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EVALUATION OF THE TRANSCRIBED WEATHER BROADCAST (TWEB) SYSTEM A--ETC(U)
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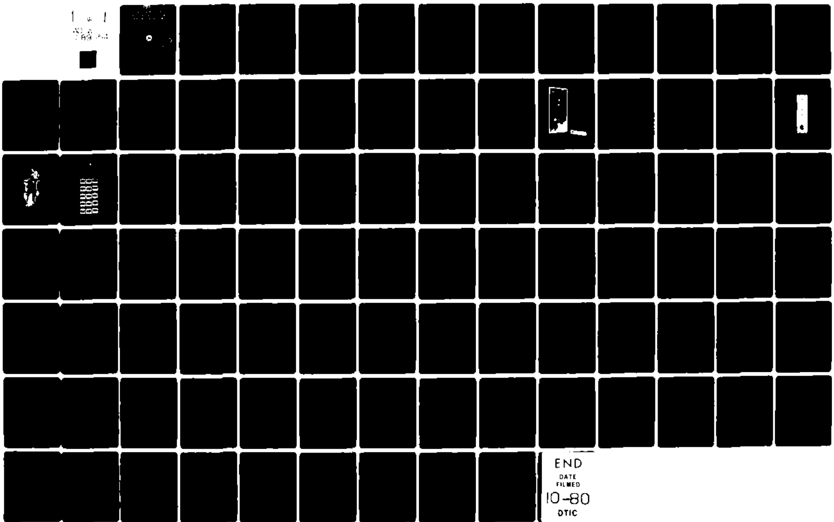

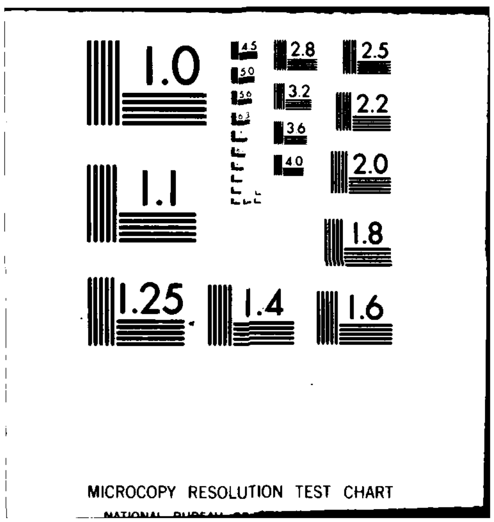
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Report No. FAA-RD-80-63-1
FAA-CT-80-6-1

LEVEL II

12

EVALUATION OF THE TRANSCRIBED WEATHER BROADCAST (TWEB) SYSTEM AND ALTERNATIVES: VOLUME 1, TECHNICAL AND OPERATIONAL ASSESSMENT AND COST SUMMARY

AD A089054

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AUGUST 1980

FINAL REPORT

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16. Abstract

This report contains findings related to the evaluation of the Transcribed Weather Broadcast (TWEB) System in its current national configuration. Primary emphasis is keyed to the technical and operational performance of TWEB at selected representative field locations. In addition, discussions concerning the review and appraisal of TWEB and Pilots Automatic Telephone Weather Answering Service (PATWAS) documentations and system design aspects of the overall TWEB configuration are given. A summary of cost analyses for TWEB and mass weather dissemination services accessed by telephone are included in this report. Details of these analyses are included in a second volume. Finally, the report provides a set of conclusions and recommendations that may be acted upon at low cost to improve short-term operational effectiveness, regardless of long-range systematic decisions. No large facilities and equipment (F&E) expenditures are recommended until completion of an overall TWEB system design. It is also recommended that near-term programing should include funding to carry out investigatory work in exploring concepts for modernizing the TWEB system through redesign.

17. Key Words

Recorded Weather, Flight Service Station, Aviation Weather, Broadcast Weather, Low Frequency Beacons, Flight Service Weather, Transcribed Weather Broadcast

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METRIC CONVERSION FACTORS

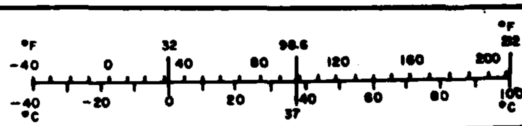
Approximate Conversions to Metric Measures

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		
in²	square inches	6.5	square centimeters	cm²
ft²	square feet	0.09	square meters	m²
yd²	square yards	0.8	square meters	m²
mi²	square miles	2.6	square kilometers	km²
	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
ft³	cubic feet	0.03	cubic meters	m³
yd³	cubic yards	0.76	cubic meters	m³
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

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		
cm²	square centimeters	0.16	square inches	in²
m²	square meters	1.2	square yards	yd²
km²	square kilometers	0.4	square miles	mi²
ha	hectares (10,000 m²)	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
m³	cubic meters	35	cubic feet	ft³
m³	cubic meters	1.3	cubic yards	yd³
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

While this report indicates primary authorship on the part of the project team, in retrospect, it represents the product of the collective efforts of many individuals and organizations, both locally and nationally. Their views, impressions, judgments, advice, and supportive services culminated in bringing this report to fruition.

Acknowledgment is given to Mr. Ken Johnson, ANA-640, whose exceptional proficiency as a pilot is deserving of special praise. As the project pilot, Ken not only flew the various aircraft associated with TWEB airborne data collection, but fully participated with the project team in the planning and conduct of the field surveys and data analysis activities.

Gratitude is extended to those representatives of the regional headquarters and TWEB Flight Service Station Facility Chiefs and their personnel who participated in conferences and discussions on the TWEB service.

Many thanks to the Frequency Management and Leased Communications Staffs of the Airway Facilities Divisions of the regions. Their personnel provided immeasurable assistance in compiling and forwarding detailed leased cost information on TWEB and the various mass telephone accessible weather dissemination services. These data were essential to the cost analyses.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

LIST OF TABLES

LIST OF ABBREVIATIONS

AAWS	Automatic Aviation Weather Service
a.c.	alternating current
ACT-640	Flight Operations Branch, Aviation Facilities Division, FAA Technical Center
ADF	automatic direction finder
AFOS	Automation of Field Organization and Services
AIM	Airman's Information Manual
AIRMET	Airman's Meteorological Information
AM	amplitude modulated
AOPA	Aircraft Owners and Pilots Association
ARTCC	air route traffic control center
ATIS	Automatic Terminal Information Service
ATP	Air Traffic Procedures
ATS	Air Traffic Service
CAP	Civil Air Patrol
DABS	Discrete Address Beacon System
DME	distance measuring equipment
DOT	Department of Transportation
DWS	direct work staffing
EFAS	En Route Flight Advisory Service
FAA	Federal Aviation Administration
F&E	facilities and equipment
FM	frequency modulated
FSS	Flight Service Station
FT	terminal forcasts
ICAO	International Civil Aviation Organization

ID	identifier
IEEE	Institute of Electrical and Electronic Engineers
IFR	instrument flight rules
kHz	kilohertz
L/MF	low/medium frequency—the frequency band between 200 and 400 kilohertz
LOM	Outer Marker Compass Locator
MOR	Military Operations Area
MTR	Military Training Routes
NAVIAD	navigational aid
NDB	nondirectional radio beacon
nmi	nautical miles
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to Airmen
NWS	National Weather Service
PATWAS	Pilots Automatic Telephone Weather Answering Service
PIREP	pilot weather report
RAREP	RADAR Reports
RWB	Radio Weather Broadcast System
SA's	Surface Aviation Weather Reports
SIGMET	Significant Meteorological Information
SRDS	Systems Research and Development Service
TABS	Telephone Aviation Briefing Surface
TELCO	Telephone Company
TEL-TWEB	telephone access to TWEB
TV	television
TWEB	Transcribed Weather Broadcast
UNICOM	Aeronautical Advisory Stations

U.S.	United States
USWB	United States Weather Bureau
VFR	visual flight rules
VHF	very high frequency
VOR	very-high-frequency omnidirectional radio range
VORTAC	very high frequency omnidirectional range/tactical air navigation
VRS	Voice Response System

INTRODUCTION

OBJECTIVES.

The objectives of this project were to perform an evaluation of the effectiveness of the Transcribed Weather Broadcast (TWEB) System in its current national configuration and to determine the feasibility and desirability of providing this weather service by other means.

BACKGROUND.

Historically, a need was recognized by the Federal Aviation Administration (FAA) to provide the general aviation community with rapid access to weather information on a mass basis. The concept of recording weather information at Flight Service Stations (FSS's) and broadcasting it over transmitter outlets influenced FAA development of the TWEB service.

The original network of TWEB outlets consisted of amplitude modulated (AM) broadcasts on the low/medium frequency (L/MF) beacons. This network came into being in the early 1950's when the original four-course low-frequency range stations were being superseded by very high frequency (VHF) omnidirectional radio range (VOR). Some four-course ranges, modified to beacons, were adapted for TWEB use to provide continuous broadcast of weather to in-flight aircraft as a replacement for some of the scheduled weather broadcast made by FSS's. The propagation characteristics of this radio frequency band were assumed to provide an adequate area of coverage. The United States (U.S.) Weather Bureau, now the National Weather Service (NWS), formulated the weather forecasts to be broadcasted over the outlets. Originally these were general forecasts for a radius of 250 nautical miles (nmi) distance from the outlets. This concept permitted today's broadcasts as specified in Flight Services Handbook, FAA Order 7110.10.

