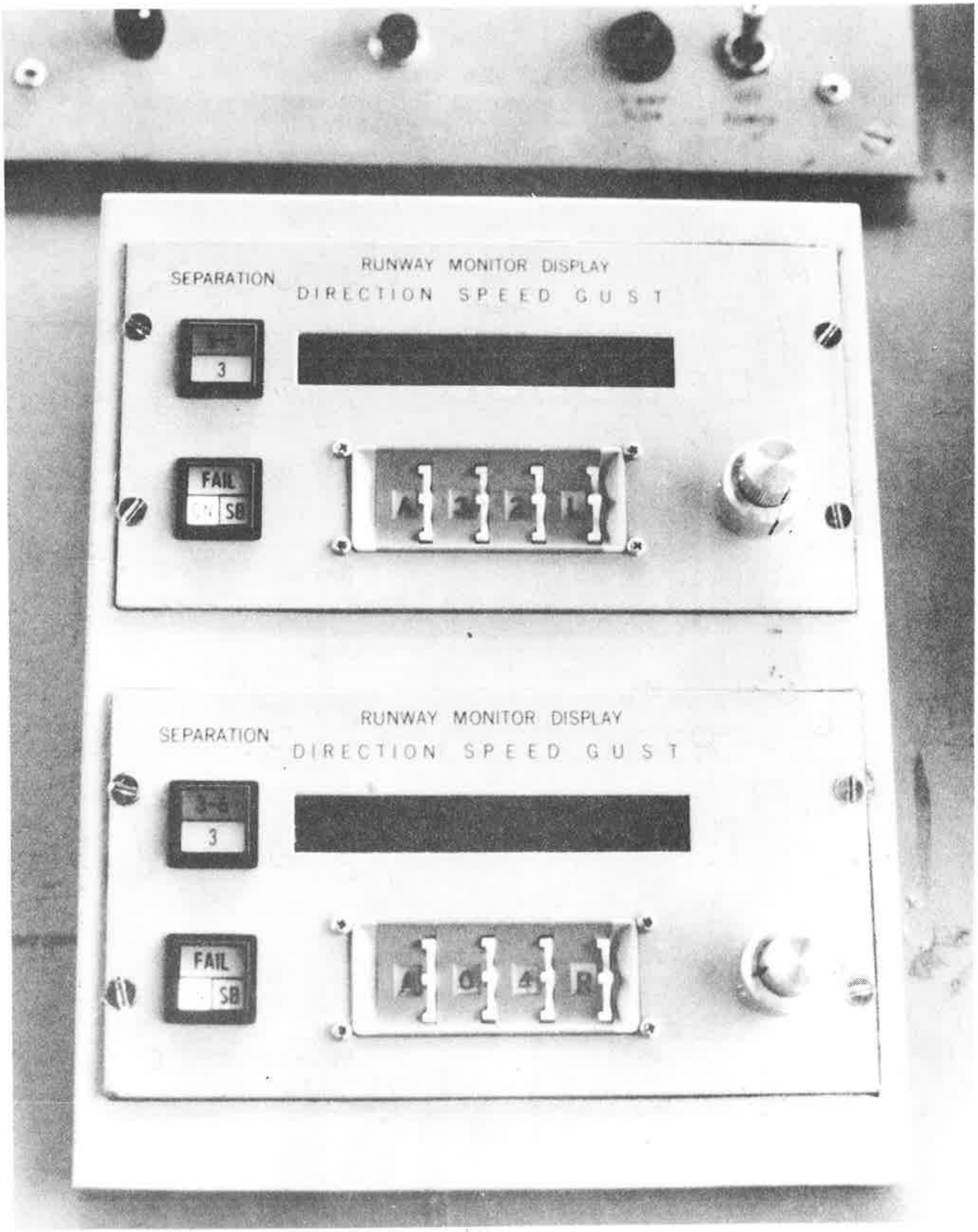


FIGURE 3-12. VAS RUNWAY MONITOR DISPLAY

System Monitor System (See Figure 3-11)

Used by AF in the equipment room and by Team Supervisors in the TRACON and the Cab to get a system overview (operational information and sensor status).

Unit displays a line for each wind sensor unit.

Window/button at the left indicates the unit number and the unit status (failed or O.K.). If the sensor data from the unit has been selected for display, the window/button unit number is lit. If not, the number is out and standby is lit. Selection/de-selection is made by sequentially pushing the button.

Windows in column two indicate the arrival runways for which each sensor is used. Lights following each runway indicate arrival separation rule which applies to that runway (red for 3-6, green for 3).

LED characters give wind associated with the sensor (as on the runway monitor display).

Windows in the column to the right of the winds indicate the departure runways for which the sensor will be used when algorithms are developed. Lights separation rule which applies to that runway.

Centerfield wind status and readings are also included on this panel.

Unit dimensions are approximately 19" wide by 10.5" high.

A. In TRACON

Runway Monitor is installed at each approach control position at O'Hare - 1 unit each. Assuming the same for Boston.

AR-1 (Arrival Radar 1)

AR-2 (Arrival Radar 2)

FC (Final Controller)

Terminal Controller would not require the unit. He either lands light traffic on the secondary runway under the 3 mile rule or hands off to another approach controller for mixing with other traffic.

System Monitor is installed for the Team Supervisor.

B. In Cab

Runway Monitor is installed at each local control position at O'Hare - 2 units each (since one local controller handles arrivals and departures). Assuming the same for Boston

NLC (North Local Control)

SLC (South Local Control).

System Monitor is installed for Team Supervisor.

(2) Surface Wind Measurement System (SWMS)

A. In TRACON

Intended primarily for use by Local Control in the Cab. However, approach controllers may require information to prepare for the potential for voluntary missed approaches. This study will assume that approach controllers require the information.

TS (Team Supervisor)

FC (Final Controller)

AR-2 (Arrival Radar 2)

AR-1 (Arrival Radar 1)

TC (Terminal Controller).

B. In Cab:

In the event of an alarm, Local Control informs the arrivals of the shear and its extent (by providing the centerfield and alarming winds). The information is advisory but may result in a voluntary missed approach.

NLC (North Local Control)

SLC (South Local Control).

Figure 3-13

Characteristics:

Centerfield wind across top of display

Direction, speed, gusts

Incandescent flatpack display (orange)

Approximately 3/4" high.

Boundary Winds below centerfield winds

2 characters fixed label (geographic location) on airport

3 characters direction (5/8" high-orange)

2 characters speed (5/8" high-yellow/green).

Push-push button before centerfield wind for "light all flat packs for filament check,"

Push-push button before each boundary wind display wind always or put in automatic mode.

<u>Automatic mode</u> - When boundary wind(s) vary from centerfield in excess of a certain threshold, the boundary winds are displayed and an audible alarm is sounded for 1 second.

Unit dimensions approx. 9" wide by 10" high.

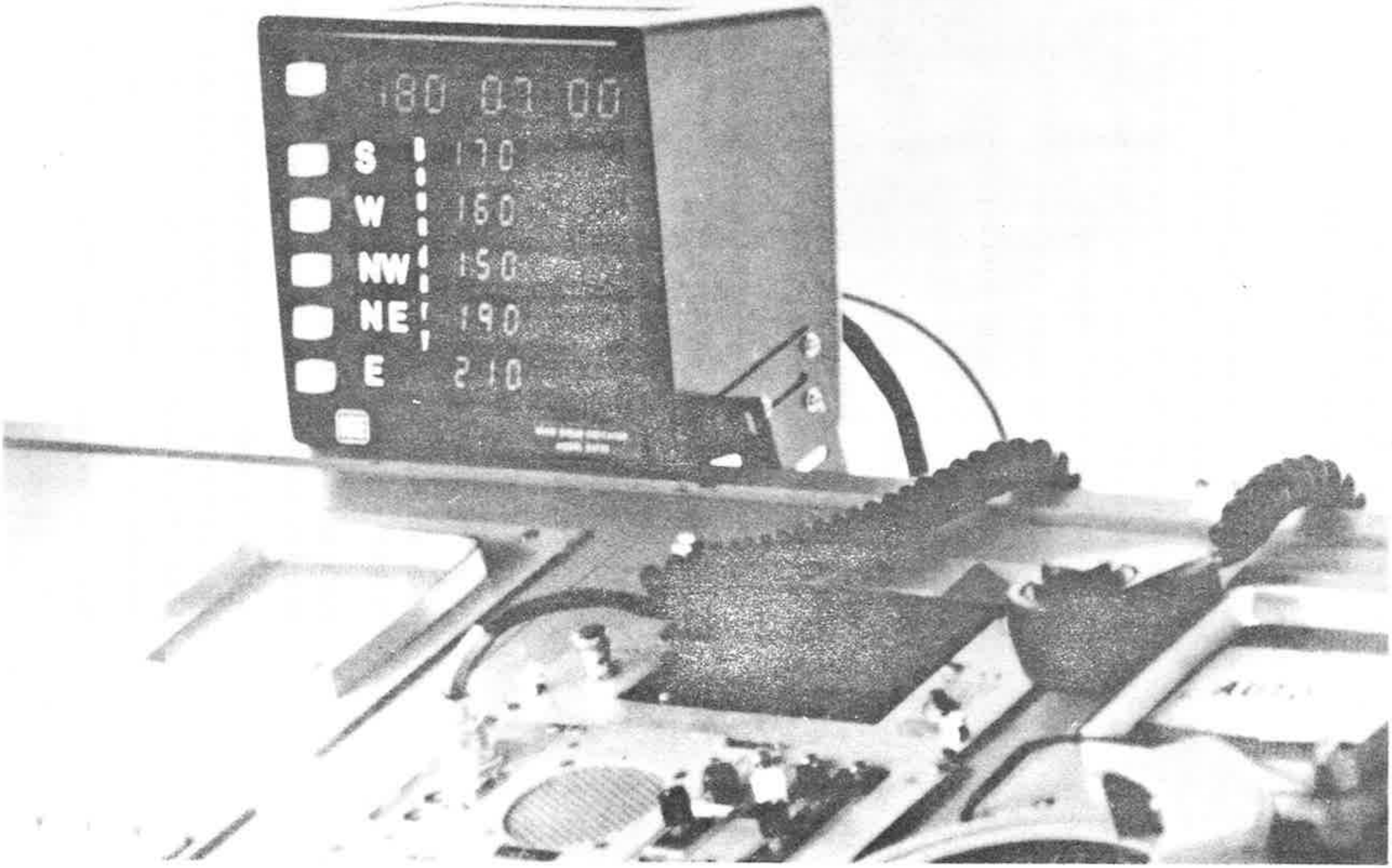


FIGURE 3-13. SWMS SETUP

4. SYSTEM REQUIREMENTS

4.1 STATUS INFORMATION

The study was intended to investigate the automatic display of all current status information. To determine what comprised the current information status at Boston, discussions were held with controllers and supervisors. To facilitate discussions, status was classified as local status on the equipment installed locally at Boston Logan and secondary status on equipment installed away from Boston Logan such as at the secondary airports of the Boston terminal area. The status requirements for the Cab are given in Table 4-1.

TABLE 4-1. CAB STATUS

LOCAL CAB STATUS	POSITIONS OF PRIME INTEREST
RVR√	TS, GC, LC
FAA radio (frequencies)	TS, GC, LC, CD, FD
TELCO	TS, GC, LC, CD, FD
ATIS	TS, GC, LC
ILS/NAVAIDS√	TS, GC, LC
ASDE	TS, GC, LC
ALS/SFL√	TS, GC, LC
Field Lights	TS, GC, LC
BRITE	TS, GC, LC
VASI	TS, GC, LC
FDEP	TS, GC, LC, CD, FD
Telautograph	TS, GC, LC
SECONDARY CAB STATUS*	
Pease VOR	TS, CD
Chester VOR	TS, CD
Manchester VOR	TS, CD
Providence VOR	TS, CD
Hyannis VOR	TS, CD

*VORs which effect Standard Instrument Departure.
√Currently automatic monitoring.

All local Cab equipment is listed under local Cab status and that equipment with automatic monitoring is checked. Where there is no automatic monitoring, outages are normally found by a controller trying to use the equipment (e.g., a radio frequency channel failure of the TELCO line outage) or by a pilot who reports the outage to a controller (e.g., on a VASI or field light segment). The controller informs the Team Supervisor who informs Airway Facilities (or Massport in the case of field lights) and controllers with a need to know. The Supervisor logs the outage (on the Daily Record of Facility Operation log) and controllers may (if deemed necessary) note the information on a blank flight strip or their briefing check list. When the outage is corrected, Airway Facilities notifies the supervisor who logs the correction and informs the controllers.

In discussions it was pointed out that while automatic status on continuously used equipment such as the Brite Radar Indicator Tower Equipment (BRITE), is not required (they know right away when a BRITE goes out), it would be very useful on intermittantly operating equipment such as FDEP and the telautograph. Currently when these items fail, it must be observed by the Cab that no messages have come for a while. However the lack of messages can be normal during a slow period and so it may be a long time before it is determined that the equipment has gone down.

As can be seen in Table 4-1, the Team Supervisor, Local Control, and Ground Control require all local status while Clearance Delivery and Flight Data need relatively little. However, Clearance Delivery needs the status of VORs which offer the Standard Instrument Departure (SID) routes. (See Secondary Cab Status, Table 4-1.)

The local status for the TRACON is shown in Table 4-2A. TRACON secondary status is shown in Table 4-2B. Local status is handled pretty much as in the Cab. However, secondary status is handled somewhat differently. The sources for secondary status are the secondary airport towers and the Boston Flight Service Station (which prepares the associated NOTAMS). This information comes by TELCO, or telephone, to the pertinent data position in the

TABLE 4-2A. TRACON STATUS (LOCAL)

LOCAL TRACON STATUS	POSITION OF PRIME INTEREST
RVR*	TS, AR-1, AR-2, FC
FAA radio (frequencies)	TS, all radar positions
TELCO (lines out)	TS, all positions
ATIS	TS, AR-1, AR-2, TC, CI
ILS/NAVAIDS*	TS, AR-1, AR-2, FC, TC, CI
ASR	TS, all radar positions
ARTS	TS, all radar positions
FDEP	TS, TD, BD, DD, CI
Telautograph	TS, CI, BD
ARSR	TS, BD, AR-3
Boston VOR/DME	TS, all radar positions

*Currently have automatic monitoring.

TRACON (e.g., Bedford Data for NAVAIDS of the Bedford Secondary Airspace) who reports to the Team Supervisor for his information and logging, and directly to the Team Supervisor in the Cab. Subsequently, an outage NOTAM is received in both facilities on the teleautograph. When the outage is corrected, the associated NOTAM is also received at both facilities. The correction is logged and the information is distributed to the controllers.

4.2 EQUIPMENT REQUIREMENTS

The types of equipment to be considered are listed in Table 1-1 along with the operational display data required. Table 4-3 shows the distribution of that equipment and the status information discussed in the previous section. Except for VAS and SWMS, the "X" denotes that the controller either is a user (based upon controller discussions) or has the equipment located at his position. Boston does not have VAS or SWMS. However, a VAS operational display (runway monitor) was noted for both Local Control positions

TABLE 4.2B. TRACON STATUS (SECONDARY)

EQUIPMENT	TS	FC	AR-2	AR-1	TD	CI	TC	AR-3	BD	DR-2	DD	DR-1
Norwood												
LOC (IOWD)	X			X		X	X					
LOM (STOGE-OW)	X			X		X	X					
MM	X			X		X	X					
Whitman VOR(HTM)	X			X		X	X					
Weymouth												
NDB(NZW)	X			X		X	X					
PAR	X			X		X	X					
TACAN	X			X		X	X					
Bedford												
ILS (IBED)	X					X		X	X			
Shaler Hill NDB (SKR)	X					X		X	X			
Dickenson NDB(DKO)	X					X		X	X			
Fitchburg NDB(FIT)	X					X		X	X			
Beverly NDB(TOF)	X					X		X	X			
Lawrence VOR(LWM)	X					X		X	X			
Haget NDB(HGX)	X					X		X	X			
Gardner VOR(GDM)	X		X			X		X				
Pease VOR(PSM)	X		X			X		X		X		X
Manchester VOR(MHT)	X		X			X		X				X
Hyannis VOR(HYA)	X		X	X		X				X		
Providence VOR(PVD)	X		X	X		X				X		
Chester VOR(CTR)	X									X		
Kennebunk VOR(ENE)	X		X	X								

TABLE 4-3. EQUIPMENT DISTRIBUTION

	TOWER CAB									TRACON											
ITEMS TO CONSIDER	TS	NLCC	NLC	GC	SLC	SLCC	HV	CD	FD	TS	FC	AR-2	AR-1	TD	CI	TC	AR-3	BD	DR-2	DD	DR-1
OPERATIONAL DISPLAY DATA																					
DIGITAL CLOCK	X		X	X	X				X				X	X		X		X		X	
ALTIMETER SETTING			X	X	X						X	X	X			X			X		X
CENTERFIELD WIND			X	X	X					X		X	X			X		X			
RVR			X	X	X						X	X	X								
TEMPERATURE/DEW PT.			X	X	X							X	X								
VAS(Runway Monitor)			X		X						X	X	X								
SWMS			X		X					X	X	X	X			X					
ATIS	X			X	X			X		X	X	X	X			X					
CONTROL/STATUS PANELS																					
RVR			X	X	X						X	X	X								
VAS(System Monitor)	X									X											
SWMS			X		X						X	X	X			X					
ILS MONITOR	X		X		X					X	X	X	X								
ALS/SFL			X		X																
FIELD LIGHTS																					
RUNWAY			X		X																
TAXIWAY				X																	
VASI	X		X		X																
STATUS INFORMATION																					
LOCAL SUBSET			X	X	X			X	X		X	X	X	X		X	X	X	X	X	X
SECONDARY SUBSET								X			X	X	X	X		X	X	X	X	X	X
ALL STATUS	X									X					X						

and for three approach control positions, and a control/status panel (system monitor) was noted for both Team Supervisors. This is generally how VAS is installed at Chicago. The SWMS unit (both display and control/status integrated) was noted for both Local Control positions and all four Approach Control positions.

Table 4-3 indicates that in the Cab, Local Control has the most extensive requirements for operational display data and control/status panels. In the TRACON, the most extensive requirements exist at Arrival Radar 1. Arrival Radar 1 will demand an operational display format which includes all items to be considered. Local Control very nearly requires all items on the operational display and also, very nearly all control/status panels.

5. HARDWARE SELECTION

This section describes the hardware which was selected as the basis for the preliminary system design. The selection was based upon a brief survey of available flexible format data entry devices which is presented in Appendix B.

5.1 SYSTEM CONCEPT

The concept aimed at providing for the requirements consists of two physically identical flexible touch-entry panels. One would be used as an operational display, the other would be used as a controller-paged set of control/status panels. The operational display would be available as a page of the control/status unit so the latter unit could provide a backup in the event of operational display unit failure. In addition, the units would be light weight (e.g., less than 20 lbs), would be built to simply slide into the console and plug in when seated, and would be interchangeable to facilitate repair and minimize downtime. The units would eliminate all current equipment in Table 4-3 and provide a flexible system of paged panels for growth (e.g., to add weather, NOTAMS, new equipment controls).

5.2 DISPLAY SELECTION

For the display associated with both units, a CRT monitor was chosen. For the Cab, a high brightness tube would be used. For the TRACON, a normal tube would suffice. The monitors and software driving the monitors would be identical to facilitate repair and the stocking of spare parts.

The constraint on the monitor size was taken from the TRACON positions. The monitor selected should be as large as possible while still readily permitting installation above the ARTS. The dimensions should be no larger than 10 inches in height and 13 inches in width, The pacing dimension is the height. The monitor should use a 15 inch tube which provides at least an 8 inch high by 11 inch wide useable display area. The tube is readily available and a monitor using it is owned by FAA NAFEC. The installation in the TRACON at Arrival Radar 1 is shown in Figure 5-1. In addition, a Cab installation at North Local Control is shown in Figure 5-2. In both cases installation appears straightforward.

The devices passed over in selecting a CRT monitor were a plasma dot matrix and a set of incandescent characters. The first alternative was excluded due to the excessive development required (see Appendix B) and the questionnable performance in high ambient light. The second alternative was excluded due to its inflexibility in format presentation relative to a CRT monitor. The smallest characters are quite large (0.3 inches high) and require a good deal of space between them. This makes the labeling of control buttons difficult. Either the buttons must be very big or very far apart, both of which are wasteful of space. The capability to display small alphanumerics for labels and large alphanumerics for operational information at any location on the display is possible with the CRT monitor and is useful, if not required, in the design of panel formats.

It should be pointed out that the use of a bright, high contrast CRT as a basis for a flexible format data entry device does have potential problems. Experience with the new high contrast tube for the BRITE display monitor currently being installed in the tower cabs has revealed a problem with finger prints. Oil from the controllers fingers which can be deposited on the display while pointing out targets tends to reflect light. This can make the display difficult to read and some controllers have complained about this. If a high contrast anti-reflective coat is used on the flexible format data entry unit, this could be a serious problem, a problem which the incandescent characters would not have. While there have not been resources available in this study, incandescent characters should be considered as a backup in case a bright, high contrast CRT monitor does not prove feasible for this application.

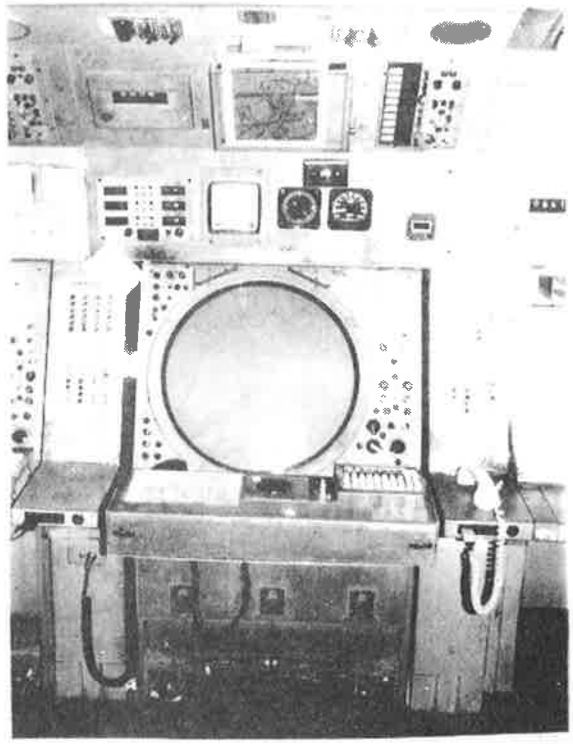
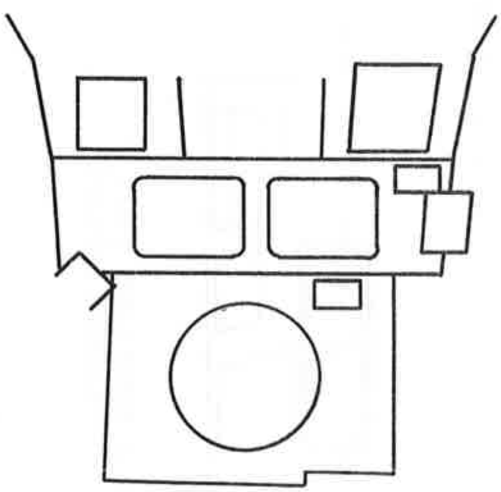
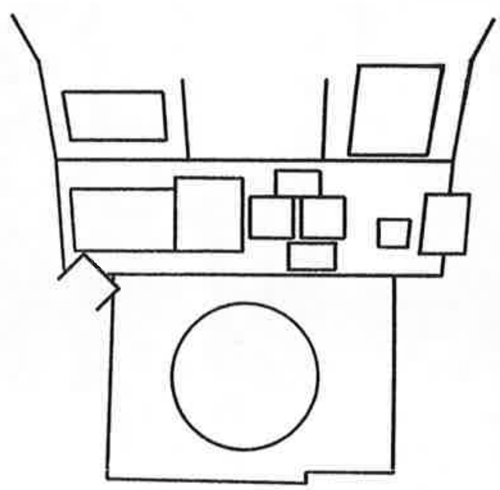


PHOTO OF CURRENT ARRIVAL RADAR 1 POSITION



SKETCH OF ARRIVAL RADAR 1 POSITION WITH CONSOLIDATED DISPLAYS



SKETCH OF CURRENT ARRIVAL RADAR 1 POSITION

FIGURE 5-1. CONSOLIDATED DISPLAYS AT ARRIVAL RADAR 1

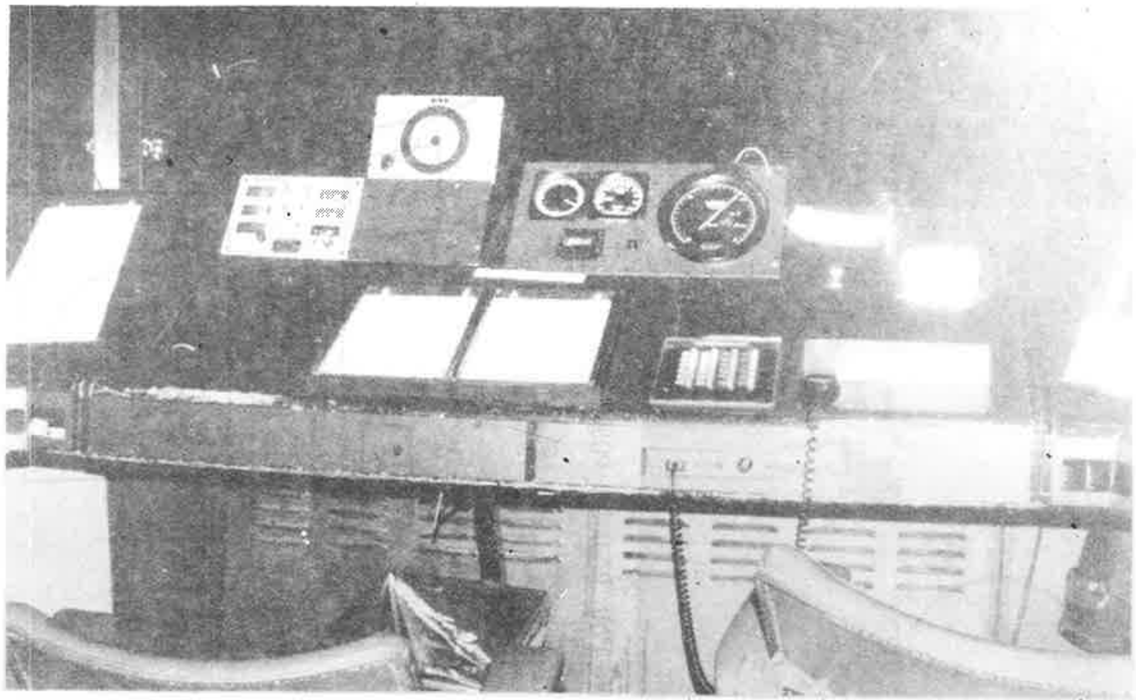
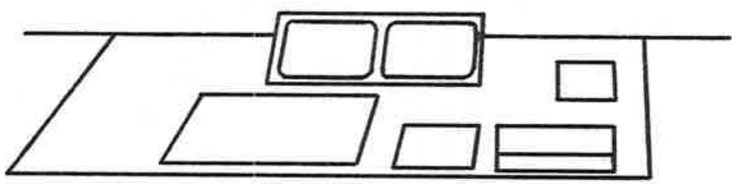
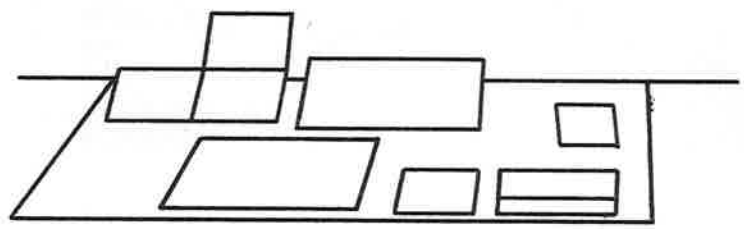


PHOTO OF CURRENT NORTH LOCAL POSITION



SKETCH OF NORTH LOCAL POSITION
WITH CONSOLIDATED DISPLAYS



SKETCH OF CURRENT NORTH LOCAL
POSITION

FIGURE 5-2. CONSOLIDATED DISPLAYS AT NORTH LOCAL CONTROL

5.3 MONITOR CHARACTERISTICS

To assist in achieving bright alphanumerics, a technique which has been used by the FAA (at NAFEC) was assumed wherein each raster line of the display is written at 60 times/second (rather than the more standard 30 times/second). This also would minimize the tendency for the display to flicker in high ambient light. Based upon the capabilities of existing high resolution display systems (See Appendix B), it was further assumed that a monitor with the qualities specified in Table 5-1 could be purchased at a reasonable price with no new technology development required.

As seen in Table 5-1, the minimum character size with this unit is 0.14 inch high. This is a good size for control button and displayed data labels. The approximate character size for labels on current equipment is shown in Table 5-2. The minimum character size is quite representative of existing lables. Using a viewing requirement of 13 arc minutes[(1)], a viewing distance for this size character is 37 inches which would be adequate for button labels which must be within arm's length to be used.

Also shown in Table 5-2 are operational data character sizes for existing equipments. From this table it is seen that characters twice the size of the minimum (i.e., 0.28 inch high) are fairly representative. This size was used in this study and would simplify character generator design. The generator would be based upon a fixed grid of 44 character cells in height and 60 character cells in width with operational characters taking a 2 cell by 2 cell area. The operational characters would be viewable from 6 feet, a viewing requirement which has been confirmed during controller interviews.

[(1)] Shurlteff, D., M. Marsetta, D. Showman, "Studies of Display Symbol Legibility, Part II," Project 7030, The MITRE Corporation Bedford, Mass., Contract AF19(628)-5165(May 1966).

TABLE 5-1. MONITOR CHARACTERISTICS

External dimensions no greater than 10" high x 13" wide
Useable frame area - 8 high x 11" wide
60 frames/second refresh rate
400 raster lines/frame
9 dots high x 7 dots wide character matrix
7 dots high x 5 dots wide characters
44 character lines/frame
60 characters/line
Minimum character size (for labels) - 0.14 inch high x 0.13 inch wide
Double size characters (for operational data) - 0.28 inch high x 0.26 inch wide

TABLE 5-2. ALPHANUMERIC SIZES

EQUIPMENT	ALPHANUMERIC HEIGHT (INCHES)	
	OPERATIONAL DATA	LABELS
Clock		
Cab	0.3	
TRACON	0.5	
Altimeter Setting	0.25	
Wind Speed	0.25	0.15
RVR	0.25	0.15
ILS Monitor		0.10
ALS/SFL		0.15
Field Lights		0.13
VASI		0.15
VAS	0.3	0.10
SWMS	0.63	
ARTS Data Blocks		0.08

It should be pointed out that the 13 arc minute viewing requirement of Reference 1 is based upon tests as described in Table 5-3. The conditions do not match the conditions in which the system would be used. The system characters, digitally generated, would presumably be superior to the scan converted characters in the test. However, the high ambient light of the Cab would tend to compromise the display legibility. How much this could be offset with the bright display is unclear. As with the potential fingerprint problem previously discussed, this might seriously compromise the CRT based design and suggests investigation of the more conventional, although less flexible, incandescent character based display as a backup.

TABLE 5-3. VIEWING REQUIREMENT TEST CHARACTERISTICS

MONITOR
CONRAC 21 inch, Model CQC
945 lines/frame
Character brightness, 20 foot-lamberts
Background Brightness, 2 foot-lamberts
ALPHANUMERICS
Video scan converted standard Leroy
0.16 inch high, cut by 8 raster lines
ENVIRONMENT
Dimly lit room, 6 to 9 foot-candles

5.4 TOUCH-ENTRY DEVICE CHARACTERISTICS

The touch-entry devices available are touch-wire panels and infrared panels (see Appendix B). For this study a selection was not made and instead unit characteristics were selected which would permit the use of either device. It was assumed that the touch-input device would respond to an input at a fixed-grid of "switches." For implementation with the touch-wire device, each switch would be a pair of crossing wires. For the infrared device the appropriate switch would be inferred from the touch-entry coordinate.

This grid of switches would overlay the grid of character cells which would be used to label the associated buttons and, with special characters, draw the buttons themselves. An example of different button sizes overlaying the character grid is given in Figure 5-3. For this study a grid 7 switches high by 10 switches wide was chosen with the switches located vertically and horizontally on 1.10 inch centers. In this way either button A or button C could be used, each being centered on a switch.

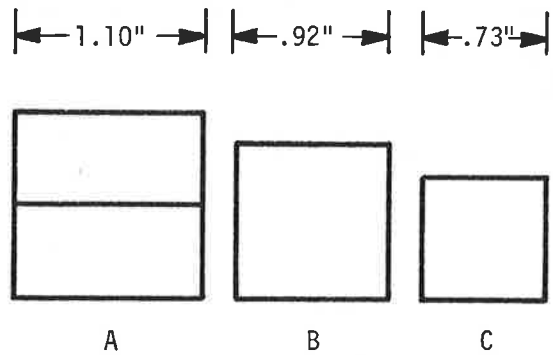


FIGURE 5-3. VARIOUS BUTTON SIZES

Button size A proved to be the largest button required during the format design. With this size button there are 5 lines of 5 characters each available for labels. In addition, the button can be divided in half (see Figure 5-3) and still have 2 lines available per half. Of course, operational size characters could be and were used in some cases to label the buttons. They simply took four small character size cells.

5.5 HARDWARE CONSIDERATIONS

5.5.1 Touch-Entry Devices

A format has been selected which will permit the use of either type of touch-entry device, infrared or touch-wire. If infrared is chosen, since no fingertip pressure is required to interrupt the infrared beam, the potential for accidentally exercising control (e.g., turning off the approach lights) becomes a critical consideration. A possible solution to this problem is to add a "controls on/off" button to each control panel. The controller would then use this button to activate/deactivate the associated control panel. This would reduce the potential for the accidental control of equipment. However, it would increase the amount of button pushing required to address the panel (by two extra pushes).

The touch-wire system is based upon two fine wires (per switch) imbedded in layers of plastic. Pressing on the plastic brings the wires in contact triggering the switch. The fingertip pressure required can be specified to be quite high (e.g., 16 oz.) and may be adequate to rule out accidental inputs. If this is the case, then in this regard, the touch-wire system is superior. However, this system may have a problem regarding the high contrast CRT.

The current BRITE 4, high contrast tubes rely on a frequency sensitive filter bonded to the tube and then coated with an anti-reflective film. It is that film which is particulary sensitive to fingerprints, the reflection of which can trouble the controllers. The frequency sensitive filter is designed to pass the CRT phosphor characteristic frequency but not other frequencies. This reduces the reflection from the phosphor/tube surface. The anti-reflective coating reduces the reflection from the filter outer surface. In the touch-wire application, the plastic would cover the antire-flection coating neutralizing its effect. It is unknown whether or not an antireflective coating could or should (considering the fingerprint problem) be placed on the plastic. Without the coat-ing, reflections from the plastic might be reduced by etching a mat finish on the plastic itself. This is an area of study which has not been pursued, but which should be as part of the unit design process.

5.5.2 Display Devices

A CRT was selected as the basis for the format designs. A set of incandescent characters has been mentioned as a backup to this choice, in case a bright high contrast CRT does not prove feasible. In considering the incandescent characters, the relia-bility of these characters versus that of the CRT should be investi-gated. To duplicate the operational characters on the proposed operational display (see Section 6), approximately 250 characters would be required. Each character is important in providing operational information and would have to be working to provide a useful display. Each unit would have to be 250 times as reliable as a CRT to provide equal reliability per unit on the average. No reliability information was obtained during the brief survey of equipments but should be as part of the design effort if the backup incandescents are chosen. Subsequent analysis will show that at Boston Logan nine units would be required in the Cab. Even if a different unit such as a CRT were used in the TRACON, this would mean that well over 2000 characters would have to be kept operating.

6. PRELIMINARY DESIGNS

6.1 UNIT FORMATS

In developing the unit formats, trial formats were generated and then discussed with two controller/supervisors and two controllers. Based upon these discussions, the formats were revised. The following formats are the revised set.

6.1.1 Operational Display

The operational display format is shown in Figure 6-1. The labels would have independent intensity control and could be dimmed or turned off. Controllers indicated that once trained on the display, the labels would not be required. They serve primarily for training and when dim or turned off will provide space between items of information to enhance readability at a glance.

All operational data listed in Table 4-3 is displayed. Local Boston weather is shown in place of just temperature and dew point. Controllers did not feel temperature and dew point would be of much value. It is needed very rarely and can be read off the telautograph. However, automatic display of local weather (as a telautograph replacement) would be of value. If this is unachievable, then more writing space for status could be provided. The weather as shown would read, "recorded observation of 1500 ft. with scattered clouds, measured ceiling of 2500 ft. and overcast, visibility 1 mile in light rain and smoke, pilot tops report of overcast, 5500 ft."

Centerfield wind is shown above wind shear as is now the case with the SWMS display. In the normal mode of operation, the wind shear window would be empty. In the event of an alarm, the line associated with the boundary wind would be activated and would be inverted, i.e., instead of dark print on a light background, light print on a dark background. (See Figure 6-2A.) In addition, a 1 second duration audible alarm would sound.

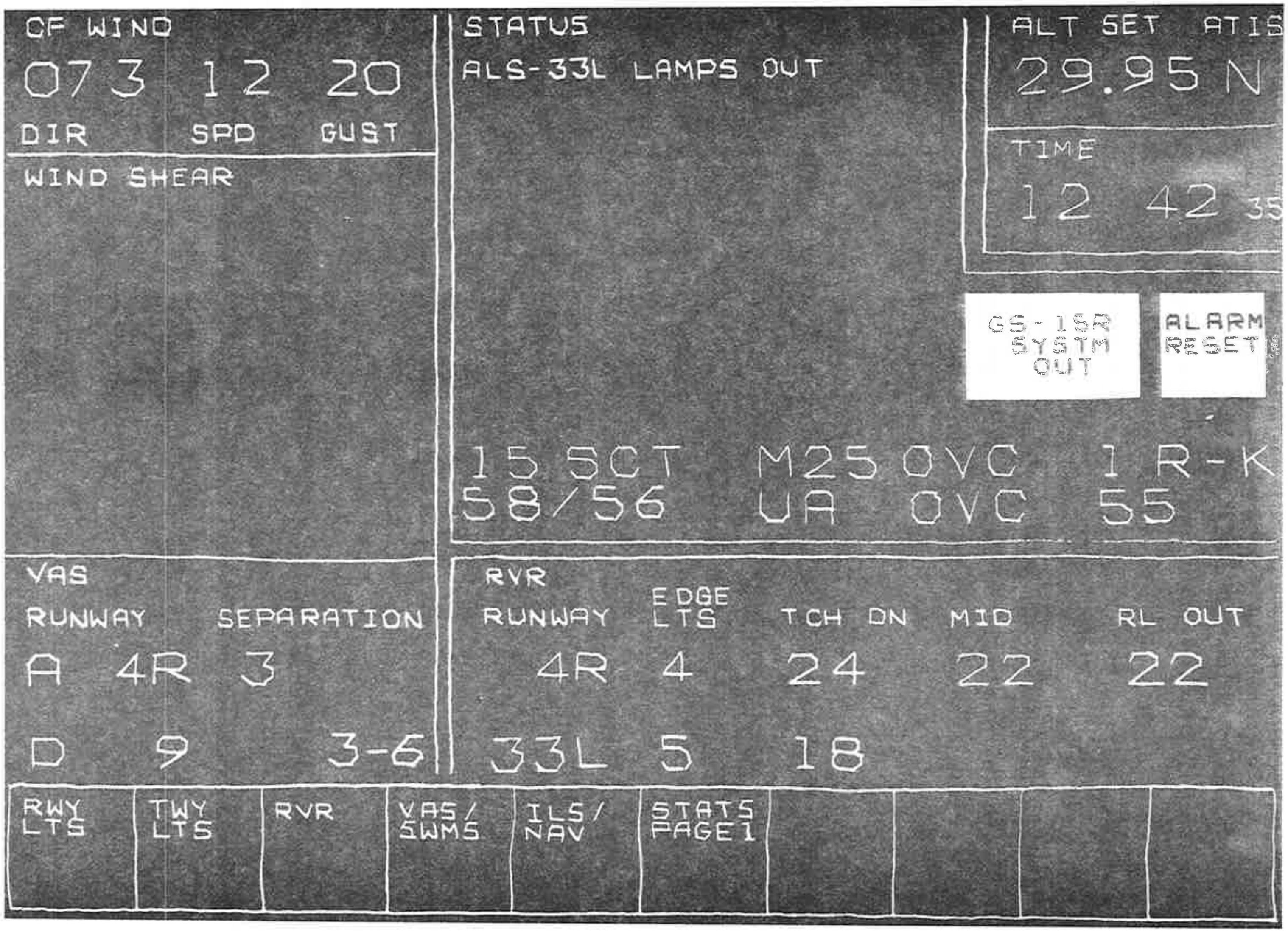


FIGURE 6-1. OPERATIONAL DISPLAY

FIGURE 6-2A. WIND SHEAR ALARM

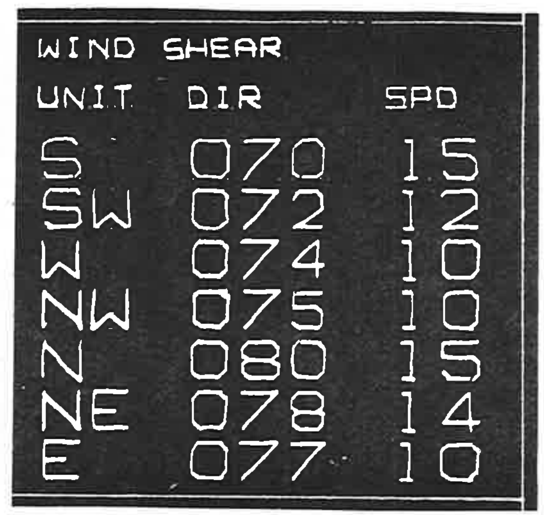


FIGURE 6-2B. BOUNDARY WIND MANUAL CALL-UP

There is room in the window for seven boundary winds. Five are now used, but the Chicago VAS would make seven available. All (or any) of the boundary winds can be manually called up from the VAS/SWMS control panel and will show without inversion. (See Figure 6-2B.) While manually called up, an alarm will invert the line and sound the audible.

The VAS window will indicate separation rules required for the selected runways (and their usage - arrivals or departures). There is room in the window for three runways. The runways are selected from the VAS/SWMS control panel. VAS winds are not displayed based upon the assumption that VAS and SWMS will be integrated and that the VAS winds will be the boundary winds. The close association of these systems also motivates the integrated control panel.

Equipment outages which are relevant to the controller will be listed in the status window. All equipment outages will be displayed on a status panel which can be called up on the control/status unit. Also on that panel, the controller will be able to select that equipment on which he wishes the outage to be listed in the status window of his operational display. Figure 6-1 shows an outage for the ALS on runway 33L. The nature of the outage is 5 or more "lamps out." This item would be found on the displays of the Team Supervisor in the Cab, Local Control, and Ground Control. (See Table 4-1.)

When an outage occurs, an alarm will be given before the outage is listed. The alarm will at least consist of an inverted and flashing box (shown below TIME in Figure 6-1), and will appear on each display for which the item of equipment has been selected. Figure 6-1 shows an alarm for the glide slope on runway 15R. At each station which receives an alarm, the controller will be required to push the ALARM RESET button. This action will deactivate the alarm and replace it with a line in the status window. The window will hold 18 items single spaced. If desired, to aid readability, the window could be filled first in double space

(9 items) and then filled in if more than 9 items were out. This would occur very infrequently.

A good deal of concern was expressed by the controllers over the inclusion of an audible sound with the alarm. They clearly did not like audible alarms, but were reluctant to say they were not needed. They did indicate that there were a lot of alarms, that many of them were false alarms, and due to their number they were more of a nuisance than an aid. This included items which were not considered a part of the ACD (e.g., MSAW). In the preliminary design we have chosen a 1 to 2 second burst of audible to cue the controller to a visual alarm. This is a compromise solution and should be given more attention as the system design is developed.

Some of the equipment on which status is required furnishes operational information for controller use (e.g., centerfield wind). The controllers did not believe that outages on these equipments needed to be listed in the status window, but rather wanted them indicated where the operational information would otherwise be. (See Figure 6-3.) In addition, the alarms could be dropped on centerfield wind, altimeter setting, and RVR (not VAS or SWMS).