The recording device originally developed for the transcribing function was the FA-5210, multichannel recorder having variable message length. Later, as decisions were being reached to expand the TWEB network by incorporating VOR outlets, it became apparent that additional recording/transmitting equipment would be needed. A single-channel recorder, the Stancil-Hoffman TRC-89, was selected for use. Although this recording device had only a 3-minute message length capacity, it was available, and implementing it did not incur development costs.

Over the past 5 years, Ampro 6P2 and leased telephone company Telephone Aviation Briefing Service (TABS) multichannel recorders with variable message length capability have been installed as replacements to the aging FA-5210 at several facilities. More recently, Sonicraft multichannel recorders were procured as replacements for the balance of the FA-5210 recorders. Delivery of these newer recorders has been completed, with some already operational at TWEB field facilities.

As of August 1979, there were 129 FSS's with TWEB capability. Most of the original L/MF beacons and a large number of VOR's are used as TWEB outlets. These outlets were later combined so that today, within the total TWEB configuration, a large number of "multi" subsystems exist wherein one recorder feeds more than one outlet. Additionally, 19 TWEB FSS's provide telephone access to TWEB (TEL-TWEB), a service similar to the Pilots Automatic Telephone Weather Answering Service (PATWAS).

An explicit statement of system mission and an evolving TWEB system design have been lacking. This has led to a situation in which the effectiveness and utility of the present TWEB configuration, and associated annual operations and maintenance expenditures, are subject to question. Further, the original equipment has reached a point where maintenance is difficult due to lack of manufacture of spare parts. The Air Traffic Service, realizing the lack of in-depth information on TWEB, felt the need for a study on which to base decisions for upgrading, changing, or discontinuing the service. This effort, therefore, originated as a result of requirements contained in Air Traffic Service's "Request for Research, Development, and Engineering Effort" (FAA form 9550-1) number AAT-300-26.

In a meeting with System Research and Development Service and Air Traffic Service personnel, additional guidelines for the conduct of the study were received. These expanded the study to include the total TWEB service rather than only the L/MF TWEB, clarified the scope of the effort, and provided clarification of the schedule and intent. For instance, the term "effectiveness of TWEB" means: How well does the TWEB system meet the needs of the pilot in terms of providing required weather information to permit the pilot to make an adequate go/no-go decision without requesting an individual pilot briefing.

LIMITATIONS AND CONSTRAINTS.

The following limitations and constraints regarding the presentation of data and the completion of certain project guidelines should be noted:

1. This study is constrained to data collected during calendar year 1978; however, the figures depicting the L/MF and VOR TWEB outlets, as well as the regional TWEB configurations are current as of August 1979. This is also true for the table showing the regional distribution of TWEB FSS's and associated outlets.

2. A demographic factors study of potential and actual pilot users of TWEB across the U.S. was not accomplished. Two questions regarding mass weather dissemination usage were included in an Office of Management Systems survey of general aviation pilots. This survey was conducted at selected airports nationwide by the Civil Air Patrol (CAP) in the summer of 1978. At the time of this writing, not all of the CAP data has been reduced; however, some data relating to TWEB usage have been furnished to the team. Where it was possible to make judgments based on the limited data available, these are cited in the Findings sections of this report.

The primary source of such data for this project, however, was intended to be from a comprehensive survey of pilots planned by the Aircraft Owners and Pilots Association (AOPA). At their request, a rather complete set of questions regarding acceptability, availability, and usage of TWEB and other mass weather dissemination systems was prepared and forwarded to them for inclusion in the survey. At this date, the survey has not been started. The questions submitted to the AOPA are shown in appendix A.

3. During the early stages of this project, agreement was reached with Air Traffic Service to cancel the project guideline addressed to the cost/benefit relationship (for TWEB) with possible alternatives. However, to meet near-term needs for substantive program planning, it was agreed that the project team would conduct a comprehensive analysis of the existing costs of both the TWEB radio service and telephone accessible mass weather dissemination services on a national basis.

Further, regarding the cost/benefit analysis of alternative mass weather dissemination services, it was agreed that such an analysis would be more appropriately carried out either during or following the accomplishment of a national plan for mass weather dissemination. Likely in-house technical support for this effort would be the Office of Economic Policy.

4. In investigating the cost tradeoff of providing toll-free PATWAS capability to those communities now served by TWEB, it was found that limited experience with toll-free PATWAS and lack of knowledge of the current PATWAS usage potential in areas served by TWEB made such a determination virtually impossible. However, 1978 cost data for the PATWAS service is included.

5. For purposes of reducing the volume of detailed information and data covering cost analyses, this report chiefly contains a summarization of the overall results. Comprehensive details of all aspects of the cost analyses (methodology of approach, data collection, procedures of analysis, etc.) appears in volume II.

TECHNICAL APPROACH.

There were six general areas of study, most of which were performed concurrently. These consisted of the following:

1. Operational and Functional Evaluation. Visits were made to all regional offices and to representative FSS's around the country providing TWEB services. These facilities were chosen for variety of climate, geography, and TWEB outlet configurations. This included interviews of local FSS personnel, regional office conferences, and reactions of local pilots to TWEB services.

2. Technical Assessment. A study was made of technical literature available; e.g., equipment performance logs and flight check records. Technical personnel were also interviewed. Local flight checks were made in rented general aviation aircraft, and cursory ground checks were made using a portable receiver and rental car.

3. TWEB Alternative Study. Studies were made of other weather information services such as telephone, television (TV), other broadcasting media, and one-on-one type briefings.

4. Pilot Survey. As mentioned previously, limited data were obtained from random samplings. The team interviewed various pilots and there were some local surveys that had been made that contributed to gaining insight into the pilots' viewpoints. A questionnaire (see appendix A) was made and furnished to AOPA. A survey they intend to make has not been accomplished to date.

5. Cost Analyses. This phase consisted of the collection and analyses of data concerning overall TWEB service costs, telephone-accessed mass weather dissemination services costs, and comparison of usage for facilities having both TEL-TWEB and PATWAS.

6. FSS Automation/TWEB Relationship. A study was made of material available on the FSS automation program. Interviews and conferences also were conducted with personnel involved with the program.

SYSTEM DESCRIPTION.

OVERVIEW. A typical TWEB functional block diagram is shown in figure 1. The control console is used by the specialist to control the recording equipment for the purposes of updating TWEB messages by making recordings and to monitor the output of the recorder. Telephone Company (TELCO) switching equipment is used to test the inputs/outputs of the equipments and to interface with the telephone long lines. The line drivers are used to set the correct levels of voice for the telephone lines. Similarly, the line compensation amplifiers are used to adjust the incoming voice to make up for losses in microphones, telephone lines, different voices, and to furnish correct levels to the transmitter. The TELCO equipment at the transmitter site is used for similar purposes as at the sending location. The transmitter amplifies the voice and modulates the radio signal for transmission from the antenna.

The control console may be located at a dedicated desk in a quiet room set aside for TWEB use, or it may be located on a bench desk running the length of a room in the midst of all the FSS activity. There, the operator-specialist controls the recording-reproducer equipment and monitors its input. The monitoring may or may not include access to a receiver to monitor the "live" broadcast. At the control console, the specialist composes his messages, records them on tapes, and controls the output to the telephone lines.

The telephone switching equipment may range from a complete setup for checking all incoming/outgoing lines to a simple plugboard to disconnect the lines for test. The line drivers, which are used to establish the voice levels put on the telephone lines, may or may not be present.

The recorder-reproducer equipment (to be described later) consists of:

Type FA-5210
Sonicraft
Ampro 6P2 Radio Weather Broadcast (RWB)
Stancil-Hoffman TRC-89
Telephone Aviation Briefing Service (TABS)

The multichannel equipments (FA-5210, Sonicraft, Ampro 6P2 RWB, and TABS) generally provide recorded voice to L/MF outlets, although there are many instances of remoted voice to L/MF and VOR mixed outlets. The TRC-89 is used exclusively for recorded voice to one or more VOR outlets while being used as the recorder/reproducer for Automatic Terminal Information Service (ATIS). In short, there is no "standard" recorder outlet configuration for TWEB.

Most of the original L/MF beacons and a large number of VOR's are used as broadcast outlets in single and multiple configurations. The multioutlet configurations can be pure (two or more L/MF's or two or more VOR's) or mixed (one or more L/MF's and one or more VOR's). Each outlet configuration is fed by one type of TWEB recorder or, in certain instances, by a TABS equipment.

Of 292 FSS's, 129 comprise the contiguous U.S. TWEB service, 20 FSS's provide TWEB solely over L/MF's, 80 over VOR's, and 29 over mixed outlets. Table 1 provides a regional distribution breakout of TWEB FSS's and outlets. As of August 1979, there were 89 L/MF and 154 VOR outlets for TWEB use. The L/MF outlets are depicted in figure 2. Their advertised range is 75 nmi as shown in the legend. The VOR outlets are depicted in figure 3. Their advertised range is 25 nmi.

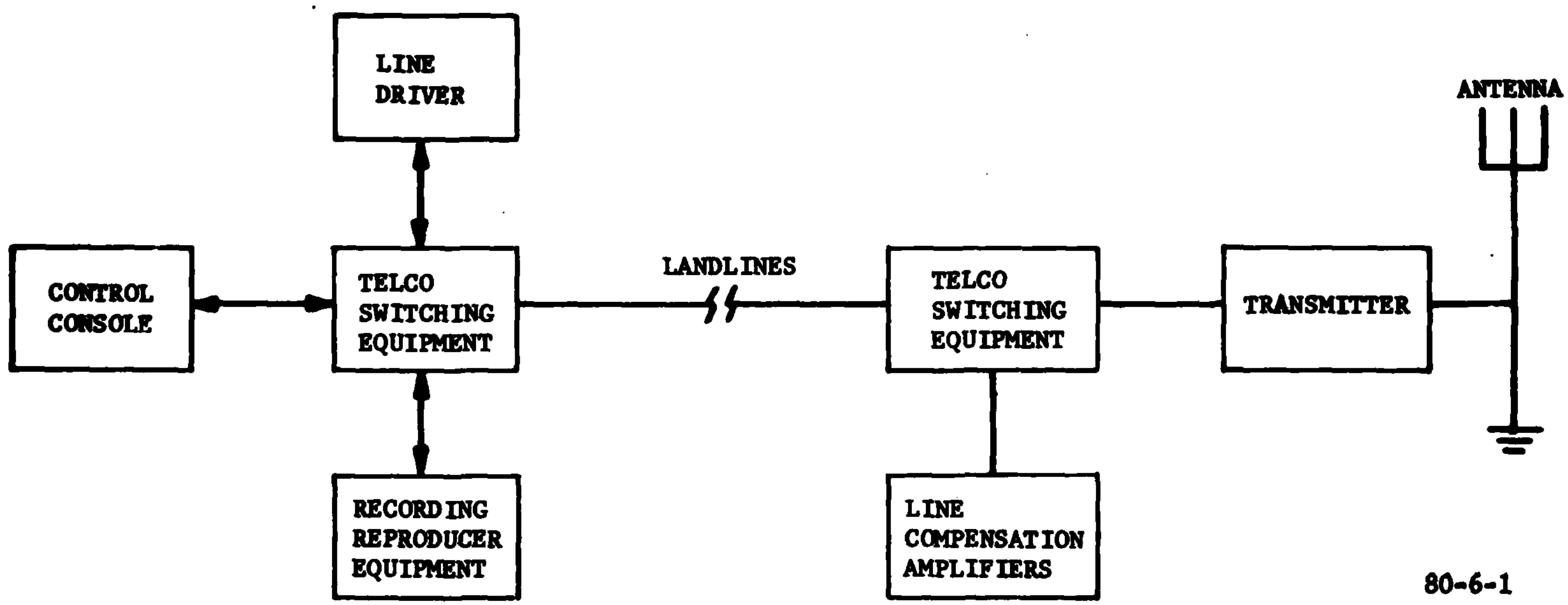


FIGURE 1. TYPICAL TWEB SYSTEM BLOCK DIAGRAM

TABLE 1. REGIONAL STATISTICAL DATA—TWEB FSS SERVICES—AUGUST 1979

REGION	Total TWEB FSS's	VOR TWEB FSS's	L/MF TWEB FSS's	Mixed TWEB FSS's	Number of TWEB Outlets VOR	Number of TWEB Outlets L/MF	Total TWEB Outlets
New England	2	1	0	1	2	3	5
Eastern	13	10	2	1	11	5	16
Southern	24	17	6	1	17	14	31
Great Lakes	19	10	3	6	16	16	32
Central	13	8	1	4	15	7	22
Southwestern	17	11	6	0	12	11	23
Rocky Mountain	13	5	2	6	13	15	28
Western	19	13	0	6	31	10	41
Northwestern	9	5	0	4	37	8	45
Totals	129	80	20	29	154	89	243