The RVR window provides for touchdown, mid-range, and rollout RVR on three runways. In addition, the runway edge light readings used by the RVR computer are displayed. The runways to be displayed would be controller selectable from the RVR control panel. Minimum RVR alarms would also be set from the control panel. Upon alarm, the associated RVR reading would invert and flash, the alarm window would display "RVR below MIN" inverted and flashing, a burst of audible alarm would sound and the ALARM RESET button would have to be pushed to cancel the alarm. However, as long as the RVR was below minimums, the value would remain inverted (but not flashing) in the RVR window.

It is possible that before the controller resets an alarm, either RVR or status, a second alarm will occur. In this case,

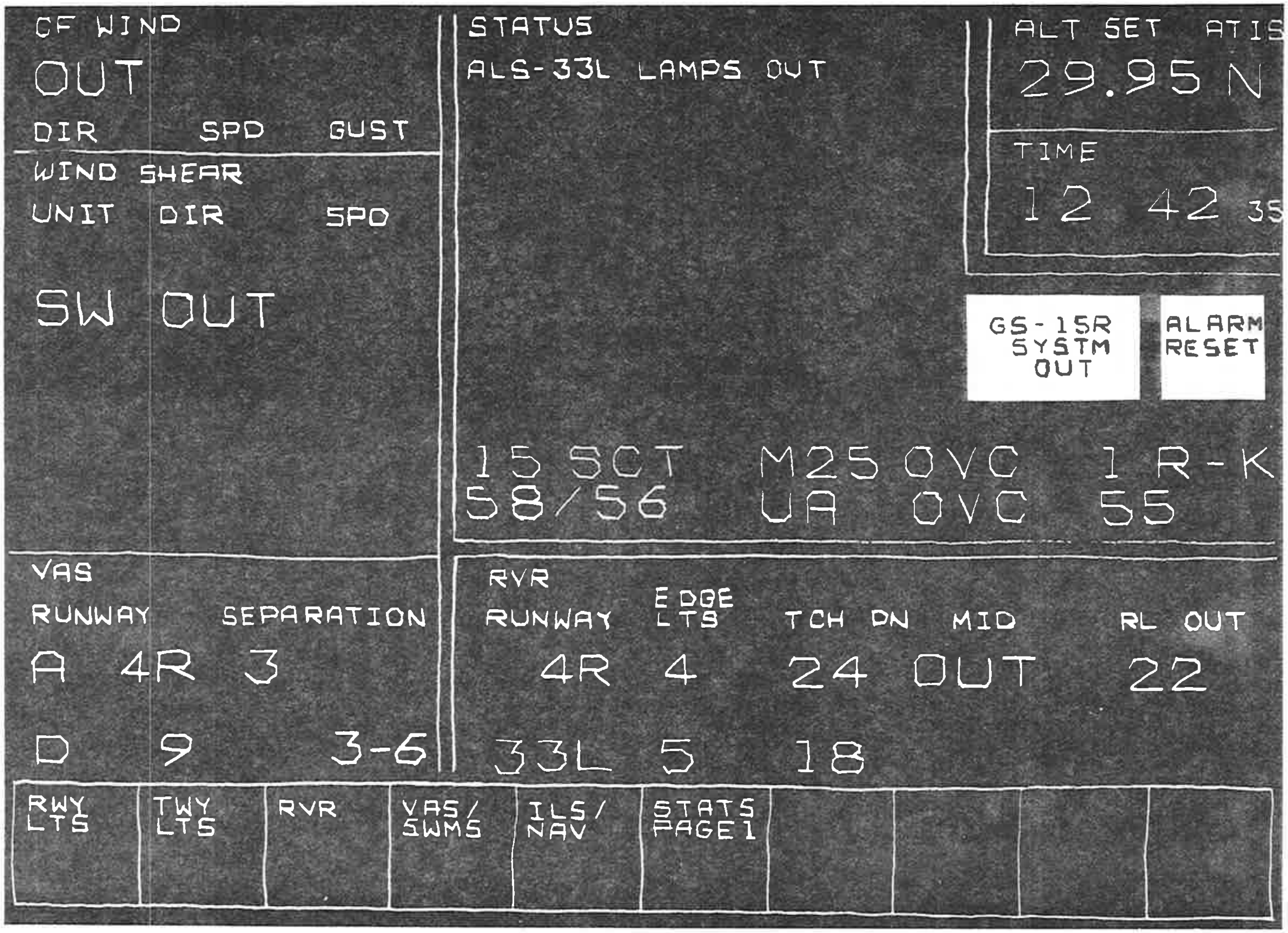


FIGURE 6-3. DISPLAYED EQUIPMENT OUTAGES

the preceding alarm (or alarms) will be listed in the status list but inverted and flashing. The latest alarm associated with the last audible cue, therefore would be written in the alarm window. Pushing the ALARM/RESET button would reset all alarms.

Also, included on the operational display is the menu for the control/status unit. In this way the menu is always displayed but need not be included on every page of the control/status unit. This will save space on each page of the unit. When a page is selected (by pushing the appropriate button), it will invert and remain inverted until another selection is made.

6.1.2 Full-Status Panel on Control/Status Unit

The full status panel will present outages on all equipment included in the system. In addition, the equipment is categorized based upon status information requirements (Tables 4-1 and 4-2) so that each controller can choose just that information (and alarms) which he needs. Due to the amount of information addressed, the full status panel is itself a paged display (i.e., full status will take more than one page). Page one is shown in Figure 6-4.

In Figure 6-4 the controller has chosen only the standard items for inclusion on his operational display by pushing the STAND button which is now inverted. The items included in that category are all listed, and if there are no outages, show as O.K. If there are outages, they are listed and inverted as shown for the glide slope on 15R under ILS and the two taxiway light segments under field lights. As outages occur, the list grows longer, pushes the information below the list onto the next column, and eventually pushes the information on the last column onto the next page.

Each page of the status information has a menu along the bottom for selection of status pages. In addition, the operational display and other key control panels can be called up onto the control/status unit from this menu. When called up on this unit the operational display will simply have a single PRIME DISPLAY

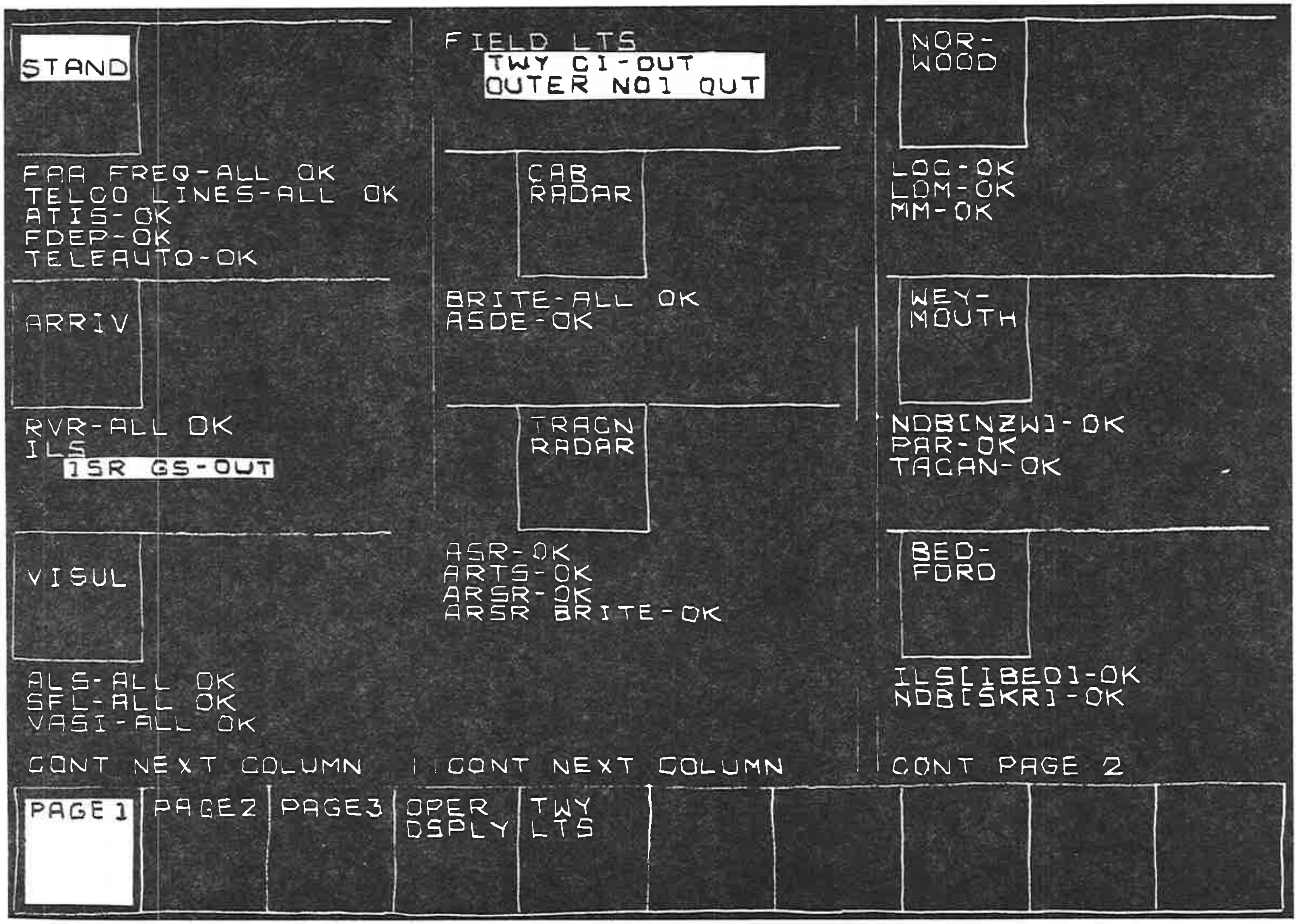


FIGURE 6-4. FULL-STATUS PANEL (PAGE 1)

button in the lower right hand corner of the display (as will each control panel). When this button is pushed, page 1 of the status panel will be returned to the control/status unit. With this menu feature, the control/status unit can be used as a backup to the operational display in the event of failure and still provide for control of key equipments, although in this mode the controller will have to do without operational information while exercising control.

Page two of the status information is shown in Figure 6-5. Each beacon is individually selectable and the status is displayed within the selection button since no list is required. Standard 3 letter FAA designator codes are used. In Figure 6-5 the non-directional beacon HAGET (HGX) is out and the VORs at Pease AFB, Hyannis, Manchester, Providence, and Chester have been selected for the operational display. It should be noted here that the Chester VOR, while influencing Boston SIDs, is not an item of equipment within the Boston Maintenance Sector. Chester is in Westfield Mass. approximately 90 miles from Boston. Intersector status reporting would be required to automatically provide this status information.

6.1.3 Runway Lights Panel on Control/Status Unit

Runway light controls are operated quite frequently by the local controller. At night, during poor visibility, the pilots require the runway lights on full intensity (level 5) until they break out. Upon breaking out the light can be overpowering. Most often the pilot asks that the SFL ("rabbit") be turned off until he has landed. Quite often it is requested that the ALS be dropped to level 4, and occasionally, a pilot will even ask that runway edge or centerline lights be dimmed. Since these controls are frequently addressed. They have been put on a single panel. Controllers indicated that at night, this panel would be kept on the local controller's control/status unit for ready access.

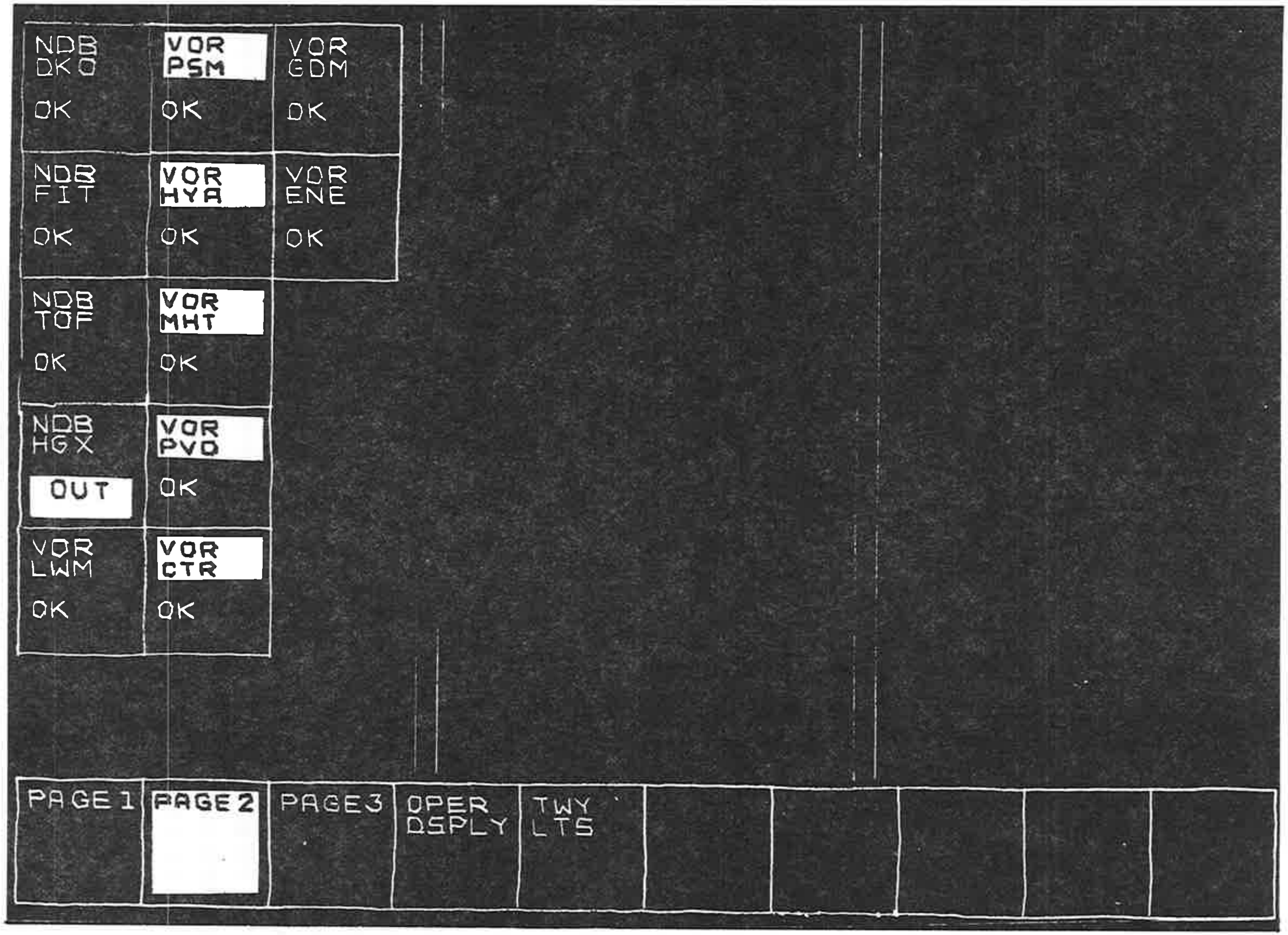


FIGURE 6-5. FULL-STATUS PANEL (PAGE 2)

The panel for Boston is shown in Figure 6-6. As can be seen there is a good deal of space available for growth. This panel would provide adequate space for Chicago O'Hare with their current equipment. On the panel, the ALS and SFL for runway 4R are turned on (i.e., show inverted) and the intensity is set at level 4. To turn the ALS on and off, the ALS button is sequentially pushed. Both the ALS button and intensity level will invert/de-invert as the button is pushed. The same is true for the runway lights (e.g., Runway 4R/22L centerline lights are shown turned on). The SFL lights do not have intensity controls of their own and are simply turned on and off by sequencially pushing the appropriate SFL button.

To set the intensity of the lights, the controller selects the appropriate intensity level in the intensity selection window and then enters the intensity setting for the appropriate runway by pushing the associated runway intensity button. In Figure 6-6, intensity level 5 has been selected and so is displayed inverted. Any lights can now be set at level 5 by pushing their intensity button. Levels will remain selected until changed by pushing a different intensity level.

The ALS currently operates only 15 minutes on level 5. At 14.5 minutes, an audible alarm sounds and continues for 30 seconds. At 15 minutes, the ALS automatically drops to level 4. The controller must push a timer reset button to regain level 5 for another 15 minutes. On this panel, this feature can be implemented by an alarm message on the operational display, a burst of audible (1-2 seconds in duration) to cue the controller of the "impending time out" alarm, and the intensity indicator box flashing on the appropriate ALS, all at the 14.5 minute mark. Any time after 14.5 minutes the controller can reselect intensity level 5. If it is not reselected, at the 15 minute mark it will stop flashing and automatically change to level 4.

In discussing the time-out feature with controllers, it was clear that it was considered a nuisance. When level 5 is needed, they hit timer reset as soon as they can after the alarm goes off.

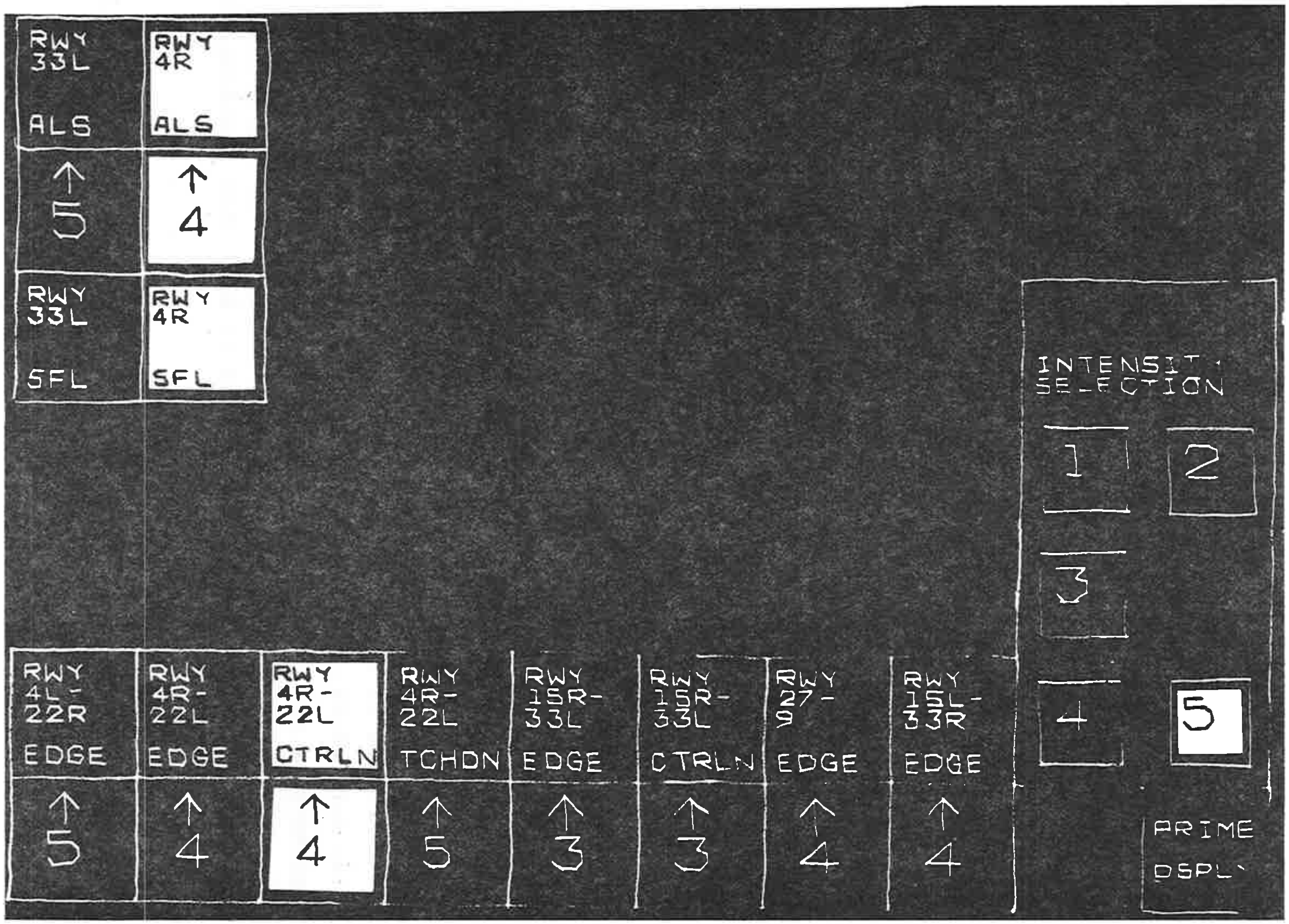


FIGURE 6-6. RUNWAY LIGHTING PANEL

If it is not needed, the pilots demand it be kept down since level 5 is so bright. They did not think that at Boston (a busy airport with a lot of arrivals) the lights would stay on level 5 if they were not required. The audible burst in the above description was selected to at least reduce the problem. However, if a continuous audible were required, a specially toned ALS alarm would be necessary so as to not mask other alarms such as from the ILS system.

6.1.4 Taxiway Lights Panel on Control/Status Unit

The taxiway lights control panel is shown in Figure 6-7. The layout of buttons is similar to that on the current Boston panel. The controllers indicated that this was not layed out well and should be done better before implementation. No specific recommendations were made, however, a replica board showing the segments on a map with associated on-off switches was suggested. In Figure 6-7 each button is sequentially pushed to turn the lights on and off. The button inverts to indicate it has been turned on (e.g., the main outer and K taxiway segment).

6.1.5 RVR Control Panel on Control/Status Unit

The control panel for the RVR is shown in Figure 6-8. It is not set up for Boston since Boston has so few units (i.e., 4 units versus 11 units at Chicago O'Hare). Rather, it is set up for a fictitious airport to demonstrate all the features. In the upper left hand corner the RVR window of the operational display is repeated. Below the window, all RVR data on one runway is given. The runway is selected by pushing the appropriate runway select button. In Figure 6-8, runway 14L has been selected.

If a controller desires to display the RVR on a runway not shown in the RVR window, he simply selects that runway from the runway select buttons and then enters that data on the line he desires by pushing the appropriate ENTER-LINE button. The runway data will clear from the "all RVR data" space and replace the data currently on the selected line. If the controller desires a blank

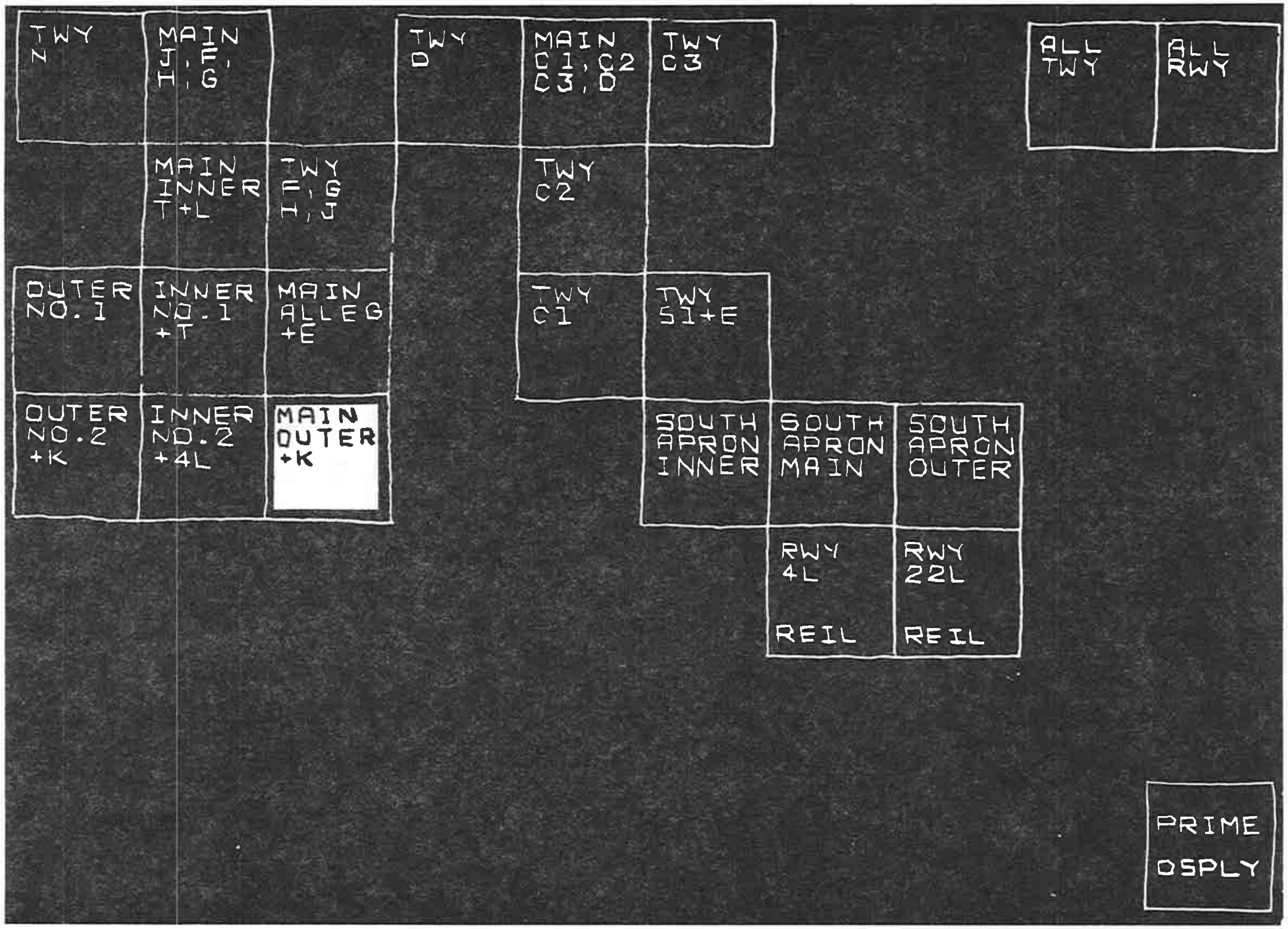


FIGURE 6-7. TAXIWAY LIGHTING PANEL

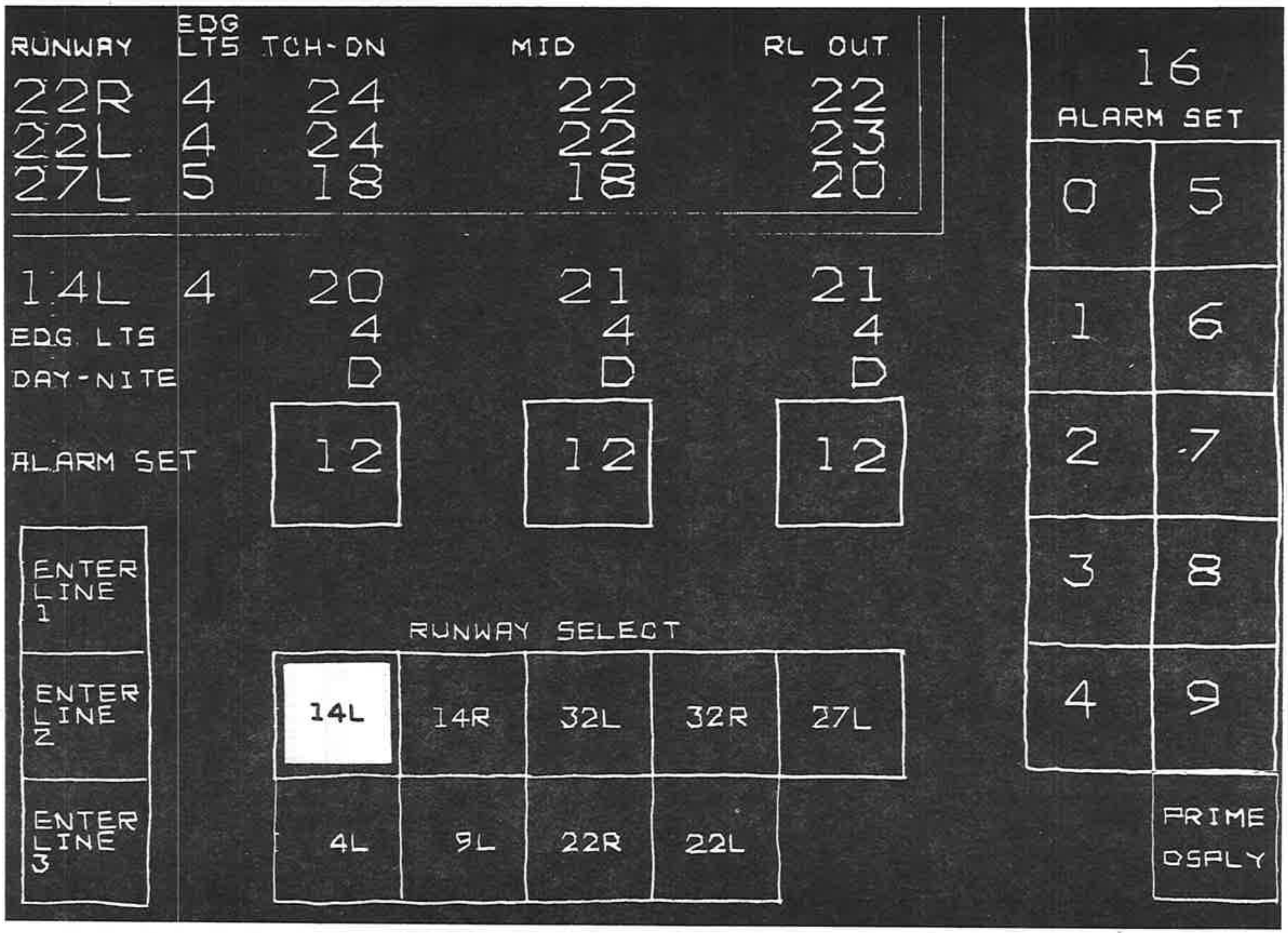


FIGURE 6-8. RVR CONTROL PANEL

line, he simply enters the blank "all RVR data" space into the line he desires blank (which is line 2 in Figure 6-1).

If a controller desires to change the RVR minimum alarm setting for an RVR unit, he first calls the unit up into the "all RVR data" space by pushing the appropriate runway select button. He then pushes the appropriate alarm set buttons. The new alarm setting will be displayed in the top of the alarm set window. In this example a setting of 1600 feet has been selected. The controller then enters the setting into the appropriate RVR unit by pushing the appropriate alarm set button in the "all RVR data" space. For example, to enter 1600 feet into the touchdown RVR on 14L, the controller would push the associated alarm set button and the value, now 1200 feet, would change to the new alarm setting of 1600 feet. Sixteen hundred feet will remain in the alarm set window (available to be entered elsewhere) until a new value is entered.

6.1.6 VASI Control Panel on Control/Status Unit

This panel was not designed for Boston. Two of the current VASIs (the newer VASIs) are fully automatic with no control required from the Cab. The trend appears to be toward fully automatic VASIs. If necessary a control panel can be added. It would be similar to the runway lights with on-off and intensity controls. In fact, if there were room on the runway lighting panel, they could be included there.

6.1.7 ILS Monitor Panel on Control/Status Unit

The ILS Monitor Panel at Boston Logan is much more complex than is desired by the controllers. This is due to equipment contraints which would (should) not be present with the ACD/RMM system. Therefore, rather than duplicate the panel on the control/status unit, the requirements for a new unit were discussed with the controllers. The results of those discussions revealed the following:

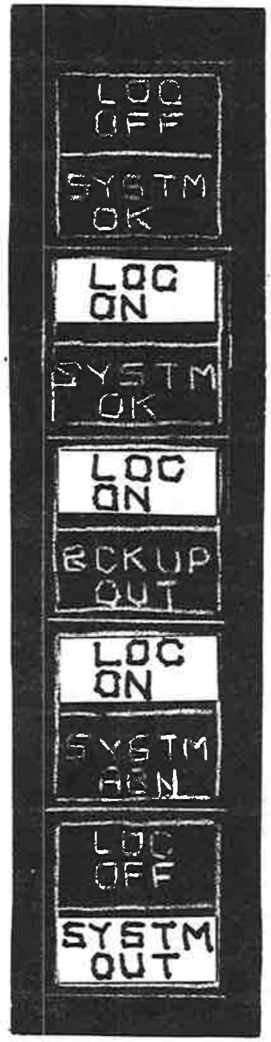
(a) The only controls which should be required are to select which of two ILS systems should be operating when they cannot operate together (e.g., 15R or 33L - see Section 3.2, item (1)). Recycling equipment to remain in or regain operational status should be done automatically. The controller/supervisor should be required only to acknowledge alarms or equipment-back-in-service cues.

(b) The types of status on the elements of ILS which are required are shown in Figure 6-9. All atatus changes, (B) to (C), (B) to (D), (C) to (E) and (E) to (A), would be noted through the alarm feature of the operational display. In addition, should the ILS monitor panel be up at the time of the alarm, the new status information would flash until reset and could be reset on the panel by pushing the flashing button.

As with the ALS time out alarm, the audible burst associated with the alarm feature is different than the current continuous audible of the ILS monitor. If a continuous audible (until reset) is desired, a unique tone would be required so as not to mask other system alarms which might sound prior to reset. However, the controllers are not pleased with the current continuous tone on the ILS as can be seen from the tape used to mute the audible speaker on the panel. (See photos 51 and 223 of Figure 3-6.)

6.1.8 VAS/SWMS Control Panel on Control/Status Unit

The VAS/SWMS control panel is shown in Figure 6-10. This panel displays all boundary winds and permits the controller to select boundary winds for display in the wind shear window of the operational display by pushing the associated button. In Figure 6-10 the West boundary wind has been selected and shows inverted. To de-select, the button is simply pressed a second time. Wind shear alarms will show on this display with an inverted line of boundary wind data.



A	LOCALIZER ON THIS RUNWAY IS TURNED OFF
	LOCATIZER SYSTEM IS O.K. - IF SYSTEM HAS BOTH A MAIN AND BACK UP UNIT, BOTH UNITS ARE O.K
B	LOCALIZER ON THIS RUNWAY IS TURNED ON
C	
	THE BACKUP UNIT ON THIS RUNWAY IS OUT. A SINGLE UNIT FAILURE WILL CAUSE SYSTEM OUTAGE
D	
	THERE ARE ABNORMAL CONDITIONS ASSOCIATED WITH THE UNIT
E	LOCALIZER SYSTEM IS OUT. IF SYSTEM HAS BOTH A MAIN AND BACKUP UNIT, BOTH UNITS ARE OUT

FIGURE 6-9. TYPES OF ILS STATUS INFORMATION

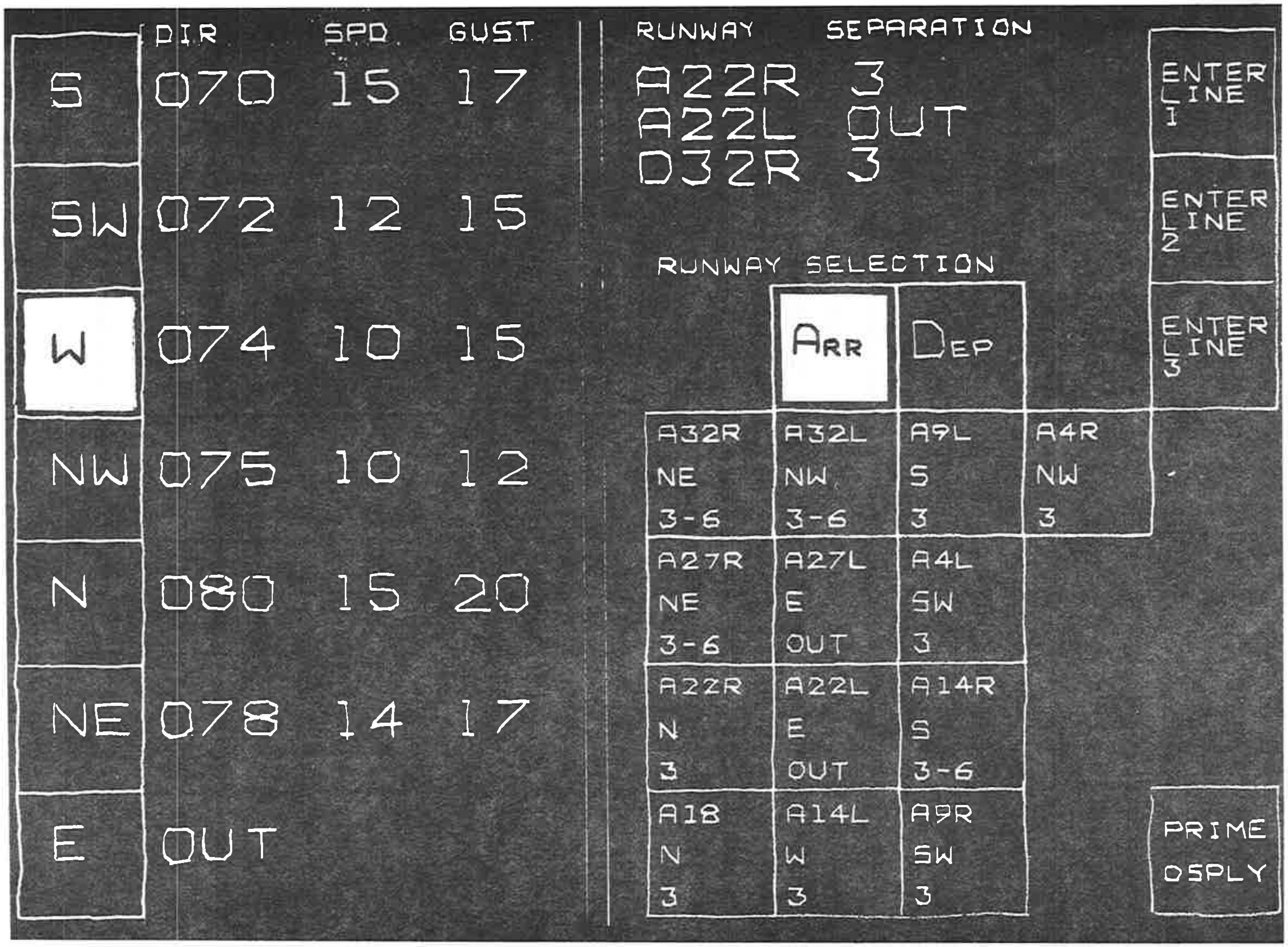


FIGURE 6-10. VAS/SWMS PANEL

The VAS portion of the panel provides the information now available on the System Monitor Panel (see Section 3.3, item 1). The VAS window on the operational display is repeated at the top of the display. Below the window is the runway selection area. All runways are listed. The 13 shown represents Chicago O'Hare's current configuration. There is room for 16 runways. The controller would select either the arrival or departure mode for the runways by pushing the appropriate button. In Figure 6-10, the arrival mode has been selected. Each runway is then depicted in the arrival mode on a button. Also displayed is the boundary wind sensor upon which the VAS separation rule is based and the rule in effect for that runway in the selected mode of operation. If it is desired to monitor a runway other than those shown on the operational display, the controller would push the appropriate runway select button (which would invert to show it was pushed) and then the appropriate enter line button (which would de-invert the runway select button and replace the information on the associated line with the new runway data).

6.2 EQUIPMENT ASSIGNMENT

After discussing the individual unit formats with the controllers, the current status and equipment distribution (Table 4-3) was reviewed and recommendations as to the distribution of the new units solicited. The results were pretty much in agreement and are given in Table 5-1. Items relevant to the distribution are as follows:

a. The control/status unit for both local controllers should be installed so that the associated Cab Coordinator can help with equipment control (e.g., turning off the SFL).

b. Despite little operational information being needed, the the Departure Radar positions should get an operational display to permit their use as Arrival Radar positions in case of Arrival Radar equipment (radar display) malfunction.

c. Bedford Data now controls the approach lights for Hanscom Field after 11:00 PM when the Bedford Tower is not staffed. These controls may become part of this system and may proliferate (e.g., to Norwood, etc.). The control panel call-up feature of the full status page would facilitate this at the data positions.

d. The distribution in Table 6-1 results in 12 operational displays and 13 control/status units for a total of 25 units at Boston Logan airport.

e. A special keyboard entry system was hypothesized for each team supervisor. This would permit the supervisor to assign functions to each unit location, e.g., unit location 21 in the Cab (the left hand unit at the North Local Control position) is an operational display; to correlate operational displays with control/status units (e.g., unit location 21 is an operational display and is correlated with unit 22, a control/status unit. The menu on unit 21 effects unit 22, and the alarms, etc., set up on unit 22 are displayed on unit 21); and to call-up the units of the controllers on his units to see how they are set up (e.g., duplicate units 21 and 22 on the supervisor's units). In addition, it was suggested by a controller/supervisor that in the event of an operational information sensor failure (e.g., centerfield wind) the supervisor might use the keyboard to enter the weather bureau reported winds for use until the sensor was repaired.

6.3 CONTROLLER DISCUSSIONS

Comments made by controllers regarding the formats have been integrated into the format section. However, added system related areas were covered as well. Items of particular interest are listed below.

a. There should be no data entry required from the keyboard. The controller/supervisors were adamant regarding this.

TABLE 6-1. PANEL ALLOCATION

ITEMS TO CONSIDER	TS	NLCC	NLC	GC	SLC	SLCC	HV	CD	FD	TS	FC	AR-2	AR-1	TD	CI	TC	AR-3	BD	DR-2	DD	DR-1
OPERATIONAL DATA																					
DIGITAL CLOCK	X		X	X	X				X				X	X		X		X		X	
ALTIMETER SETTING			X	X	X						X	X	X			X			X		X
CENTERFIELD WIND			X	X	X					X		X	X			X		X			
RVR			X	X	X						X	X	X								
TEMPERATURE/DEW. PT.			X	X	X							X	X								
VAS (RUNWAY MONITOR)			X		X						X	X	X								
SWMS			X		X					X	X	X	X			X					
ATIS	X		X	X	X			X		X	X	X	X			X					
CONTROL/STATUS PANELS																					
RVR			X	X	X						X	X	X								
VAS (SYSTEM MONITOR)	X									X											
SWMS			X		X						X	X	X			X					
ILS MONITOR	X		X		X					X	X	X	X								
ALS/SFL			X		X																
FIELD LIGHTS																					
RUNWAY			X		X																
TAXIWAY				X																	
VASI	X		X		X																
STATUS INFORMATION																					
LOCAL SUBSET			X	X	X			X	X		X	X	X	X		X	X	X	X	X	X
SECONDARY SUBSET								X			X	X	X	X		X	X	X	X	X	X
ALL STATUS	X									X					X						
SYSTEM PANELS																					
OPERATIONAL DISPLAY	X	←X		X	X→					X	X	X	X			X	X→		X→	←X	
CONTROL/STATUS UNIT	X	←X		X	X→			(S)→		X	X	X	X	(S)→		X	←	X	←	X	→
KEYBOARD	X									X											

→ SHARED BY

(s) PRIMARILY FOR FULL STATUS PAGE

The current status distribution system is manual and it is difficult to keep all posted outage information current, especially when outages are corrected. That the automated system would have the most current status is important. We were told that, "If manual entry of status information is required, a piece of plexiglass and a grease pencil will do as well, and save the money."

b. The controllers were told that when a control panel was selected, there might be a waiting time until the panel came up for use. The controllers indicated that up to a 3 second wait would be acceptable. However, this wait time is acceptable for the runway lighting panel only because the Local Control position would keep this on his control/status unit available for immediate use. The 3 second wait for runway lights when a lighting change request came in while the controller had called up a panel to replace the runway lights (e.g., to set an RVR alarm) would be alright since it would occur so rarely.

c. The concept of installing only one unit at each position, displaying the operational display most of the time, and calling up the control/status panels on that one unit (at the expensive of the operational display) was discussed with the controllers. Three of the four controllers found this unacceptable, even if all panels responded instantaneously. The controllers did not want to give up the operational information. The controllers liked the flexibility provided by the second unit. For example, Local Control could keep the runway lighting control panel up for immediate use while Ground Control might keep the taxiway lights control panel up. Finally, they liked the backup feature in the event that one of the two units failed.

d. The potential for system failures was discussed with the controllers. As mentioned above, the controllers liked two units with one available as backup to the other. The light-weight, plug-in aspect of the unit (i.e., the unit would weigh less than 20 lbs. and slip into the out-of the console) to facilitate repair and reduce downtime was well received. One controller even suggested that under certain conditions he might pull a bad unit and plug in a spare if it were available.