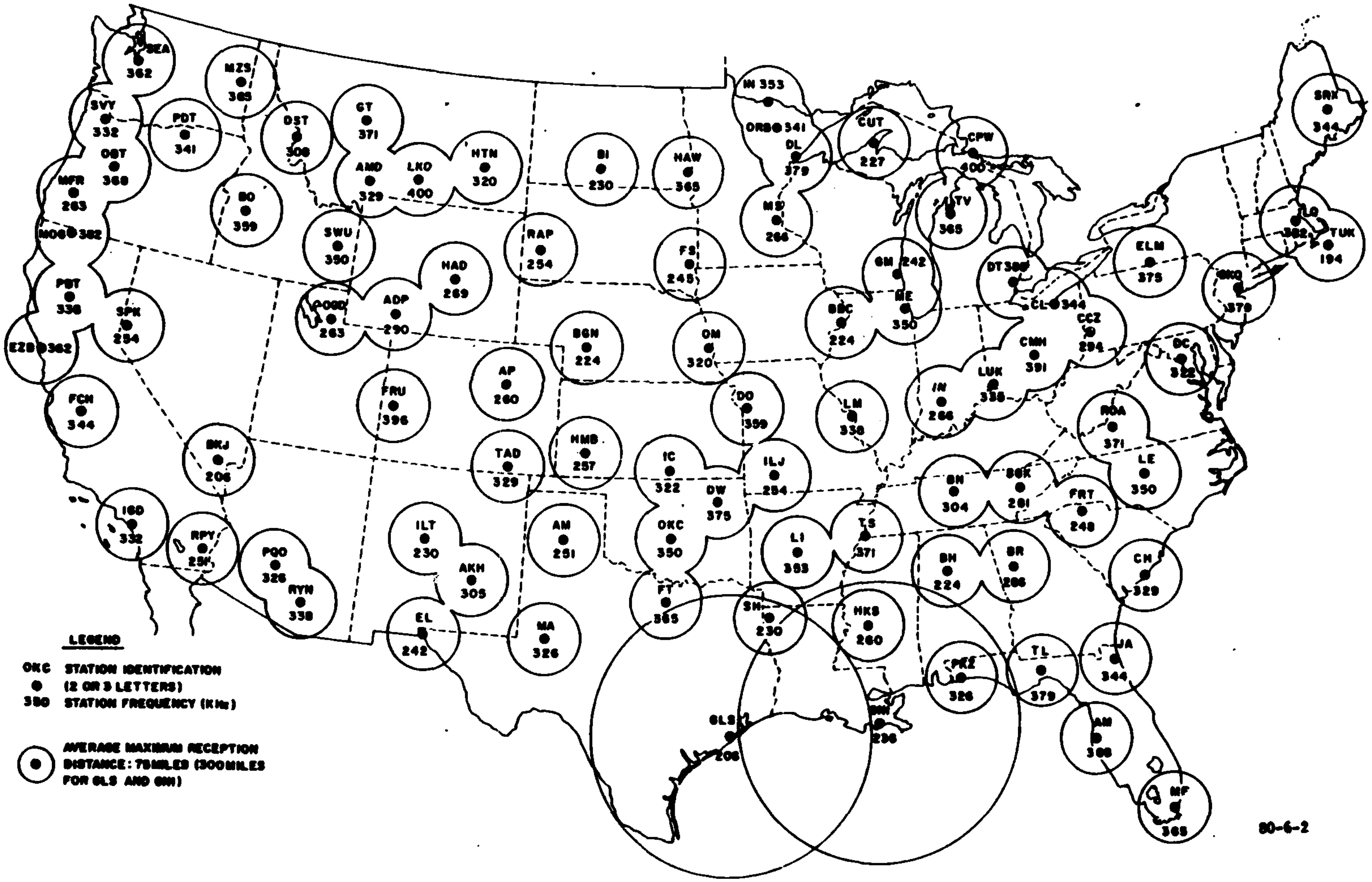


FIGURE 2. TWEB LOW FREQUENCY OUTLETS

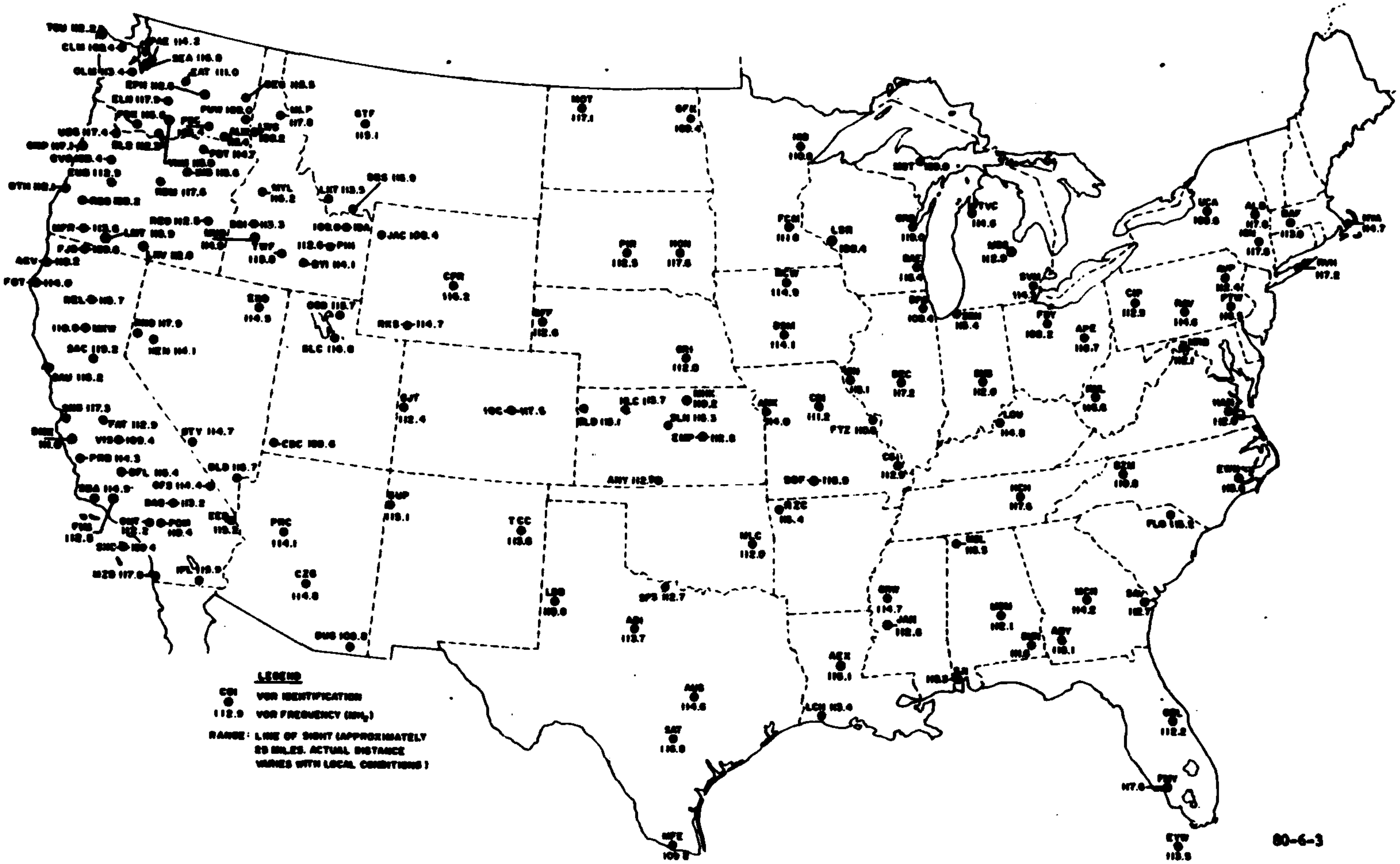


FIGURE 3. TWEB VOR OUTLETS

As to the total number of recorder equipment in use for TWEB radio services, there were 140 throughout the contiguous U.S. during August 1979. By type of equipment, there were 39 FA-5210/Sonicraft, 7 Ampro 6P2 RWB's, 91 Stancil-Hoffman TRC-89's, and 3 TABS. Although the majority of TWEB FSS's employ one recorder, several instances exist where two recorders are in use at TWEB FSS's. Seattle FSS is unique in that it has three recorders: one Sonicraft and two TRC-89's.

To provide the reader with an insight into the magnitude and extent of today's TWEB configurations, regional charts are furnished in appendix A.

The landlines are generally leased telephone lines that carry the recorded voice messages to the transmitter site. There are a few FAA-owned lines, but the general case is to lease the service from the telephone company. The lines may be of normal commercial voice grade quality or they may be required to meet an FAA-1142a specification to ensure high-quality voice and high-reliability service. Generally, they are referred to as 1142 lines. In most instances, the 1142 lines would be installed whether TWEB existed or not; however, there are instances where they are installed for TWEB purposes only.

TRANSMITTERS. The transmitters are of two types; the VHF type transmitters or the L/MF type. The transmitters and their antenna systems will be briefly described.

VHF Transmitters. The VHF transmitters in use range from among the first units of VOR's purchased to the latest replacements. They are usually dual switchable vacuum tube units. They include signal output monitoring to assure output and quality control, but no voice monitoring. Unfortunately for TWEB, the voice modulation cannot exceed 30 percent of the radiated signal since higher levels affect navigational signals. Thus, the voice airborne range is limited to less than the signal range. The antenna system is designed to optimize the signals for the airborne user. They are adjusted in such a way that the minimum energy possible impinges on the surrounding ground. This is done to prevent "lobing" which results in detrimental effects on the navigational signals. Thus, ground coverage of TWEB is severely restricted.

L/MF Transmitters. The L/MF transmitters are old, pre-World War II vintage units which were used in the four-course range navigational system. They are vacuum tube transmitters, with spares becoming scarce and expensive. They were not built as voice transmitters, although they do carry a tone, and voice modulation undergoes some distortion when used. In some of the transmitters, the voice is inserted early in the lower levels of the amplifying chain causing further voice distortion. In the latter case, the modulation levels are severly limited causing voice range limitation. The antenna used is generally the omnidirectional antenna from the four-course range system, and it is generally not designed to optimize the present operation. The airborne range is a variable, and the ground coverage of these transmitter sites is unknown.

RECORDERS/REPRODUCERS. When TWEB is discussed, the consensus among FAA personnel is to mean the recorder-reproducers; however, they are only part of the system. They are such an essential element that they need to be described further.

Type FA-5210. The first and oldest of these, the type FA-5210, figure 4, is a 15-channel, automatic tape recorder-reproducer system specifically designed for use with FAA communications broadcast equipment to provide continuous recorded weather reports.

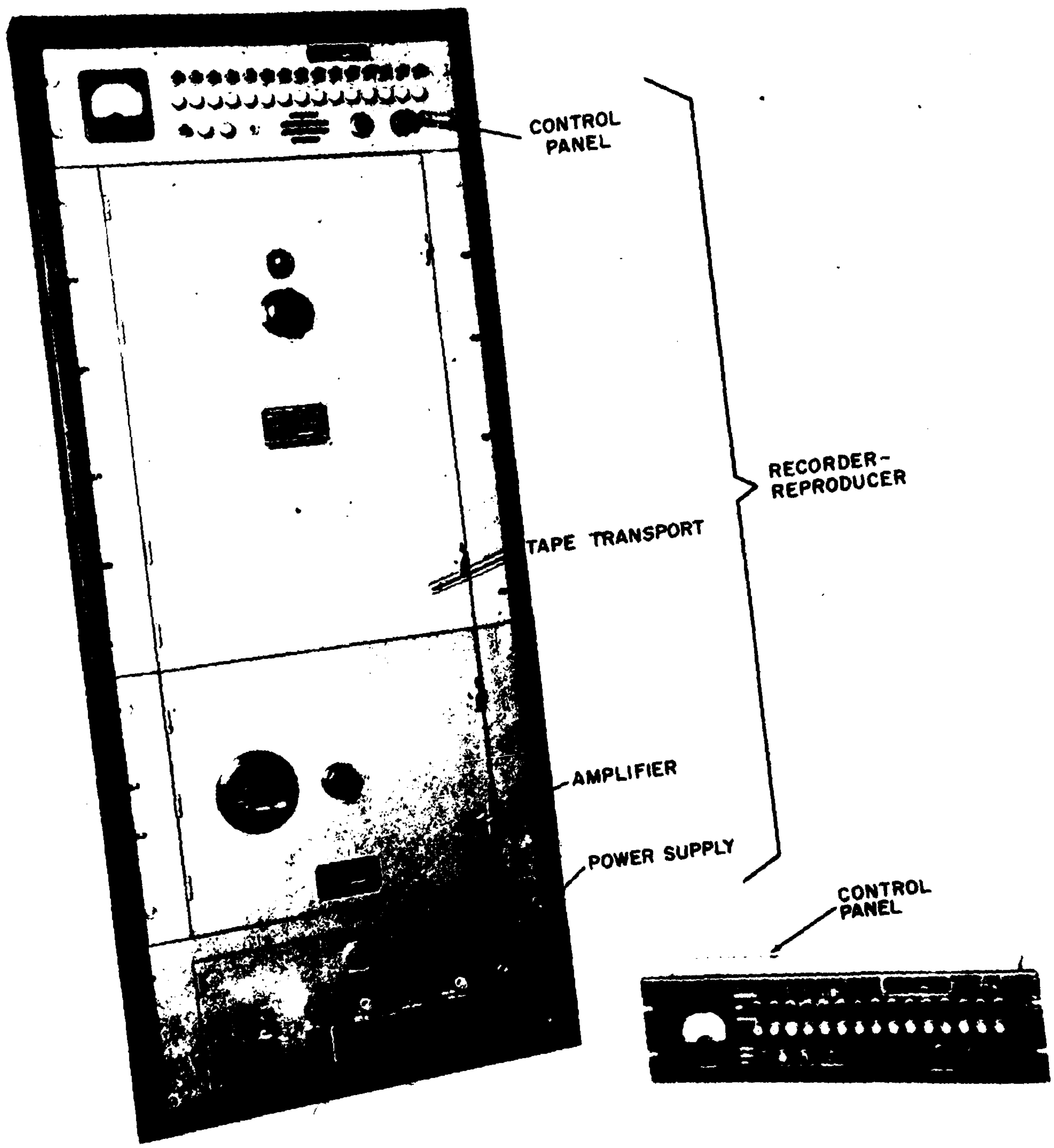


FIGURE 4. TWEB FA-5210 EQUIPMENT

The system records, stores, erases, rerecords, and automatically plays back in any desired sequence up to 15 messages of from 5 to 60 seconds duration. It simultaneously erases old material and records new material for any individual report without interrupting the sequential reproduction of the other reports. Provisions are made for editing the recorded information, monitoring the broadcast messages, and overriding the automatic broadcast of the recorded messages to make direct voice transmissions from other broadcast equipment over the same broadcast transmission lines. The FA-5210 equipment provides for automatic reproduction of recorded messages in any consecutive order in channels from 1 through 15. It is possible to include or exclude one or more channels from the subsequent broadcast, even while selected channels are recording or broadcasting or are being edited or monitored.

When the tape for an operating channel has completed its message, the system switches automatically to the next higher number channel selected for operation.

Automatic switching from one channel to the next higher numerical channel is prompt. Thus, a tape may start playing while the previous tape is still running out its unrecorded length until the aluminum foil stop is reached on the closed loop tape. The voice-sensing circuit recognizes the end of a message and the switching system selects the next higher numerical channel. The tape on the first channel will also be moving, but only the second channel will be broadcasting.

After the tape has completed the desired function, another tape may be selected for another function. The one exception to this sequence is that, for the "record" function, no other channel may be selected for record or edit until the channel on which the recording is being placed has completed its full 60-second cycle.

Stepping switches scan the channels to determine which channel has been selected to operate next. When contact is made with that channel, the system performs the function for which the switches have been selected. Upon completion of this function, the stepping switches seek the next channel for operation and this sequence continues until the equipment is shut down.

The signal paths of the TWEB equipment, type FA-5210, are shown in the block diagram (figure 5). During the "record" function, recordings are usually made from the remote control unit by speaking into a microphone connected to the unit. During the broadcast function, the recorded signal on the selected tape is picked up by the record/playback head. The signal is then connected through switching circuits and voice-sensing circuits to the broadcast amplifier for tape equalization and amplification. The output connects to the remoting lines.

The recorded message may be monitored as the broadcast is being made, or messages may be played back for editing after a recording is made, by means of the monitor-edit amplifier circuit. The output signal from the broadcast amplifier is fed through switching circuits to the input of the monitor-edit amplifier. The amplifier provides tape equalization and raises the signal to a usable level.

Direct broadcast signals are connected from the external broadcast equipment. Switching circuits permit transmitting a message that completely bypasses the system.

The power supply circuits operate from a 105- to 130-volt alternating current (a.c.) power source and furnish the various voltages necessary for the operation of the TWEB system.

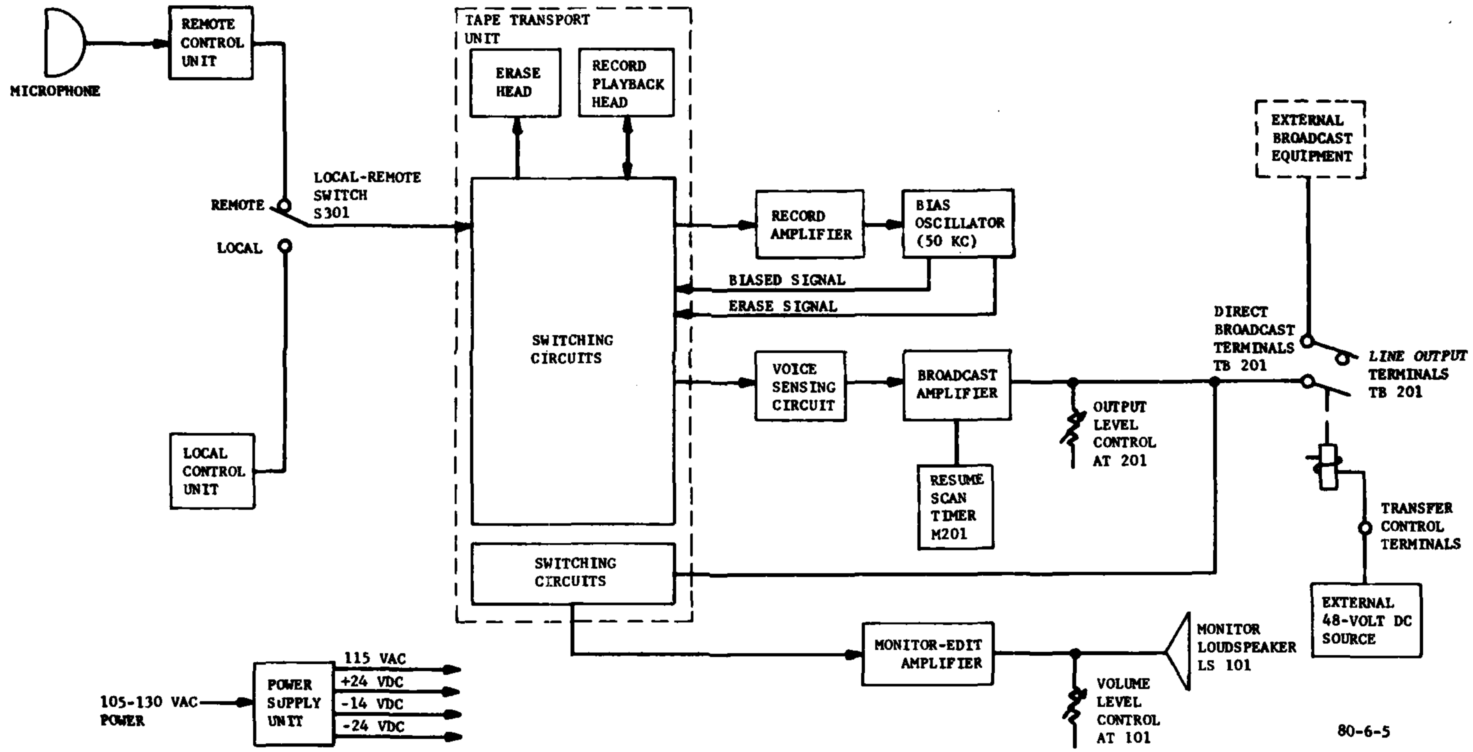


FIGURE 5. TWEB FA-5210 FUNCTIONAL BLOCK DIAGRAM

When the LOCAL-REMOTE selector on the tape transport front panel is in the LOCAL position, the equipment is operable from the local control panel installed in the equipment rack. Setting the switch to the REMOTE position switches control of the equipment to the control panel located in a control console. The local and remote control panels are identical, and most of the operation will be performed from the remote position.

The control units, one located in the equipment rack and one located in the control console, are shown in figure 6. The volume level control, AT101, controls only the monitor audio in the loudspeaker and not audio levels sent on the remoting lines to the transmitter.

Stancil-Hoffman TRC-89. The Stancil-Hoffman TRC-89 is still in wide-spread use. The operation of this equipment is quite different from that previously described. There is only a single tape drive with a 3-minute capacity. The tape unit is located in a rack-mounted chasis (see figure 7). To the left of the tape unit is the remote control assembly which is located in the control console. The tape unit plays its 3-minute message. At its end, the unit automatically rewinds at a speed ratio of about 20:1 and then begins to replay the recorded message. Editing of the recorded messages requires that the entire message be rerecorded.

The Sonicraft TWEB. This equipment is essentially a modern-day replacement for the original FA-5210 (see figures 8 and 9). The original purchase was for 9-channel units, which limits the flexibility of the equipment. When configured as a 15-channel unit, the Sonicraft has approximately the same operational capabilities and limitations of the equipment it replaces. A single Sonicraft channel may be operated at from 5 to 180 seconds, giving greater overall time, if required. There is presently under development telephone accessed systems providing for computer update of weather. One such system is the Voice Response System at the FAA Technical Center.

Ampro 6P2 RWB. The Ampro 6P2 RWB System Control Station, hereafter referred to as the Ampro, is a 15-channel recorder. Since the Ampro is essentially the same as the expanded 15-channel Sonicraft, no visual of the equipment is provided. The Ampro preceded the Sonicraft in development.

TABS. The TABS equipment is leased from the telephone company and exists in various multichannel configurations. Although four TABS are in use nationally, only three provide radio-transmitted weather broadcasts. These are the TABS located at the Roanoke, Virginia (Va.); Oakland, California (Calif.); and Los Angeles, Calif. FSS's. The fourth TABS, at the Washington, D.C. FSS, is used strictly for telephone access, while Ampro equipment there provides recorded TWEB messages broadcast over its multioutlet configuration.

Another distinguishing feature of the variation in TABS equipment is the level of sophistication in design. To meet the pilot demand for various mass weather dissemination services, the TABS at Roanoke, Oakland, and Los Angeles also enable telephone accessibility to the en route recorded messages which are also broadcast over their respective multioutlet configurations. In duration, message length ranges from approximately 12 minutes at Roanoke, 15 minutes at Oakland, to 17 minutes at Los Angeles. In addition, Oakland and Los Angeles TABS equipment enable telephone accessibility to recorded local area weather messages; i.e., an expanded Oakland Bay area message and an expanded Los Angeles basin area message, respectively.