To get an understanding of tolerable system failure, the controllers were told the whole system might go out 2 or 3 times per year for 3 to 4 hours. A backup concept was described wherein one position in each facility (i.e., Cab and TRACON) would be provided analog-direct feed displays of center field wind, altimeter setting and RVR and that equipment controls would be available in the equipment room for AF personnel to use upon verbal requests via TELCO. Furthermore, ILS outages would be available to AF personnel in the equipment room who would immediately report via TELCO. Three of the four controllers thought this backup would be acceptable and would operate with the system as described. The fourth controller questioned the time lag in ILS outage reporting and thought an analog-direct feed monitor in one of the two facilities (probably the Cab) might be required. Otherwise, he also found the system acceptable.

While indicating the backup concept would be good, one controller believed that a digital system could be made fail operational and should be. He believed the backup would never be required, but should be installed for the pessimists.

e. A concept of runway status was discussed which would have the computer check on the operational status of each runway. For example, for runway 4R to be ready for Cat. I ILS operation the following must be set up:

1. ALS/SFL operational and turned on at level 5.

2. Glide slope, localizer, inner marker, middle marker,

and outer marker operational and turned on (i.e., selected from monitor panel).

3. Runway edge, centerline, and touchdown lights operational and turned on at level 4 or 5.

4. RVR operational and set with proper alarms. These are conditions which will all be available for the processor to check on. If satisfied, a status message could read "4R CAT I OPERATIONAL." If all equipment was operational but not all turned on, it might read "4R CAT I AVAILABLE - ALS NOT ON LEVEL 5." If not all equipment was operational, it might read "4R CAT I OUT-LOCATIZER OUT."

   This type of status could be provided on a page of the status panel. It would cover all runways for their key operational modes (e.g., 4R would include CAT II). The controllers thought this could be quite useful.

f. In general, the ACD concept was very well received by the controllers. They liked having everything they needed right in front of them. They also liked the consolidation of alarms, so they would always look to their operational display when an audible cue was sounded.

6.4 SYSTEM IMPLEMENTATION CONSIDERATIONS

6.4.1 Discussion

Consolidation of displays and controls for a number of airport systems can be readily accomplished. However, to implement this consolidation: 1) existing control switches must be replaced by computer-controlled relays, and 2) existing status signals must be converted to computer-readable voltages. This re-formatting of status and control information would allow a central processor (which is needed to drive a consolidated flexible format display) to interface to the existing airport systems, but would require additional signal wiring and additional equipment for each system to be "consolidated."

One means of re-formatting the status and control information would be to simply add a box of equipment to <u>each</u> system that would be controlled and monitored at the display and to interface each box with the central processor. However, this would make fault isolation and repair more difficult since the additional equipment and signal wiring would provide new locations where faults could occur, and this would increase both the number of faults and the number of places to check.

An example of this problem exists in the ILS monitor at Boston Logan. This system provides control and monitoring of all ILS facilities at Logan. A monitor panel was designed by the Boston maintenance personnel under a constraint that the status and control signals for each ILS facility would not be altered at the site, but would be consolidated in the monitor panel without changing the ILS facility, signalling, or equipment. In effect, the ILS Monitor Panel is a "front end" for several existing ILS facilities. The problem is that the ILS facilities differ in the nature of their status signals, their control sequence and their operation, and because the consolidated panel had to be implemented without altering the ILS facilities many of these differences appear in the controls and status indicators on the panel. Further, incorporating this front end necessarily meant the addition of another layer of electromechanical equipment in each system, thus increasing its complexity and probability of faults.

The ILS Monitor Panel <u>does</u> allow monitoring and control of several ILS facilities on one panel. However, due to the constraints under which it was designed, the operation of each column of status and control buttons is different, and the extra equipment required to support the monitor panel supplies a disproportionately large quantity of problems for maintenance personnel. In short, the controllers have trouble understanding and using the panel and maintenance personnel have trouble maintaining it.

A brief list of some of the problems may help illustrate why operation and maintenance of this panel is difficult:

a. A conductor carrying one function can pass through as many as 5 terminal connections and 5 relay contacts.

b. Many lines are not accessible via jacks or printouts so location of loose connections requires probing. This often loosens several other connections.

c. Mechanically sequenced relays can get out of sequence from spurious transients (i.e., introduced when probing for faulty connections) and must be pried open and re-sequenced by hand.

d. Typically, the ILS equipment is more reliable than the equipment that monitors it. Therefore, a majority of the alarms are caused by the monitoring equipment.

e. The monitor panel is very difficult to comprehend since each facility has different status conditions, commands, and operating sequences. Figure 6-11 shows consolidation of displays and controls using the existing equipment configuration serving the ILS monitor panel and simply adding a box of interface equipment. It can be seen that there are many wire links through which the signals must pass. Consolidation, in this case, would be a front end on a front end.

To illustrate a way this consolidation could better be implemented, Figure 6-12 shows a possible implementation of consolidation of displays and controls for ILS in conjunction with upgraded remoting of control and monitoring information.

Note that a microprocessor would be installed at the site of each ILS facility. This microprocessor could communicate directly with a central processor in the tower, in serial fashion, on one line, with redundant transmissions or parity checking for reliability. All status information could be collected by this microprocessor and remoted to the central processor on request or via interrupt to the central processor if an alarm occurs. The microprocessor would receive all control information from the central

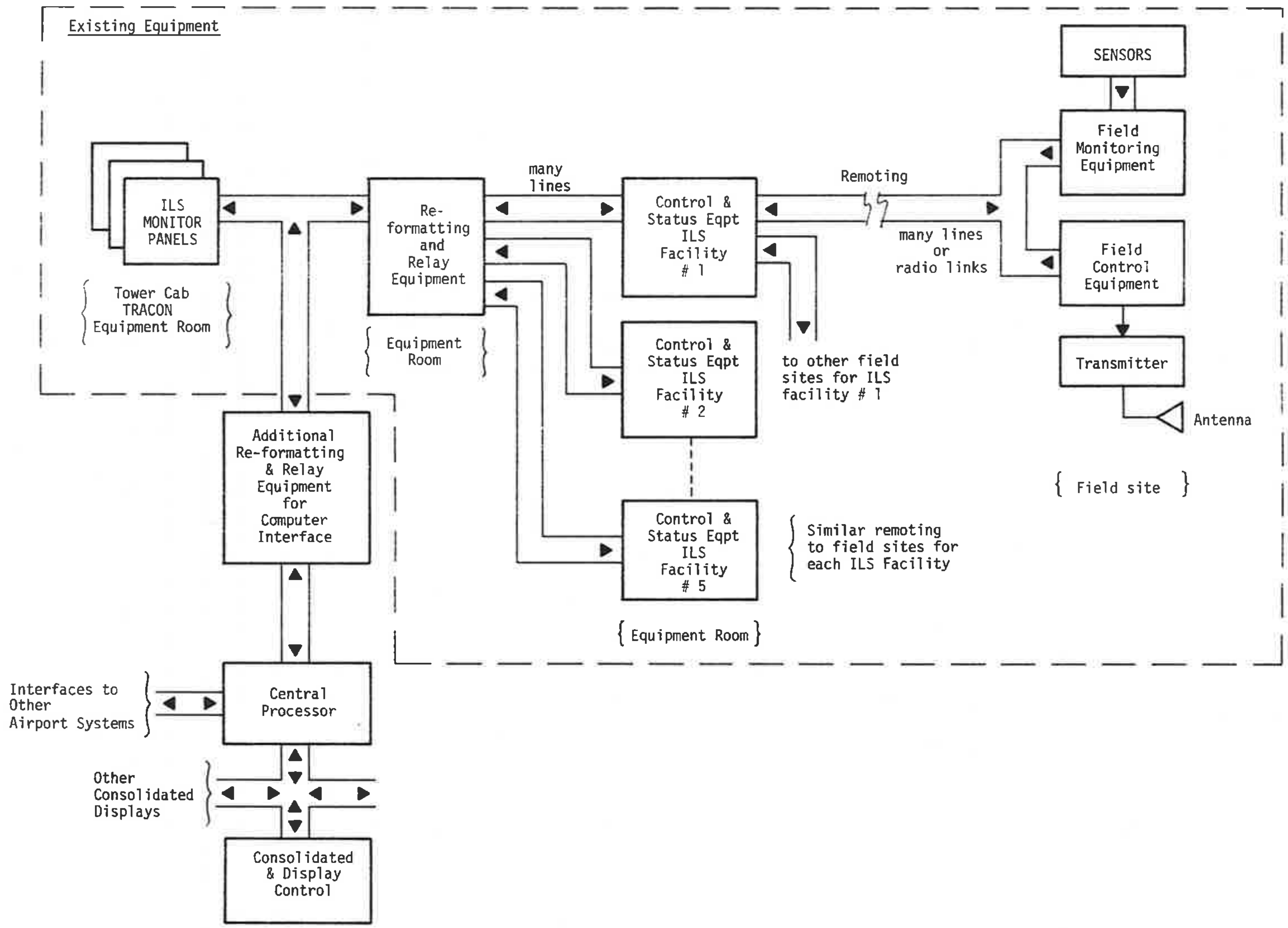


FIGURE 6-11. ILS CONSOLIDATION ALONE

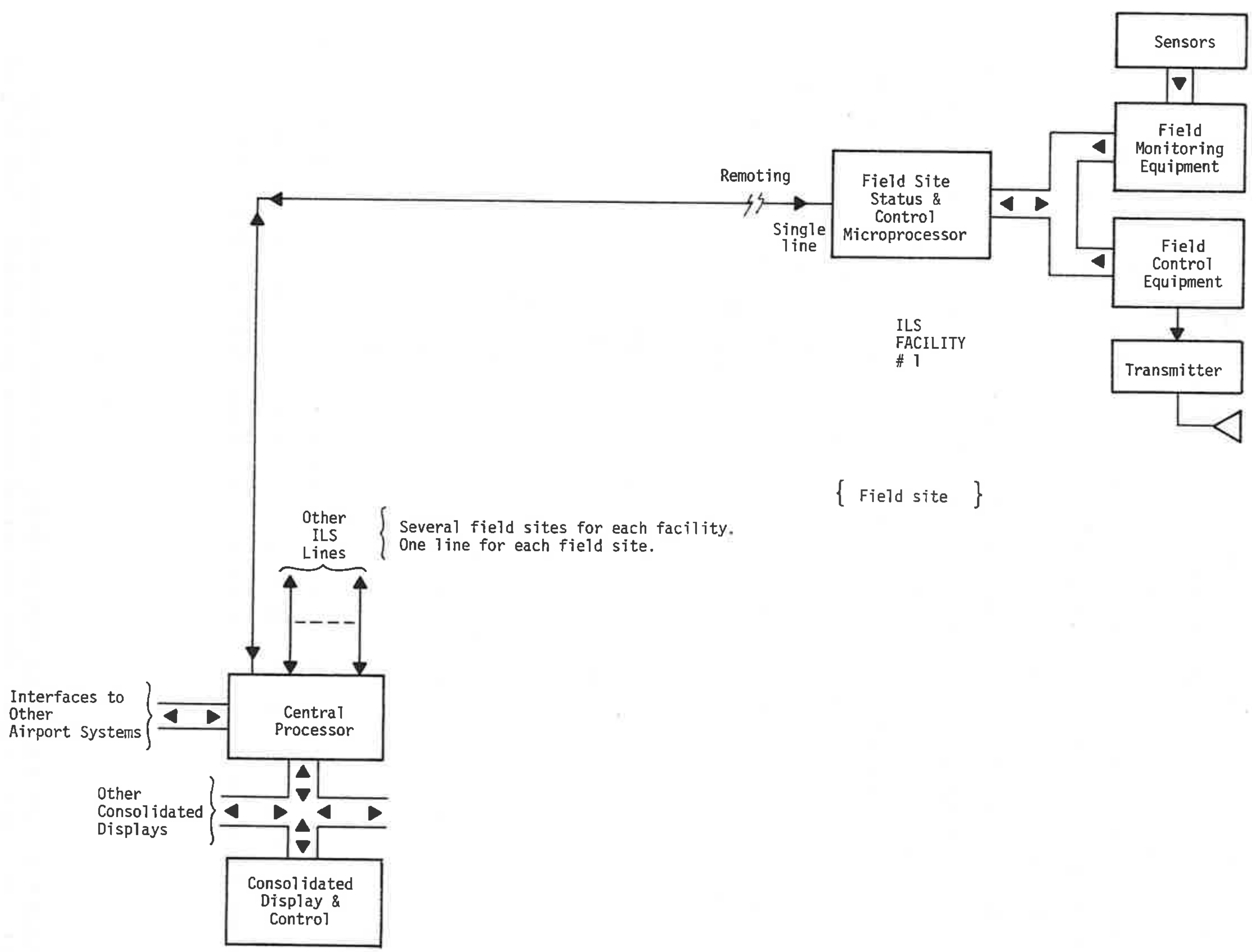


FIGURE 6-12. ILS CONSOLIDATION WITH UPGRADED REMOTING OF CONTROL AND MONITORING INFORMATION

processor, decode it, and trigger the appropriate relay(s) in the control equipment at the site.

Sequencing of relays could be done in software in the microprocessor at the site. It should not be necessary to have relays triggering other relays for sequencing. This use of software would reduce the number of relays required and would thus increase system reliability (fewer moving parts) and reduce the time required to locate and repair faults.

Status and control information for varying versions of equipment (different models or configurations of ILS facilities in this case) could be re-formatted into one uniform set of status and control readouts in the central processor or in the microprocessor at the site.* This would be done in software, not extra circuitry, and thus would be more reliable. Because software is inherently more flexible than hardware, the resulting consolidated status and control information could be made much more comprehensible to the operator.

Both the central processor and each microprocessor at a field site could perform some self-checking during idle time. If desired, both processors could also be provided with backup processors. This certainly would be advisable for the central processor, which would probably be one of the more capable minicomputer systems and thus could be 'backed-up' at moderate cost.

6.4.2 Summary

Consolidation alone adds yet another layer of wiring and signal formatting equipment on top of existing complex equipment. At present there are, in some cases, so many links, connections,

*Re-formatting at the site would make certain information unique to that site less accessible to maintenance personnel, but would simplify central processor software.

and relays through which each signal line passes that location of a simple break in the signal line can be difficult. An additional relay rack and wire hookup would deteriorate an already difficult situation.

However, if display and control consolidation takes place simultaneously with upgrading of the remote monitoring and control functions, the situation can be vastly improved. A microprocessor at each equipment site is the key to obtaining maximum benefit out of such an upgraded system. In conjunction with a central consolidating processor, these microprocessors can simplify the equipment required for each system, make the monitor and control functions more flexible, ease maintenance, and increase reliability.

APPENDIX A: SYSTEM SUMMARY DESCRIPTIONS

CONTENTS

I. <u>TWIDS</u>

a. TIME

SYSTEM ACRONYM:

SYSTEM NAME: CLOCK (DIGITAL)

SYSTEM FUNCTION: DISPLAY TIME

SYSTEM DIAGRAM:

1) CLOCKS ARE INDEPENDENT
2) CLOCKS ARE MANUALLY SET AND SYCHRONIZED
3) THERE ARE NO TIME STAMPS
4) THERE ARE TWO TYPES OF CLOCK
    a) CRYSTAL CLOCK WITH LED READOUT (2 CLOCKS OF THIS TYPE)
       DIMENSIONS: 4"x4"x3" DEEP
    b) CONVENTIONAL ELECTRIC CLOCK WITH MECHANICAL DIGIT DISPLAY (ALL THE REST)
       DIMENSIONS: 5"x11"x6" DEEP
       H x W x D
5) ONLY INPUT TO CLOCKS IS POWER
6) ANNUAL MAINTENANCE IS APPROXIMATELY 1 HOUR

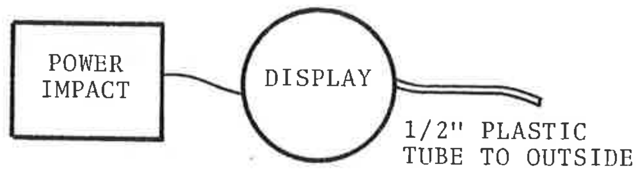
b. ALTIMETER SETTING

SYSTEM ACRONYM:

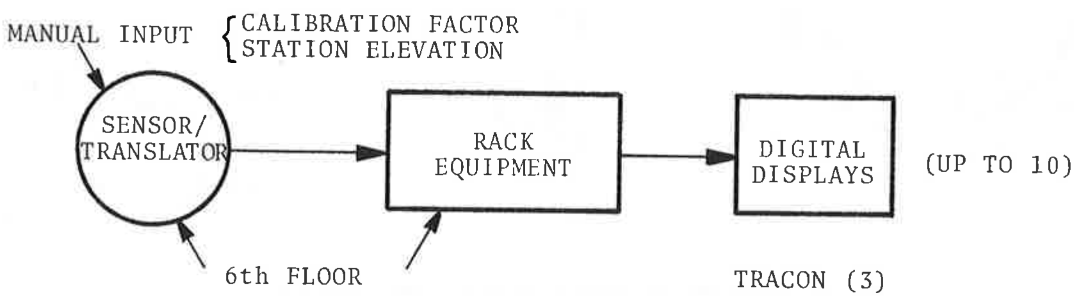
SYSTEM NAME: ALTIMETER SETTING IDICATOR

SYSTEM FUNCTION: Provide the altimeter setting information required by pilots for the proper setting of the barometric pressure dials of altimeters in aircraft.

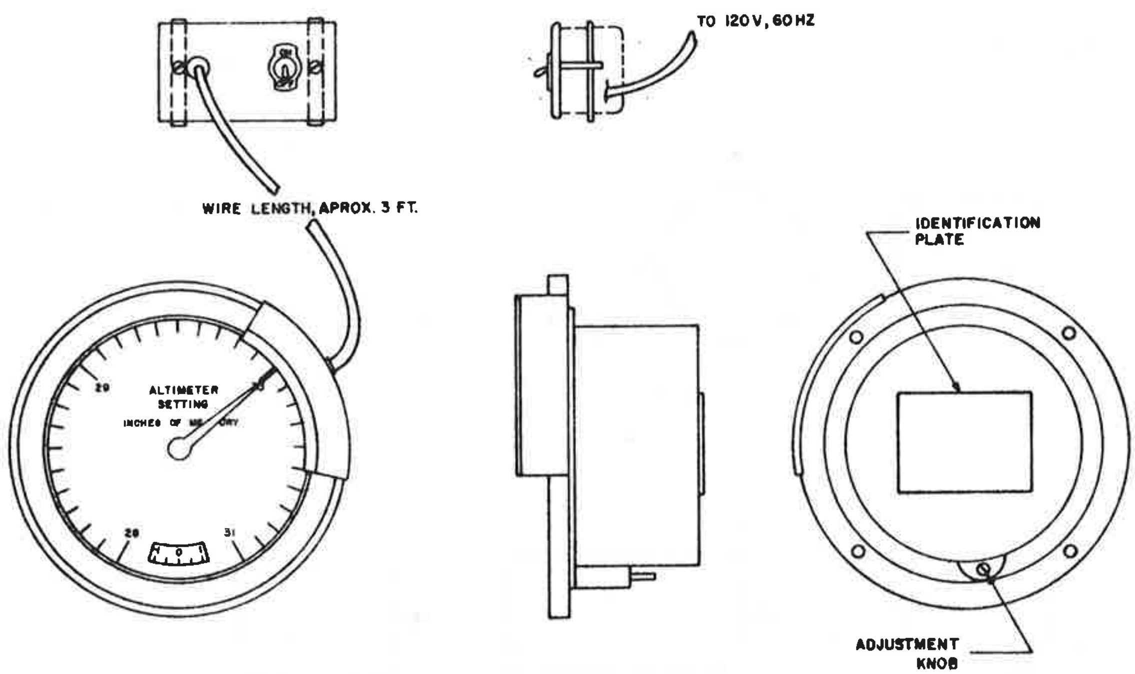
SYSTEM DIAGRAM:



ANEROID (6 or 7 in TRACON & CAB)



DIGITAL ALTIMETER SETTING INDICATORS (DASI)



Aero Mechanism Model 8096 Altimeter Setting Indicator

SYSTEM ELEMENTS

SYSTEM: DASI

NO.	NAME	LOCATION	#	FUNCTION
1	Sensor/Translator	6th floor	1	Measure barometric pressure
2	Rack Equipment	6th floor	1	Convert measurement to proper format for digital display (remote)
3	Remot Digital Display	TRACON	3	Display Altimeter Setting

SYSTEM INFORMATION FLOW

SYSTEM: DASI

NO.	SOURCE ELEMENT	DESTINATION ELEMENT	DESCRIPTION
1	1	2	Barometric Pressure Reading
2	2	3	Altimeter Setting

SYSTEM: ALTIMETER SETTING INDICATOR

CONSOLE ELEMENTS

NO.	NAME	DIMENSIONS (L x W x D)	INSTALLATION CONSTRAINT
1	Aneroid Display	7" diameter, 4" deep	1/4" plastic tube to outside world
1	DASI Display	4"x4"x10"	None

OPERATIONAL CERTIFICATION

PERIOD	PERFORMANCE CHECKS	NO. VISITS	TIME	RECORDING/ REPORTING
--------------Aneroid ----------				
Weekly	Check against weather bureau	x	Few min.	x
----------------DASI------------				
Weekly	Check against weather bureau every Sunday AM	x	5 min.	x

SYSTEM: ALTIMETER SETTING INDICATOR

CONTROLS AND INDICATORS

NAME	FUNCTION
Aneroid	
Dial Display	Display Altimeter Setting
DASI	
LED Display	Display Altimeter Setting

ALARMS

SOURCE	EVIDENCE
None	

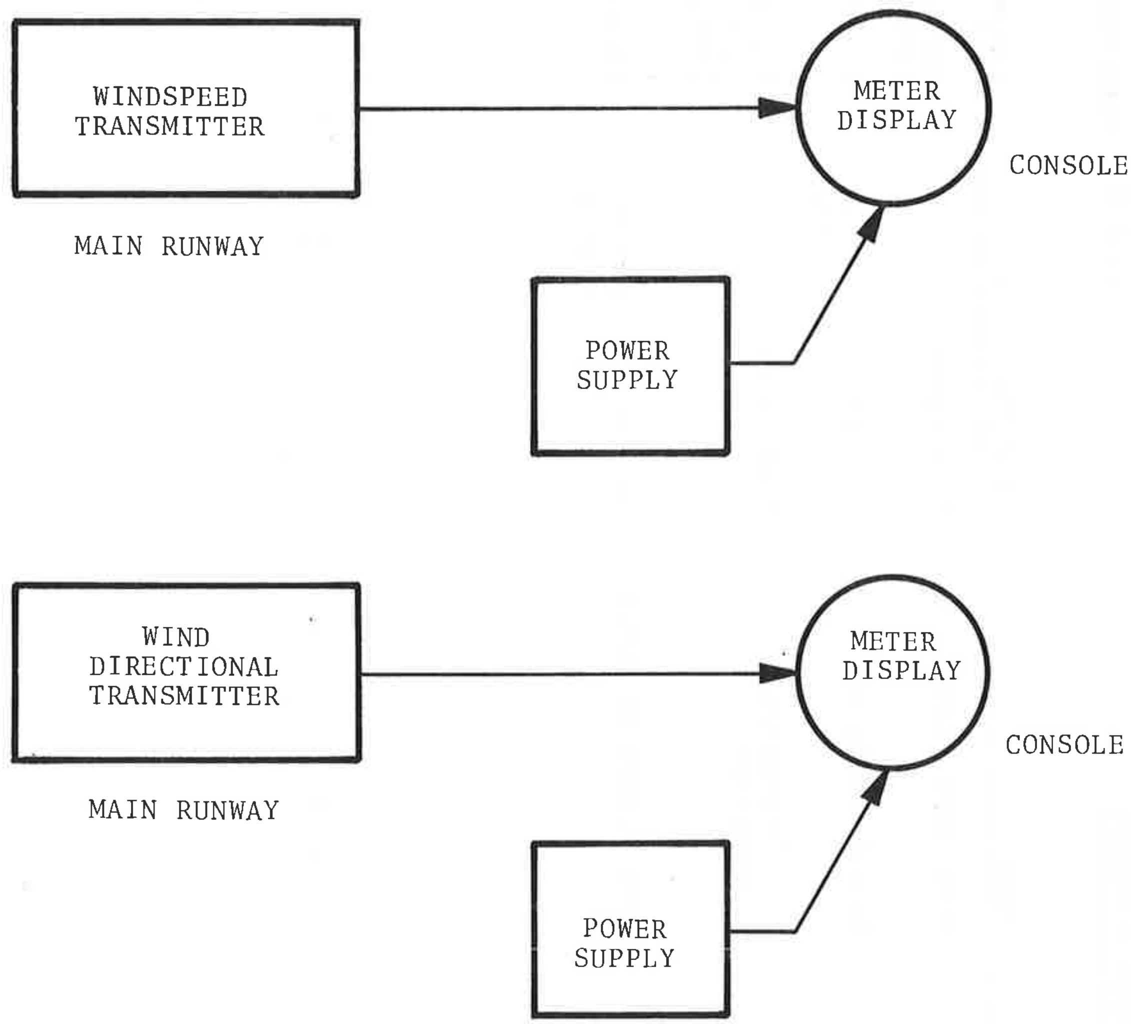
c. WINDSPEED & DIRECTION

SYSTEM ACRONYM:

SYSTEM NAME: WIND MEASUREMENT EQUIPMENT
(Windspeed and wind direction)

SYSTEM FUNCTION: Measure and indicate wind condition information pertinent to local aircraft navigation and takeoff and landing operations

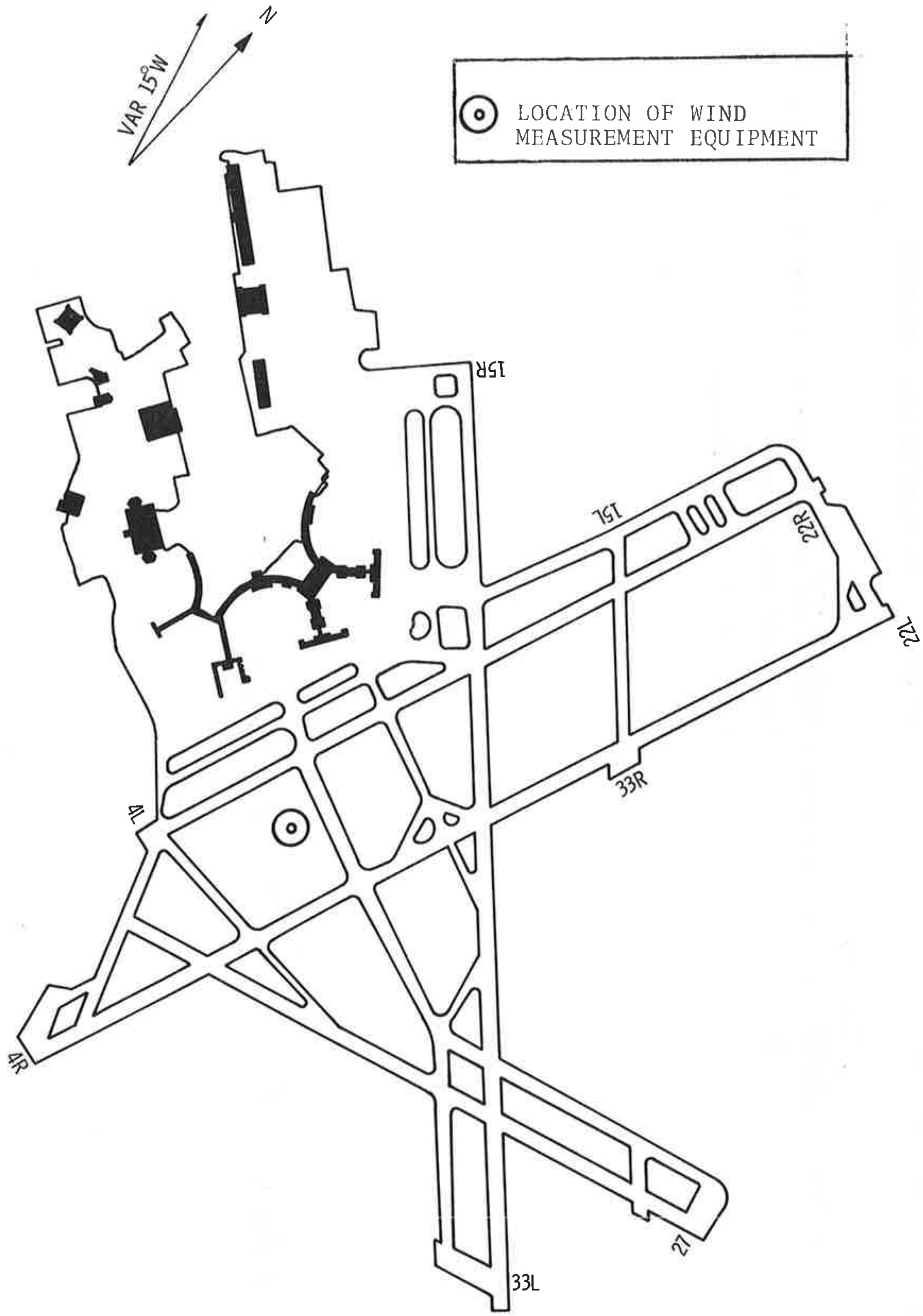
SYSTEM DIAGRAM:



SYSTEM ELEMENTS

SYSTEM: WIND MEASUREMENT EQUIPMENT

NO.	NAME	LOCATION	#	FUNCTION
1	Windspeed Transmitter	Main runway	1	Sense and transmit wind speed (uses small generator).
2	Windspeed Meter	Console	can be several	Display calibrated wind speed.
3	Wind Direction Transmitter	Main runway	1	Sense and transmit wind direction (uses resistance coil--resistance changes as wind vane moves).
4	Wind Direction Meter	Console	can be several	Display calibrated wind direction


VAR 15°W
N
LOCATION OF WIND
MEASUREMENT EQUIPMENT
15R
15L
22R
22L
33R
4L
4R
27
33L

SYSTEM INFORMATION FLOW

SYSTEM: WIND MEASUREMENT EQUIPMENT

NO.	ELEMENT	DESTINATION ELEMENT	DESCRIPTION
1	1	2	Windspeed measurement
2	3	4	Wind direction measurement

SYSTEM: WIND MEASUREMENT EQUIPMENT

CONSOLE ELEMENTS

NO.	NAME	DIMENSIONS (L x W x D)	INSTALLATION CONSTRAINT
1	Windspeed Meter	LxW: as appears, D: 2"-3"	None
2	Wind Direction Meter	LXW; as appears, D: 2"-3"	None

OPERATIONAL CERTIFICATION

PERIOD	PERFORMANCE CHECKS	NO. VISITS	TIME	RECORDING/ REPORTING
Semi-annual	Sensor checks (calibration)	X	1/2 day	X
	Meter checks (calibration)	X	2 days	X

SYSTEM: WIND MEASUREMENT EQUIPMENT

CONTROLS AND INDICATORS

NAME	FUNCTION
Windspeed Meter	Display Windspeed Reading
Wind Direction Meter	Display Wind Direction Reading

ALARMS

SOURCE	EVIDENCE
None	

Comment: "Constant use obviates the need for monitoring." i.e., erratic behavior becomes obvious right away

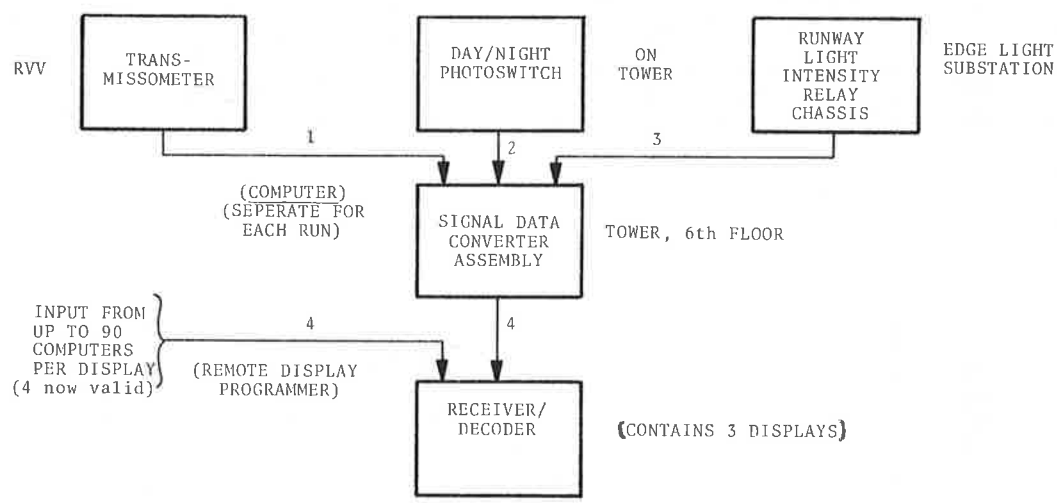
d. RVR

SYSTEM ACRONYM: RVR

SYSTEM NAME: RUNWAY VISUAL RANGE

SYSTEM FUNCTION: Measure atmospheric transmissivity along a runway and translate this value into a digital visual range reading. The reading indicates the distance that lights or markers delineating the runway can be seen from a position corresponding to the eye level of pilots at touchdown.

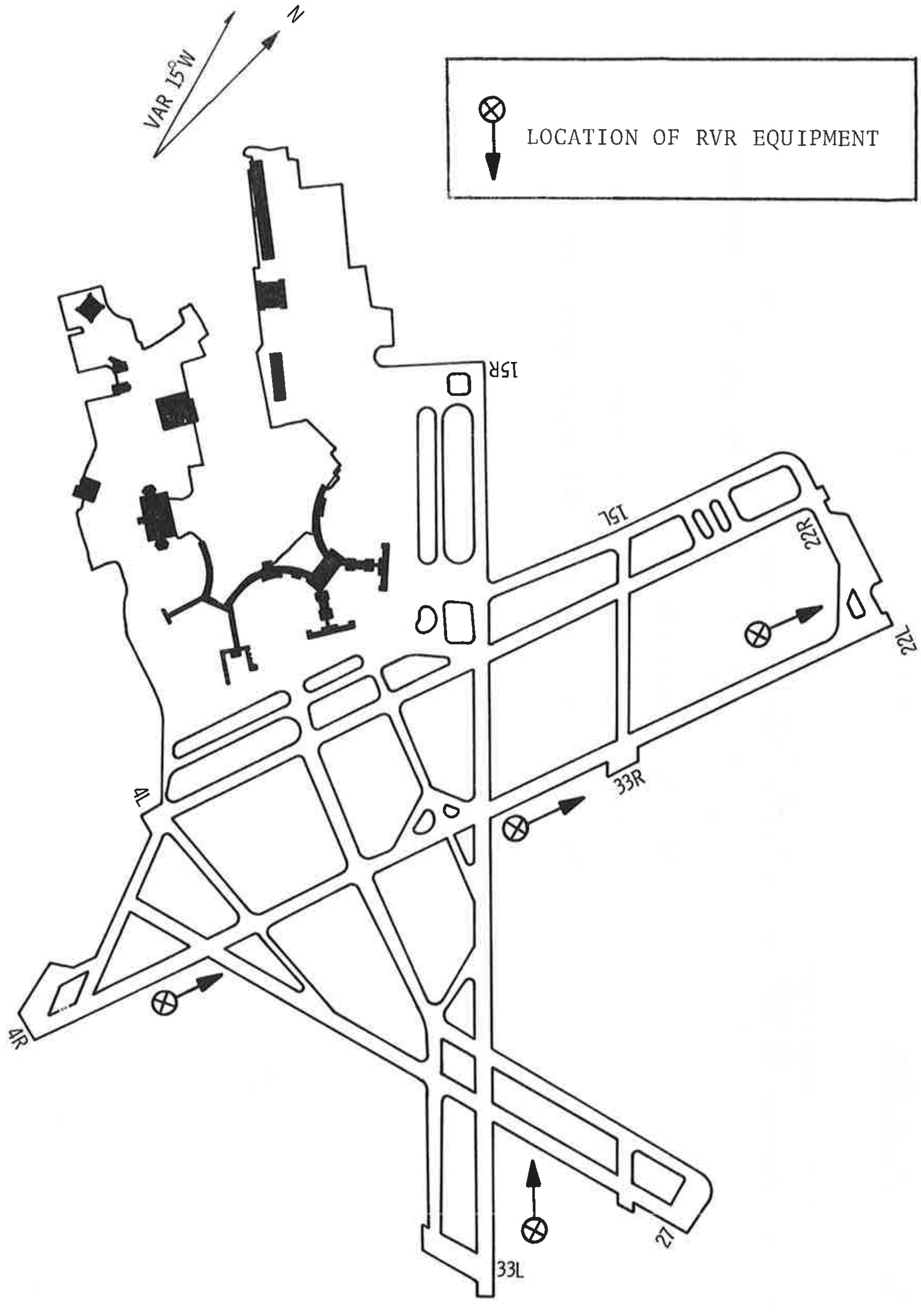
SYSTEM DIAGRAM:



SYSTEM ELEMENTS

SYSTEM: RVR

NO.	NAME	LOCATION	#	FUNCTION
1	Transmissometer	Along runway	1	Determine atmospheric transmissivity. The projector directs a light beam toward the receiver. A photoelectric detector in the receiver produces a signal in the form of pulses, the pulse rate being directly proportional to the amount of light collected by the receiver. This pulse signal is transmitted to the indicator where it is converted to a signal that is directly proportional to pulse rate.
2	Day/night photoswitch	Outside of tower	1	Change state when ambient light level crosses the 2 foot-candle level.
3	Runway light intensity	Runway edge light substation at runway edge	1	Provide relay closings corresponding to runway light settings of: no light, LS3, LS4, LS5, and one other.
4	Signal data converter assembly (Computer)	Tower--6th floor	1	Accept the pulse output from a transmissometer, day/night condition information, and runway light intensity, and compute runway visual range via table lookup.
5	Receiver/Decoder	Tower-Control Console	1	Receive pulse information from (4); decode it, and change it to a form suitable for operating displays. Can accept input from up to 10 computers. Contains 3 displays.



N
VAR 15°W
LOCATION OF RVR EQUIPMENT
15R
15L
22R
22L
33R
4L
4R
27
33L

SYSTEM INFORMATION FLOW

SYSTEM: RVR

NO.	SOURCE ELEMENT	DESTINATION ELEMENT	DESCRIPTION
1	1	1	Atmospheric transmissivity: pulses, rate proportional to amount of light collected
2	2	4	Day/night condition
3	3	4	Runway light intensity information
4	4	5	Runway visual range information, in pulse format

SYSTEM: RVR

CONSOLE ELEMENTS

NO.	NAME	DIMENSIONS (L x W x D)	INSTALLATION CONSTRAINT
1	Remote Display Programmer	8"x11"x11"	None

OPERATIONAL CERTIFICATION

PERIOD	PERFORMANCE CHECKS	NO. VISITS	TIME	RECORDING/ REPORTING
Daily	a) Observe operation of all equipment in service. Make adjustment as required b) Computer checks		45 min	Tower is called to take equipment out of service
Weekly	a) Check projector lamp, receiver lens, and receiver lens heater b) Check atmospheric calibration--meter and recorder transmission indications and reported visibility c) Check receiver and projector alignment d) Check receiver head heater if temp <40F e) Aurally check signal at output jack of amplifier power supply f) Check operation of day/night switch g) Check operation of light setting central switch h) Test with computer selector i) RVV backup meter			
Monthly	a) Check receiver leakage current b) Check pulse amplifier heater c) Check operation of alarm system d) Signal data connector tests from remote position e) Check RVR correlation to transmissivity f) Check replacement projector lamp calibration factor g) Check recorder and indicator meter mechanical zero set			

SYSTEM: RVR

CONTROLS AND INDICATORS

NAME	FUNCTION
1. Runway Selector Switch	Select the RVR to display. There are 3 switches. Each can select up to 10 RVR's.
2. Alarm Setting	Set an RVR value for alarm threshold. The alarm system will respond when the RVR is at a value equal to or below the alarm setting.
3. Alarm Indicator Light	Lights when RVR value is equal to or less than selected value.
4. Audio Alarm	Sounds every 4 seconds when RVR value is equal to or less than selected value
5. Day/Night Indicators	Appropriate indicator lit according to reading from photo-switch.
6. Runway Light Setting Indicators	Indicates when runway lights are set on 3, 4, or 5. This is a true monitor of the runway lights' setting on the field. The RVR computer only works on light settings 3, 4, or 5.
7. Illumination Control	Sets illumination of display.
8. Power Switch	Switches system power on or off.
9. Display Values	Display RVR Reading. Left 2 digits are RVR in 100's of feet. 3rd (right) digit has the following meaning: -RVR is less than prefixed value +RVR is greater than prefixed value E - Error or insufficient light from high intensity runway lights to activate the RVR restart (Blank) - Normal T, +T, -T } Test for maintenance

SYSTEM: RVR

SOURCE	EVIDENCE
RVR reading falls below a value preset on the "alarm setting" switch	Alarm light lit Audible alarm every 4 seconds

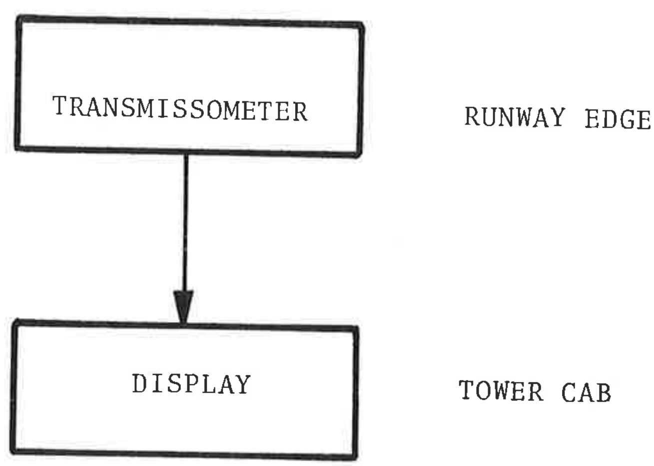
e. RVV

SYSTEM ACRONYM: RVV

SYSTEM NAME: RUNWAY VISUAL VALUE

SYSTEM FUNCTION: Measure the transmissivity of the air at the sensor location. The output is % transmission which can be calibrated to visibility in miles on a day or night scale. NOTE: An "RVV" is the "Transmissometer" element of an RVR system, with a calibrated display. (Scheduled for upgrading to RVR by end of summer 1978)

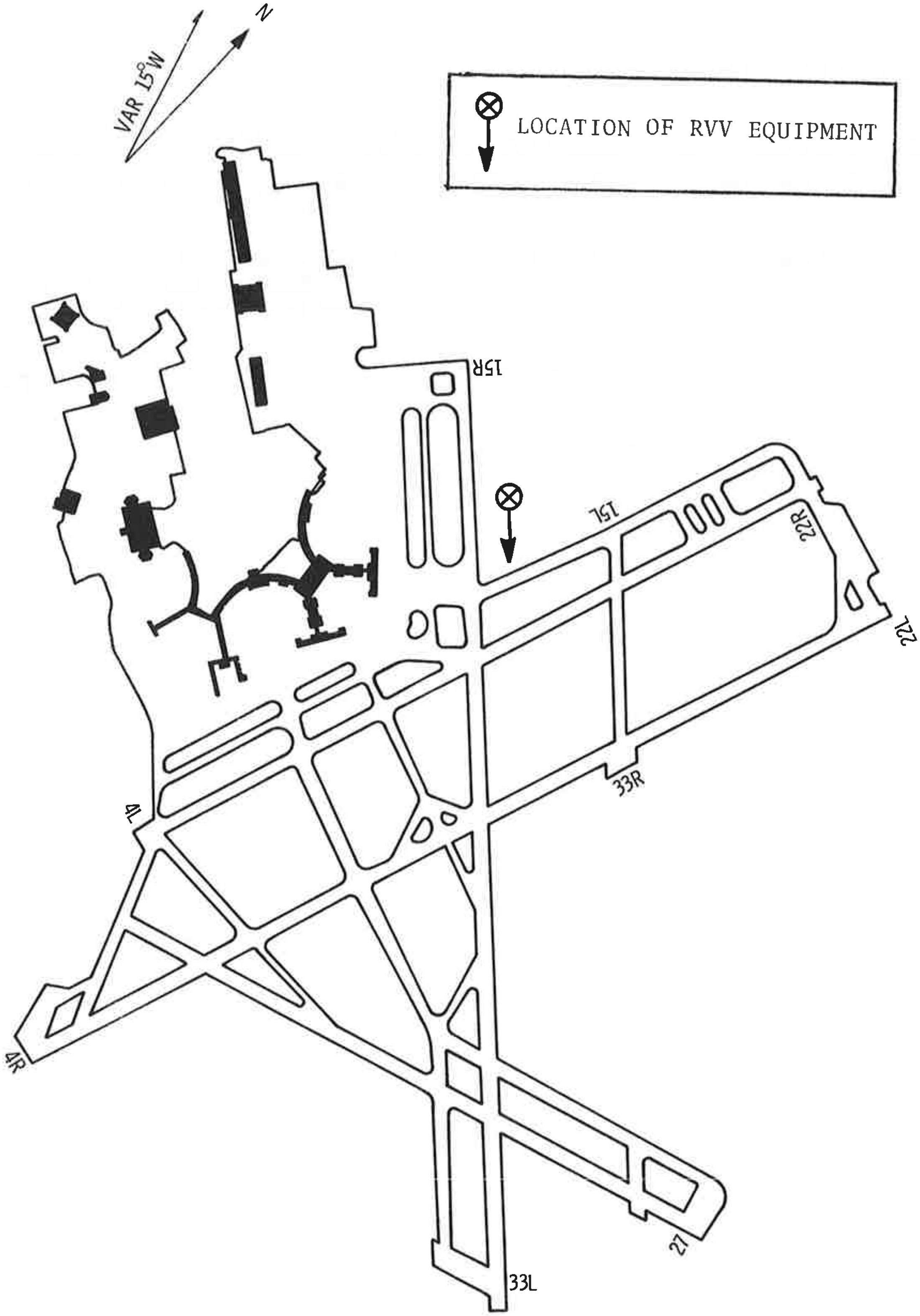
SYSTEM DIAGRAM:



SYSTEM: RVV

SYSTEM ELEMENTS

NO.	NAME	LOCATION	#	FUNCTION
1	Transmissometer	Runway Edge	1	Measure transmissivity air
2	Display	Tower Cab	1	Display calibrated % transmission as "visibility" in miles


N
VAR 15°W
LOCATION OF RVV EQUIPMENT
15R
15L
22R
22L
4L
33R
4R
27
33L

SYSTEM: RVV

SYSTEM INFORMATION FLOW

NO.	SOURCE ELEMENT	DESTINATION ELEMENT	DESCRIPTION
1	1	2	% Transmission Reading

SYSTEM: RVV

CONSOLE ELEMENTS

NO.	NAME	DIMENSIONS (L x W x D)	INSTALLATION CONSTRAINT
1	Display	LxW: As appears D: ~ 6"	None

OPERATIONAL CERTIFICATION

PERIOD	PERFORMANCE CHECKS	NO. VISITS	TIME	RECORDING/ REPORTING
	Similar to RVR			

CONTROLS AND INDICATORS

NAME	FUNCTION
1. Display	Display runway visibility in miles

ALARMS

SOURCE	EVIDENCE
None	

f. TEMPERATURE & DEW POINT

SYSTEM ACRONYM:

SYSTEM NAME: TEMPERATURE & DEW POINT

SYSTEM FUNCTION: Provide weather data to controllers

SYSTEM DIAGRAM:

1) This information comes via telautograph from the Weather Bureau

2) Every hour a complete weather sequence is transmitted. This includes: temperature, dew point, cloud cover, etc.