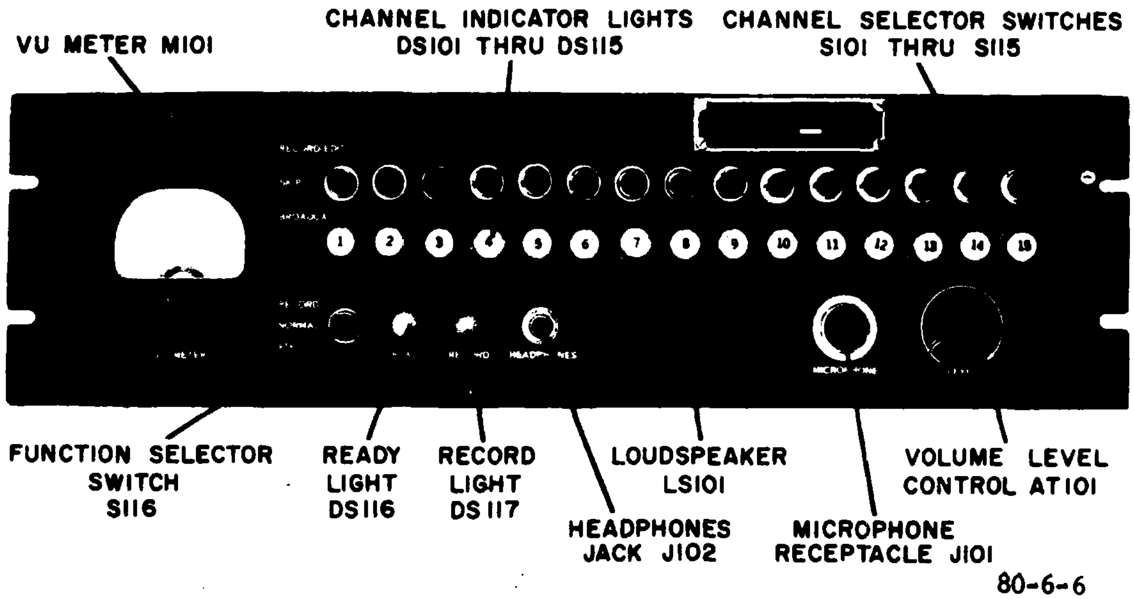


FIGURE 6. FA-5210 CONTROL PANEL UNIT

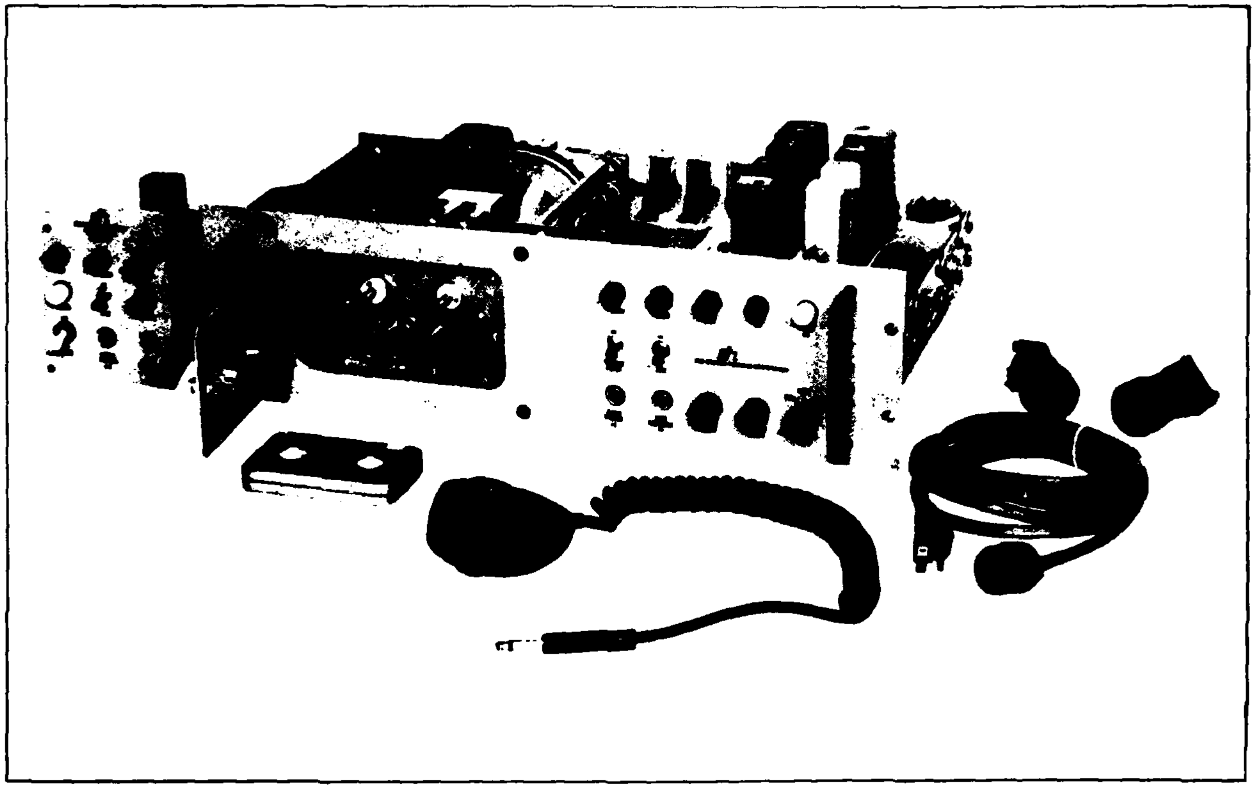


FIGURE 7. RECORDER REPRODUCER STANCIL--HOFFMAN TRC-89

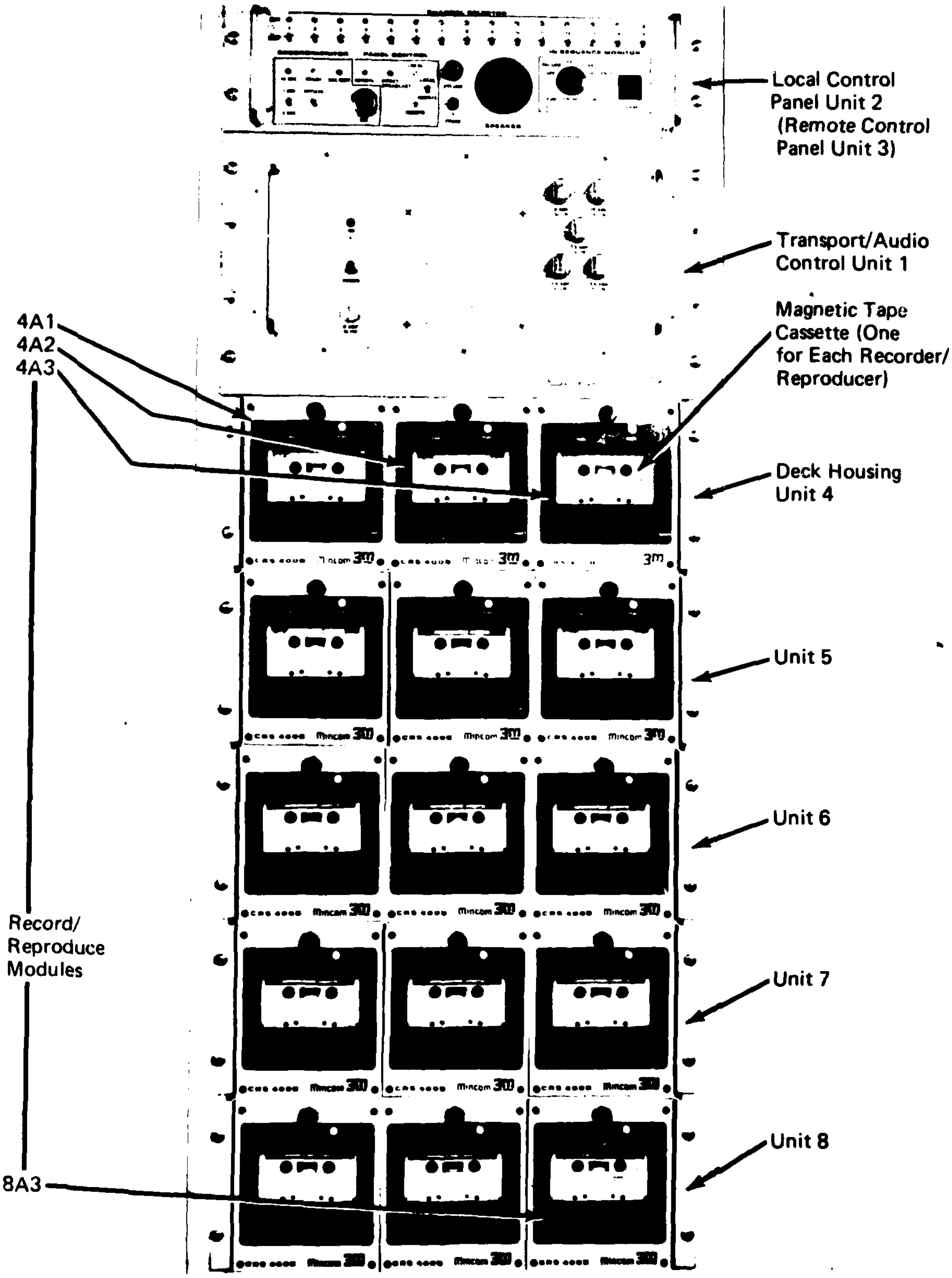


FIGURE 8. TWEB SONICRAFT EQUIPMENT

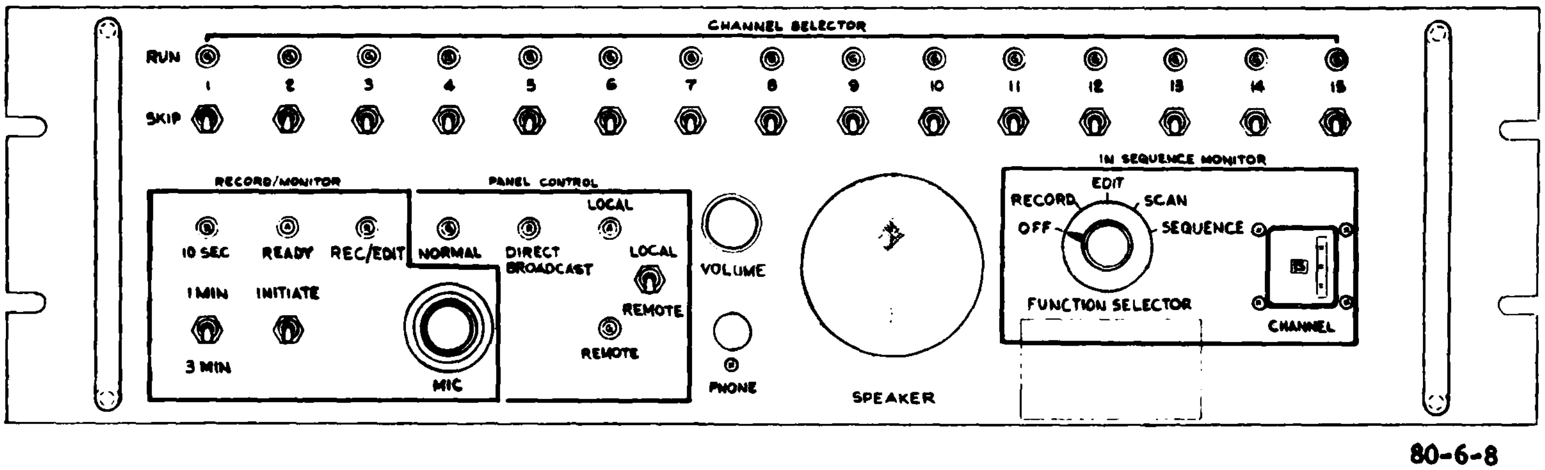


FIGURE 9. SONICRAFT CONTROL PANEL UNIT

TWEB SYSTEM FINDINGS

DOCUMENTATION REVIEW.