3) Telautograph transmitters are located at:

   Weather Bureau
   Flight Service Station
   Port Authority
   Tower Cab

4) The telautograph copies at all air lines.

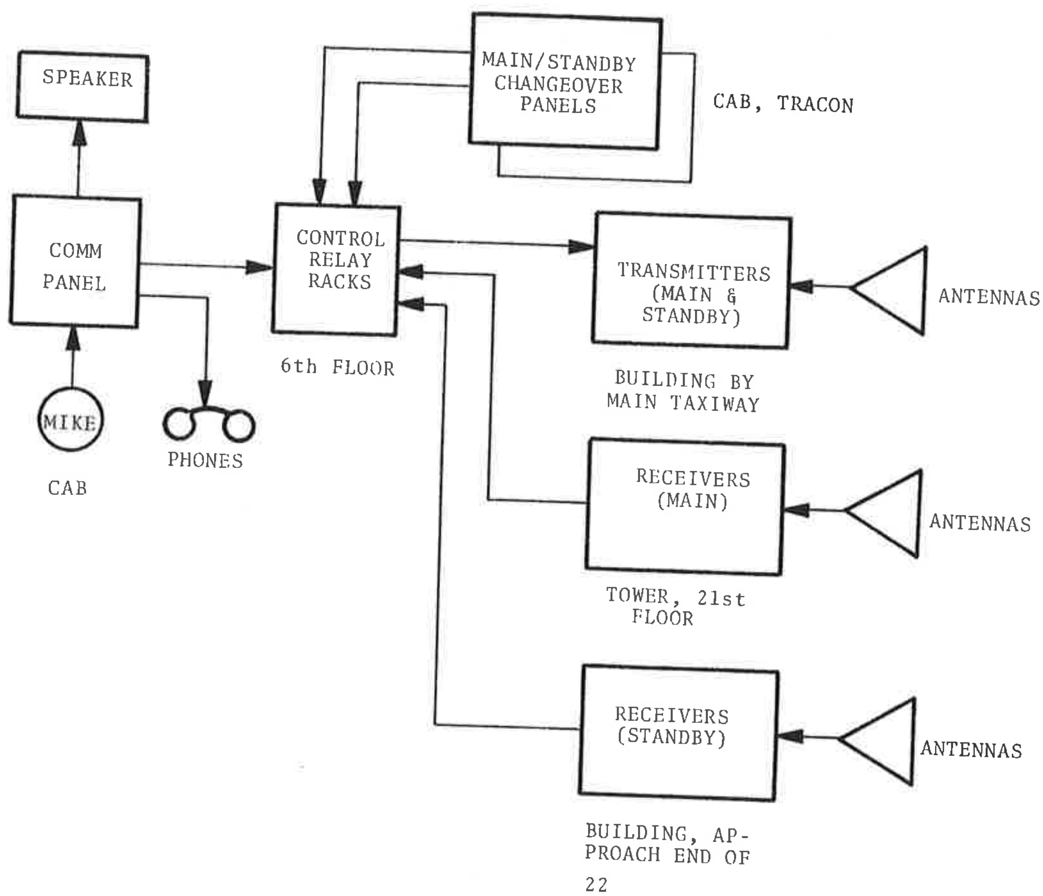
II. FAA RADIO

SYSTEM ACRONYM:

SYSTEM NAME: FAA RADIO COMMUNICATION PANEL

SYSTEM FUNCTION: Select frequencies for receive and transmit on FAA radio.

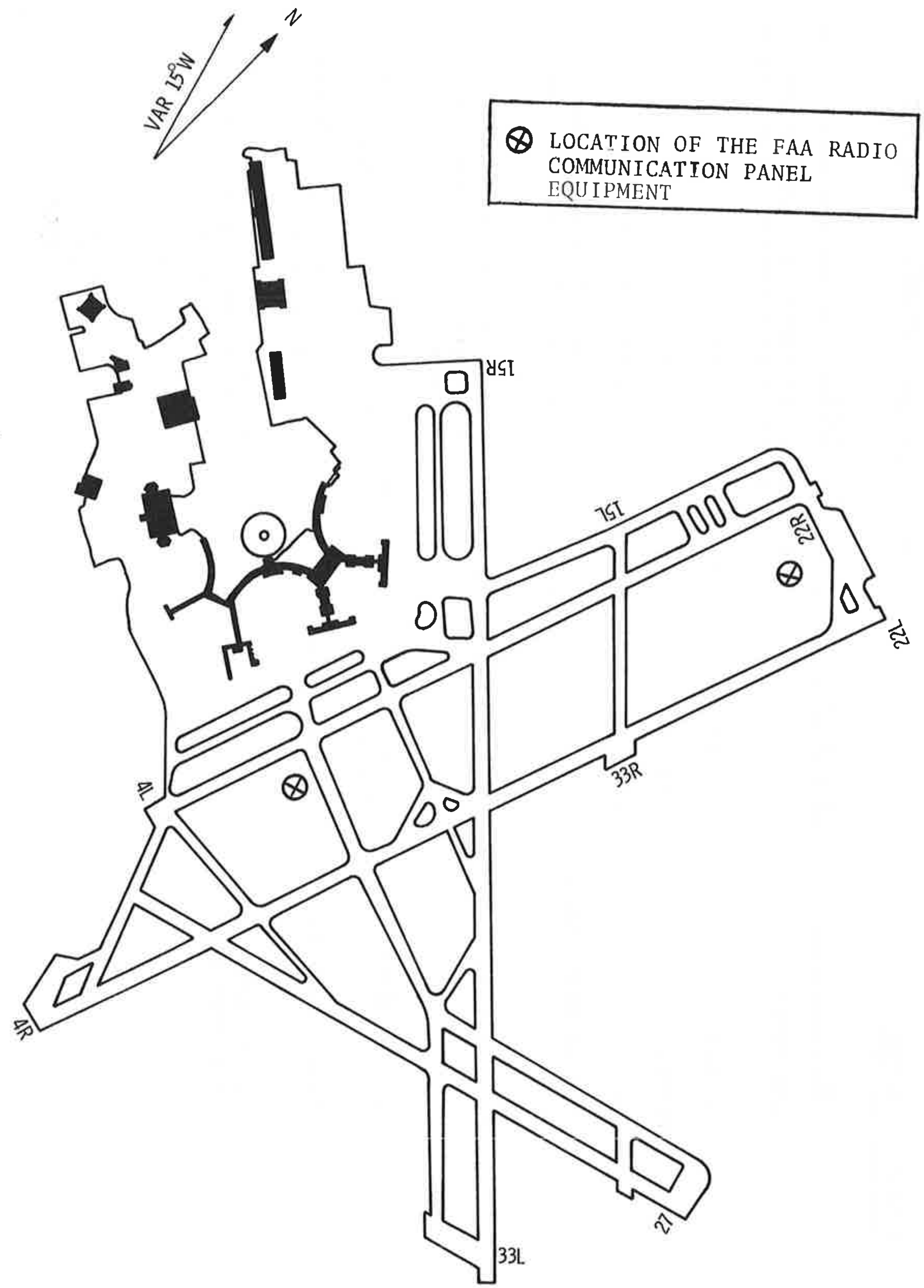
SYSTEM DIAGRAM:



SYSTEM ELEMENTS

SYSTEM: FAA RADIO COMMUNICATION PANEL

NO.	NAME	LOCATION	#	FUNCTION
1	Comm Panel	Console	Lots	Select transmit/receive frequencies, select speaker/phones, select volume
2	Speaker	Console	Lots	Output voice
3	Phones	Console	Lots	Output voice
4	Mike	Console	Lots	Input Transmit voice
5	Control Relay Racks	6th floor	sev-eral	Implement selection of frequencies, receivers, and transmitters, and route signals
6	Transmitters	Main taxiway	38	Transmit RF signal on 19 frequencies (2 transmitters, main and standby, on each frequency)
7	Main Receivers	Tower, 21st floor	19	Receive RF signal on 14 frequencies. (1 receiver for each frequency)
8	Standby receivers	Approach end of 22	19	Receive RF signal on 19 frequencies. (1 receiver for each frequency)
9	Main/Standby Changeover panels	Cab, TRACON (Supervisor)	>1	Select main or standby transmitter or receiver on frequencies used exclusively in that area



VAR 15°W
N
LOCATION OF THE FAA RADIO COMMUNICATION PANEL EQUIPMENT
15R
15L
22R
22L
4L
33R
4R
27
33L

SYSTEM INFORMATION FLOW

SYSTEM: FAA RADIO COMMUNICATION PANEL

NO.	SOURCE ELEMENT	DESTINATION ELEMENT	DESCRIPTION
1	3	1	Voice input
2	1	2	Voice output
3	1	3	Voice output
4	1	5	Control signals for selection of frequencies, and volume
5	5	6	Switching signals for implementation of transmitter and transmit frequency selection
6	5	7,8	Switching signals for implementation of receiver and receive frequency selection
7	9	1	Control signals for selection of transmitter and receivers

SYSTEM: FAA RADIO COMMUNICATION PANEL

CONSOLE ELEMENTS

NO.	NAME	DIMENSIONS (L x W x D)	INSTALLATION CONSTRAINT
1	Comm. Panel	LxW: as appears D: <6"	None

OPERATIONAL CERTIFICATION

PERIOD	PERFORMANCE CHECKS	NO. VISITS	TIME	RECORDING/ REPORTING
Daily	All receivers and transmitters for operation			Call tower and tell to go to standby if main is down. (generally, tower informs AF first.)

SYSTEM: FAA RADIO COMMUNICATION PANEL

CONTROLS AND INDICATORS

NAME	FUNCTION
1. Receive Lights (8)	Lit if a signal is coming in on that frequency
2. Receive select toggle switches (8)	Left→ receive on speaker Ctr→ Don't receive on this frequency (off) Right→ Receive on phones (if more than 1 frequency is selected the user hears on all simultaneously)
3. Transmit Lights (8) Transmit select toggle swithces (8)	Lit if someone is transmitting on this frequency. CTR→ Don't transmit on this frequency (off) RIGHT→ Transmit on this frequency (on) May transmit on more than one frequency simultaneously. Transmit is locked out if someone else is already transmitting on that frequency. A local buzzer sounds if transmission is attempted while another is transmitting.
4. Transmit button (on mike)	Key transmission
5. Phone Volume Knob	Adjust phone volume
6. Speaker Volume Knob	Adjust speaker volume
7. Receiver Selection Buttons* (one for each frequency)	Select main or standby receiver; Push once--goes to standby, lite goes on; Push again--goes to main, lite goes off.
8. Transmitter Selection Buttons* (one for each frequency)	Select main or standby transmitter push once--goes to standby, lite goes on; push again--goes to main, lite goes off.

*Located in main/standby changeover panels

SYSTEM: FAA RADIO COMMUNICATION PANEL

SOURCE	EVIDENCE
Attempt to transmit on a frequency on which a transmission is already taking place.	Local Buzzer

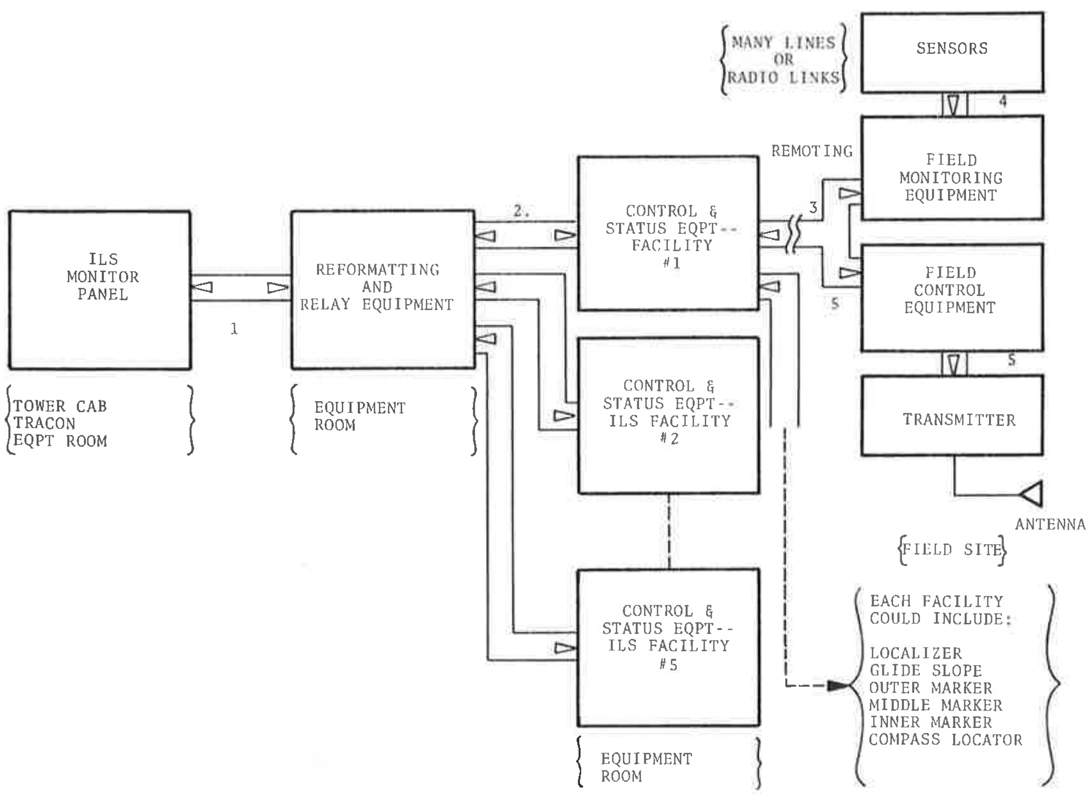
III. ILS

SYSTEM ACRONYM:

SYSTEM NAME: ILS MONITOR PANEL

SYSTEM FUNCTION: Provide status monitoring and controls for all ILS facilities

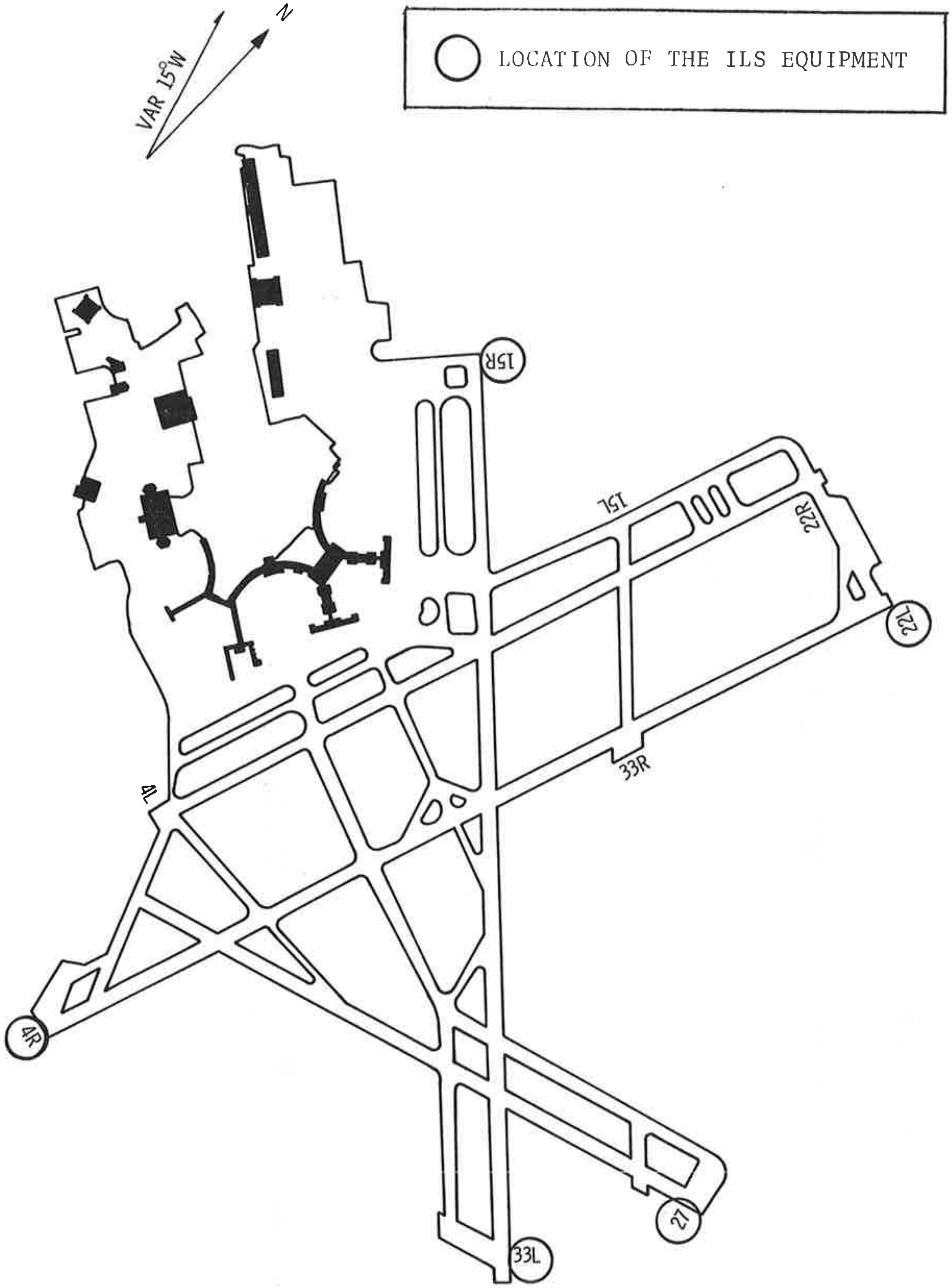
SYSTEM DIAGRAM: (general)



SYSTEM ELEMENTS

SYSTEM: ILS

NO.	NAME	LOCATION	#	FUNCTION
1	ILS Monitor Panel	Cab, TRACON, Equipment room	3	Display status & enter controls (TRACON & Eqpt. Room only).
2	Re-formatting & relay eqpt.	Equipment room	1	Consolidate status & control signals from/to all ILS facilities for monitor panel.
3	Control & Status Equipment	Equipment room	5	Interface & output control for each ILS facility.
4	Field monitoring equipment	Field site for many subsystems of many ILS facilities	Lots	Monitor status sensors and format information for remoting to equipment room.
5	Sensors	With each of (4)	Lots	Sense status of ILS facility --radio transmission, excessive heat, main/backup equipment, etc.
6	Field control equipment	Field site for many subsystems of many ILS facilities	Lots	Convert control signals received from equipment room to appropriate switching for ILS equipment at site.
7	Transmitter(s)	With each of (6)	1 or 2 for each (6)	Transmit ILS signal.
8	Antenna	With each of (6)	1 for each (6)	Generate appropriate ILS signal pattern in space.



N
VAR 15°W
LOCATION OF THE ILS EQUIPMENT
15R
15L
22R
22L
33R
4L
4R
27
33L

SYSTEM INFORMATION FLOW

SYSTEM: ILS

NO.	SOURCE ELEMENTS	DESTINATION ELEMENT	DESCRIPTION
1	1	1	Control
	2	1	Status
2	2	3	Control
	3	2	Status
3	4	3	Status
4	5	4	Status
5	3	6	Control
	6	7	Control

SYSTEM: ILS

CONSOLE ELEMENTS

NO.	NAME	DIMENSIONS (L x W x D)	INSTALLATION CONSTRAINT
1	ILS Monitor Panel	19"x12"x<6"	None

OPERATIONAL CERTIFICATION

PERIOD	PERFORMANCE	NO. VISITS	TIME	RECORDING/ REPORTING
Daily				AF calls tower to re-port system restoration

ILS MONITOR PANEL

CONTROLS,

INDICATORS

&

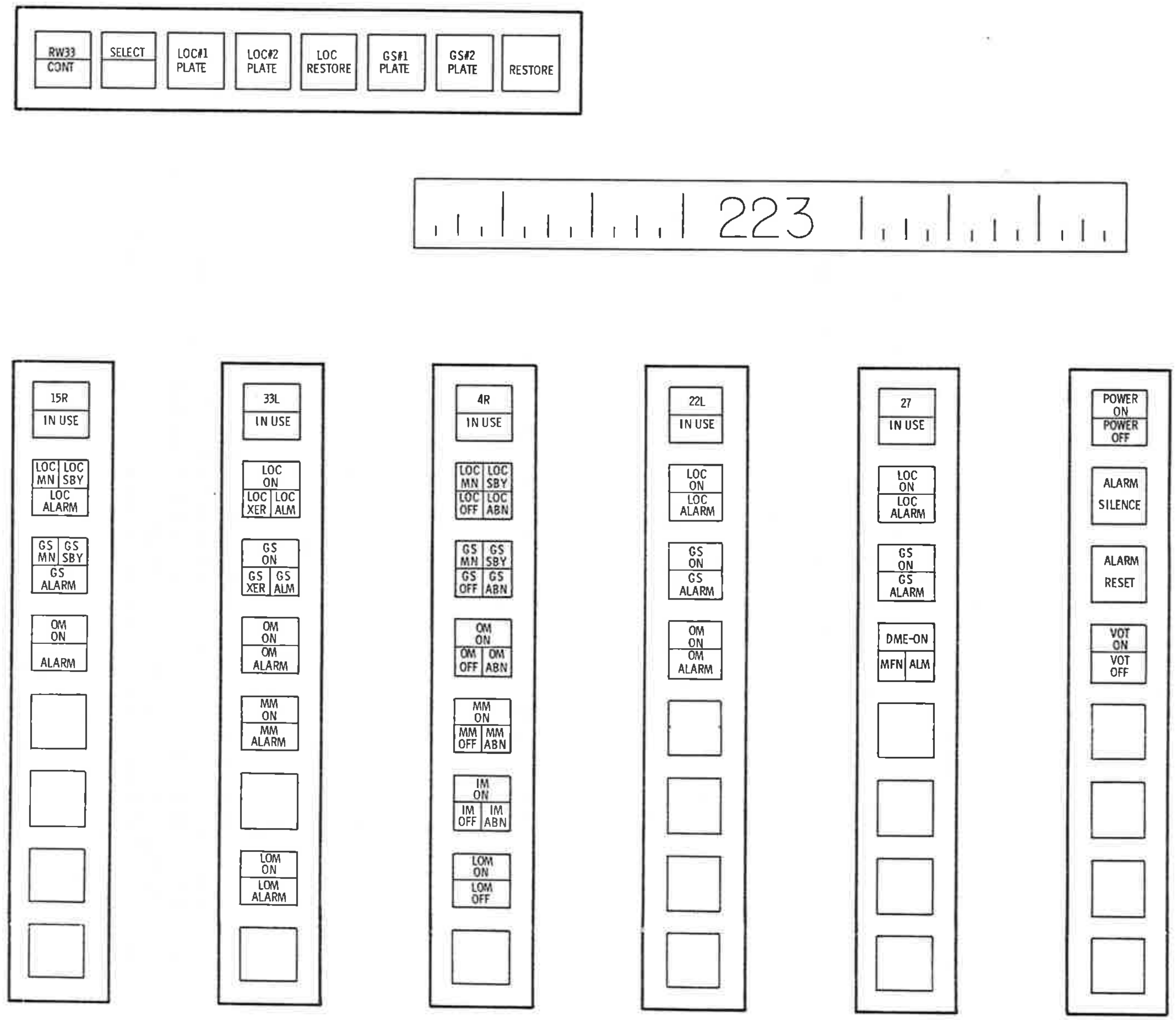
ALARMS

General

The TRACON has controls. The Cab does not.

The only exception to this is the alarm silence button which operates at all three locations (TRACON, Cab and Equipment Room) and, when operated, will silence the alarm at all locations even though only operated at one location.

Alarms may not mean that the alarming equipment is off the air. It could mean that there is an open control line, burned out light bulbs, etc. AF more frequently has troubles with the monitoring equipment than with the actual ILS equipment.



ILS MONITOR PANEL (TRACON)

RUNWAY 33L

Selection

1) Interlocked with RWY 15R

2) When selected via push at "33L IN-USE" button

   a) "IN-USE" Lights on 33L
   b) "IN-USE" goes off on 15R
   c) LOC & GS Alarms Light on 15R
   d) 33L LOC & GS comes up on whichever equipment (#1 or #2) was previously selected. IF "XER" existed before, it reappers
   e) The audible alarm for 15R LOC & GS is automatically silenced
   f) LOC & GS Alarm lites go off on 33L, the audible is auto-silenced.

3) NOTE: ALL Markers (OM, MM, SM) on all ILS systems are continuously on (unless down for failure or maintenance) and are not affected by operation of "select" switches. (Same is true for LOC and VOT.)

LOC & GS:

1) LOC #1 Plate & LOC #2 Plate are interlocked. Pushing #1 turns on the #1 localizer transmitter plate and turns #2 off.

2) "Both #1 & #2 off" cannot be accomplished except via dial-up from the equipment room.

3) When ALARM occurs: (on LOC, for example)

   a) The "LOC ON" light goes off
   b) The "alarm" light goes on
   c) The audible goes on
   d) The system automatically transfers to the "other" equipment, if it is operational, if so, then:
   e) The "XER" light goes on--and remains on until it is manually reset at the site
   f) The "alarm: light stays on until "alarm reset" is pushed
   g) The "LOC ON" light goes on
   h) The audible remains on
   i) If the "other" equipment is not operational then conditions a), b), and c) remain and the system is shutdown.

4) If a transfer has already occurred (automatically, leaving the "XER" light on), and the "XER" light has not been reset manually in the field, and other alarm occurs, the system is automatically shutdown, whether or not the "other" equipment is operational. Transfer cannot occur automatically again until the manual reset of "XER" has taken place.

However, the operator may still manually dial back to either equipment (using the "LOC #1 plate"--"LOC #2 plate" buttons) at any time he wishes.

5) XER does not light when "LOC #1 or LOC #2 plate" buttons are pushed. Only lights when an auto transfer takes place.

6) Alarms only turn the navigation signals off for 33L ILS. The ID and main transmitter remain on. "Restore" turns these navigational "modulating" signals back on for whatever equipment is selected.

The "restore" function does not exist as such on the other runways' ILS.

The "plate" and "restore" buttons for GS function identially to those for LOC.

Markers & Locater

1) These are go--no go indicators. They have no control functions.

2) Alarms (audible) from these must be handled with the general "alarm silence" and "alarm reset" buttons.

3) An ALARM causes the "on" light to go off and the "alarm" light to come on. If the fault goes away or is repaired at the site the "ON" light will go back on but the "alarm" light will remain. "Alarm reset" will have to be pushed then to re-enable an audible alarm for this equipment and put out the "alarm" light.

4) These markers do not have an auto-shutdown feature like the LOC & GS do. (Markers on other runways do have an auto-shutdown feature).

General - 33L

1) The XER feature on Logan 33L tube-type ILS is unique in its operation. This was set up for "compatibility" with the other ILS systems. This feature won't be on most other tube-type equipment.

2) 33L ILS is the poorest performing ILS at Logan, in terms of reliability. Replacement of it is currently in the talking stage, (7/78). It would be around 3 years minimum before a new system was ordered, and probably 5 years before it would be complete.

Runway 15R

Selection:

1) Interlocked with RWY 33L

2) Selection results in opposite of what is described under 33L, except: LOC & GS come up in "main"[1] regardless of whichever equipment was previously manually selected. But if an auto-transfer occurred previously and the system was left in standby it will (after de-selection and re-selection) come up just as it was.

LOC & GS

1) "Main" and "standby" equipment are interlocked so pressing the "LOC" button causes the LOC to cycle: Main→SBY→off→ etc.

2) When manual pushing of "LOC" button cycles the system to "off" an alarm (light and audible) occurs.

3) When ALARM occurs:

   a) The "main" light goes off
   b) The "alarm" light goes on
   c) The audible comes on
   d) The system transfers to standby if the standby equipment is operational, if so, then:
   e) The "standby" light goes on
   f) The alarm light stays on until "alarm reset" is pushed.
   g) The audible remains on [2]
   h) If standby eqpt. not operational, conditions a), b), and c) remain and system is shut down.

4) If the system was operating on "standby" equipment when the ALARM takes place, the system is automatically shut down, whether or not "main" equipment is operational.

   a) The "standby" light goes out
   b) The "alarm" light goes on
   c) The audible comes on

---

[1] What really happens is whatever equipment you had selected last time is brought back up again and "called" main. The system will execute one auto-transfer to the other equipment, in the event of alarm, regardless of which equipment is "called" main.

[2] After "alarm silence" and "alarm reset" this condition looks the same as if the operator had manually selected the standby equipment.

5) After an alarm--if the fault was temporary (or if the equipment has been repaired)--the operator may manually cycle the system to "off" and to "main." In the event of another alarm on this equipment, an auto-transfer to "standby" will then occur. The transfer capability does not have to be reset in the field as it does on 33L. However, the auto-transfer will only work from "main" to "standby."

   If the operator cycles the equipment to "main" and main is not operational, an auto-transfer to "standby" will occur within 30 sec.

6) Alarm Silence and Alarm Reset work in the normal fashion for LOC and GS.

Marker

1) This is a go-no go indicator. It has no control functions.

2) This is the same as for 33L--except the marker and the LOM for 15R do have an auto-shutdown feature. (The LOM is collocated with the OM.) (The LOM could be wired to the monitor could be wired to the monitor panel, but it is only required to monitor one of two collocated equipments as long as they both have auto shutdown.)

3) These could be controlled remotely but because of the cost of telephone lines it was decided not to do so. The OM has only 1 monitor line, no telephone. The LOM is monitored in the FSS, by radio.

Runway 4R

Selection

1) Interlocked with RWY 22L

2) Selection of 4R operates identically (in terms of "alarm" lights vs "on" lights with respect to 22L) as selection of 15R does VS33L. Any displays that have been brought about by alarms or abnormalities are restored when 4R is de-selected than re-selected, they are not forgotten.

LOC-GS

1) This equipment functions like the equipment on 15R except:

   a) The cycle is MAIN→OFF→SBY→OFF→MAIN--etc.
   b) An auto-transfer can occur from "main" to "SBY" (skipping the intervening "off" condition). But a failure when the equipment is operating in "SBY" causes an auto-shutdown and leaves the equipment the same as if it had been manually cycled to off.

2) Alarm Conditions

   I. a) "Main" light stays on
      b) "Abnormal" light goes on steady
      c) Audible goes on. ("Alarm Silence" must be pushed) This means there is a problem at the site (air conditioning off, battery voltage low,---etc.), but the equipment is still working. (Maintenance should be notified.)

   II. a) "Main" light goes off
      b) "Abnormal" light goes on-steady
      c) Audible goes on. ("Alarm silence" must be pushed.)
      d) "SBY" light goes on. ("Alarm reset" must be pushed to get another audible.) This means the "main" equipment went off the air but the facility is still on the air with the standby equipment.

   III. a) "SBY" light goes off (or "Main" light if facility operating on main equipment and standby equipment is down.)
      b) "Abnormal" light goes on steady.
      c) Audible goes on ("alarm silence" must be pushed)
      d) "OFF" light (red) goes on. This means the facility is off the air. The operator should try to "re-set" it (cycle to the other equipment) by holding this button in for 5 sec.

IV. a) "Abnormal" light goes on--blinking. This means that there is a technician at the site who has bypassed the monitor for maintenance.

3) "Abnormal" light will remain on while one or both equipments are down, as well as during the "problem" conditions described in (1).

Markers

OM-MM-IM

1) These are controls and can turn the marker ON or OFF.

2) The "ABN" light indicates a "problem" condition (operating on battery power but still on the air, for example).

3) The "OFF" light indicates the facility is off the air. (The "ABN" light will be lit at the same time.)

4) The "ON" light indicates the facility is on the air.

5) An audible alarm will occur when a problem causes the "ABN" light to light or when a failure causes the "OFF" light to light.

LOM

1) This is an ON/OFF the air indicator.

2) It does have a "reset" capability. Pushing will try to turn LOM back on* after loss of both power sources has shut it down.

*To commercial power.

Runway 22L

Selection

1) Interlocked with RWY 4R.

2) Selection of 22L operates identically (in terms of "alarm" lights versus "on" lights with respect to 4R) as selection of 15R does versus 33L. Any displays brought about previously by alarms or abnormalities are restored when 22L is de-selected then re-selected, they are not forgotten.

LOG-GS

1) These are ON/OFF controls and go/no-go monitors.

2) There is no standby equipment.

3) Otherwise these controls/alarms function like 15R.

OM

1) This is a go/no-go indicator.

2) The marker is on all the time.

LOM

This is not monitored on the ILS monitor panel. It is monitored at the FSS. It is a high-power, omni-directional station that broadcasts weather. (HLOM)

RUNWAY 27

Selection

This ILS is on all the time, and monitored by three radio receivers.

LOC and GS

These are go/no-go indicators. There are no control functions.

DME

1) This also is an indicator--not a control.

2) "MFN" light indicates there has been a malfunction but the facility is still on the air, and a man should be sent out to check. (Receiver sensitivity could drop by 1.5 dB, for example.)

3) "ALM" indicates the facility is off the air (or the receiver in the tower died--[down by 3 dB]. (In general, the monitor system gives more trouble than the ILS equipment.)

Alarm

Audible alarm is triggered by "alarm," "ALM" or "MFN" events, and is silenced and reset as on other systems.

RIGHTMOST CONTROL COLUMN

Alarm Silence

An audible alarm can be shut off only by this control. The audible will remain on after an alarm until this button is pushed--even if an auto transfer to standby equipment has taken place.

After "alarm silence" is pushed the alarming equipment can no longer trigger audible alarms, but all other equipment that was not in alarm condition can still trigger audible alarms.

If the equipment that alarmed was the sort that has backup equipment (33L LOC, for example) and it is brought into operation (either by auto transfer or manually) then that backup equipment will not be able to trigger audible alarms until "alarm reset" is pressed. This is true even though that backup equipment is operational, is up and the system is in service.

Alarm Reset

Re-enables the triggering of audible alarms on all equipments that have triggered audible alarms and had them silenced by the operator pushing the "alarm silence" button.

On systems that experienced a momentary alarm (where the equipment did not go out of service so the green "ON" or "MN" light stayed on or came back on), or on systems that experienced a real failure (where the backup equipment came into service and the "SBY" or "XER" lights came on), or on systems which experienced a real failure but had no backup equipment (or it wasn't operational) but which subsequently had equipment manually restored to service at the site (causing a green light to go on at the monitor panel), pushing "alarm reset" (after pushing "alarm silence") will also cause the red "alarm" on "off" light to go out.

If, since triggering the audible alarm and being silenced, the equipment has come back up, been repaired, or transferred to backup equipment, it will not trigger a new audible alarm when "alarm reset" is pushed.

If, however, there is an equipment that has alarmed and been silenced, and has not been repaired or its backup equipment is also not operational, then when "alarm reset" is pushed this equipment will trigger a new alarm and have to be silenced.

VOT

This is a go/no-go indicator. It will show "on" or "alarm" condition. If after alarm the equipment is restored it will revert to displaying the "on" condition.

The audible alarm which is also triggered when the alarm light goes on can now be silenced in the same way as all other audible alarms.

IV. LIGHTING

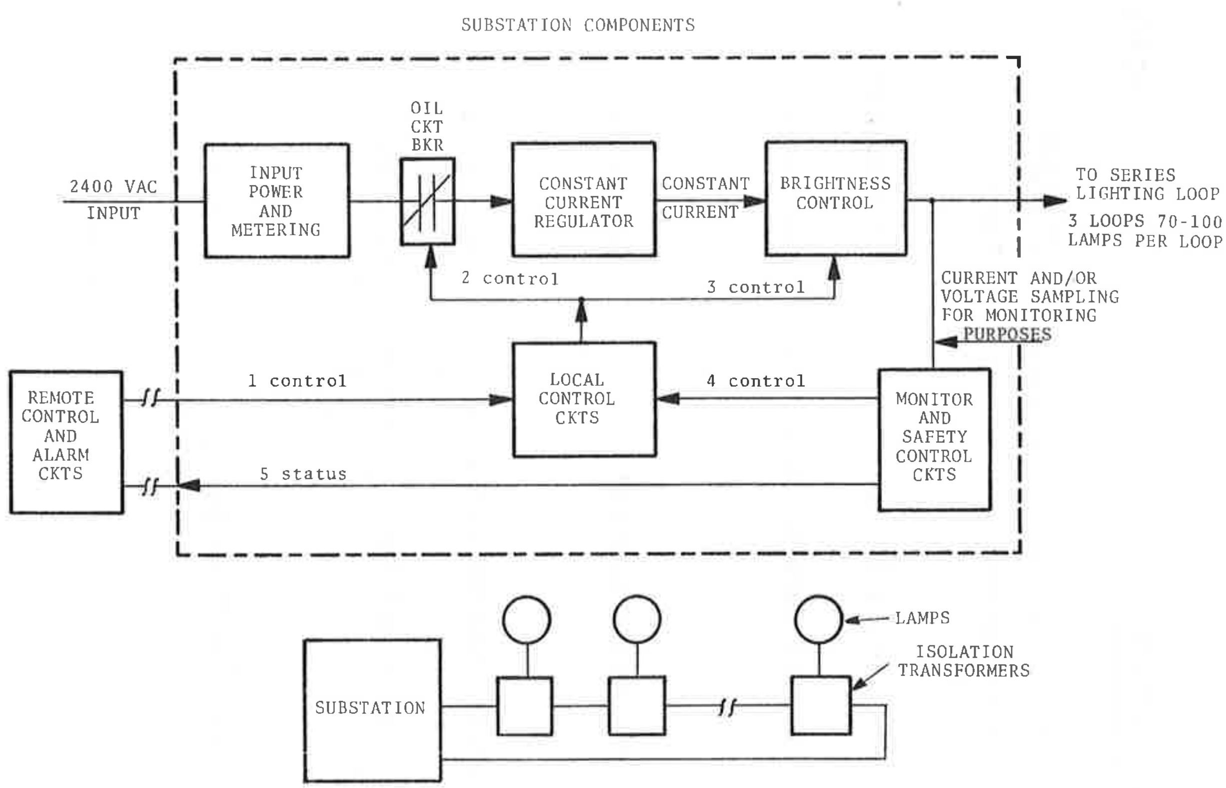
a. ALS

SYSTEM ACRONYM: ALS

SYSTEM NAME: (HIGH INTENSITY) APPROACH LIGHTING

SYSTEM FUNCTION: Provide a visual ground reference to the pilot when making an approach to the runway. Provides: 1) lateral guidance, 2) horizontal banking position, 3) impending touch-down position, 4) runway threshold location, and 5) 21 high intensity sequential flasher lights.

SYSTEM DIAGRAM:



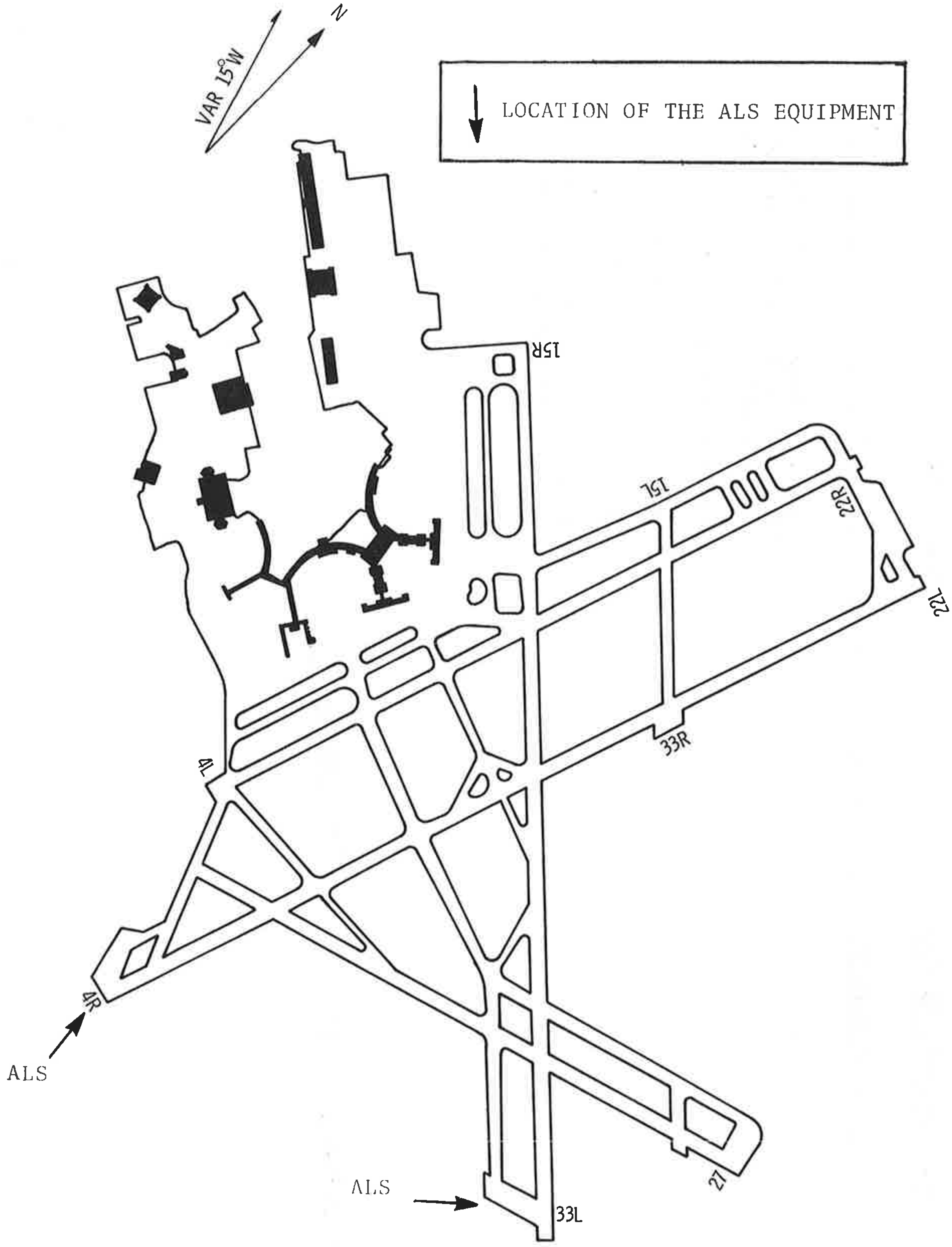
SERIES LIGHTING LOOP

SYSTEM ELEMENTS

SYSTEM: ALS

NO.	NAME	LOCATION	#	FUNCTION
1	Remote Control and Alarm Circuits	Tower	1	Provide, at remote site, control inputs to ALS monitor circuits.
2	Oil Circuit Breakers	Substation*	1	Controls commercial power input.
3	Constant Current Regulator	Substation	1	Maintains constant current input to the lighting loop in the event of lamp burn-out changing the circuit load.
4	Brightness Control	Substation	1	Selects brightness that is desired on the ALS lights, as determined at the control inputs.
5	Local Control Circuits	Substation	1	Provides control inputs to ALS at the substation.
6	Monitor and Safety Control	Substation	1	Detect malfunctions and cause a visual and aural alarm at the remote site, shut down ALS as appropriate.
7	Isolation Transformers	Runway	At each lamp	Provide series circuit continuing in case of lamp failure.
8	Lamps	Runway	>200	Provide the visual presentation to approaching aircraft

*Substation is at side of runway, near end of runway


VAR 15°W
N
LOCATION OF THE ALS EQUIPMENT
15R
15L
22R
22L
4L
33R
4R
ALS
ALS
33L
27

SYSTEM INFORMATION FLOW

SYSTEM: ALS

NO.	SOURCE ELEMENT	DESTINATION ELEMENT	DESCRIPTION
1	1	5	Control: Power on/off, brightness level, AUX circuit control (not operational)
2	5	2	Control: Power on/off
3	5	4	Control: Brightness level
4	6	5	Control: Power on/off
5	6	1	Status: Normal/alarm--lamp out, or system shutdowns

SYSTEM: ALS

CONSOLE ELEMENTS:

NO.	NAME	DIMENSIONS (L x W x D)	INSTALLATION CONSTRAINT
1	Remote Control Panel	LxW: as appears D:≈ 8"	None

OPERATIONAL CERTIFICATION

PERIOD	PERFORMANCE	NO. VISITS	TIME	RECORDING/ REPORTING
Weekly	a) Make visual operational checks of all lights (including flashers) on all steps.	1	2-3 hr	FAA Form 6030-1 Log at each equipment site. HF calls (Tel or radio) the tower to report any equipment outage
Monthly	Test ALS monitor physically remove lamps). Test ALS 15 min Step 5 timer	1	4-5 hr	
Semi-annually	Check all light fixtures for alignment			

SYSTEMS: ALS

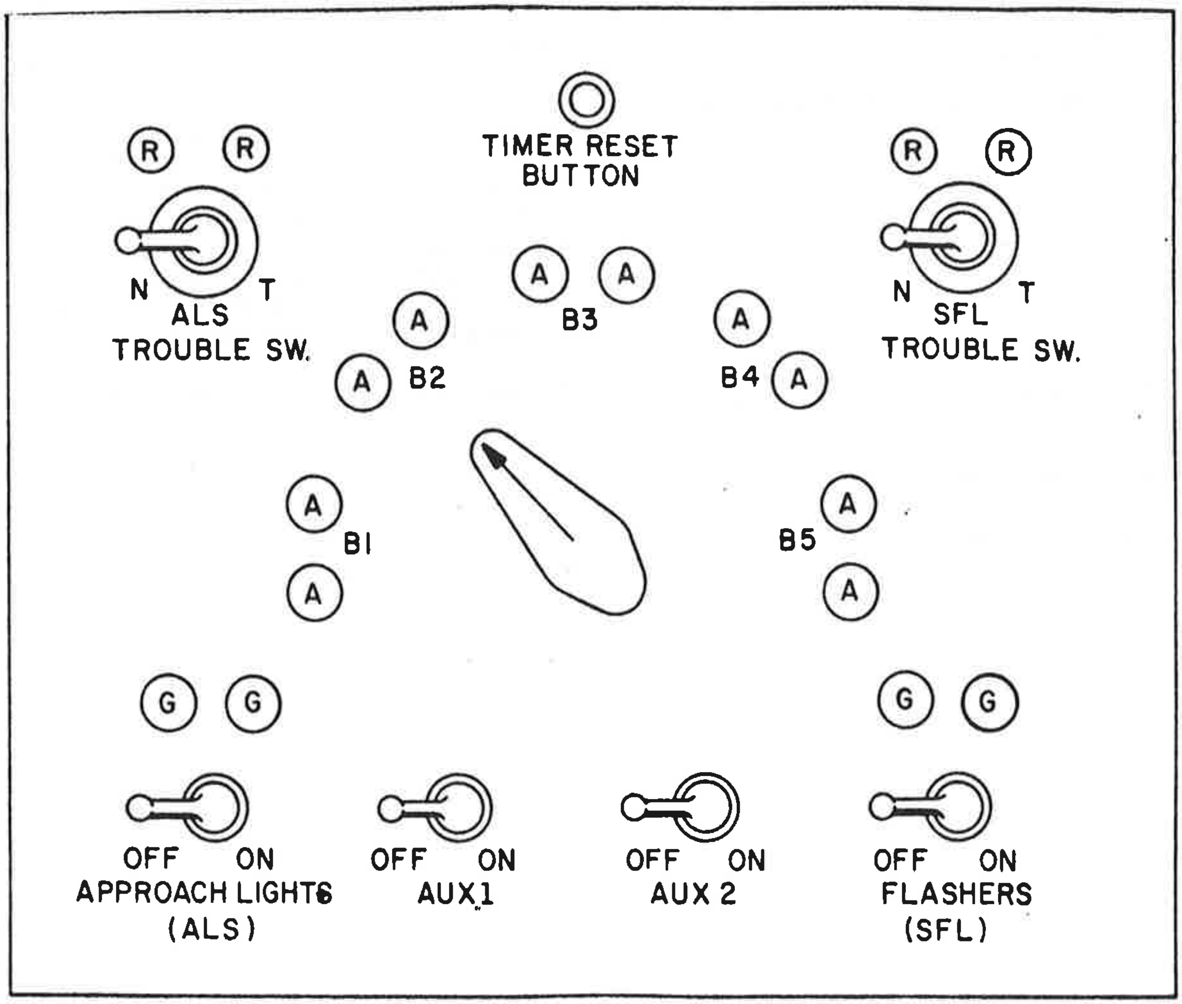
CONTROLS AND INDICATORS

NAME	FUNCTION
1. ALS on/off switch [(4) should be at setting 1 to prevent current surges and outages.]	Powers the ALS. Lights green ALS monitor lights (2). Lights amber lights (5) for brightness level 1 (system operates initially at brightness level 1 for 2 sec.).
2. ALS monitor lights--green	Lit when (1) is on and no alarms are active. One light out of the pair means the bulb is bad.
3. ALS monitor lights--red	Lit when an ALS monitor alarm is active. 1 lite out = bad bulb.
4. ALS brightness selector switch	Selects one of 5 brightness levels. System comes up at brightness level 1 for 2 sec. When brightness level 5 is selected the system will remain there for 15 min. only, then will return to level 4, although the selector switch (4) remains at the level 5 setting. (The level 4 brightness lights will come on.) Buzzer sounds at 14.5 min of BR5 for 30 sec. The trouble/normal switch (7) won't kill the buzzer. The brightness selector switch (4) the timer reset (6) will kill the buzzer.
5. ALS brightness lights--amber	Indicate which brightness level the ALS is really operating on. Respond to the control relay settings, not the setting of the brightness selector switch (4). One light out of a pair means the bulb is bad.
6. ALS timer reset button	Resets the timer for the brightness 5 setting to retain that setting for 15 minutes.

SYSTEM: ALS

CONTROLS AND INDICATORS

NAME	FUNCTION
7. ALS trouble-normal switch	Silences monitor alarm buzzer by moving to T position. (Buzzer will sound again when the trouble has been cleared.) Silences trouble clear buzzer by restoring to N position. Will cause buzzer to sound if moved to (T/N) position during (normal/alarm) operation.
8. Buzzer	Sounds when alarm condition occurs.
9. Aux 1 on/off switch	Not operational
10. Aux 2 on/off switch	Not operational



ALS Remote Control Panel Layout.

SYSTEMS: ALS

ALARMS

SOURCE	EVIDENCE
1. Five (or more) lamps out	ALS green monitor lights go off ALS red monitor lights go on Buzzer on (ALS remains in service)
2. Short circuited light loop	ALS green monitor lights go off ALS red monitor lights go on ALS amber lights go out Buzzer on (ALS shutdown, requires field visit to bring it up)
3. Open circuited light loop	ALS green monitor lights go off ALS red monitor lights go on ALS amber lights go out Buzzer on (ALS shutdown, requires field visit to bring it up)
4. DC control power is lost	ALS green monitor lights go off ALS red monitor lights go on ALS amber lights go out Buzzer on (ALS shutdown)
5. Brightness level five 15-min timer reaches 14.5 min. point	Buzzer on (for 30 seconds) Brightness level changes to four at the end of 30 seconds (ALS remains in service)

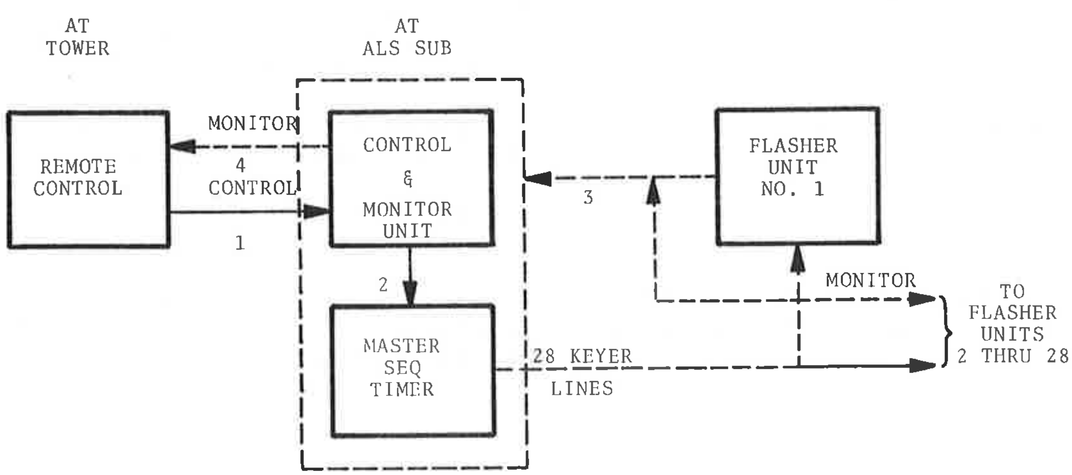
b. SFL

SYSTEM ACRONYM: SFL

SYSTEM NAME: SEQUENCE FLASHING LIGHTS
(Actually a subsystem of ALS)

SYSTEM FUNCTION: Provide vital information to planes approaching a runway under instrument conditions. Give effect of a brilliant ball of light moving towards the runway at 3600 mph. Attract the eye and penetrate severe atmospheric conidtions to provide distinct directional guidance. (Normally cannot be operated with ALS off.)

SYSTEM DIAGRAM:



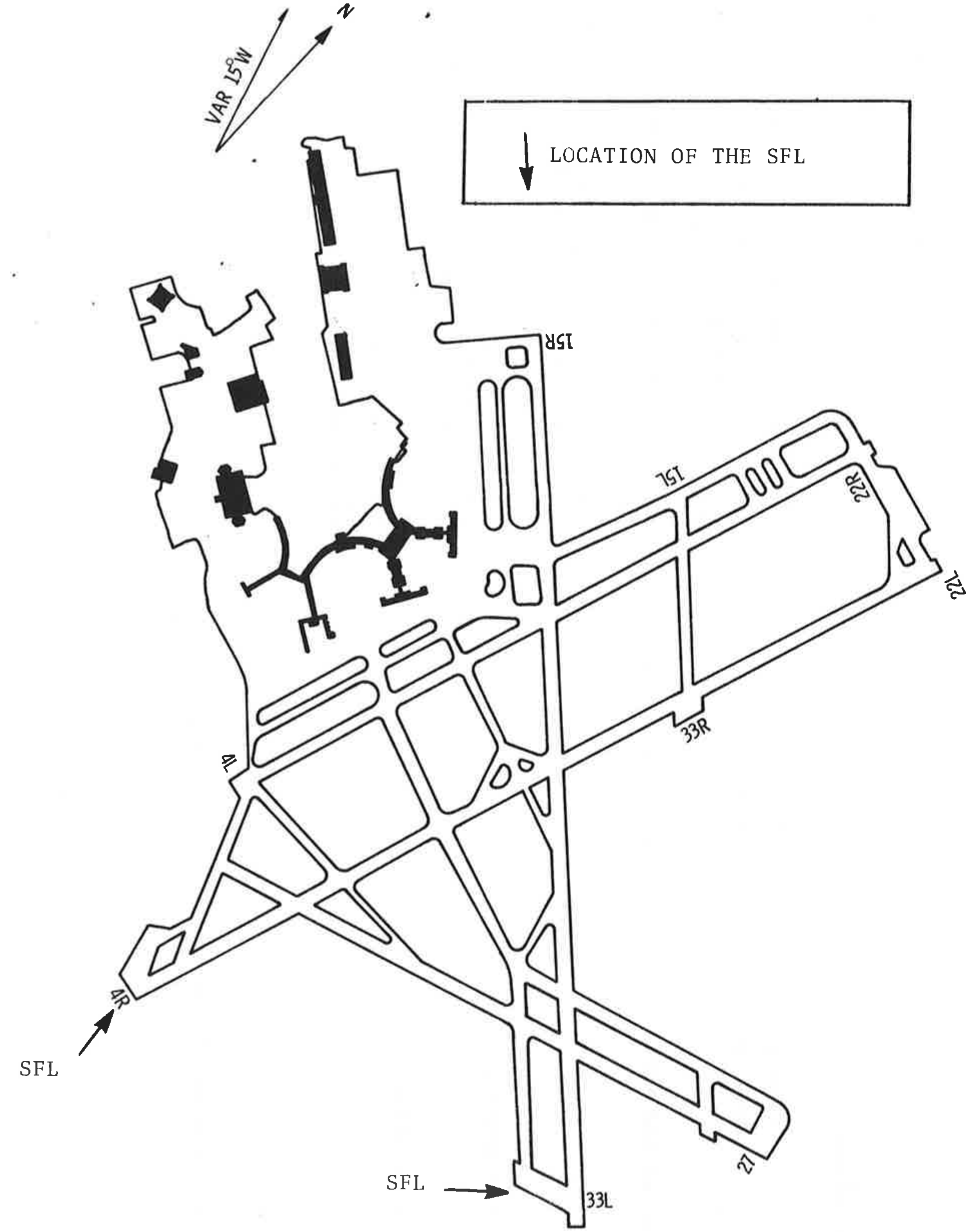
BLOCK DIAGRAM OF SEQUENCED FLASHER SYSTEM

SYSTEM ELEMENTS

SYSTEM: SFL

NO.	NAME	LOCATION	#	FUNCTION
1	Remote Control and Alarm Circuits	Tower	1	Provide, at remote site, control inputs to SFL and alarm outputs from SFL monitor circuits.
2	Control and Monitor Unit	ALS Substation*	1	Provide alarm if 3 or more light units fail (can be set to alarm for 1 or 2), supply voltages and current needed for control and indication, provide fuse protection.
3	Master Sequence Timer	ALS Substation	1	Controls the order and rate of the triggering impulses to the light units.
4	Flasher Units	Runway	28	Provide visual presentation to the approaching aircraft, in the form of distinctive blue-white bursts of light.

*Substation at side of runway, near end of runway



VAR 15°W
N
LOCATION OF THE SFL
15R
15L
22R
22L
33R
4L
4R
SFL
SFL
27
33L

SYSTEM INFORMATION FLOW

SYSTEM: SFL

NO.	SOURCE ELEMENT	DESTINATION ELEMENT	DESCRIPTION
1	1	2	Controls power on/off to SFL (interlocked with the ALS-control panel circuits so that the flushers cannot be turned on unless the approach lights are on)
2	2	3	Control: Power on/off to master sequence timer
3	4	2	Stutus: Light unit(s) out
4	2	1	Status: Normal/alarm--3 or more lamps out (may be adjusted to alarm on 1 or 2)

SYSTEM: SFL

CONSOLE ELEMENTS

NO.	NAME	DIMENSIONS (L x W x D)	INSTALLATION CONSTRAINT
1	Common with ALS remote control panel		

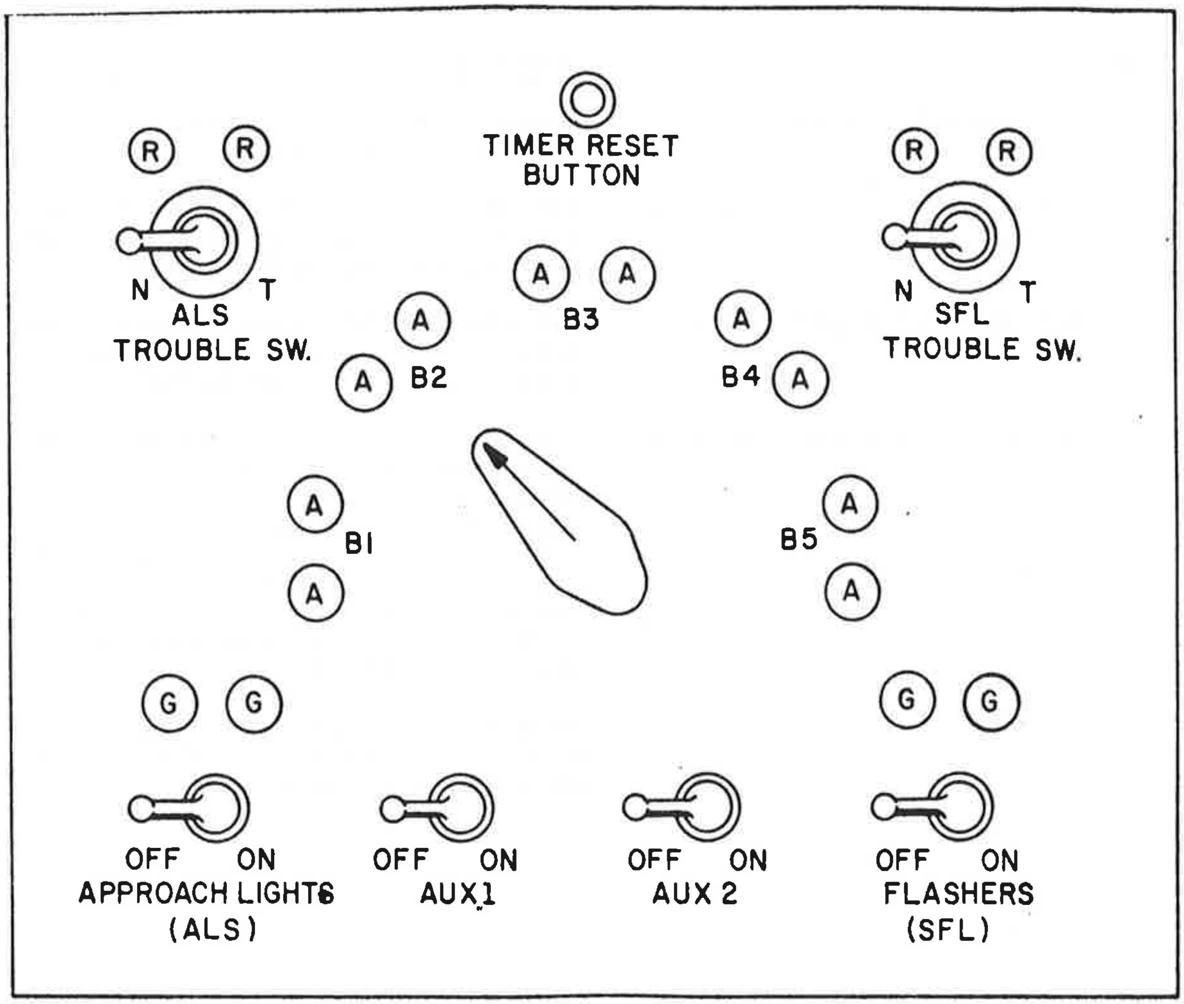
OPERATIONAL CERTIFICATION

PERIOD	PERFORMANCE CHECKS	NO VISITS	TIME	RECORDING/ REPORTING
Weekly	a) Make visible checks of flashers b) Record meter readings c) Check SFL monitor	Common with ALS		
Monthly	Test SFL monitor			

SYSTEM: SFL

CONTROLS AND INDICATORS

NAME	FUNCTION
1. SFL on/off switch	Powers the SFL. Lights green SFL monitor lights (2).
2. SFL monitor lights--green	Lit when (1) is on and no alarms are active. One light out of the pair means the bulb is bad.
3. SFL monitor lights--red	Lit when an SFS monitor alarm is active. One light out of the pair means the bulb is bad.
4. SFS trouble-normal switch	Silences monitor alarm buzzer by moving to the "T" position. (Buzzer will sound again when the trouble has been cleared.) Silences trouble clear buzzer by restoring to N position. Will cause buzzer to sound if moved to (T/N) position during (normal/ alarm) operation.
5. Buzzer	Sounds when alarm condition occurs. (Common with ALS buzzer when in same panel.)



SFL Remote Control Panel Layout.

SYSTEM: SFL

ALARMS

SOURCE	EVIDENCE
3 (or more) lamps out (may be adjusted to alarm for 1 or more, or 2 or more).	SFS green monitor lights go out SFS red monitor lights go on Buzzer on

c. FIELD LIGHTING

SYSTEM ACRONYM:

SYSTEM NAME: AIRPORT LIGHTING PANEL

SYSTEM FUNCTION: Control:
1. Runway Edge Lights
2. Runway Center Line Lights
3. Taxiway Lights
4. Runway End Identifier Lights (REIL)

SYSTEM DIAGRAM:

1) RUNWAY EDGE LIGHTS SYSTEM IS ESSENTIALLY THE SAME AS ALS.* THE EDGE LIGHTS ARE MONITORED WHEREVER AN RVR* IS INSTALLED.

2-3) THE CENTERLINE AND TAXIWAY LIGHTS SYSTEMS ARE ALSO SIMILAR TO ALS,* EXCEPT TAXIWAY LIGHTS DON'T HAVE BRIGHTNESS LEVELS.

4) THE RUNWAY END IDENTIFIER LIGHTS SYSTEM IS DESCRIBED UNDER REIL.*

*See other appropriate writeups.

SYSTEM ELEMENTS

SYSTEM: AIRPORT LIGHTING PANEL

NO.	NAME	LOCATION	#	FUNCTION

Similar to ALS and REIL

SYSTEM INFORMATION FLOW

NO.	SOURCE ELEMENT	DESTINATION ELEMENT	DESCRIPTION

Similar to ALS and REIL

SYSTEM: AIRPORT LIGHTING PANEL

CONSOLE ELEMENTS

NO.	NAME	DIMENSIONS (L x W x D)	INSTALLATION CONSTRAINT
1	Panel	LxW: As appears D: <8"	None

OPERATIONAL CERTIFICATION

PERIOD	PERFORMANCE CHECKS	NO. VISITS	TIME	RECORDING/ REPORTING

Similar to ALS and REIL

SYSTEM: AIRPORT LIGHTING PANEL

CONTROLS AND INDICATORS	FUNCTION
On/Off	Turn on light system
Brightness Level	Select brightness level 1-5, where appropriate
Panel Light Power	Adjust panel lighting
Circuit Breaker	
Lighting Vault Control	
LGN Test	

NOTE: After on/off button is pressed, it lights. This does <u>not</u> mean that a monitor has detected that the particular lighting system has received power. It indicates that the button has been pushed.

The runway edge lights are monitored at brightness levels 3, 4, and 5 wherever an RVR is located.

<u>ALARMS</u>

SOURCE	EVIDENCE
None	

There is <u>no</u> monitoring on this panel.

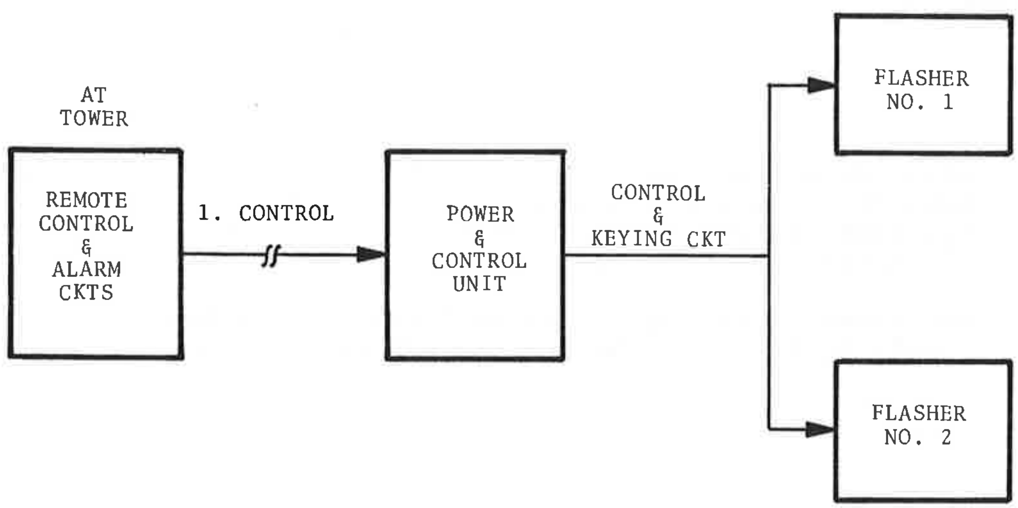
d. REIL

SYSTEM ACRONYM: REIL

SYSTEM NAME: RUNWAY END IDENTIFIER LIGHTS

SYSTEM FUNCTION: Provide a visual reference point for the pilot so that he can positively identify the end of the runway when making an approach for landing.

SYSTEM DIAGRAM:

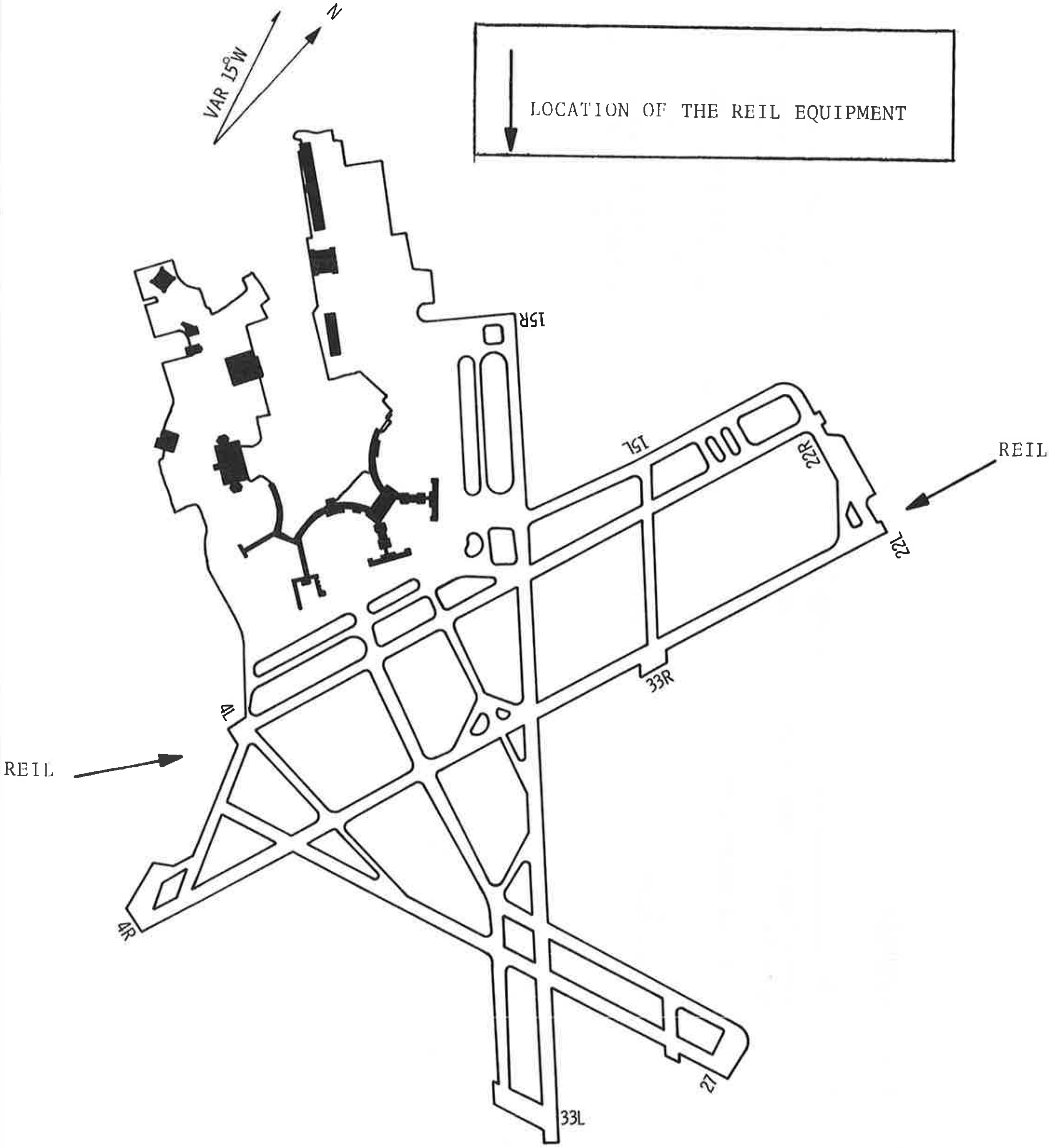


BLOCK DIAGRAM OF REIL SYSTEM

SYSTEM ELEMENTS

SYSTEM: REIL

NO.	NAME	LOCATION	#	FUNCTION
1	Remote Control and Alarm Circuits	Tower	1	Provide, at remote site, control inputs to REIL.
2	Power and Control Unit	Runway edge	1	Provide power and timing to the lights. Also contains local control panel.
3	Flasher Unit	Runway end	2	Provide the visual presentation to approaching aircraft


VAR 15°W
N
LOCATION OF THE REIL EQUIPMENT
15R
15L
22R
22L
REIL
REIL
4L
33R
4R
27
33L

SYSTEM INFORMATION FLOW

SYSTEM: REIL

NO.	SOURCE ELEMENT	DESTINATION ELEMENT	DESCRIPTION
1	1	2	Control: power on/off

SYSTEM: REIL

CONSOLE ELEMENTS

NO.	NAME	DIMENSIONS (L x W x D)	INSTALLATION CONSTRAINT
1	On/Off Button	Very Small	None

OPERATIONAL CERTIFICATION

PERIOD	PERFORMANCE CHECKS	NO. VISITS	TIME	RECORDING/ REPORTING
Weekly	Visually check lamps	1	45 min	FAA Form 6030-1 Log at each equipment site. AF calls (tel or radio) the tower to report any equipment outage
Monthly	a) Check both fixtures for alignment and angle using the built-in inclinometers b) Read and record input voltage at power and control cabinet c) Check device to shut down REIL if one flasher fails (if applicable)			

SYSTEM: REIL

CONTROLS AND INDICATORS

NAME	FUNCTION
1. REIL on/off switch (only 4L controlled by AT from tower)	Turns on power to REIL. Light in switch is not a monitor of whether lights received power, it indicates that someone pushed the button.

ALARMS

SOURCE	EVIDENCE
None	

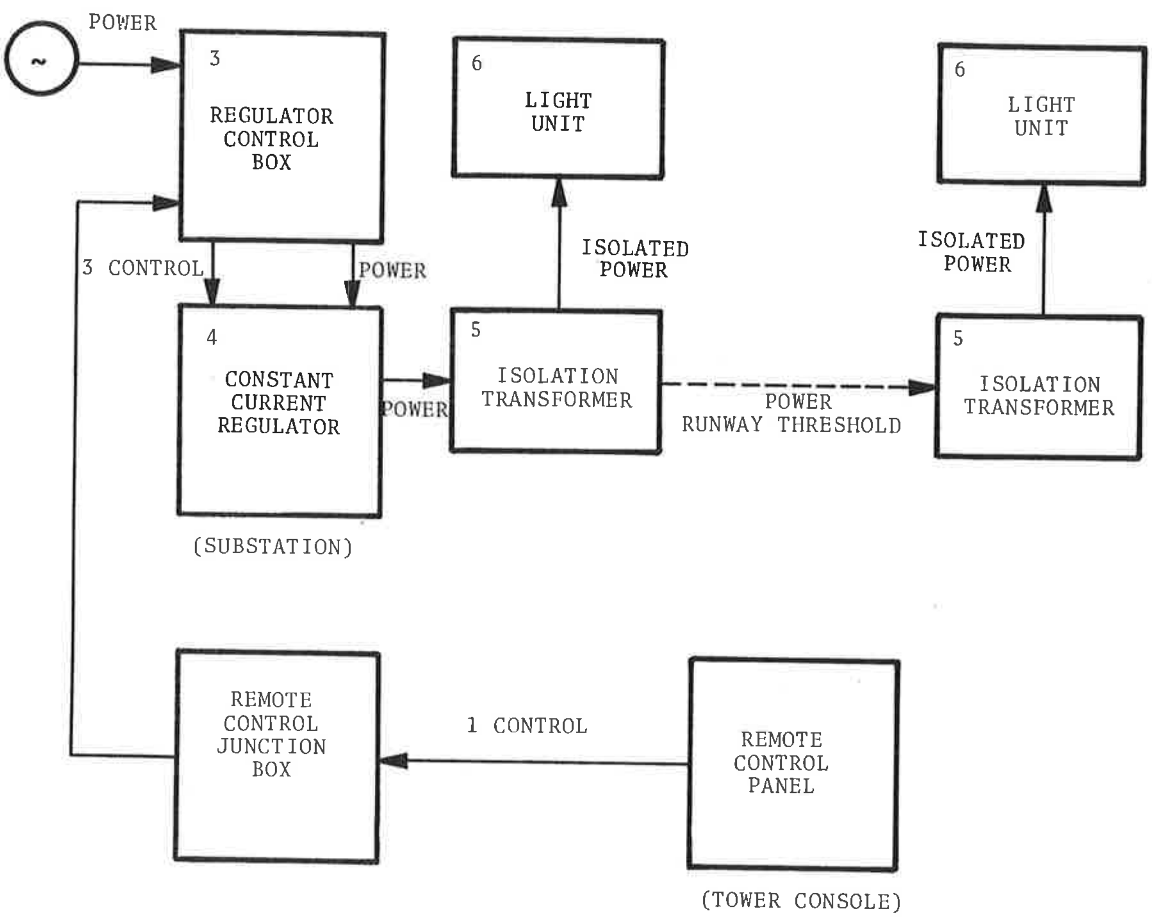
e. VASI

SYSTEM ACRONYM: VASI

SYSTEM NAME: VISUAL APPROACH SLOPE INDICATOR

SYSTEM FUNCTION: Provide the pilot with a visual glide slope by which he can descend to a touchdown point on the runway during VFR operations.

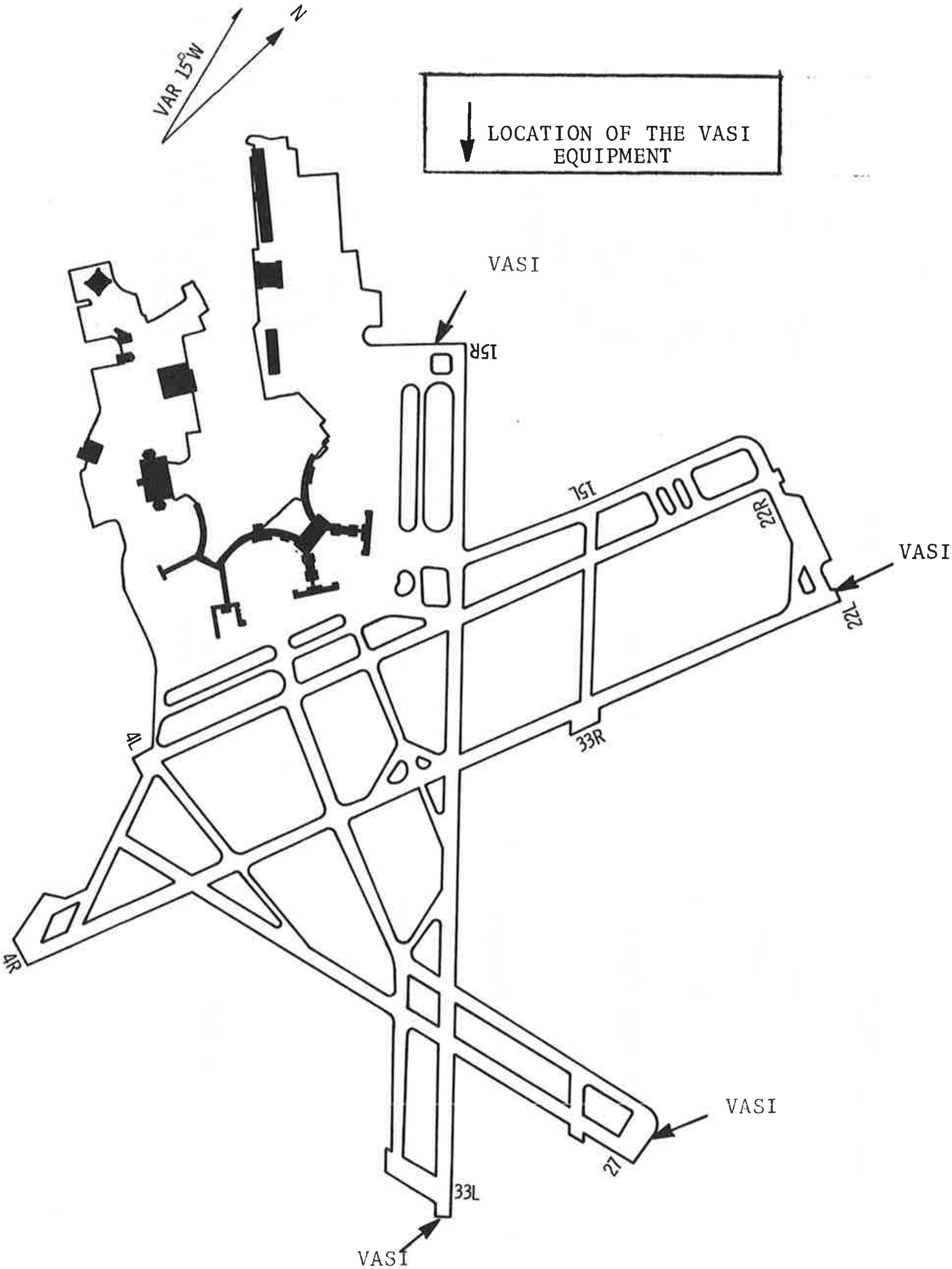
SYSTEM DIAGRAM:



SYSTEM ELEMENTS

SYSTEM: VASI

NO.	NAME	LOCATION	#	FUNCTION
1	Remote Control Panel	Tower Console	1	Control power application to the VASI system.
2	Remote Control Junction Box	Tower (6th Floor)	1	Transmit control signals to substation (?)
3	Regulator Control Box	Substation	1	House components necessary to control intensity of light units by selecting appropriate current setting of the regulator.
4	Constant Current Regulator	Substation	1	Maintain loop current constant on selected brightness step.
5	Isolation Transformer	Runway Threshold	4	Provide series circuit continuity in case of lamp failure, and provide LOW voltage 6.6 amp service to each lamp (failure of 1 lamp will not effect the operation of the other 2 lamps in the light unit).
6	Light Unit	Runway Threshold	4	Provide the visual presentation to approaching aircraft.



VAR 15°W
N
LOCATION OF THE VASI EQUIPMENT
VASI
15R
15L
22R
VASI
22L
4L
33R
4R
VASI
27
33L
VASI

SYSTEM INFORMATION FLOW

SYSTEM VASI

NO.	SOURCE ELEMENT	DESTINATION ELEMENT	DESCRIPTION
1	1	2	Power on/off, brightness level (low-med-high)
2	2	3	Power on/off, brightness level (low-med-high)
3	3	4	Brightness level (low-med-high)

SYSTEM: VASI

CONSOLE ELEMENTS

NO.	NAME	DIMENSIONS (L x W x D)	INSTALLATION CONSTRAINT
1	Remote Control Panel	LxW: As appears D: $\approx$ 8"	None

OPERATIONAL CERTIFICATION

PERIOD	PERFORMANCE CHECKS	NO. VISITS	TIME	RECORDING/ REPORTING
Weekly	a) Visually check lamp alignment b) Check for and replace burned out lamps c) Check controls	1	45 min	FAA form 6030-1 Log at each equipment site AF calls (tel or radio) the tower to report any equipment outage
Monthly	a) Record required information and readings b) Check approach slope line of sight for vegetation and other observations c) Check tilt-switch, VASI-2			
Quarterly	Check evaluation and alignment of all light boxes			
Annually	a) Check regulator b) Check photoelectric control			
Biannually	Check dielectric strength of oil in current regulators			

SYSTEM: VASI

CONTROLS AND INDICATORS only on: ISR (on/off)
27 (on/off, level 1, and 3)

NAME	FUNCTION
1) ON/OFF switch	Applies power to VASI system
2) BRIGHTNESS switch (low-medium-high)	Varies intensity of light units to compensate for variance in visibility conditions
3) IND. LIGHTS DIMMER	Performs uniform increase or decrease of intensity of panel indicators.
4) DUAL INDICATOR LIGHTS	Monitor setting of brightness switch (2) and power. If both lights are out one of the following applies: 1) Both lamps are burned out 2) The control panel fuse is blown 3) Power to the control panel has been lost (due to defective ON/OFF switch, for example) and power to the VASI may be lost. 4) Power to the control panel and VASI is lost. (However, it is assumed that power to VASI is lost, and that is most likely.)

ALARMS

SOURCE	EVIDENCE
None (the speakers near the control panel are not associated with VASI)	

V. ADDITIONAL CONTROLS

ADDITIONAL CONTROLS FOR CONSOLIDATION

For CAT II operation the prime power source must not be interruptable. For transistorized equipment, such as 15 ILS, batteries provide this immediate backup power. However, ALS and other lighting systems are too demanding of power to be supplied by batteries. An engine-generator is provided for back-up power for these systems.

To make engine-generator vs commercial power into an uninterruptable system, the engine-generator is used for prime power to the lighting during CAT-II conditions. (This is because relay switchover to commercial power is immediate, whereas startup of an engine-generator upon loss of commercial power takes too long to be considered "non-interrupted" power.)

There is _now_ a control near the field lighting panel to turn on this generator, and there is a monitor light that indicates whether or not the generator is on (not just whether the switch is set to the "on" position).

(It is intended to add in a control to bypass the "far field monitor" [for ILS] during CAT-I conditions and reactivate it during CAT-II conditions. This control _could_ be taken from the generator control as the generator is to be off for CAT-I and on for CAT-II. [Probably it is safer to make it a separate control.] [There is a good reason for wanting to turn this monitor on/off with weather, but the details obtained are not sufficient to report here.])