Prerequisite to the project team evaluation and assessment of TWEB, it was necessary to have a comprehensive and reliable listing of TWEB facilities, the recorder/reproducer equipment in use, the associated broadcast outlets, and their respective locations. Beyond that, the additional information needed included the identifiers and the assigned broadcast frequencies.

At the outset of this effort, an in-depth review was performed of part 3 of the Airman's Information Manual (AIM), the AOPA Handbook for Pilots, sectional charts, and Aviation Weather Services document AC 00-45A. Additionally, a document compiled in 1977, entitled "Summary of PATWAS/TWEB Facility Data" (limited circulation), was reviewed. A comparison of the documented TWEB information revealed many inconsistencies, errors, omissions, etc. Next, the team requested the Airways Facilities Service to provide the responses to its September 1977 regional survey of TWEB locational and equipment data. A comparison of that data with that which had been previously gathered uncovered numerous discrepancies. A chart received from Air Traffic Service purportedly showing the most current locations of TWEB equipment and associated outlets, was also compared with the Airway Facilities Service survey responses and found to have inaccuracies. Subsequently, inaccuracies were also found in the 1977 survey.

A request was made to the Air Traffic Service's National Flight Data Center for computer printouts by region listing VOR and L/MF facilities having TWEB, voice, or autobroadcast. Following receipt, the data were compared with the regional survey responses. It was found that the data contained in the printouts were also unreliable owing to omissions and inaccuracies.

Current, accurate, and reliable source information on PATWAS was also recognized as being important, particularly for investigating alternatives to TWEB and performing cost analysis studies.

An assortment of source documentation which had direct bearing on this subject was collected and analyzed. Existing documentation consisted of: an unpublished FAA compilation of PATWAS locations; a brochure published by the National Oceanic and Atmospheric Administration (NOAA) in 1976 containing PATWAS information for pilots entitled "Pilot's Guide to Aviation Weather Services"; a joint publication of the FAA and NOAA entitled "Aviation Weather Services" (Handbook AC 00-45A, revised 1977); the last issue of part 3 of the AIM; and its replacement, the seven-volume Airport/Facility Directory dated July 13, 1978.

Based on initial cross-comparison of these source documents, it was found that inconsistencies existed. This was further confirmed when Letters to Airmen obtained from the various FSS's visited were reviewed and this information was compared to the source documents. A request for PATWAS location data was made to the National Flight Data Center and to other offices at the Washington FAA Headquarters; however, it was revealed that current PATWAS location data were not available.

Each of the FAA regions was then requested to verify the information in the July 13, 1978, volume of the Airport/Facility Directory applicable to the region. Further, it was pointed out that the Special Notices section should be critically reviewed for apparent errors and omissions in PATWAS information.

Summarized below is a listing of generalized findings that resulted from the regional inquiries concerning PATWAS capabilities:

1. In a few instances, the regional spokesman was unaware that parts 2 and 3 of the AIM had been replaced by the Airport/Facility Directory. One regional spokesman asked for an explanation of the acronym "PATWAS." Confusion apparently exists due to the various types of dial-up services in use and their own identifying acronyms, like TABS, TEL-TWEB, and AAWS (Automatic Aviation Weather Service).

2. Most regional spokesmen requested time to reexamine their available information on PATWAS. Evidently, the material was not readily on file or they desired to contact their respective FSS's to confirm or obtain current information on the subject.

3. Spokesmen indicated surprise at the many inaccuracies and omissions existing in the Airport Facility/Directory Special Notices section. Examples include: incorrect telephone numbers or telephone numbers not listed; incomplete listings of all PATWAS services (local and foreign exchanges); legend symbols missing or inaccurate, not only for PATWAS but for AAWS, Fast File, etc.; route nomenclature incomplete or incorrect; and inability to draw distinction between PATWAS and AAWS as dial-up services. In addition, comments were made on the lack of adequate descriptions for preflight services indicated in the Special Notices section, while the Fast File Flight Plan System was elaborate in descriptional detail, no description was given for AAWS.

In summary, the survey of TWEB and PATWAS capabilities uncovered numerous deficiencies existing in documentation, especially those of a published nature like the Airport/Facility Directory. Inherently, the deficiences are attributable to weaknesses in the total system of reporting, documenting, accounting, and auditing of TWEB and PATWAS information. Unfortunately, the problem is a large one and there is no clear-cut method for restoring credibility on a quick reaction basis. Since government-sanctioned publications are widely circulated as sources of reference for the flying public, this situation should be viewed with alarm. It is apparent from these findings alone that the unreliability of the published information on TWEB and PATWAS would discourage use of the system.

REGIONAL MEETINGS.

Each of the regional offices in the contiguous U.S. and Alaska were visited, with meetings held to discuss the TWEB program. These coalesced into a pattern of similarity as the meetings continued. The most important insights gained from them include: the conflict between the frequency requirements of TWEB and the requirements on the same band for additional low-powered nondirectional beacons for small airports; the general disaffection for, and the perception of, the TWEB function as anachronistic, yet the acknowledgment, sometimes reluctant, of its utility; and the need for additional mass weather dissemination and the concern that these capabilities be found.

These perceptions were confirmed by the following facts. One region had reduced all L/MF beacon power levels to no more than 50 watts. Another region had acquired a TRC-89 tape recorder, modified it to run longer than its designed 3 minutes, and then tried to put it into service as a TWEB in spite of a distorted audio output. Finally, a third region had made a serious proposal to modify a beacon to transmit on a frequency just below the broadcast band—530 kilohertz (kHz)—to exploit the wide availability of receivers in the general population, thereby competing NOAA's VHF/frequency modulated (FM) broadcast service with an aviation weather program—a TWEB.

Many suggestions that FAA should somehow piggyback or emulate the NOAA FM system were received. However, that system broadcasts local weather for the general public and explicitly prohibits any aviation weather programs. To emulate that system would require utilization of hard-to-come-by frequencies, with no guarantee that receiving equipment would be again as readily available as the NOAA VHF/FM units. Another duplicate FM network would be quite expensive for discrete (aviation) use.

Some regions have evidently decided that the best direction is PATWAS, and they have developed various devices to exploit this mode with the help of regional telephone services. One region regards TWEB as a proven method, and indeed the quality of its outlets reflect this view. They are all "good" or "better," and the frequency management office of that region has done ground coverage checks which provide known geographic coverage. The same region was aware of problems with TWEB forecast update currency and had recommended certain changes for forecast collections which would alleviate them. Another regional office approved the installation of TWEB on a frequency below the lower limit of most L/MF and automatic direction finder (ADF) equipment extant, thereby making it available to a known, but small, user population which was equipped to receive it. This population is comprised of certain overseas airlines which have receivers that tune below 200 kHz. Another regional office furnished responses to local surveys which indicated support for TWEB services by responsible members of the local population, including aviation and business interests.

STATION VISITS.

A total of 24 FSS's were visited (a listing of these stations is shown in table 2). These stations were chosen with regard to their geographical location and the type of service they provided. Specialists at these stations were interviewed. The pattern mentioned in the previous section was also discerned at FSS's, and discussions confirmed our findings at the regional offices. One station was installing a "live" weather broadcast on two L/MF beacon outlets for local aviation use. The live program was a 20-minute per hour "international meteorological" broadcast, which was being conducted at this facility on high frequencies, and was intended for transoceanic flights. It was thought that this weather was also of value to a local pilot population which had expressed a need for "more weather." This latter group of pilots lived within the coverage area of another L/MF TWEB outlet, at a distance which should have guaranteed adequate reception.

Two other FSS's had conducted local pilot surveys. Though the samples were small, they did show TWEB was used and appreciated to some extent. Requests were received for additional weather reports to be included. There were no strong dissatisfactions with normal TWEB content.