APPENDIX B: A Brief Survey/Study of Flexible Format Touch - Entry Devices As of August 1978*

Provided below are the results of a brief survey/study as to the validity of the assumptions made with respect to "flexible format touch entry devices".

These assumptions were:

1. such devices are technically feasible, operationally acceptable and readily available,

2. these devices can be obtained at a size compatible with the TELCO key pack (approximately 7"x7"), and

3. a grid of 1/2"x1/2" entry cells is feasible with a full cell boundary around each entry cell to assure single cell triggering.

Four candidate implementations for flexible format touch entry devices were considered. These were:

A. high-contrast cathode ray tube (CRT) monitors with touch entry panels,

B. plasma dot-matrix display panels with touch entry panels,

C. individual incandescent alphanumeric displays with lighted pushbuttons, and

D. new display technology with touch entry panels.

Two types of touch entry panels were considered. These were:

1. infrared "electric-eye" type touch panels, which sense via broken light beams, and

2. touch-wire panels, which sense via contact between conductors.

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* Costs, etc. may change rapidly for some of these devices.

The results of this survey are presented below in 2 parts:

1. a summary of the results for each assumption,
2. a summary of the features of each candidate device, and

SUMMARY OF RESULTS

Assumption 1

These flexible format touch entry devices are definitely technically feasible and are readily available. In many cases off-the-shelf items are available which are very close to our exact requirements. In most other cases made-to-order devices would be available in 2 to 4 months for reasonable engineering fees. No new technology development would be involved in these cases.

Reports of some specific applications of these devices in the field, in addition to personnel communications from people who have developed and tested this technology for many years have tended to confirm that these devices will be operationally feasible.

Candidates A and B both have high ambient light capability, with proper filtering. However, with the use of touch entry panels fingerprints on the exterior anti-reflective coating may be visible under high ambient light conditions.

Candidate C would require more custom development than Candidate A, and would be less flexible, but once implemented should be the least questionable, operationally.

Candidate D is not usable at present, but represents new technology which merits serious consideration and should be followed as it is developed.

Assumption 2

Not all of the candidate implementations can satisfy this requirement. The plasma dot-matrix panel (B) is not compatible with the 7"x7" limitation, since the glass panel itself occupies considerable surface area beyond the active display area. CRT's (A) would satisfy the requirement unless a depth restriction made it impossible to accomodate the tube.

Assumption 3

Two technologies are available that satisfy this requirement. Some off-the-shelf devices adapted to particular displays are available. Custom built touch-entry panels are available within a short period at reasonable cost.

SUMMARIES OF CANDIATE DEVICES

A. High-Contrast CRT's

CRT's are readily available in a wide range of sizes. If a high-contrast CRT is not available with the required dimensions, one can be made in a standard size in 3 months for about $5K. Several vendors are available.

High-contrast CRT's are in widespread use in high-ambient light environments, including tower cabs and airplane cockpits. Filters are used to absorb ambient light that is not of the same precise color as the phosphor. Anti-reflective coatings are applied at the exterior surface to reduce glare.

B. Plasma Dot-Matrix Display Panels

Plasma panels which can be addressed at any x, y cordinate are presently available in one size only. The panel itself is 50% larger than the active display area. The costs for made-to-order units would be prohibitive since this is not a high-volume item and the technology is complex.

Plasma displays are also available with a restricted format which can only generate alphanumeric characters of a specific size. This severely limits their flexibility. (Button images can't be produced for example.) However, these units use significantly less surface area beyond the active display area, are available from two vendors, in several sizes, and in green as well as orange.

Plasma panels have seen only limited use in high-ambient environments. One application on a ship's bridge was reported to us. Details have not been obtained yet. Personnel at the MITRE E-TABS project have tested plasma panels, in addition to other display technologies for several years. They have found them operationally acceptable. Similar filtering techniques to those used with CRT's are applied.

A,B-1 Infrared (IR) Touch Entry Panels

This device uses infrared transmitting light emitting diodes (LEDs) and photo transistors to set up a grid of invisible light beams over the surface of a display device. In attempting to touch the surface the operator breaks two of these beams (one in each coordinate direction) and the location of the touch point is thus sensed in the same manner as an "electric eye" operates.

IR touch entry panels are available off-the-shelf in a number of sizes for about $600/ single unit. Made-to-order units are available for $3K-6K with 2-4 months delivery.

A grid as fine as 1/8"x1/8" is available, if desired. An internal microprocessor can increase this resolution, can trigger a new touch point <u>only</u> after finger is removed and re-enters <u>or</u> can continuously monitor finger location, and can perform 3-D sensing of finger location to assess the assurance of the stroke.

The IR touch panel can be constructed in a "frame" that is about 1/2" wide and 1.5" deep around the display area. This is within the area occupied by the external dimensions of the CRT.

IR touch entry panels are currently in use as a subsystem of plasma panel display terminals and CRT display terminals. (Mounting the LEDs and sensors on arcs has eliminated the parallax problem with CRT's.)

A,B-2 Touch-Wire Panels

This device consists of mylar film which overlays the active display area. A grid of very fine conductors is imbedded in the film, with a separating layer, open at the contact points, between the two perpendicular conductor grids. "Bubbles" in the top layer of mylar provide "snap action" switches.

Touch-wire panels are not available as off-the-shelf products in various sizes at present. However made-to-order panels are readily available at about $15 per switch position with a 3-4 month delivery.

The switch grid is a function primarily of wire spacing. Common switch spacings are 0.4" to 1".

The touch-wire panel, like the IR touch entry panel, can be implemented within the external dimensions of a CRT.

Touch-wire panels have been in use by the Euro control R&D center (Bretigny) for some time.

C-1 Incandescent Alphanumeric Displays

These devices are small (about 1/3") single character readouts, where the character is generated by illuminating appropriate straight segments. Each segment is an incandescent filament.

These displays are available, off-the-shelf, for about $11 each, in quantity. Mounting, wiring and addressing & switching electronics would require a separate engineering cost. No new technology development would be involved in this, in fact, 8x8 arrays have been constructed.

These are the brightest displays currently available. Outputs of 9000 foot-lamberts are available. The brightness can be easily adjusted via a simple voltage control, and any color is obtainable with an appropriate filter.

These displays are currently in widespread use in airplane cockpits and other high-ambient environments.

C-2 Illuminated Switches

Illuminated pushbutton switches are available in one and two-lamp designs. The contacts for the lamps are separate from the switch contacts so, at the designer's option the lamps may be turned on or off in conjunction with the switching action, or may be illuminated separately from the switching, as a status indication.

These switches are available in a variety of designs, sizes and colors from many vendors. In general the one-lamp switch occupies a panel space somewhat less than 3/4" square and the two-lamp switch occupies a panel space somewhat less than 1" square. A 1/2" square single lamp switch may also be available.

Illuminated switches are a standard technology that is in widespread use. The switches are illuminated via incandescent bulbs whose brightness is easily adjustable via a simple voltage control.

D-1 Flexible Legend Readouts

These devices are fairly large (1.4"h x 0.9"w) displays with approximately 1/2" square active display area. Via a film and projection system, self-contained in the device, any one of 48 pre-filmed legends may be projected on the active area. The legend can be anything the designer chooses, but it is limited by the small size of the active display area. The brightness of these displays is limited to about 12 foot-lamberts.

These devices are available off-the-shelf from one vendor for in excess of $100 each, with mounting.

These displays are brightness limited, and would not be applicable to a high ambient light environment. (Contrast them with the 9,000 foot lambert brightness of incandescent alphanumeric displays.)

Switch entry capability would be provided by an overlaid touch-wire panel (made by the same company.)

D-2 Plasma Panel Character Bars

These devices are soon to enter volume production and promise to overcome many of the major stumbling blocks of plasma technology. They will be modular, (each unit containing 2 lines of 80 characters each in about 8" length) yet stackable to make a full-page continuous display. They will require less extra surface area to support the active display area. Due to improved implementation of the technology, they promise substantially reduced cost.

These devices are currently available only as prototypes (readily available with all necessary electronics, in small quantity), in the 2 rows x 80 character format. The cost is high ($4500 for prototype with electronics) since volume production has not started.

Future development of the techniques used in these devices will yield different character sizes and likely the equivalent of existing x,y addressable plasma panels but at a much lower cost. The plasma display technology is essentially identical to existing devices, the innovation is the addressing scheme and the electronics, which is a low-risk area.

APPENDIX C: OPERATIONS ANALYSIS

1. TRACON ANALYSIS

The TRACON operation is complex and dynamic, undergoing frequent adjustments. The goal of this section is to provide insight into the structure and workings of the TRACON operation without attempting to document the details of its complexity or its evolutionary trends. The facets of the operation covered in this section are:

- Staffing
- Terminal airspace structure
- Types of flights handled
- Flight strips
- Flight strip system
- Position related observations
- Flight handling scenarios

1.1 TRACON Staffing

TRACON staffing is made up of radar positions, flight data positions, a coordination position, and a supervisory position. Each radar position controls traffic and is equipped with an ARTS display, a communication frequency, and an intercontroller phone. The data positions support the radar positions in terms of flight strip handling and by taking over some of the routine intercontroller phone communications. The coordination position handles the more complex communications between controllers on the interphone. The use of a coordinator allows the individual radar controllers to concentrate on controlling traffic and increases the TRACON's ability to efficiently handle unexpected or complex operational situations. The supervisory position is responsible for the TRACON operation and also handles out-of-TRACON coordination involving such things as equipment outages and airport emergencies.

The current Boston TRACON staffing is:

Radar Positions

Arrival Radar 1	(AR-1)
Arrival Radar 2	(AR-2)
Arrival Radar 3	(AR-3)
Departure Radar 1	(DR-1)
Departure Radar 2	(DR-2)
Terminal Control	(TC)
Final Control	(FC)

Data Positions

Terminal Data	(TD)
Departure Data	(DD)
Bedford Data	(BD)

Coordination Position

TRACON Coordinator	(CI)

Supervisory Position

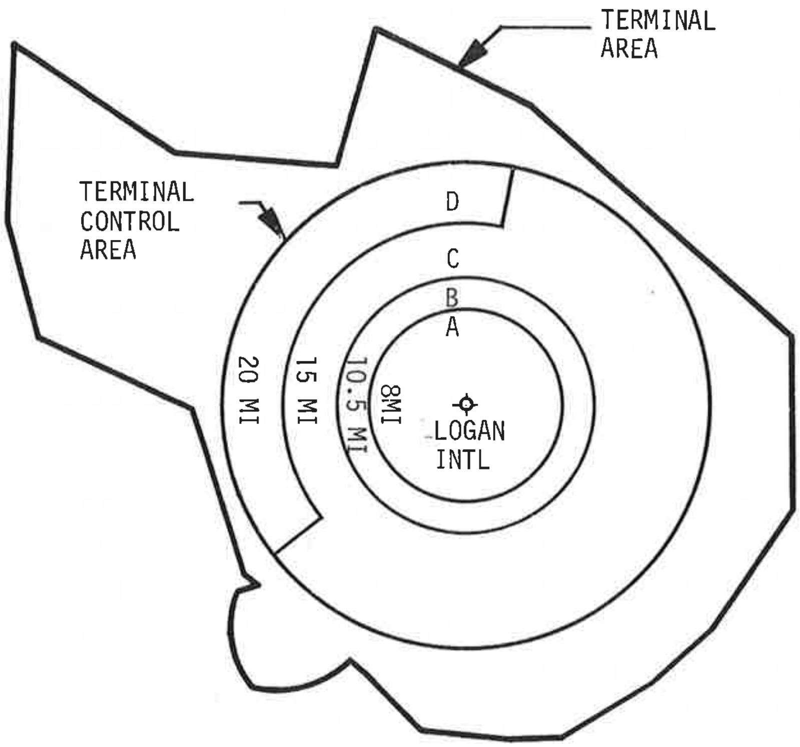
TRACON Supervisor	(TS)

1.2 Terminal Airspace Structure

The bounds of the Boston Terminal Area are shown in Figure 2-1. The airspace within the Terminal Area is subdivided into Cab and TRACON sector areas of responsibility and by the type of flight under air traffic control and by control position.

Within the Terminal Area only IFR filed aricraft are usually under air traffic control. However due to the high density of traffic over Logan Airport, the TRACON also controls all other traffic in a Terminal Control Area, located within the Terminal Area and centered over Logan Airport. (See Figure C-1.)

The second airspace structure, based on control position, is more complex. A simplified description of the airspace responsibilities of each control position in the TRACON and Logan Tower Cab is presented in Table C-1.



TCA SECTOR ALTITUDES

A	7000/GND
B	7000/2000
C	7000/3000
D	7000/4000

FIGURE C-1. BOSTON TERMINAL CONTROL AREA (TCA)

TABLE C-1. SIMPLIFIED ALLOCATION OF BOSTON LOGAN AIRSPACE BY CONTROL POSITION

LOGAN TOWER CAB POSITIONS

SKYWAY CONTROL (SC) - Controls helicopter and fixed wing aircraft that provide Boston commuter road traffic reports. SC owns fixed routes over the Metropolitan Boston Area out to 8 miles from Logan. Altitude restrictions are:

Fixed winged aircraft patrolling roads fly at 1000 feet

Helicopters patrolling roads fly at 500 feet

Helicopters arriving/departing Logan fly at 800 feet.

LOCAL CONTROL (LC) - Controls aircraft on the runways and in the vicinity of the airport (primarily on final approach and on the initial takeoff climb). On the approach side of the airport, LC owns 5 miles in and from 2000 feet to the ground. On the departure side, LC owns out to 5 miles and below 1000 feet (Figure C-2).

TRACON POSITIONS

FINAL CONTROL (FC) - Controls/merges traffic arriving on Logan's primary arrival runway. Hands off traffic to LC. FC owns the Descent Zone (Figure C-2):

Lateral limits - 5 miles on either side on the final approach path from the Final Approach Fix to 20 miles from Logan.

Vertical limits - 4000 feet to ground from the Final Approach Fix to 10.5 miles from Logan and 4000 feet to 3000 feet from 10.5 to 20 miles from Logan.

TERMINAL CONTROL (TC) - Controls TCA aircraft within the TC airspace and merges traffic arriving on Logan's secondary arrival runway. Hands off traffic to LC. On the approach side, TC owns 2500 feet to the ground out to a radius of 10 miles excluding FC/LC/SC airspace (Figure C-2).

TABLE C-1. SIMPLIFIED ALLOCATION OF BOSTON LOGAN AIRSPACE BY CONTROL POSITION (Cont.)

<u>APPROACH RADAR CONTROLLERS</u> - Approach controllers have fixed arrival routes through the Terminal Area depending on the runway configuration in effect at Logan. The approach controllers receive turbojet aircraft at 10 to 14,000 feet and deliver them at the Descent Zone at 4 to 6,000 feet. Conventional aircraft are received at 4,000 to 6,000 feet.

<u>AR-1</u> receives turbojets from the PVD fix and enters them into the Terminal Area at MIXER and usually receives low flying aircraft at MILIS. (See Figure C-3.) AR-1 also owns the airspace within the Boston Secondary Airport Area below 2000 feet. (See Figure 2-2.)

<u>AR-2</u> receives turbojets from the west at LOBBY and the east at SCUPP; and usually receives low flying aircraft from the west at LOBBY and from the north at EXALT. (See Figure C-3.)

<u>AR-3</u> owns the airspace within the Bedford Secondary Airport Area below 2000 feet and higher in some sections. (See Figure 2-3.)

<u>DEPARTURE RADAR CONTROLLERS</u> - Like approach controllers, the departure controllers use fixed routes within the Terminal Area. However, in addition, the departure controllers also own the airspace from the surface to 4,000 feet excluding the altitudes and airspace:

- On the arrival routes
- Within the Descent Zone
- Within the TC airspace
- On final descent
- On Skyway Control's routes
- Within the Boston and Bedford Secondary Airport Areas.

<u>DR-1</u> owns the airspace to the north of Logan Airport as shown in Figure C-4.

TABLE C-1. SIMPLIFIED ALLOCATION OF BOSTON LOGAN AIRSPACE BY CONTROL POSITION (Cont.)

<u>DR-2</u> owns the airspace to the south of Logan Airport as shown in Figure C-4. In addition, DR-2 also takes departures from within the Boston Secondary Airport Area after coordinating with AR-1.

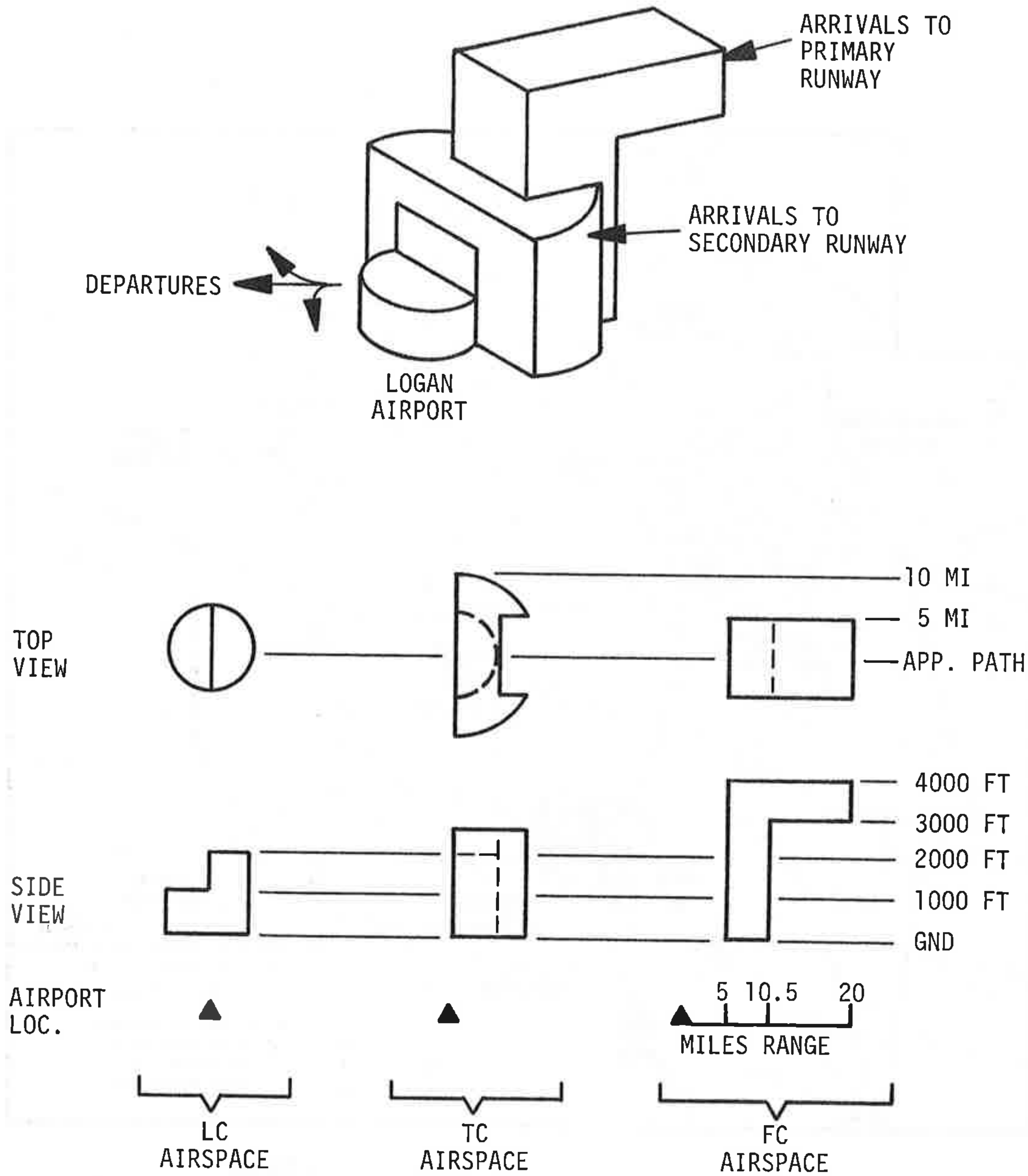
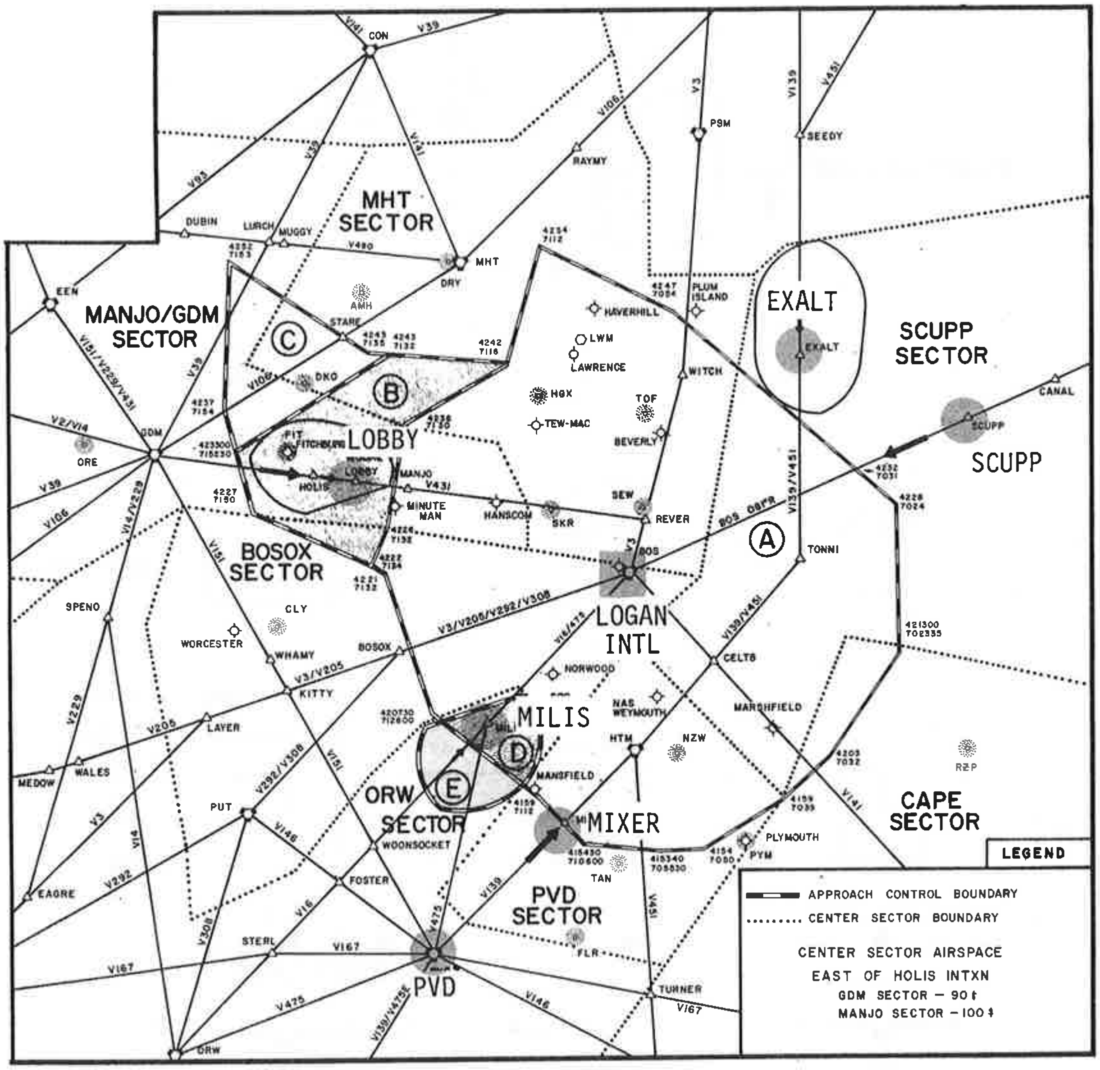


FIGURE C-2. AIRSPACE RESPONSIBILITIES OF LC/TC/FC AT BOSTON



CONTROL POSITION	COMMON ARRIVAL FIXES
AR-1 AR-2	PVD/MIXER/MILIS LOBBY/EXALT/SCUPP

FIGURE C-3. COMMONLY USED APPROACH FIXES

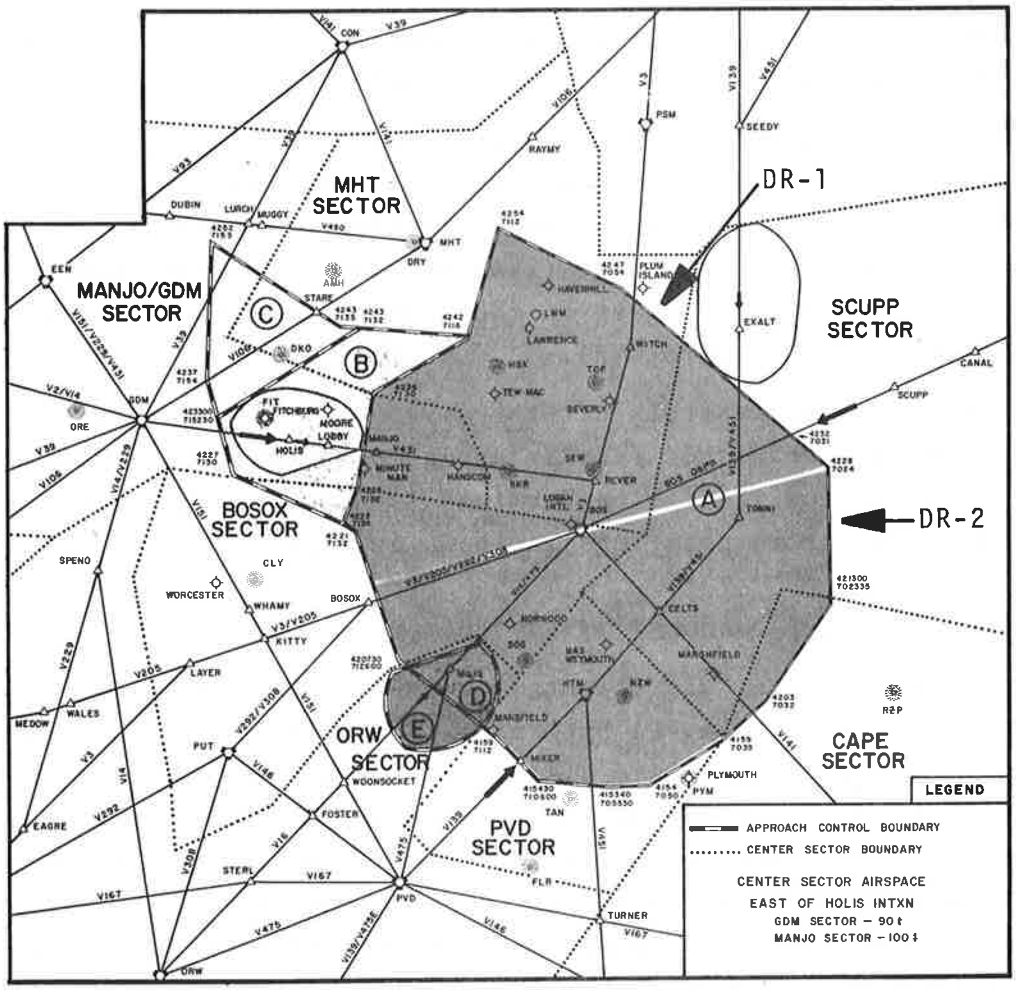


FIGURE C-4. GENERAL DIVISION OF BOSTON TERMINAL AIRSPACE BETWEEN DEPARTURE RADAR POSITIONS 1 AND 2

As seen from the Table C-1:

The airspaces controlled by LC, TC, and FC are aligned with the final approach path to Logan Airport (Fig. C-2) and rotate about the airport as the arrival runway is changed. The controller initials are identified in Table C-1.

As the arrival runway at Logan Airport is changed the approach routes to the airport are changed by the approach radar controllers to accommodate the new direction of Final Controls Descent Zone. However, the fixes at which arrivals enter the Terminal Area to start on their approaches to Logan remain unchanged (Figure C-3).

Departure Radar controls all the airspace in the Terminal Area that has not been specifically assigned to some other position. The division of the Boston Terminal Area between the two staffed departure positions is shown in Figure C-4.

1.3 TYPES OF FLIGHTS HANDLED BY THE TRACON

The TRACON handles all flights within the TCA and all IFR filed flights outside the TCA but within the Terminal Area (Figure C-1). These flights fall into classes of operations based on the pilot's flight plan and on how the flights are handled within the TRACON. These operational classes are presented in Table C-2. and are ranked in accordance to the traffic count for an example week day - 3 May 1978. The complexity of the TRACON operation is in how these various types of flights are handled in the Terminal Area. Even the simplified description presented here will be found to be somewhat involved.

IFR Filed Logan Arrival/Departures

This is the largest category, accounting for two out of every three operations handled by the TRACON. Arrivals and departures at Logan, whether they are IFR filed or not, tend to be segregated by size. The larger aircraft, which are most of the air carrier aircraft, operate on one set of Logan runways; and the smaller aircraft, which are most of the general aviation and air taxi aircraft,

TABLE C-2. RANK ORDER OF THE TYPES OF BOSTON TRACON OPERATIONS BY DEMAND

TYPE OF TRACON OPERATION	EXAMPLE WEEKDAY TRAFFIC LEVEL (5/3/78)
Filed Logan ARR/DEP	1130 (64%)
TCA Logan ARR/DEP	256 (15%)
Filed Secondary Airport ARR/DEP	178 (10%)
TCA Overflights	130 (7%)
Tower Enroute Control (TEC) Flights	35 (2%)
Filed Overflights	27 (1%)
Expanded Radar Service (ERS) Flights	5 (-)
	1761 99%

operate on a secondary set of runways. The current primary and secondary runway configurations are:

Primary Rwy. Set ARR	Primary Rwy. Set DEP	Secondary Rwy. Set ARR	Secondary Rwy. Set DEP
33L	27	33R	33L
4R	9	4L	4L/15R
27	22R	22L	15R
22L	22R	27	15R
15R	9	15L	

For arrivals, AR-1 handles the flights entering the Terminal Area south of Logan and AR-2 handles the arrivals entering from the north. The two arrival radar controllers will route the flights to FC who will merge and decend them to the Final Approach Fix. The arrival radar controllers will also separate out the smaller aircraft that are to land on the secondary and route them to the

TC who, in turn, will merge/decend them for an approach to the secondary arrival runway. Both FC and TC hand off their arrivals to LC.

The situation for departures is similar. DR-1 handles the flights that are to depart the Terminal Area to the north of Logan and DR-2 handles those flights departing to the south. The departure radar controllers receive the flights from LC shortly after lift-off and retain them until handoff to the Enroute Center when they clear the Terminal Area. The departure radar controllers keep their traffic clear of the arrival routes to Logan and try to climb their traffic above the arrival traffic as soon as it is feasible.

TCA Logan Arrivals/Departures

The second largest class, 15 percent of the TRACON traffic, consists of all the remaining traffic that wants to either land or depart Logan but have not filed IFR flight plans. This traffic tends to stay in the New England area, and in contrast to IFR filed traffic, to enter and depart the TCA at relatively low altitudes (e.g., at 2000 rather than 3000 to 4000 ft.)

Arrivals contact the TC prior to entering the TCA in order to be given entry instructions. TC routes/merges the flights for an approach to the secondary arrival runway and hands off to LC. TC will also separate out the larger aircraft that are to land on the primary arrival runway and hands them off to FC.

Departures are handled by DR-1 and DR-2 depending on their departure direction form the TCA (i.e., DR-1 to the north and DR-2 to the south of Logan). The departure radar controllers receive the flights from LC shortly after liftoff. The departures are controlled until they leave the TCA when radar service is terminated.

IFR Filed Arrivals/Departures at Secondary Airports

The third largest demand, with 10 percent of the TRACON traffic total, consists of the IFR filed arrivals and departures at the Terminal Area's 14 secondary airports. There are two clusters of secondary airports in the Terminal Area (Figure C-5). The Bedford

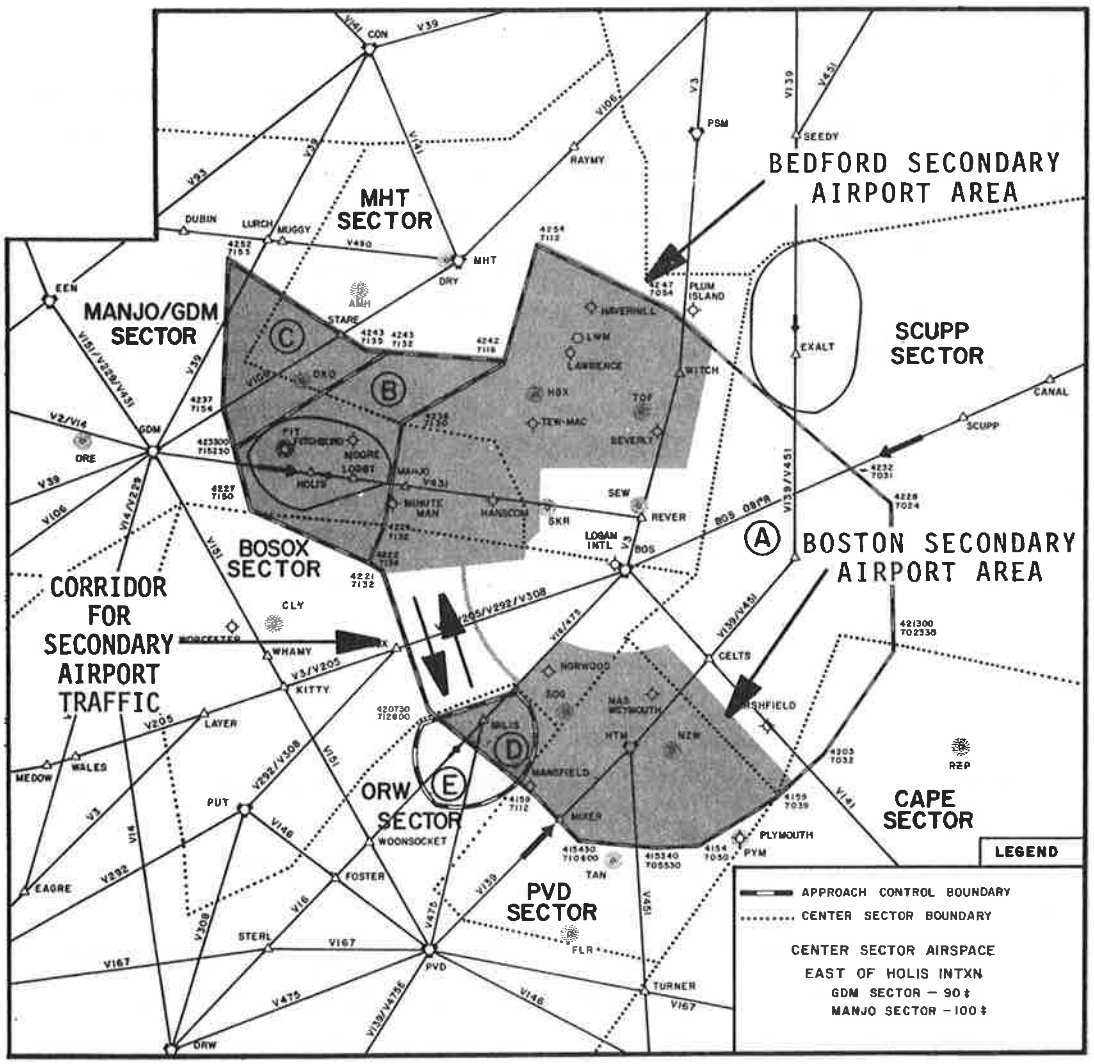


FIGURE C-5. BEDFORD AND BOSTON SECONDARY AIRPORT AREAS SHOWING INTERCONNECTING SHUTTLE CORRIDOR

Secondary Airport Area is located to the northwest of Logan, and the Boston Secondary Airport Area is located to the south of Logan. An informal corridor is used by the TRACON to shuttle IFR filed secondary airport traffic between these two areas.

IFR filed arrivals to the secondary airports usually enter the Terminal Area directly into the secondary airport areas. AR-3 and AR-1 handle the arrivals in the Bedford and Boston Secondary Airport Areas, respectively. If an arrival enters one area but is destined for the other area, the arrival controller in charge of the first area will use the shuttle corridor and then hand off the arrival to the other controller.

IFR filed departures are handled by AR-3 in the Bedford Area and by DR-2, under the supervision of AR-1, in the Boston Secondary Airport Area. The departures may not leave the Terminal Area directly from the AR-3 or DR-2 airspaces. In those cases, the departures are handled in turn by the controllers responsible for the airspace being traversed.

TCA Overflights

The fourth largest class, 7% of the TRACON traffic total, consists of the flights without IFR flight plans that pass through the TCA without landing or departing from Logan. The departure radar controllers own the airspace not specifically allocated to the other positions. For this reason, most TCA overflights are handled by DR-1 and/or DR-2. The airspace division of responsibility for the two departure radar positions is shown in Figure C-4. The goal of the TCA overflight routes is to cut the Logan approach/departure routes by 90 degrees. This is done to minimize the potential for conflicts between the overflights and the ascending and descending traffic at Logan.

Tower Enroute Control (TEC)

The fifth largest class accounts for only around 2% of the TRACON operations or on the order of 35 ops/day. An IFR filed flight originating in one terminal area and terminating in an adjacent terminal area can elect to fly below the enroute airspace structure and to be handed off directly from one TRACON to the other. This is called Tower Enroute Control or TEC.

TEC arrivals are handed off from the adjacent TRACON to either AR-1, AR-2, or AR-3 depending on their destination airport and place of entry into the Boston Terminal Area. Such flights may be handed off from one approach radar controller to another if the entry point into the Terminal Area does not permit the appropriate controller to have initial contact with the flight. TEC flights to Logan tend to use the secondary arrival runway and are, therefore, handed off to TC by either AR-1 or AR-2.

TEC departures are handled by the same controllers that handle all the other departures: DR-1 and DR-2 cover Logan, DR-2 covers the Boston Secondary Airport Area and AR-3 handles the Bedford Secondary Airport Area. Once again, if the TEC flight goes outside the airspace allocated to these positions, the flights are handed off to the appropriate control positions in the TRACON. When the TEC flight leaves the Boston Terminal Area and enters the terminating Terminal Area, the flight is handed off directly to that TRACON.

IFR Filed Overflights

The sixth largest class, accounting for only about 25 ops/day consists of the flights with IFR flight plans that pass through the Terminal Area without landing or departing from Logan. Which controller(s) handle an IFR overflight depends on who owns the airspace to be traversed. Handoffs between controllers in the TRACON is common for this type of flight. If the routing situation is complex, the TRACON coordinator (CI) will establish the route.

Expanded Radar Service (ERS)

The seventh and smallest class accounted for only 5 operations on the sample day. A flight without a flight plan operating outside the TCA normally is not serviced by the TRACON. However, if such a flight is within the Terminal Area and wishes to request a particular TRACON service, the request will be granted if workload permits. This is called Expanded Radar Service or ERS. The types of service requested include:

Vectors to help find a particular airport

Monitoring a flight over water in case it goes down

Traffic advisories.

ERS requests tend to peak on the summer weekends and can be many times larger than the five operations for the example week day.

The ERS routes tend to be free form. Once again, which controller(s) handle an ERS flight depends on who owns the airspace being traversed, and handoffs between TRACON controllers are common.

1.4 TRACON FLIGHT STRIPS

A flight strip is used for each flight handled by the TRACON. Each flight strip identifies one flight and presents information on the pilot's flight plan, his aircraft and equipment, and is used by the controllers to note pertinent control information on the flight. If a pilot has submitted an IFR flight plan prior to takeoff, then a flight strip for that flight will be printed out in each air traffic control facility along the route of the flight. If an IFR flight plan has not been submitted, then a flight strip must be handwritten by the controllers. On the example day chosen for examination, 1761 operations were handled by the TRACON and nearly 500 or 30 percent of the flights required handwritten strips.

Figures C-6 and C-17 catalog example flight strips for the various types of flights handled by the TRACON. Table C-3 defines some of the more obscure flight strip terms that are used.

<u>IFR Filed Arrival to Logan (Figure C-6)</u>

Since these flights have filed IFR flight plans, printed strips are available in the TRACON for controller use. The BOS designation on the strip indicates the strip is for a Logan operation and the location of BOS on the strip indicates that it is an arrival. The PVD/HTM fix designations indicate that the flight will be handled by AR-1. Other printed strip information of interest to the controller is the aircraft ident/type/transponder equipment/ assigned beacon code, and the approximate time that AR-1 can expect to make

EA866	AIRCRAFT IDENT
DC9/A	AIRCRAFT TYPE/TRANSPONDER EQUIPMENT
491	COMPUTER ID NUMBER
0535	ASSIGNED BEACON CODE
PVD	PREVIOUS FIX (PROVIDENCE VOR)
HTM	COORDINATION FIX (WHITMEN VOR/DME)
A2154	ETA AT COORDINATION FIX (Z TIME)
BOS	DESTINATION AIRPORT

MANUAL MARKINGS

140, 100, 60	ALTITUDE ASSIGNMENTS (14,000; 10,000; 6,000 FT)
R	RADAR CONTACT ESTABLISHED

FIGURE C-6. IFR FILED ARRIVAL TO LOGAN - EXAMPLE TRACON FLIGHT STRIP contact with the flight. The controller also uses the strip to note when radar contact with the flight has been made and to note the altitudes assigned to the pilot.

TABLE C-3. DEFINITIONS OF SOME FLIGHT STRIP TERMS - BASED ON THE AIRMAN'S INFORMATION MANUAL

Fix - A geographical position determined by visual reference to the surface, by reference to one or more radio navigational aids, by celestial plotting, or by another navigational device.
Simplified Directional Facility (SDF) - A NAVAID used for non-precision instrument approaches. The final approach course is similar to that of an ILS localizer except that the SDF course may be offset from the runway, generally not more than 3 degrees, and the course may be wider than the localizer, resulting in a lower degree of accuracy.
Z Time - is Greenwich Mean Time. To get local Boston time, subtract 4 hours. Time is presented in 4 digits, representing the hour and minutes from the 24 hour clock.

IFR Filed Arrival to a Secondary Airport (Figure C-7)

The example flight strip is for an arrival to Beverly Airport located in the Bedford Secondary Airport Area. This printed strip is very similar to the previous Logan strip except that BVY has been substituted for BOS. In addition, the controller places a check mark on the strip after contacting the Beverly Tower and giving the aircraft identity and its ETA at the airport. During this contact with the Beverly Tower, the TRACON controller will be told the runway in operation, the type of approaches being made, and the altimeter setting for Beverly. Some controllers note this information on the strip as was done in this case. AR-3 would handle this flight, and usually the data position, BD, would make the call to the Beverly Control Tower.

TCA Arrival to Logan Airport (Figure C-8)

These strips are handwritten by the controller that makes initial contact with the flight - usually TC. Being handwritten the information tends to be reduced to the essentials - aircraft ident/type/destination/altitude assignments/radar contact. In addition, a T is put on the strip to designate it as a TCA operation.

Tower Enroute Control (TEC) (Figure C-9)

TEC flights can be either arrivals to or departures leaving the Terminal Area. The example strip if for an arrival to Beverly Airport from Nashua, New Hampshire. Since these are flights with IFR flight plans, most strips are printed. However, printed strips are not always available when needed (e.g., if FDEP is temporarily down), so some strips are handwritten. The example strip is such a case. The strip is similar to the preceeding TCA strip except for the TEC designation, the altimeter setting for Beverly Airport, and the designation of the point of origin, Nashua.

IFR Filed Departure from Logan (Figure C-10)

These strips are printed. The BOS designation and its location on top of the strip indicates that this flight is a departure from Logan. The first fix, BOSOX, means that this flight would probably be handled by DR-2. Other printed information on the strip of interest to the controller are the Aircraft ident/type/transponder

N5098G	AIRCRAFT IDENT
L329/F	AIRCRAFT TYPE/TRANSPONDER EQUIPMENT
336	COMPUTER ID NUMBER
7437	ASSIGNED BEACON CODE
GDM	PREVIOUS FIX (GARDNER VOR)
LOBBY	COORDINATION FIX (LOBBY VOR)
A2037	ETA AT COORDINATION FIX (Z TIME)
BVY	DESTINATION AIRPORT (BEVERLY, MASS)

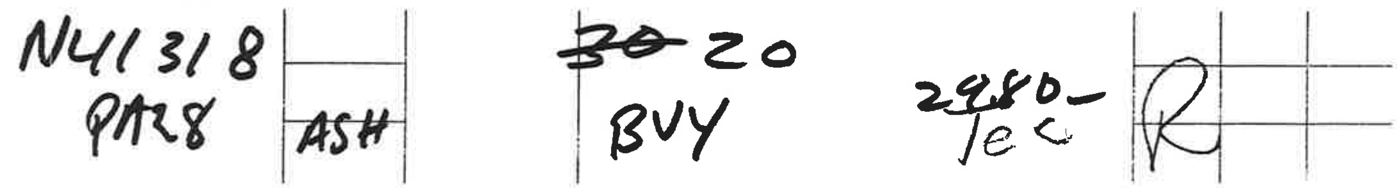
<u>MANUAL MARKINGS</u>

50	ALTITUDE ASSIGNMENT (5000FT)
✓	INDICATES BEVERLY CONTROL TOWER GIVEN AIRCRAFT IDENT AND ETA AT AIRPORT FOR FLIGHT
SDF/VA	TYPE OF APPROACH (SIMPLIFIED DIRECTION FINDING/VISUAL APPROACH)
R16	ACTIVE RUNWAY AT BEVERLY
29.76	ALTIMETER SETTING AT BEVERLY
R	RADAR CONTACT ESTABLISHED

FIGURE C-7. IFR FILED ARRIVAL TO A SECONDARY AIRPORT (BEVERLY) - EXAMPLE TRACON FLIGHT STRIP

N42B	AIRCRAFT IDENT
BE18	AIRCRAFT TYPE
20	ALTITUDE ASSIGNMENT (2000 FT)
BOS	DESTINATION AIRPORT
T	A TCA FLIGHT
R	RADAR CONTACT ESTABLISHED

FIGURE C-8. TCA ARRIVAL TO LOGAN - EXAMPLE TRACON FLIGHT STRIP



N41318	AIRCRAFT IDENT.
PA28	AIRCRAFT TYPE
ASH	POINT OF ORIGIN (NASHUA, NH)
30	ALTITUDE ASSIGNMENTS (3,000 FT THEN 2,000 FT)
~~30~~	INDICATES PILOT REPORTED LEAVING 30 (3,000 FT)
BVY	DESTINATION AIRPORT (BEVERLY, MA)
29.80	ALTIMETER SETTING AT BEVERLY
TEC	TOWER ENROUTE CONTROL
R	RADAR CONTACT ESTABLISHED

FIGURE C-9. TOWER ENROUTE CONTROL - EXAMPLE TRACON FLIGHT STRIP

EA359 AIRCRAFT IDENT
B727/A AIRCRAFT TYPE/EQUIPMENT
081 COMPUTER ID NUMBER
3460 ASSIGNED BEACON CODE
P2215 PROPOSED DEPARTURE Z TIME
160 REQUESTED ALTITUDE (16,000 FT)
BOS DEPARTURE AIRPORT
BOS..EWR ROUTE (BOSTON, MA TO NEWARK, NJ)

MANUAL MARKINGS

140 ALTITUDE ASSIGNMENT (14,000 FT)
R RADAR CONTACT ESTABLISHED
Ⓡ FLIGHT HANDED OFF TO ENROUTE CENTER
(Circle around R indicates aircraft under radar contact with adjoining center airspace)

FIGURE C-10. IFR FILED DEPARTURE FROM LOGAN - EXAMPLE TRACON FLIGHT STRIP equipment/beacon code/requested altitude (16,000 ft) and proposed departure time. The controller also uses the strip to note when radar contact has been established, the altitude assignments issued (14,000 ft), and handoff to the Enroute Center.

IFR Filed Departure from a Secondary Airport - Bedford (Figure C-11)

The example strip is for a Bedford Airport operation. This printed strip is very similar to the Logan departure strip, Figure C-10, except that BED has been substituted for BOS. The controller uses the strip to note the active departure runway at Bedford, radar contact, and the altitude assignment. Since Bedford Airport is in the Bedford Secondary Airport Area, AR-3 would handle the flight and the data position, BD, would probably handle the call from the Bedford Control Tower giving the departure details for the flight, such as the departure runway to be used. In the upper line of routing +PUT ORW+, indicates that routing between crosses is other than requested or filed by pilot, and must be verbally called out when departure clearance is given.

TCA Departure from Logan (Figures C-12 and C-13)

The air carrier/air taxi flights that operate within the local area tend to submit seasonal IFR flight plans and then to cancel them at departure time, if weather permits, in order to fly under Visual Flight Rules. These flights then become TCA departures. The controllers use the cancelled IFR flight strips for these TCA operations. Figure C-12 shows an example TCA strip for an air taxi flight from Logan to Bridgeport Conn. The IFR beacon code is replaced by the TCA assignment code, the IFR altitude request of 6000 ft. is cancelled along with the IFR route between the two end points. The conversion from an IFR to a TCA strip is usually done by the data position, DD. The departure radar controller uses the strip to note radar contact, altitude assignments (2,500 ft.), and the termination of radar service. Figure C-13 is an example strip for a general aviation TCA departure, which as a group are usually not in the computer and therefore are handwritten.

IFR Filed Overflight (Figures C-14 and C-15)

Figure C-14 shows that these strips are similar to the IFR arrival strips except that the designation for the destination

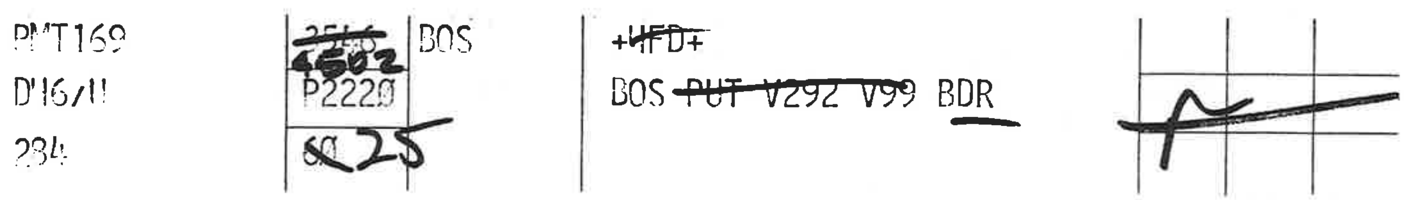
N247B	3514	BED	+PUT ORW+	
BE10/A	P1200	R29	BED BOSOX V308 ORW V16 DPK	R
336	120 ✓		FRG	

N247B	AIRCRAFT IDENT
BE10/A	AIRCRAFT TYPE/TRANSPONDER EQUIPMENT
336	COMPUTER ID NUMBER
3514	ASSIGNED BEACON CODE
P1200	PROPOSED DEP. Z TIME
120	REQUESTED ALT. (12,000 FT)
BED	DEPARTURE AIRPORT (BEDFORD)
+PUT ORW+	ROUTE CHANGE (BY CONTROLLER, NOT PILOT)
BED...FRG	ROUTE (BEDFORD, MA TO FARMINGDALE, LONG ISLAND)

MANUAL MARKINGS

✓	INDICATES CONTROLLER ISSUED THE 12,000 FT ALT. INSTR.
R29	DEPARTURE RUNWAY
R	RADAR CONTACT ESTABLISHED

FIGURE C-11. IFR FILED DEPARTURE FROM A SECONDARY AIRPORT (BEDFORD) - EXAMPLE TRACON FLIGHT STRIP

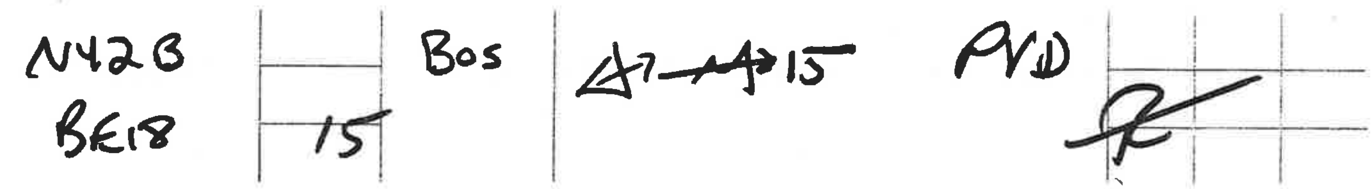


PMT169	AIRCRAFT IDENT (PILGRIM AIRLINES)
DH6/U	AIRCRAFT TYPE/TRANSPONDER EQUIPMENT
284	COMPUTER ID NUMBER
~~3546~~	CANCELLED IFR BEACON CODE ASSIGNMENT
P2220	PROPOSED DEPARTURE TIME
~~60~~	CANCELLED ALTITUDE REQUEST (6000 FT)
BOS	DEPARTURE AIRPORT
BOS...BDR	ROUTE FROM LOGAN TO BRIDGEPORT, CT (IFR PORTION - PUT V292 V99 - CANCELLED)

MANUAL MARKINGS

4502	TCA BEACON CODE ASSIGNMENT
25	ALTITUDE ASSIGNMENT (2500 FT)
R	RADAR CONTACT ESTABLISHED
~~R~~	RADAR SERVICE TERMINATED

FIGURE C-12. TCA DEPARTURE FROM LOGAN (AIR TAXI) - EXAMPLE TRACON FLIGHT STRIP



N42B	AIRCRAFT IDENT
BE18	AIRCRAFT TYPE
15	REQUESTED ALTITUDE (1500 FT)
BOS	DEPARTURE AIRPORT
∆→	LEAVING TCA
~~M~~→15	ALTITUDE ASSIGNMENT (MAINTAIN 1500 FT)
PVD	DESTINATION AIRPORT (PROVIDENCE, RI)
R	RADAR CONTACT ESTABLISHED
~~R~~	RADAR SERVICE TERMINATED

FIGURE C-13. TCA DEPARTURE FROM LOGAN (GA) - EXAMPLE TRACON FLIGHT STRIP

N294W	AIRCRAFT IDENT
7	REVISION NUMBER
WW24/F	AIRCRAFT TYPE/TRANSPONDER EQUIPMENT
569	COMPUTER ID NUMBER
2732	ASSIGNED BEACON CODE
BOS 296/038	COORDINATION FIX (38 MI DME FROM BOS VOR ON THE 296 RADIAL)
ZCB	OVERFLIGHT COORDINATION INDICATOR (IDENTIFIER FOR THE BOSTON ARTCC COMPUTER)
E1523	ETA AT COORDINATION FIX (Z TIME)
50	ALTITUDE THROUGH TERMINAL AREA (5000 FT)
DOV...MHT	ROUTE (DOVER, DE/HARTFORD, CT/MANCHESTER, NH)

MANUAL MARKINGS

R	RADAR CONTACT ESTABLISHED
~~R~~	RADAR SERVICE TERMINATED
OF	OVERFLIGHT

FIGURE C-14. IFR FILED OVERFLIGHT - EXAMPLE TRACON FLIGHT STRIP

N35DB	AIRCRAFT IDENT
C270	AIRCRAFT TYPE
140↓60	ALTITUDE ASSIGNMENT (CLEARED TO DESCEND TO 6,000 FT FROM 14,000 FT)
OF	OVERFLIGHT

FIGURE C-15. IFR FILED OVERFLIGHT - EXAMPLE TRACON FLIGHT STRIP airport has been replaced by a handwritten OF for overflight. Not all IFR overflights arriving at the Terminal Area are preceded by their printed flight strips. Figure C-15 presents an example handwritten overflight strip

TCA Overflight (Figure C-16)

Virtually all TCA overflights have handwritten strips. The TF designates that the strip is for a TCA overflight (through flight). The strip notes aircraft ident, type, altitude assignments, route, radar contact, and radar service termination.

Expanded Radar Service (ERS)(Figure C-17)

All ERS strips are handwritten and note the type of service provided and the time.

Summary - Tables C-4, C-5 and C-6 summarize this data on TRACON flight strips for arrivals, departures, and other Terminal Area operations, respectively.

1.5 TRACON FLIGHT STRIP SYSTEM

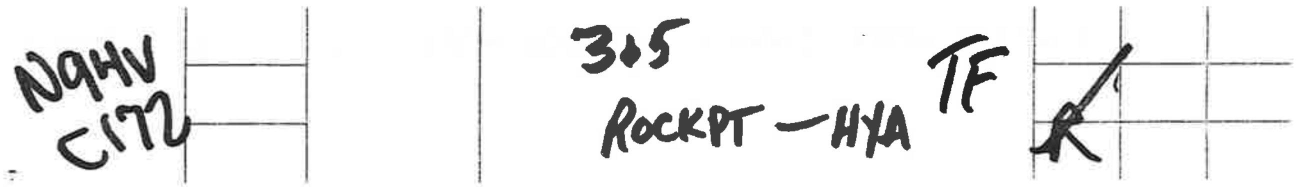
Flight strips are found at 15 locations within the TRACON. Figure C-18 shows these locations which consist of:

- two flight strip printers
- flight strip trays located next to the radar control positions
- the counters at the radar control positions.

To characterize the flight strip system in the Boston TRACON, observations were made in which the following was noted:

- the number of strips at each location
- the ETA posted on each arrival strip and the proposed departure time posted on each departure strip at each location
- the time of the observation.

Figure C-18 presents the results of these observations. For each strip location the minimum, maximum, and average number of strips observed is given along with:



N94V	AIRCRAFT IDENT
C172	AIRCRAFT TYPE
3.5	ALTITUDE ASSIGNMENT (3500 FT)
ROCKPT	POINT OF ORIGIN (ROCKPORT, MA)
HYA	DESTINATION (HYANNIS, MA)
TF	THROUGH FLIGHT
R	RADAR CONTACT ESTABLISHED
~~R~~	RADAR SERVICE TERMINATED

FIGURE C-16. TCA OVERFLIGHT - EXAMPLE TRACON FLIGHT STRIP

N54L	AIRCRAFT IDENT
CSNA	AIRCRAFT TYPE
ALT CHK	SERVICE REQUESTED (AN ALTIMETER CHECK)
ERS	EXPANDED RADAR SERVICE
0523	TIME OF REQUEST

FIGURE C-17. EXPANDED RADAR SERVICE - EXAMPLE TRACON FLIGHT STRIP

TABLE C-4. COMPARISON OF TRACON FLIGHT STRIPS FOR ARRIVALS

STRIP DESIGNATOR: MOST STRIPS ARE:	IFR FILED LOGAN ARR - PRINTED	IFR FILED SEC. AIRPORT ARR - PRINTED	TCA LOGAN ARR T HAND-WRITTEN	TEC LOGAN ARR TEC PRINTED
STRIP CONTENT:				
AIRCRAFT IDENT	P	P	H	P
AIRCRAFT TYPE	P	P	H	P
AIRCRAFT EQMT	P	P	-	P
COMPUTER NUMBER	P	P	-	P
BEACON CODE	P	P	-	P
PREVIOUS FIX	P	P	-	P
COORDINATION FIX	P	P	-	P
ETA AT COORD. FIX	P	P	-	P
DESTINATION AIRPORT	P	P	H	P
ALTITUDE ASSIGNMENTS	H	H	H	H
RADAR CONTACT	H	H	H	H
AIRPORT DATA	-	H	-	H (for non-Logan arrivals)
APPROX. NUMBER OF STRIPS ON A SAMPLE WEEKDAY	560	90	130	20

NOTE:

P - PRINTED DATA
H - HANDWRITTEN DATA

TABLE C-5. COMPARISON OF TRACON FLIGHT STRIPS FOR DEPARTURES

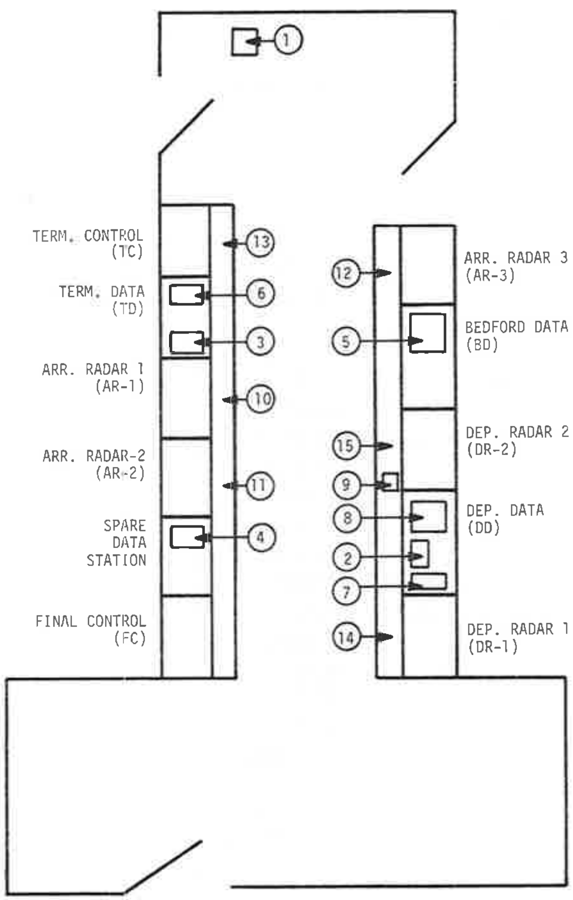
STRIP DESIGNATOR:	IFR FILED LOGAN DEP	IFR FILED SEC. AIRPORT DEP	AIR TAXI TCA LOGAN DEP	GA TCA LOGAN DEP
MOST STRIPS ARE:	PRINTED	PRINTED	PRINTED	HAND-WRITTEN
STRIP CONTENT:				
AIRCRAFT IDENT	P	P	P	H
AIRCRAFT TYPE	P	P	P	H
AIRCRAFT EQMT	P	P	P	
COMPUTER NUMBER	P	P	P	
BEACON CODE	P	P	P	
PROPOSED DEP. TIME	P	P	P	
REQUESTED ALT.	P	P		H
DEP. AIRPORT	P	P	P	H
ROUTE	P	P		DEST. AIRPORT
ALTITUDE ASSIGNMENTS	H	H	H	H
RADAR CONTACT	H	H	H	H
HANDOFF TO ENROUTE CTR	H			
RADAR SERV. TERMINATED			H	H
AIRPORT DATA		H		
APPROX. NUMBER OF STRIPS ON A SAMPLE WEEKDAY	560	90	130	

NOTE:
P - PRINTED DATA
H - HANDWRITTEN DATA

TABLE C-6. COMPARISON OF TRACON FLIGHT STRIPS FOR FLIGHTS NOT REQUESTING ARRIVAL/DEPARTURE SERVICES

	IFR FILED OVERFLT.	TCA OVERFLT.	ERS FLIGHT
STRIP DESIGNATOR:	OF	TF	ERS
MOST STRIPS ARE:	PRINTED	HAND-WRITTEN	HAND-WRITTEN
STRIP CONTENT:			
AIRCRAFT IDENT	P	H	H
AIRCRAFT TYPE	P	H	H
AIRCRAFT EQMT	P		
COMPUTER NUMBER	P		
BEACON CODE	P		
COORDINATION FIX	P		
OVERFLT. COORD. IND.	P		
ETA COORDINATION FIX	P		
ROUTE	P	H	
ALTITUDE ASSIGNMENTS	P	H	
RADAR CONTACT	H	H	
RADAR SERV. TERMINATED	H	H	
SERVICE REQUESTED			H
TIME			H
APPROX. NUMBER OF STRIPS ON A SAMPLE WEEKDAY	25	130	5

NOTE:
P - PRINTED DATA
H - HANDWRITTEN DATA



FLIGHT STRIP LOCATION	NO. OF OBS.	NO. OF STRIPS OBSERVED			TIME DISTRIBUTION OF STRIPS OBSERVED* (MINUTES)				
		MIN	AVG	MAX	EARLIEST TIME OVERALL	EARLIEST MEDIAN TIME	MEDIAN TIME	LATEST MEDIAN TIME	LATEST TIME OVERALL
1) ARRIVAL PRINTER	9	0	3	4	-2 MIN	+18 MIN	+24 MIN	+28 MIN	+33 MIN
2) DEPARTURE PRINTER	8	0	2	5	-57	+16	+21	+23	+25
3) AR-1 TRAY	9	3	7	11	-44	-2	+10	+23	+27
4) AR-2 "	6	4	6	10	-37	-4	+16	+24	+27
5) AR-3 "	9	6	13	22	-188	-91	-4	+20	+23
6) TC "	5	0	1	2	TCA STRIPS TEND NOT TO HAVE TIME POSTED				
7) DR-1 "	8	5	10	17	-79	-56	-1	+21	+25
8) DR-2 "	9	5	13	18	-115	-79	-1	+24	+33
9) DR-2 CTR TRAY	9	7	8	9	-117	-71	-3	+3	+12
10) AR-1 COUNTER	9	0	2	3	-44	-5	-4	-2	+3
11) AR-2 "	9	0	1	4	0	+3	+3	+4	+11
12) AR-3 "	9	0	1	3					
13) TC "	5	0	1	3	TCA STRIPS TEND NOT TO HAVE TIME POSTED				
14) DR-1 "	9	1	2	4	-44	-16	-15	-12	0
15) DR-2 "	9	1	3	8	-59	-31	-17	-13	-4
FC	DOES NOT USE FLIGHT STRIPS								

* TIME = (ETA OR PROPOSED DEPARTURE TIME POSTED ON FLIGHT STRIP) - (TIME OF OBSERVATION)

TIME ZERO: ARRIVALS SCHEDULED TO ENTER TERMINAL AREA AND DEPARTURES SCHEDULED TO TO LEAVE GATES

+TIME: TIME PRECEEDING POSTED TIME OF STRIP

-TIME: ARRIVALS SCHEDULED TO HAVE ENTERED TERMINAL AREA AND DEPARTURES TO HAVE LEFT THEIR GATES

FIGURE C-18. FLIGHT STRIP LOCATIONS IN TRACON AND STATISTICS ON STRIPS FOUND AT THOSE LOCATIONS the earliest (i.e., oldest) posted strip time noted - both the very earliest time and the median value over all the observations

the latest (i.e., most recent) posted strip time noted - again both the maximum and median values over all the observations

the posted strip time of the median strip.

The two FDEP printers tend to be found with up to 5 strips printed out. These strips are printed out 25 to 35 minutes before the arrivals are due to enter the Terminal Area or the departures are due to leave their gates. However, strips for departures up to an hour past their posted gate push back times were observed being typed out. These strips were for flight revisions and cancellations.

Every few minutes TD will collect the strips from the Arrival Printer, and DD will do the same at the Departure Printer. Strips for arrivals/departures in the Bedford Secondary Airport Area are given to BD. All 3 controllers put the strips into holders and post them into the appropriate controllers flight strip tray. The strips are usually in the trays 20 to 30 minutes before the operations are scheduled to enter the Terminal Area or to leave their gates. These strips stay in the trays until the flights are about to come under the control of the TRACON. Strips for flights near or under TRACON control are usually pulled out of the trays and are placed on the counters immediately in front of the responsible radar controller. Strips for flights that are late, have varied from their flight plans, or have cancelled remain in the trays. Each overdue flight strip remains in the tray until the flight makes contact or, the TRACON is notified of the flight's revision or cancellation via the FDEP printers. Strips up to 3 hours overdue were found. Strips tend to stack up in the trays - particularly for the positions that handle departures (i.e., for DR-1, DR-2, AR-3). The worst case involved DR-2, who had over 20 strips in his trays on the average. In addition to the built-in strip tray used by DR-2, he also tends to use a smaller portable tray located at his elbow on the counter.

The strips on the counters are for flights that are being actively worked by the controllers. The number of strips observed averaged 3 or less depending on the position, and the highest number observed was 8 flight strips at the DR-2 position. The median strips for the arrival positions were within a few minutes of their posted ETA's. This means that the arrivals were operating close to their schedules in general. Similarly, the departures were found to be on schedule in general. The median strips for the two departure positions had posted gate departure times that were around 15 minutes old - the time it normally takes to taxi to the runway, to take off, and to be airborne for a minute or two.

After the flights have left TRACON control, the data positions collect the strips, take them out of the holders, and store them at their positions. The strips are used to make hourly traffic counts; and at the end of each day, the strips are sorted, packaged, and stored for 15 days.

1.6 TRACON Position Related Observations

A limited set of data was taken in the TRACON in order to characterize the activity of each controller at his position. Specifically, the following data were obtained:

> the frequency with which each controller used the equipment at his position
>
> the frequency with which each controller left his position and why.

To collect this data, an observer stood behind and to one side of each controller at his position for 10 minute periods and recorded his actions in terms of his scan, his hands, and when he left his position, his destination in the TRACON. These observations were made on weekday mornings between 0800 and 1100, which contained Logan's morning traffic peak of about 85 operations/hr. Due to time limitations, only two or three sample periods could be obtained for each position - insufficient for averaging purposes, but adequate as examples of the controller activity to be found in the Boston TRACON. For each control position, the period of greatest activity was chosen as the example. Controller activity levels at least as great as presented in these examples exist.

The example activity levels of the radar control positions are presented in Table C-7. The first item covered for each position is the estimate of the controller's workload made by the observer at the end of the 10 minute observation period. These varied from low to busy:

> Busy (DR-2) - only brief lulls observed in controller activity or apparent concentration (i.e., periods in which controller sat quietly and relaxed at his position or conversed casually with other controllers or with the observer).
>
> Moderately busy (AR-1, AR-3, TC) - controller activity remains high but distinct lulls in that activity observed.
>
> Low (DR-1) - prolonged breaks in controller activity observed.
>
> Near communication saturation (FC) - FC used the communication microphone almost continuously over the 10 minute period.

The first controller activity presented in Table C-7 has to do with flight strip usage at the radar control positions. Controllers scan their strips for flight data information, make notations on the strips for control purposes and manipulate their strips by taking them from the flight strip trays, by changing their order and by handing them off to another controller. Over the ten minute periods, the controllers:

> Scanned their strips only a couple of times
>
> Made notations on their strips from 2 to 16 times
>
> Manipulated their strips from 1 to 10 times.

Another item used by the radar controllers is the TELCO keypack. The TELCO system permits the controllers in the Terminal

TABLE C-7. FREQUENCY OF USE OF STATION EQUIPMENT BY THE TRACON RADAR CONTROLLERS OVER A 10 MINUTE PERIOD

	ARRIVAL RADAR CONTROLLERS			TERMINAL CONTROL (TC)	FINAL CONTROL (FC)	DEP. RADAR CONTROLLERS	
	AR-1	AR-2	AR-3			DR-1	DR-2
OBSERVED CONTROLLER WORKLOAD	MOD. BUSY	VARIED SLOW TO HECTIC[1]	MOD. BUSY	MOD. BUSY	NEAR COMM. SATURATION	LOW	BUSY
Flight Strips							
Strips Scanned	1	0	2	2	-	1	2
Strip Notations Made	7	9	2	3	-	7	16
Strip Manipulation	1	3	1	6	-	5	10
TELCO Keypack	2	0	3	0	1	5	2
Headset Microphone	25	20	29	21	40	15	38
ARTS PVD	← ALMOST CONTINUOUSLY →						
Keyboard	6	14	7	2	1	2	8
Track Ball	8	10	6	2	8	2	7
Other Equipment	o PVD CONTROLS (1) o ALTIMETER (1)	o PVD CONTROLS (1) o FAA COMM. PANELS (3)	o POSTED ATC DIRECTORY INFO. (1) o POSTED STATUS INFO. (1) o POSTED WEATHER INFO. (1)		o FAA COMM. PANELS (1)		DD HEADPHONE (1) (DD AWAY FROM STATION)

NOTES: (1.) Uncontrolled aircraft in TCS-explaining the considerable keyboard/track ball and FAA comm. panel usage

Area, to communicate among themselves and with the Enroute Center. The TELCO keypack permits a controller to contact another control position by depressing the button associated with that position. Over the 10 minute observation periods. the controllers used their keypacks from 0 to 5 times. The count involves the number of times a button was depressed on the keypack.

Other than the ARTS Plan View Display, the most used item by radar controllers is their headset microphone, through which they communicate with pilots and with other controllers (via the TELCO system). Over the 10 minute observation periods the controllers used their microphones from 15 to 40 times. FC with 40 communications was near voice channel saturation in that batches of communications occurred in rapid succession over the entire period with only brief lulls breaking the sequence. A count was made whenever the controller started a communication with a flight number.

The ARTS Plan View Display (PVD) is used almost continuously by the radar controllers. When busy, the controllers will only look away from the display to do some necessary function such as use the TELCO, or to mark a flight strip, etc. During slack times, the controllers still keep their eyes on the display unless they become involved in a conversation. When involved in a conversation, the controllers will still frequently glance at the display.

The ARTS keyboard and track ball are used to accept and initiate radar handoff of targets between controllers and to control the flight data presentation on the PVD. Observed utilization of these devices varied from 1 to 14 times for the keyboard and from 2 to 10 times for the track ball. The 14 and 10 values, associated with the AR-2 position, may be higher than normal in that an uncontrolled aircraft was in the TCA and the TRACON Coordinator (CI) was working through the AR-2 position to use the ARTS computer to investigate the the situation and to have AR-2 try to raise the aircraft on some other ATC frequency. For the keyboard, a count was made whenever the controller moved his hand to the keyboard and started pushing buttons. For the track ball, a count was made whenever the track ball was used and the enter button was depressed. Incidentally, the controllers tended to take from 2 to 3 seconds to make a track-ball entry, including the time to maneuver the track ball.

Of the other equipment at the stations, the following were observed being used by the positions:

FAA communication panels (4 times)

PVD controls (2 times)

Altimeter (1 time)

Posted information on the Bedford Secondary Airport Area (1 time)

Handphone at DD station (1 time).

Finally, no controller was observed leaving an active radar control position without being relieved. When a radar controller requires assistance, he will either call upon one of the data positions if the matter is routine or upon the TRACON Coordinator (CI) or supervisor (TS) if the matter is complex or unusual in character.

Table C-8 presents the observed activity levels for the TRACON support positions. The CI was observed during a very busy period involving the coordination of almost all of the control positions, such as during a major runway shift at Logan. During the 10 minute observation period, the CI made a total of 40 moves between the various stations and made a total of 10 TELCO calls. Typically, when the CI comes to a radar control position, he will indicate on the controller's PVD how the traffic situation is developing and what changes that control position should institute in handling his traffic. The CI will then watch developments on the PVD at that position until he is required to talk to some other position.

The three data positions are primarily involved with flight strip handling. Flight strip handling is made up of a sequence of actions. Flight strips retrieved from the FDEP printers contain both printed and blank strips. The printed strips are inserted into holders and the blank strips are either stored or are inserted into holders for use as handwritten flight strips. The data

TABLE C-8. FREQUENCY OF USE OF STATION EQUIPMENT AND WALK PATTERNS OF THE TRACON SUPPORT CONTROLLERS OVER A 10 MINUTE PERIOD

	TRACON COORDINATOR (CI)	TERMINAL DATA (TD)	DEPARTURE DATA (DD)	BEDFORD DATA (BD)
Observed Controller Workload	Very busy	Busy	Busy	Light
Flight Strips				
. Insert Strip into Holders	-	3	19	2
. Insert Blank Strip into Holder	-	1	0	0
. Store Blank Strip	-	2	14	0
. Strip Manipulated	-	2	21	3
. Strip Notations Made	-	10	9	4
. Strips Scanned	-	0	1	2
. Used Strip Stored	-	11	8	2
		29 strip actions	62 strip actions	13 strip actions
TELCO Keypack	10	6	1	9
Type of Phone Used	Headset	Handphone	Handphone	Handphone
FDEP Departure Printer	-	-	8	-
Teletype	-	-	2	-
ARTS PVD	-	(AR-1) 3	(DR-2) 6	(AR-3) Often
Keyboard	-	-	-	(AR-3) 1
Track ball	-	(AR-1) 2	-	(AR-3) 1
WALK to AR-1 Station	7	-	-	-
AR-2 Station	11	2	2	-
AR-3 Station	1	-	-	-
TC Station	7	-	-	-
FC Station	3	-	-	-
DR-1 Station	4	-	-	-
DR-2 Station	1	-	-	-
TD Station	4	-	-	-
DD Station	1	-	-	-
BD Station	0	2	4	-
TS Station	1	-	-	-
Teleautograph	-	1	-	-
FDEP Arr. Printer	-	2	-	-
Other Equipment	Posted Weather (1)			

personnel make the necessary notations on the strips and then deposit them in the appropriate flight strip trays. These trays can be located away from the data personnel positions. If a flight revision of cancellation comes in on the printers, the data personnel scan the strips to find the original strip. The data personnel also assist the controllers having trouble finding particular flight strips. After handoff of a flight by the TRACON, used strips will be taken from their holders by the data personnel and stored. The frequency with which these actions occurred over the 10 minute observation periods for the three data positions can be seen in Table C-8. By far the greatest flight strip activity was shown by DD with a total of 62 strip actions or approximately 1 every 10 seconds.

During lulls in flight strip activity, each data position observed the PVD at one of the adjacent radar control positions and assisted the radar controller with his keyboard/track ball entries. This can be seen in Table C-8.

In summarizing the activities of the three data positions over the 10 minute observation periods, it is seen that TD:

collected the weather report from the Telautograph once

collected the strips form the Arrival FDEP printer twice

delivered the strips for arrivals to the Bedford Secondary Airport Area to BD twice

delivered the strips in their holders for Logan arrivals entering the Terminal Area north of Logan to AR-2 twice

in strip activities, was busiest making strip notations and storing strips

assisted AR-1 in making TELCO calls and track ball entries as time permitted.

that DD:

collected the incoming strips from the Departure FDEP printer eight times used the FDEP Teletype to make flight strip requests, corrections, or inquiries twice

delivered the strips for departures from the Bedford Secondary Airport Area to BD four times

in his strip activities, was busiest with inserting strips into their holders and manipulating the strips

had insufficient time remaining to assist a radar control position with either TELCO calls or keyboard/track ball entries, but did watch the traffic on the DR-2 PVD as time permitted.

and that BD:

remained at his positions

had little flight strip activity

assisted AR-3 with TELCO calls and keyboard/track ball entries.

1.7 TRACON FLIGHT HANDLING SCENARIOS

This section presents the typical sequence of controller actions that take place in the TRACON in handling an arrival to and a departure from Logan Airport. The two scenarios are based on observations of the TRACON operation and on discussions with controllers.

1.7.1 IFR Arrival to Logan Airport

This scenario is a reconstruction of flight UA658 from its flight strip and makes the assumption that it landed on Logan's most used arrival runway - 4R. The flight strip is shown in Figure C-19 and the reconstructed flight path in Figure C-20. The flight was a B727 that entered the Terminal Area at the LOBBY Coordination Fix and was scheduled to be at that fix at 1320 Z-time or 9:30 AM local Boston time. The typical sequence and timing of

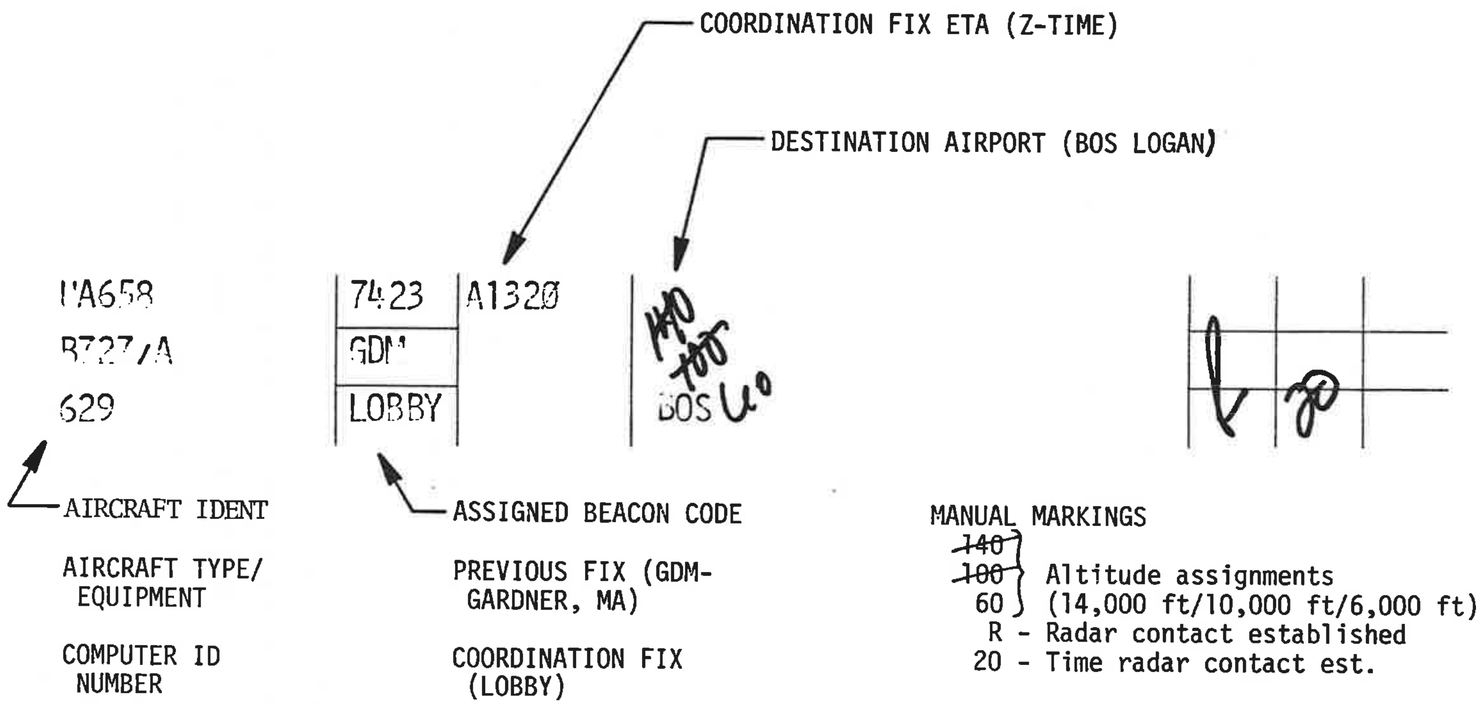


FIGURE C-19. FLIGHT STRIP FOR LOGAN ARRIVAL UA658

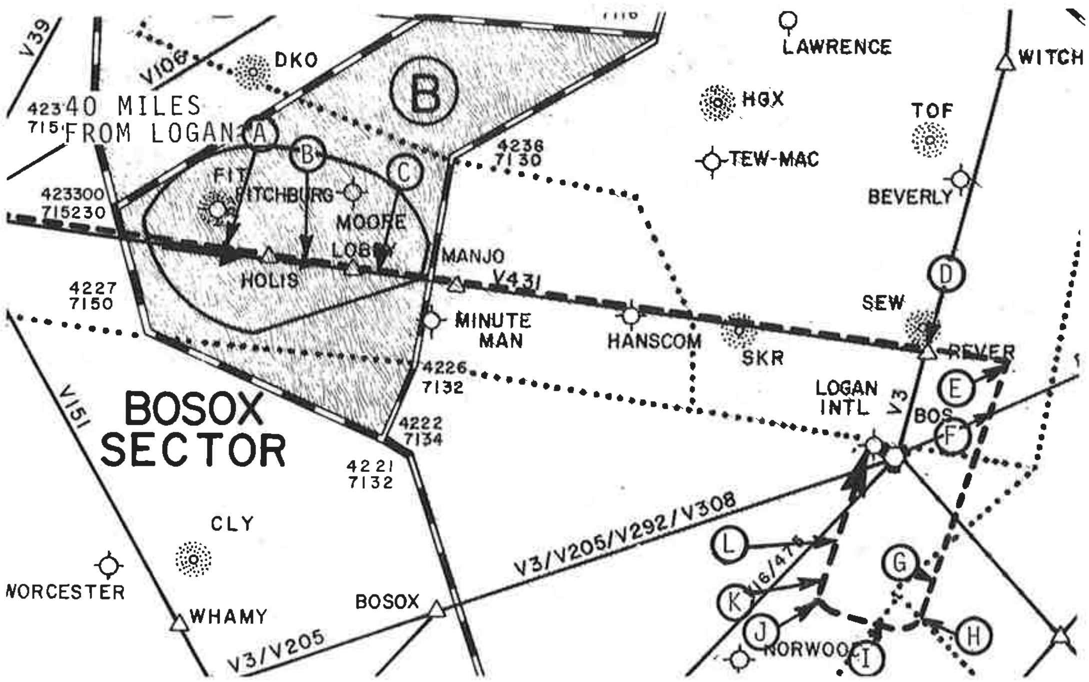


FIGURE C-20. TYPICAL APPROACH PATH FOR UA658 FROM THE LOBBY FIX TO LOGAN'S RUNWAY 4R

TRACON actions in handling this flight was:

8:50 AM - UA658 flight strip prints out on the Arrival FDEP Printer.

8:53 AM - Terminal Data (TD) retrieves the strips from the printer, inserts them into holders, and distributes the strips into the appropriate radar controllers strip trays. The UA658 strip would be put into AR-2's tray.

9:20 AM (Map location A in Figure C-20) - ARTS handoff of UA658 from the Enroute Center to AR-2. The ARTS handoff sequence consists of (Controller A to Controller B):

To initiate the handoff, Controller A uses the ARTS keyboard to instruct the processor that the handoff will be to Controller B. Controller A then slews the trackball to the target on his PVD and depresses the ENTER button.

The target now flashes on the Controller B display.

To accept the handoff, Controller B slews his track ball cursor to the flashing target and depresses that ENTER button.

The result of this action is to cause the target to stop flashing on the Controller B display and to cause the target to start flashing on the Controller A display. The target will flash for four or five sweeps indicating the acceptance of the handoff by Controller B.

On accepting the ARTS handoff, AR-2 will take the UA658 flight strip from the tray and mark on the strip:

R for radar contact

20 for 20 minutes after the hour

140 for the target's displayed altitude (14,000 ft).

9:21 AM (Map location B) - Pilot makes initial contact with AR-2. Typical message content is:

Always present - pilot altitude report, ATIS code in effect, and the Logan altimeter setting

Usually present - an altitude instruction (in this case, "cross LOBBY at 14,000 ft").

9:22 AM (Map location C) - AR-2 issues an altitude instruction to UA658 "Decent to 10,000 ft" and marks the flight strip 100

9:29 AM (Map location D) - AR-2 issues another altitude instruction to UA658 "Descent to 6,000 ft" and marks the flight strip 60.

9:30 AM (Map location E) - AR-2 issues a heading instruction.

9:31 AM (Map location F) - AR-2 issues a speed instruction "decrease speed from 250 to 210 knots" and initiates an ARTS handoff of UA658 to Final Control (FC).

9:34 AM (Map location G) - AR-2 makes final contact with UA658. Typical message content is:

Always present - frequency change instruction

Usually present - an altitude instruction, such as "Descend to 4000 ft".

Flight strip is then passed to TD for storage.

9:34 AM (Map location G) - Pilot makes initial contact with FC. Typical massage content is:

Always present - pilot altitude report and an altitude instruction

Usually present - a speed instruction "Decrease speed to 160 (or 180) knots"

9:35 AM (Map location H) - FC issues a heading instruction.

9:36 AM (Map location I) - FC issues and altitude instuction "Descend to 2000 ft".

9:37 AM (Map location J) - FC issues a heading instruction.

9:38 AM (Map location K) - FC issues a visual approach instruction if it applies.

9:39 AM (Map location L) - FC makes final contact with UA658. Usually, it only contains a frequency change instruction.

In this arrival scenario, the flight was under TRACON control for about 18 minutes and its flight strip took about 49 minutes to go from printer to storage. As seen from Figure C-20, Runway 4R requires a relatively long approach path from the LOBBY Fix. A direct path to Logan, such as to Runway 15R, would reduce the time the flight was under TRACON control by at least one-half.

1.7.2 IFR Departure From Logan Airport

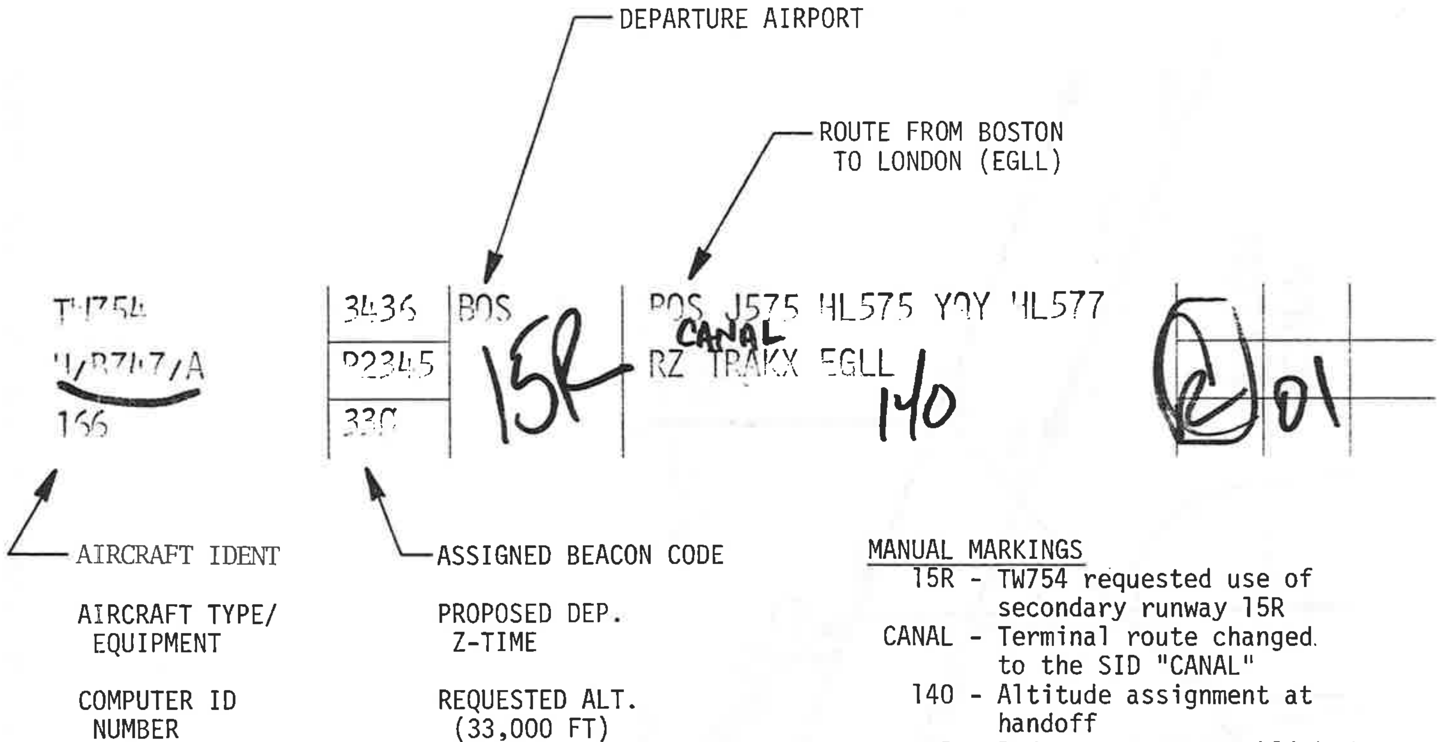
This scenario is a reconstruction of flight TW754 from its flight strip. The flight strip is shown in Figure C-21 and the reconstructed flight path in Figure C-22. The flight was a B747 destined for London and scheduled to leave its gate at 2345 Z-time or 7:45 PM local Boston time. The typical sequence and timing of TRACON actions in handling this flight was:

7:15 PM - The TW754 flight strip prints on the Departure FDEP Printer.

7:17 PM - Departure Data (DD) takes the strips from the printer, inserts them into holders, marks them as necessary, and then distributes them to the appropriate radar controller flight strip trays. In this case, DD underlines the aircraft weight class and type to emphasize that it is a heavy and puts the strip into DR-1's tray.

7:25 PM - Clearance Delivery in the Logan Tower Cab calls DD on the TELCO phone to advise the TRACON of a terminal route change to the Canal SID (Standard Instrument Departure) for TW754. DD locates the strip in the tray and writes in Canal.

7:50 PM - Local Control in the Logan Tower Cab calls DR-1 on the TELCO phone and requests that TW754 be permitted to take off from 15R, which is not the primary departure runway in operation. DR-1 grants the request and takes the TW754 strip from the tray and notes the departure runway, 15R.



MANUAL MARKINGS
- 15R - TW754 requested use of secondary runway 15R
- CANAL - Terminal route changed to the SID "CANAL"
- 140 - Altitude assignment at handoff
- R - Radar contact established
- 01 - Time of handoff to Enroute Center
- Ⓡ - Hand-off to Enroute Center

FIGURE C-21. FLIGHT STRIP FOR LOGAN DEPARTURE TW754

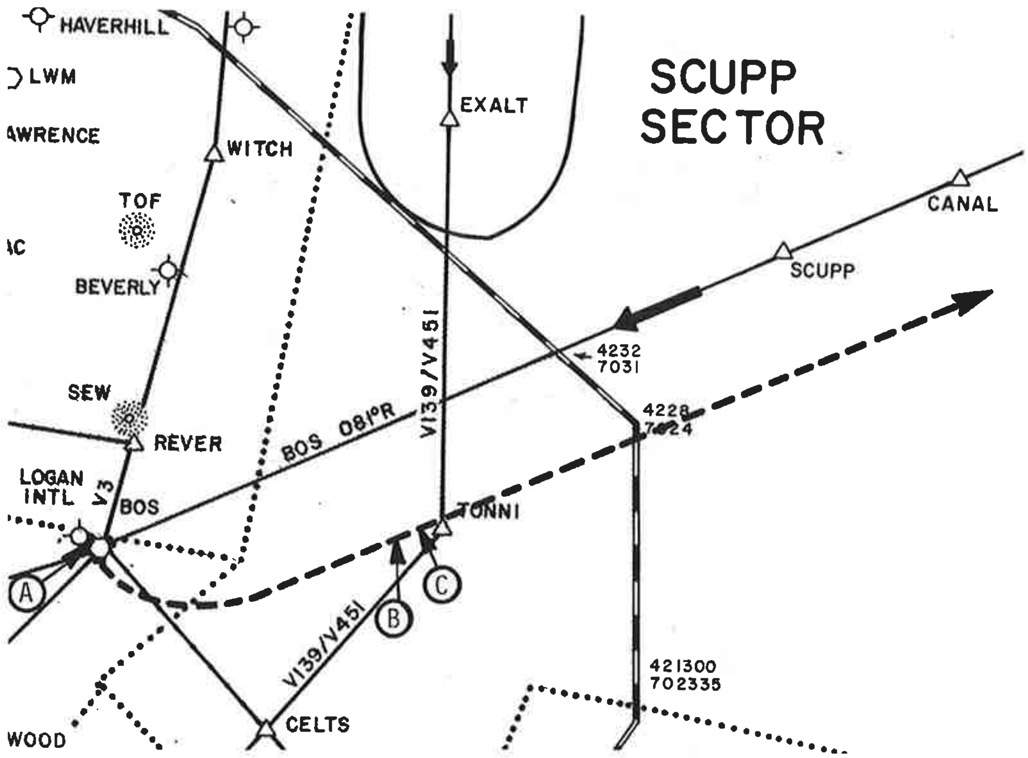


FIGURE C-22. TYPICAL DEPARTURE PATH FOR TW754 FROM RUNWAY 15R FOR AN OVERSEAS FLIGHT

7:53 PM (Map location A) - Pilot of TW754 makes initial contact with DR-1 shortly after liftoff. Typical message content is:

> Always present - radar contact assurance and an altitude instruction like "climb to 5000 ft"
>
> Usually present - a heading instruction.

DR-1 marks the strip with an R to indicate TW754 in radar control.

8:00 PM (Map location B) - DR-1 initiates an ARTS hand off to the Enroute Center for TW754 (ARTS handoffs were described in Section 1.7.1).

8:01 (Map location C) - DR-1 makes final contact with TW754. Typical message content is:

> Always present - a change frequency instruction
>
> Usually present - an altitude instruction (in this case, "climb to 14,000 ft").

DR-1 then marks the strip with 140 for the 14,000 ft altitude instruction, with 01 for the time (i.e., one minute past the hour), and with a circle about the R indicating handoff to the Enroute Center. The strip is then passed to DD for storage.

In this departure scenario, the flight was under TRACON control for about 8 minutes and its flight strip took about 45 minutes in going from printer to storage.

2. TOWER CAB ANALYSIS

2.1 CAB CONFIGURATION

The positions of the controllers in the Cab and the ceiling-hung displays which they use may be changed depending upon the configuration of active runways which is being used. Most of the observations made in this study were done with the Cab organized in the "north" configuration. That is, with the Cab Coordinator operating from the console labeled NLCC and the Local Controller operating from the console labeled NLC in Figure C-23. This orientation is used when it provides the controllers with the better line of site viewing of the threshold of active runways and so is preferred when 22L, 22R, 15R and 27 are used (Figure 2-4).

The Coordinator, Local Controller and Ground Controller tend to cluster together at the intersection between the Local and Ground Controller's consoles when working traffic. The LC and CC share the same BRITE display which is positioned so that they both can see it, with some preference being given to Local Control. When in this arrangement, the Local Controller appears to use the wind and RVR instruments at the Ground Control position. The Ground Controller has his own BRITE display which may be on the ASR or the ASDE setting depending upon visibility conditions. When in the north configuration, the Skyway Controller operates between the south local and south coordinator positions. This controller does not have visual contact with the helicopters that he monitors, so does not need access to the window. Therefore, he can sit at any unoccupied controller position with radio equipment and an ASR display.

The pairs of parallel lines shown at several consoles in Figure C-23 represent racks for flight strips. Different controllers may use the trays differently and tend to arrange them according to their own operating style. Other trays are present in the Cab, but those not used during the north operations observed are not shown. The trays shown in the figure are labeled according to the how they were used by the controllers.

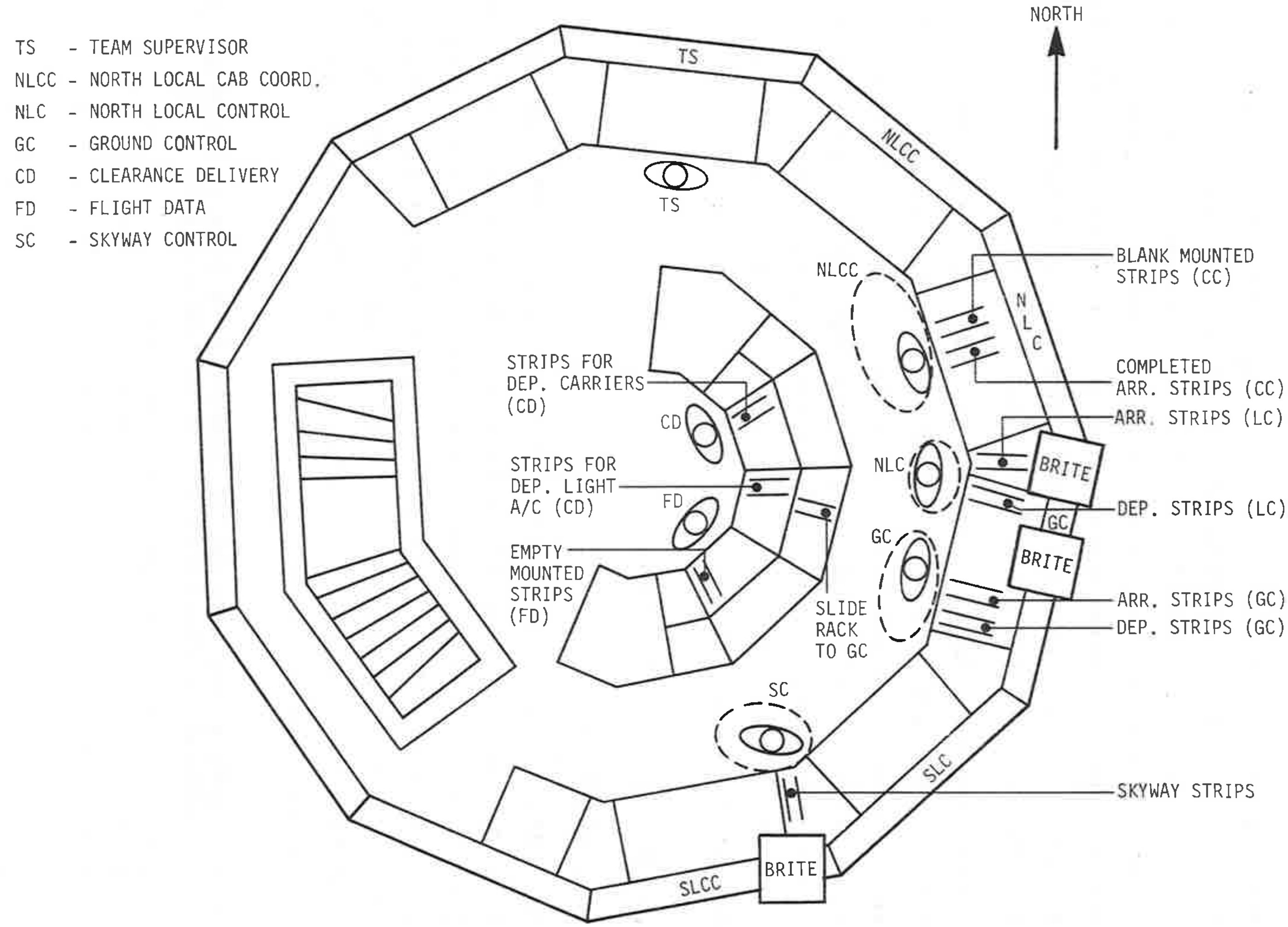


FIGURE C-23. TOWER CAB LAYOUT SHOWING CONTROLLER POSITIONS FOR "NORTH" OPERATION

The controllers rarely move from their positions during the hours of peak operations. The positions of the four controllers operating at the Cab windows was noted at 30 second intervals for 20 minutes starting at 8:00 a.m. EST during the morning peak of operations. The dashed circles drawn around the controller symbols indicate the area where the controller was observed most of the time. In each case at least 35 of the 40 observations made during the 20 minute observation period found the controllers within these circles, or walk areas, and the Local Controller was in the area on 39 of the 40 observations.

Excursions outside the walk areas: the Local Controller walked to Flight Data one time and asked for a beacon code for an arriving General Aviation flight, the Coordinator made several excursions to the coffee pot, and the Ground Controller walked to the island several times to get Departure Flight Strips from Clearance Delivery. Both Clearance Delivery and Flight Data remained at their stations during these observations.

2.2 FLIGHT STRIP ACTIVITIES

Types of Operations

Arriving and departing aircraft processed by the Cab are divided into four operational categories, are counted hourly, and summed for a total count at the end of each day. These categories are listed in Table C-9 by number and proportion of the total for one typical day of operations. The table shows that the majority of operations are commercial air carriers, and that very few military planes are serviced.

TABLE C-9. NUMBER AND PERCENT OF AIRCRAFT IN FOUR CATEGORIES OF OPERATION PROCESSED BY LOGAN TOWER CAB ON 3 MAY 1978

Category	Number	Percent
Air Carrier	632	56
Air Taxi	239	21
General Aviation	252	22
Military	7	1
TOTAL	1130	100

All flight strips for aircraft arriving at Logan are handwritten by the Cab Coordinator, or by the Local Controller if the Coordinator position is not staffed. Most commercial aircraft file their departure flight plans with ARTCC well in advance, and so departure flight strips for these operations are computer generated. Flight strips representing aircraft for which IFR flight plans have not been filed such as those for GA are handwritten by Clearance Delivery.

Arrival Flight Strips

Arrival strips are written on the back of empty flight strip forms. The following information is handwritten across the strip in four fields from left to right:

1. Indication in red if other than the primary runway or if some variation of the primary runway is to be used - 33R
2. Aircraft ID-Q061
3. "H" in red if the aircraft is a heavy or the type of aircraft indicated in red if it merits special consideration - not indicated on the sample strip
4. "T" used to indicate TCA operations, or code number for special handling.

33R / Q061 T

The life of the flight strip starts with its generation by the Cab Coordinator and ends when the Ground Controller removes the strip from its holder and files it out of sight in a storage bin for counting at the end of the hour. The average duration of this process timed for an air carrier and an air taxi was 12 and 11 minutes, respectively. Selected actions and the times between the start of these actions are shown in Table C-10.

TABLE C-10. TIMED HISTORY OF TWO ARRIVAL FLIGHT STRIPS IN THE LOGAN TOWER CAB

EVENT	AC/ID	STRIP PREPARED	ARRIVED LOCAL	TALKED TO AC	ARRIVED GROUND	FILED
TIME OF ACTION	DE 43	00:00	00:01	00:05	00:10	00:12 Minutes
TIME OF ACTION	ANE 422	00:00	00:01	00:05	00:08	00:11 Minutes

The detection of the arriving aircraft on the BRITE display by the Cab Coordinator starts a standard and relatively fixed set of actions required for the aircraft to land and be processed safely and expeditiously to the company gate. During this process the cognizance and control of the aircraft is handed off among three Cab Controllers. The flight strip representing the aircraft serves as an aid to remembering the identification and key characteristics of the aircraft, special considerations for its processings, and for communicating this information to each controller. It also serves as a physical token of the shifting in responsibility for its control from one control position to another.

The following is an example of a typical sequence of actions taken by the controllers with regard to an arrival air carrier and the corresponding actions taken with the flight strip.

a. Air Carrier Strips

The Cab Coordinator detects arriving air carrier on the BRITE and prepares a flight strip from the information shown on the aircraft data block. Only the aircraft ident is written on most arrival strips.

AL152

The coordinator puts the prepared strip in LC arrival rack in the order in which the aircraft is expected to arrive. The pilot calls Local Control on radio frequency 119.1 from the outer marker and gives the aircraft ident and his approximate location, e.g., at the outer marker.

Local Control determines that the approach path and the runway is clear, checks the nearest weather instruments and then gives the pilot clearance to land, wind speed and direction and the RVR. Many controllers place a slash (/) or check mark in the left side of the strip when they give the landing clearance.

Local Control observes the aircraft land, tells him where to turn off the runway, when to cross active runways and then to call Ground Control after crossing. When the aircraft is taxiing, Local Control has the flight strip cocked in the arrival rack as a reminder to monitor the aircraft when it crosses the active runway.

When the aircraft crosses, Local Control will take the flight strip from his rack and place it in the arrival rack of the Ground Controller. The pilot will call Boston Ground Control on frequency 121.9 and give the aricraft ident and announce that it is clear of the active runway.

Ground Control gives the pilot routing instructions to its gate, slides the strip out of its holder and puts it out of sight in the compartment for air carrier strips in the bin on the edge of his console.

b. TCA Flight Strips

Incoming TCA flights are handled in the same manner as the air carriers except for the generation of the flight strip. The TCA pilot calls Approach Control when he is approximately 30 miles from the airport. Approach Control makes up a flight strip for the TRACON and puts it in the arrival rack for the secondary runway. If the aircraft is fast, such as a Lear jet, it may be assigned to a primary runway. Approach Control then calls up the Cab Coordinator on the TELCO equipment and gives him the ident of the approaching TCA aircraft and any special information on the aircraft which would be important to its handling.

The Cab Coordinator makes up the flight strip and puts it in the Local Controller's arrival rack.

22L/27 ANE 528 T

The sample illustrates that Air New England is to land on runway 22L holding short of runway 27. The T indicates that the aircraft is a TCA and is put on the strip so that when the strips are counted it will be appropriately categorized. If the aircraft were General Aviation rather than scheduled, the registration number rather than the flight number would be used on the strip. The aircraft and its flight strip will be handled exactly as in the case of the air carrier described above for the remainder of the processing cycle.

c. Through-Flights Strips

Local Control monitors flights at 1500 feet and below, excluding the descent area which belongs to the TRACON. Therefore, through flights handled by this position are usually small aircraft. On approaching the Terminal Control Area, the aircraft calls Local Control (Boston Tower) and requests permission to go through the area. Local Control makes up a strip with the aircraft altitude, ident and TF (for through flight) on it and calls over

500ft N84W TF

his shoulder to Flight Data to get a beacon code for him. Flight Data types into the FDEP for a code on the ASR but doesn't use it. The code is for use by the pilot. Local Control uses the tail numbers, i.e., aircraft registration number.

When the aircraft leaves the area and is told to squawk, Local Control removes the strip from the holder and puts it in his storage bin for counting at the end of the hour.

d. Missed Approach

When an aircraft coming into land refuses to touch down and so executes a missed approach, the Cab Coordinator calls the TRACON using the TELCO key pack and asks for an Approach Controller to volunteer to "take" the aircraft. The Local Controller tells the pilot to maintain runway heading, climb to a specified altitude, and change over to approach control frequency. At this point, most controllers remove the strip from the holder and file it for mounting as a separate operation. Some controllers save the strip and reuse it when the aircraft comes around again to land.

Departure Flight Strips

The flight strips for departing aircraft may be either typed or handwritten. Strips for IFR flights are scheduled and generated through the ARTCC computer system and so are printed out by the FEDP in the Cab. Strips for non-scheduled aircraft (e.g., General Aviation) are handwritten by Clearance Delivery. For both cases the operational life of the flight strip starts with its generation in the Cab and ends when the Local Controller removes the strip from its holder and files it in a storage bin for counting at the end of the hour. The time for this process for one flight observed from printing to filing was 34 minutes.

a. IFR Flight Strips

The typed strips are printed about 15 to 30 minutes before departure time and contain the following categories of information:

Aircraft ident (EA 1121)
Aircraft type/transponder equipment (DC 9/A)
Computer number (687)
Beacon code (3514)
Proposed departure time (P2300)
Requested altitude (160)

Departing airport (BOS)
Routing (Boston, HFD, etc.)

EA1121	3514	BOS	BOS HFD JFK J48 FLYPI J80			
DC9/A	P23ØØ		V5 CVG			
637	16Ø					

Flight Data pulls the printed flight strips and usually several empty ones from the FDEP printer, separates them from one another, and inserts the separated strips into holders which are stacked in his strip rack.

Flight Data then examines the strips for errors, underlines the aircraft type in red, if it is heavy, and makes revisions on the strip if necessary. Such revisions might be changes in altitude or routing which were indicated earlier via the FDEP printer. Flight Data places the strip in Clearance Delivery's left rack if it is for an air carrier (as the example is) or in the right hand rack, if it is a military aircraft or a General Aviation.

The pilot calls Clearance Delivery and gives ident, destination, altitude and the letter of the ATIS message he listened to for weather, etc. Clearance Delivery writes the ATIS letter (E) on the corresponding flight strip while giving the pilot departure clearance.

EA1121	3514	BOS	BOS HFD JFK J48 FLYPI J80			
DC9/A	P23ØØ		V5 CVG		E	
637	16Ø					

Clearance Delivery puts the strip of the cleared aircraft in the slide rack (Figure C-23) for Ground Control. The Ground Controller retrieves departure flight strips from the slide and places them in the suspense section of his departure rack. When the pilot calls for push back clearance, Ground Control may note the gate number on the strip. When he is given push-back clearance, he may cock the strip in its rack as a reminder that this clearance has been given.

The pilot may request taxi clearance, or if Ground Control wants to move him out for some reason he may ask the pilot if he is ready to go. Before giving taxi clearance, Ground Control checks the strip to determine if the ATIS letter listed is the latest one, if not he will give the pilot a weather update.

While giving taxiing instructions most controllers monitor the aircraft out the window. As he gives taxiing instructions, the Ground Controller will mark on the strip any variations from standard departure procedures to be used by the aircraft such as a different departure heading (2/240) or departure control frequency (124.1).

EA1121	3514	BOS	BOS HFD JFK J48 FLYPI J80		
DC9/A	P2300	2/240	V5 CVG 124.1		E
637	160				

The ground controller puts the strip in the taxiing portion of the departure rack when taxiing instructions have been given.

When taxiing, pilots are instructed by Ground Control to hold short of active runways which they must cross. When Ground Control has permission from Local Control he clears the pilot to cross the active runway. As soon as the pilot is clear to go to the departure queue without further assistance, Ground Control puts his flight strip in the top of Local Control's departure rack. This makes the last plane to arrive the last one to depart, since Local Control processes the strips from the bottom of the rack first.

Local Control often takes the mounted flight strip in his hand when working the departing aircraft and calls for the aircraft to take its position at the end of the runway on hold. The controller examines the traffic out the window using the BRITE; and then, if clear, gives the pilot clearance to take off. When the aircraft is rolling, Local Control informs Departure Control of this fact by depressing the appropriate TELCO keypack button and saying the aircraft ident, e.g., "Eastern 1121." Although not required, when LC notifies DC of the departure he often puts a check (✓) mark on the strip. Some put the mark next to the aircraft ID, others put it to the left of the ATIS letter. The departure time in minutes past the hour is recorded just beneath the ATIS letter. The time used is approximately the time the aircraft rotates as indicated by the digital clock on the weather turret.

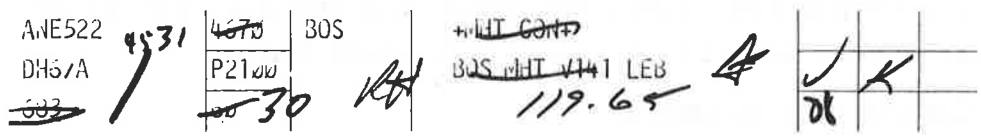
EA1121	3514	BOS	BOS HFD JFK J48 FLYPI J80			
DC9/A	P2300	2/240	V5 CVG 124.1	✓	E	
637	160				08	

After writing the departure time, the controller takes the strip out of its holder, and puts the strip in the bin in the edge of the of the console in the section for carriers. At the end of the hour the strip will be removed from the bin and given to Flight Data for counting.

b. VFR Flight Strips

VFR flight strips are generated for aircraft initially scheduled for IFR but who request a VFR flight plan, and for aircraft that initiate their flight plans as VFR. When the pilot scheduled to fly according to an IFR plan wishes to go VFR he tells Clearance Delivery. Then Clearance Delivery or Flight Data change the plan and modify the printed strip to reflect this change. To change the plan, the controller types on the FDEP keyboard for the plan to be cancelled and the flight strip removed from the system. This cancels the beacon code as well so the controller must also request a new beacon code using the ARTS keyboard. Finally, the controller calls Departure Data on the TELCO system to inform him of the IFR to VFR change. The sample flight strip below indicates these changes.

Cancellation of the computer number 683
Change beacon code from 4670 to 4531
Reduction of cruising altitude from 6,000' to 3,000'
The check mark (✓) next to the left of the ATIS letter indicates that the change was coordinated with the TRACON.



Once the strip has been changed, it is processed normally through the controller positions in the Cab.

Most flight strips for VFR flights are handwritten on blank strip forms by Clearance Delivery as he gets the required information from the pilot calling in for departure clearance. Except for the absence of a computer number, proposed departure time and detailed routing, the VFR strips contain the same categories of information as those generated by computer. The sample VFR slip represented below contains:

The aircraft ident number N3821Q
Aircraft type - C172
Beacon code - 4513
Pilot requested altitude - 1500 Ft.
Destination - HYA (Hyannis).

When Clearance Delivery is writing out the strip, he may ask Flight Data to get the beacon code for him or he may get it himself by typing the request with the aircraft ident into the ARTS keyboard. If he must wait to get the code, he places the strip in the rack cocked as a reminder that he must get something from Flight Data for that flight. Usually, the process of writing the strip, obtaining the code, and providing the departure clearance takes about 23 seconds.

When the strip is completed, Clearance Delivery uses the TELCO to tell Departure Data the information necessary to make up a strip for use in the TRACON. After departure clearance has been given, Clearance Delivery puts the mounted strip in the slide rack for the Ground Controller who processes the aircraft to the appropriate runway on a first come first serve basis.

c. Gate-Hold Procedures

Tower operation procedures preclude more than five aircraft waiting in a departure queue at one time. This limitation is to reduce fuel use and the accumulation of pollution resulting from idling aircraft engines. To satisfy this requirement, gate-hold procedures often must be instituted during peak operations. This necessitates that a gate-hold controller position be manned to take care of increased communications with the waiting pilots, and it changes the routing of departure flight strips.

When gate-hold procedures are in effect, departing pilots are instructed on the ATIS to contact Boston Gate Hold at 121.75 before contacting Ground Control for pushback clearance. And, Gate-Hold Control, rather than Ground Control, retrieves departure flight strips from Clearance Delivery's slide rack. When the pilot calls him, the controller writes the time of the call and the anticipated taxi time that he gives the pilot. He then cocks the strip in his flight strip rack to indicate that this information has been transmitted. When he puts the strip in Ground Control's departure rack, he calls the pilot and directs him to contact Ground Control on 121.9. From then on the departing flight is handled normally.

d. Aborted Takeoff

When a takeoff is aborted, Local Control retains the strip unless the aircraft goes back to the ramp area. Usually the aircraft turns off at the nearest exit and comes back up into the departure queue. If the aircraft goes into the Ground Controller's territory, Local Control gives Ground Control the strip, who handles the plane as if it were an arrival.

2.3 CONTROLLER ACTIVITIES

Tower Cab activities were observed on four separate weekday mornings during August, 1978. These observations included recording the activities of the four tower controllers plus Flight Data and the Team Supervisor to determine the physical actions required in accomplishing their work, and relative frequency of the most common actions, and the duration of selected actions. The observations were made in the tower on a non-interference basis and so were necessarily incomplete. Local and Ground Controllers were observed during the busiest hours of the morning, while other controllers whose jobs are less time critical were observed as time permitted. Most observations were made during VFR conditions.

Local Control

Major duties of the Local Controller (LC) include issuing air traffic control clearances and traffic information to arriving and departing aircraft. The LC assumes responsibility for the separation standards for traffic under his jurisdiction, and transmits weather, field conditions, NOTAMS, RVR values, and other required data to arriving and departing aircraft as necessary. The LC authorizes Ground Control the crossing and/or use of active runways, and recommends to the Team Supervisor the selection of appropriate active runways according to prescribed procedures.

The LC position was observed for 20 minutes. During this time he did not leave the positions once and seemed to alternate his vusual attention more or less equally between the window and the BRITE display. The position was very busy but there were brief moments to relax. When working, the LC was often engaged in more than one activity at a time; therefore, time durations of many actions have little meaning with regard to the minimum time necessary to accomplish discrete actions.

The activities which were observed are shown in Table C-11 with their frequency of occurance. This list, however, is not complete because some actions were too subtle to be seen and others were concealed by the controller's body when the LC was facing away from the observer. For example, the controller looks at the digital clock on the weather instrument turret before writing aircraft departure times on the strip, but the glance was so subtle that it was never seen -- nor were the controller's glances at the weather instruments prior to giving each aircraft its clearance to land.

TABLE C-11. LOCAL CONTROLLER ACTIONS DETECTED DURING ONE, 20-MINUTE OBSERVATION PERIOD

Action	Detections	Duration (Seconds)
Surveillance		
Window	15	2.0
BRITE	17	1.6
Communications		
To Aircraft	35	2.0
To Ground Control	2	-
To Flight Data	2	-
To Cab Coordinator	5	-
Used TELCO	9	6.0
Flight Strip		
Strip Holder to Coordinator	7	-
Wrote on Strip	12	-
Passed Strip to Ground Control	12	-

The table illustrates the following points:

- At least 19 aircraft were processed
- Attention was divided fairly equally between the window and the BRITE display
- Information was extracted quickly (1.6 sec) from the display
- Although the window and display were referenced at a high rate (over 1.5 times per minute), total time spent looking at these during the 20 minutes was very low, only 58 seconds

A limited number (10) observable actions transpired.

Ground Control

Ground Controller (GC) is responsible for aircraft and vehicles operating on the airport taxiways and runways which are not active. Close coordination with Local Control is required for vehicles to cross active runways. Activities include controlling ground traffic on the airport movement area; emergency vehicles on the airport; and relaying weather, field conditions and RVR information to outbound aircraft when required.

Ground Control was observed for 15 minutes during the morning traffic peak. The Ground Controller was backed up by and instructor who did not interfere with the ground operation during the observation period. The controller was obviously working to capacity and stroked the flight strips nervously while talking to the various taxiing aircraft. The GC looked away from the window for only brief moments and frequently walked down the south side of the Cab to get a better view of the western areas of the airport. The observable activities of the controller are shown in Table C-12 with their frequency of occurrence. The durations are medians of the sample of measured durations which varied in number from 1 to 10.

TABLE C-12. GROUND CONTROL POSITION ACTIONS DETECTED DURING ONE, 15-MINUTE OBSERVATION PERIOD

Action	Detections	Duration (seconds)
Surveillance		
Used Window	Almost continuously	
Communications		
To Aircraft	20	3.0
Flight Strips		
From CD	3	2.0
Wrote on Strip	5	3.5
Strip from LC	2	-
Strip to LC	5	2.0
Moved Strip from Suspense to Taxiing Rack	7	-
Removed Strip from Holder and Filed	10	3.0

The table illustrates the following points:

Judging from the strips filed and those removed from the suspense bay, 17 aircraft were processed during the 15 minute observation period

The GC's most frequent action was talking to aircraft, and he does so at the rate of 1-1/3 communications per minute

Writing on the strip is one of the more time consuming actions

Ground Control is very dependent on visibily out the window for processing aircraft.

Clearance Delivery

Clearance Delivery (CD) formulates and transmits IFR and TCA departure clearances for aircraft and relays clearance information to the Departure Data position in the TRACON on aircraft not represented in the computer but which will be under TRACON jurisdiction. CD ensures that all aircraft have current ATIS information, and obtains beacon codes for departing TCAS from Flight Data or by himself through the ARTS key board if Flight Data is unavailable.

Clearance Delivery was observed for approximately 50 minutes following the morning operations peak. This was a relatively quiet period for CD during which he found time to look at sector maps, answer a question asked by another controller, casually walk to the window and look out, walk to the Local Controller position and examine some of his strips, and separate and mount some strips from the FDEP for Flight Data. The 50 minute observation period was required to provide a "reasonable" sample of work activity because of the slow operational pace of this position.

Table C-13 shows the count of work-related actions made by the controller during the observation period. The table illustrates the relative inactivity of this controller in showing that he handled only 7 aircraft strips during the 50 minute observation period. The fact that CD wrote on flight strips on 23 separate occasions does not mean that this many strips were processed by

CD. For example, CD might write on a single strip three different times, and upon receiving the strip might underline the aircraft type indicating that it is a heavy, or rewrite the strip to change an IFR flight to a VFR flight (at pilot request), and record the new beacon code necessitated by that change.

TABLE C-13. CLEARANCE DELIVERY ACTIONS DETECTED DURING ONE, 50-MINUTE OBSERVATION PERIOD

Action	Detections	Duration (Seconds)
Surveillance		
Used ARTS Keyboard	5	3.0
Communications		
To Aircraft	13	-
To Other Controllers	3	-
Used TELCO Equipment	1	14.0
Flight Strip		
Received Strip from FD	4	-
Wrote on Strip	23	-
Strip to Ground	7	2.0
Completed Transactions		
a. Provide Clearance to A/C & Annotated Prepared Strip.		22.5
b. Wrote Strip for TCA, Obtained Beacon Code & Annotated Strip.		26.0

The a and b entries in the table represent comparable composite activities done for IFR and TCA flights. It is interesting that preparing a strip from scratch for a TCA takes only four seconds more than annotating a prepared strip even though the time for the TCA strip includes obtaining a beacon code through the ARTS system. The reason for this similarity in time duration is that in both cases the strips are prepared while giving the pilot departure clearance. The communication exchange is not shown as a separate entry in the table because the pilot's part of the exchange was unavailable to the observer.

Flight Data

Flight Data (FD) is responsible for all activities related to the FDEP equipment and the ARTS alphanumeric system. Flight Data personnel remove, edit and mount the flight strips, and make appropriate queries and changes to the ARTCC system flight plans through ARTS key pack entries as requested by Clearance Delivery and Local Control. Flight Data dissemenates flight data to the correct position of operation and, relays pilot reports (PIREPS) to the appropriate agencies. FD also does many of the housekeeping functions of the Cab such as changing the roll on the telautograph, counting and categorizing flight strips each hour, and filling the FDEP with blank flight strips.

The responsibilities of this position are not demanding and during nonpeak hours allow the occupant considerable time for relaxation. Often other controllers such as Clearance Delivery, trainees, and the Team Supervisor share in the accomplishment of Flight Data tasks on an ad lib basis. When this position is not manned such as in quiet evening hours, when Flight Data is on an errand outside the Cab, or getting coffee, the responsibilities of the position are assumed by Clearance Delivery.

Flight Data was observed for 30 minutes during a relatively quiet period on a normal weekday morning. The job-related activities observed during that time are shown in Table C-14. These are Flight Data's most frequent activities. The first five are the standard sequence of actions which transpire each time the FDEP prints out new strips. Often from three to five strips would be typed out at a time. The average time to take the strips from the FDEP to installing each one into holders was over 35 seconds. This time is not an indication of the time required to execute these actions, since this was a relatively low workload situation.

TABLE C-14. FLIGHT DATA ACTIONS DETECTED DURING ONE, 30-MINUTE OBSERVATION PERIOD

Action	Frequency	Duration (Seconds)
Surveillance		
Used ARTS Keyboard	1	3.0
Communications		
Used TELCO Equipment	2	9.0
Flight Strips		
Strips from FDEP		
Separated Strips		
Discarded Empty Strips		
Inserted Typed Strips in Holders	7	35.5
Underlined Heavies		
Put Mounted Strips in CD's Rack		
Typed on FDEP	2	6
Removed Strip from CD's Rack and Discard	1	-

When no action was detected by the computer on a computer-generated flight strip, the FDEP prints out a message to Flight Data to discard the inactive strips. These were retrieved from Clearance Delivery's departure rack for this reason. The calls on the TELCO equipment were to inform the TRACON of flights changing their plans from IFR to VFR. The nine seconds is from depression of the keypack button to its release - not actual talking time, which was much less.

Cab Coordinator

The Cab Coordinator (CC) is always positioned beside Local Control and shares a BRITE display with him. The CC maintains close visual surveillance of inbound aircraft and prepares inbound flight strips for LC and coordinates these arrivals with Approach Control Coordinator/Arrival Data which achieves a smooth flow of arrival aircraft to the runway. The Cab Coordinator also works with the other Cab positions as necessary and/or when requested by Local Control. This position has no direct contact with the aircraft.

The actions made by the Cab Coordinator while exercising his duties during a 20 minute observation period are shown in Table C-15. It can be seen that this controller referenced the BRITE display more than once each minute - almost twice as often as the Local Controller. This reference rate reflects the fact that the Cab Coordinator's major responsibilities relate to arrival aircraft. The Coordinator looked at the display for an average of 5 seconds on each occasion - a relatively long period of time when compared to the 1.5 second durations of Local Control. This difference in time illustrates that the two controllers look for different things. The Cab Coordinator most often searches for arrival aircraft, whereas Local Control was probably extracting data from a target whose location on the BRITE was already known.

TABLE C-15. CAB COORDINATOR ACTIONS DETECTED DURING ONE, 20-MINUTE OBSERVATION PERIOD

Action	Detections	Duration (Seconds)
<u>Surveillance</u>		
Window	11	-
BRITE	29	12.0
<u>Communications</u>		
Spoke to Local	7	2.0
Spoke to Other Controllers	6	2.0
Used TELCO keypack	3	12.0
<u>Flight Strips</u>		
Mounted Flight Strip	8	5.0
Wrote Flight Strip	8	12.0
Strip to Local	10	2.0
Examined Racked Strips	5	-

Communications on the TELCO system were about the same duration as those of Flight Data (9 sec) and Clearance Delivery (12 sec) and were relatively few, indicating little contact with the TRACON during this observation period.

Writing flight strips was one of the most time consuming actions (per event) observed, even though it took less than half the time taken by Clearance Delivery to accomplish the same task with departure strips. The Coordinator's arrival strips usually contain little more than the aircrafts ident number and they are prepared from data on the BRITE without communicating with the aircraft.

The Coordinator spoke to other controllers on job related matters on at least 13 separate occasions in 20 minutes -- half again as often as the Local Controller who was the next most communicative controller. This large number of within-Cab communications is a reflection of the coordination-related activities required of this position.

Skyway Control

The Skyway Control (SC) position is staffed by a tower rated controller between 0800 to 0900 and 1600 to 1800 hours to handle skyway and helicopter traffic over the Boston area. SC occupies the South Local or North Local Control position, whichever is unoccupied.

Skyway Control is responsible for monitoring the separation of fixed-wing aircraft and helicopters in his jurisdiction among themselves and from the arrival and departure traffic under the jurisdication of Local Control; this responsibility includes coordinating with Local Control regarding active runway configurations and when crossing the paths of arrival and departure aircraft.

The activities of Skyway Control were observed for 20 minutes during the morning tour of duty. The activities and their frequencies are shown in Table C-16. SC's major activity was monitoring the BRITE. The median duration of looks at the display was 13 seconds, and they ranged from the shortest of 5 seconds to the longest of 45 seconds. SC watched the aricraft on the display when talking to the pilot, and spent approximately 13 percent of the time looking at the display. This is over 5 times the time Local Control spent looking at his display. This controller spent most of the time engaged in non-work activities. SC's hands were often not near his PTT switch, a condition that was not observed for the Local Control and Ground Control positions at this time of day (8:10 AM). The conversations with the other controllers, although usually work-related, were not concerned with immediate responsibilities.

TABLE C-16. SKYWAY CONTROLLER ACTIONS DETECTED DURING ONE, 20-MINUTE OBSERVATION PERIOD

Action	Detections	Duration (Seconds)
Surveillance		
Window	-	-
BRITE	9	13.0
ARTS Keyboard	1	9
Communications		
To Aircraft	8	-
To Other Controllers	6	-
Flight Strips		
Strip to Ground	1	-

Team Supervisor

The Team Supervisor (TS) supervises the overall activity of the Cab, provides the necessary assistance and final decisions in operational situations, maintains proper discipline and conduct, determines staffing, and assures that official procedures and policies are followed. The Supervisor accomplishes and records what checks are made on the operation of selected equipment, and responds to outages by activating standby equipment, notifying maintenance technicians and affected facilities, publishes NOTAMS, and displays the status of the equipment in the Cab.

The Supervisor determines weather from various official sources and formulates and tapes the ATIS message hourly, and more frequently when required by weather changes. The TS alerts controllers to important weather changes and ensures that the current ATIS letter is displayed on the ARTS system. The TS also handles telephone/interphone calls from user agencies pertinent to handling particular aircraft flights, and coordinates with emergency service groups and the Coast Guard during periods of emergency.

Two Supervisors were observed for approximately 30 minutes each on different mornings. In each case it was found that performing their duties required moving around the Cab to a considerable degree and frequently required performing the tasks of Flight Data and Cab Coordinator. One Supervisor was away from his desk 62 percent of the observation period -- the other appeared to be away more than this. Although the total amount of time away from the desk is long, the Supervisor frequently, returns to the desk to answer the telephone. Table C-17 is a list of Supervisor activities noted during one observation period.

It is clear from Table C-17 that the variety of tasks accomplished by the Supervisor require him to be very mobile. He is often the only "spare controller" in the Cab. He was the only member of the Cab staff to be seen adjusting equipment and he is the first to know of changes in weather conditions.

Telephoning can be accomplished any place in the Cab that there is a dial box. Of the six calls observed, four were taken at the TS's desk, one at the South Cab Coordinator position, and one at the Flight Data position. These calls ranged in duration from 20 seconds to 5 minutes.

TABLE C-17. SUMMARY OF TEAM SUPERVISOR ACTIVITIES DURING ONE, 30-MINUTE OBSERVATION PERIOD

TALKED ON TELEPHONE	REPORT WRITING
o Reported a Bird Strike o Reported an Obstacle on Runway o Discussed Departure Spacing with TRACON and Sector	o Copied ATIS Message o Entry into Runway-use Log o Typed Watch Report
TALKED TO CONTROLLERS	ASSISTED CONTROLLERS
o Performance of Trainee o Routing of Training Aircraft o Announced Runway Closing o Discussed Overtime o Relayed ASR Information	o Checked Telautograph for Weather Update o Adjusted BRITE o Typed on FDEP and Mounted Strips o Prepared and Passed Arrival Strips to Local

Talking with the different controllers varied from casual non-work conversations to discussions of how the work at hand should be performed.

The Supervisor appears to be surveying the Cab continuously and to provide assistance to the controllers in a spontaneous and helpful manner.

In many ways the TS can compensate for poor design and placement of equipment. The TS reads the telautograph and relays the information to all the controllers, and uses the changeover panel to select back-up radio frequency channels at the request of controllers having problems with their primary channel. Both pieces of equipment are out of reach of most of the controllers who need them.