SPECIALIST INTERVIEWS. Some of the responses of the FSS specialists to questions about TWEB (along with the project teams comments, in parentheses) are quoted and partially paraphrased in the listing which follows. While realizing that the listing is somewhat contradictary, lengthy, and repetitious, a reading will convey

TABLE 2. LIST OF FLIGHT SERVICE STATIONS VISITED

MIV - Millville, New Jersey

TEB - Teterboro, New Jersey

PNE - Philadelphia, Pennsylvania

LAX - Los Angeles, California

FUL - Fullerton, California

ONT - Ontario, California

LAS - Las Vegas, Nevada

FTW - Fort Worth, Texas

HOU - Houston, Texas

GLS - Galveston, Texas

NEW - New Orleans, Louisiana

JAX - Jacksonville, Florida

MIA - Miami, Florida

SEA - Seattle, Washington

ANC - Anchorage, Alaska

PAQ - Palmer, Alaska

RNO - Reno, Nevada

OAK - Oakland, California

DEN - Denver, Colorado

SLC - Salt Lake City, Utah

MKC - Kansas City, Missouri

CHI - Chicago, Illinois

DET - Detroit, Michigan

DUJ - Dubois, Pennsylvania

the feelings of the specialists administering the system. Though this list was edited to remove some obvious repetitions, some remain since they provide added insight due to different, though equally valid, views. Comments are in no particular order and several may have been made by a single individual. The list was also deemed especially apt in illustrating the great diversity of opinions even though the majority of the thoughts are negative with regards to TWEB. Since systematic, analyzable data are absent, this method of presentation was chosen as being the most meaningful to the reader.

1. The TWEB content as specified in "the Air Traffic Procedures (ATP)" manual is good information.

2. Notice to Airmen (NOTAM) and military operations information, while in need of dissemination, have no place in a weather broadcast. (This is a valid comment if TWEB is a weather only program.)

3. The TWEB system is very difficult to keep updated for mechanical reasons. (Request-reply teletype access queues, slow circuit speed, and awkward tape recorder functions were cited.)

4. TWEB meteorological content is often deficient in currency and correctness due to the tardiness of the weather service in making amendments and the difficulty of getting amendments on the broadcast in time. (This tardiness in rapidly changing weather may be insuperable.)

5. TWEB services have often been shut down, either partially or entirely, due to lack of currency and the inability to update the broadcast.

6. The weather service must often be prodded into making needed amendments. (This is understandable since the FSS, through pilot reports, is among the first to hear that a forecast has gone sour.)

7. Some TWEB material is out of currency, even at its inception, especially TWEB routes.

8. When weather is critical and fast changing, TWEB is cumbersome and lags well behind actuality.

9. The average general aviation pilot, who is the prime user of the FSS briefing service, is "incapable" of utilizing modern meteorological information and is sorely in need of a "one-on-one" briefing service so that the weather can be interpreted for him. (This is a common observation. It may be the briefer's perception that the private pilot is "slow" to draw conclusions out of the material the briefer has already reviewed. Therefore, it may only reflect the pilot's lack of information, not necessarily his lack of expertise.)

10. Flight watch is an ideal service for the average private pilot. (A general appreciation for this service exists, and its real-time weather capability is probably the main reason.)

11. There are very few listeners to TWEB radio.

12. There are very few listeners to a live weather broadcast issuing from an FSS.

13. TWEB broadcasts can be dangerous because they may be disseminating incorrect material.

14. We are notified when our TWEB system goes "down." (Usually by the same person, a local pilot or a farmer.)

15. We are seldom notified of an outage. We usually discover it first.

16. Our TWEB program material regularly becomes noncurrent—on every "good IFR (instrument flight rules) day."

17. TWEB should be done away with and only SA's (current weather reports) broadcast.

18. TWEB has too high a priority. It should be shut down, when necessary, due to short staffing.

19. Half the time the weather bureau can't keep up with it.

20. Our area is too great—a thousand miles long and a thousand miles wide—no one can keep up with it. (These comments reflect the specialist's frustration at his inability to amend the TWEB program.)

21. Make a PATWAS only. TWEB is very poor.

22. Need more sequences (current weather reports). Distances now are too great to accurately reflect conditions in between. (This probably indicates a specialist's knowledge of different weather conditions prevailing which are not being reported in the TWEB program specified for his facility.)

23. Provide a transmitter and antenna with more ground coverage.

24. Even the SA stuff (current weather reports) is old and only gets older.

25. We receive 60,000 phone calls yearly into the TWEB (TEL-TWEB). This has remained unchanged for the last 5 to 6 years, even with an increase in the number of phone lines.

26. I would restructure TWEB because it is too itemized. It should be more general. They teach us to summarize when briefing and then have us be specific in the TWEB.

27. The synoptic portion of the TWEB is too generalized.

28. Our TWEB outlets can be monitored (for correct operation) directly off the air, but we don't do it.

29. The voice quality should be improved. Too much background noise. We don't have a quiet area for making the recording.

30. A smaller outlying station has more time to prepare TWEB than a large briefing complex.

31. TWEB specifications result in deceiving pilots in that they provide information which is not a complete briefing. TWEB broadcasts are thus dangerous.

32. The use by meteorologists of mean sea level altitudes in areas where terrain is high and the use of two measuring systems (above ground and mean sea level) is especially dangerous.

33. "USWB" (U.S. Weather Bureau) meterologists are not aviation-oriented.

34. Briefings increase markedly when the telephone access or the TWEB outlet is "down."

35. TWEB routes always go bad toward the end of the forecast period.

36. Our TWEB system is excellent but it should also include the local FT's (terminal forecasts).

37. TWEB is too lengthy to be effective. Phone brief is the better way.

All of the points made in the above list are reflected in the portions which follow.

SYSTEM CONFIGURATION DEVIATIONS.

In addition to material included in this report, which describes the system configuration in detail, it must be pointed out that TWEB configurations, as advertised, vary in surprising and various ways. TWEB outlets were monitored where the TWEB program was absent entirely. Reasons for this varied from "unknown breakdowns" to "station too busy doing training to maintain TWEB," or "the weather turns bad." One VOR outlet was converted to an ATIS-like format which included the local weather report and, if VFR (visual flight rules), a notice to call on Aeronautical Advisory Stations (UNICOM); if IFR, to call the local approach control. Frequencies were given in each case. Yet this system is depicted in reference sources as being a TWEB system. In other instances, the TWEB may be referred to (by the specialists and in advertising) by the name of the equipment doing the recording and not as a TWEB.

The project team has found that there is no provision in the Airway Facilities reporting system covering TWEB service performance. Since the TWEB service is not contained in the list of facilities provided by appendix 1 of Order 1380.40, it is, therefore, currently not a reportable item in the facility reporting system.

OUTLET CHECKS. A total of 40 TWEB outlets were checked during the course of 17 flights. In addition, ground checks of various TWEB outlets were made by automobile using an inexpensive, but surprisingly sensitive, hand-held receiver, such as one might expect a general aviation pilot to use. Recordings of the transcribed broadcasts were made of those outlets checked. In this way, both shortcomings and advantages of the system were demonstrated to the project team.

TRANSMITTERS. The L/MF transmitters are old, usually dating from the late 1930's. They are massive units, built to last. However, they are vacuum tube transmitters and subject to the unreliability of this type of equipment. Availability of replacement parts is, in some instances, causing problems, and when obtainable, these parts are very expensive. The outstanding capabilities of the field technicians have been the main factor in keeping these old, obsolete transmitters working.

L/MF transmitters were built as the old four-course ranges of pre-World War II vintage, and the antennas of these stations are the omnidirectional portion of the old Adcock antenna arrays. The transmitters were located to serve the old airways network and, therefore, are not generally well sited in terms of the populace they are now intended to serve. Many illustrative instances of this were found.

Most TWEB stations double as IFR navigation aids (NAVAID's) for ADF approaches to airfields. They are flight-checked for the navigational purpose. The flight check pilot has a block on his log sheet and if he hears a voice he checks it. There are no criteria for a depth-of-modulation check, a voice clarity check, a bandpass check, or any other quality check. Since these transmitters are sometimes modulated at a low level, the percentage modulation is usually much less than 100 percent. Indeed, the standards call for it to not exceed 95 percent. Under the low-level modulation conditions, the voice will not be usable for the full range of the carrier.

There are 13 VFR NAVAID TWEB's which are not flight-checked. A regional breakout listing of these NDB's is provided in table 3.

The nature of the TWEB VOR transmitter is such that voice modulation is limited to 30 percent. In practice, it has been found to be much less. Therefore, as noted earlier, the limitations on range are even more stringent than for the L/MF facilities. Ground coverage is minimized, and in some instances, was found by the survey team to be almost nonexistent. Consequently, TWEB data are broadcast primarily to airborne aircraft. Despite this, the content of the TWEB message is generally recognized by the briefing specialists to be for preflight use, which suggests that its primary use is on the ground. Apparently only one FAA region of those visited, has performed ground checks for TWEB. No other region was able to furnish data on ground coverage to the survey team.

During the course of the study, the team learned that the FAA was planning a series of procurements of solid-state transmitters to replace the tube-type L/MF and VOR facilities. A priority type implementation schedule furnished to the team indicated that approximately 90 percent of existing TWEB L/MF facilities would be replaced by the initial procurement. Although none had been implemented at the end of the study period, the first procurement was scheduled to be completed in 1981. Coordination with Airways Facilities procuring personnel was effected to make them aware of the team findings.

LINE DRIVERS. The line drivers and line compensation amplifiers are equally old and subject to the same problems as the transmitters. In more than one case the line driver was used to set the modulation level of the transmitter; a most unsatisfactory arrangement (one technician adjusts the voice modulation level to the telephoned instructions of another).

MICROPHONES. The microphones in use are generally the old hand-held dynamic type. They are often used in a noisy area, there being no quiet area provided. The microphones have low-frequency response, are themselves noisy and cause distortion of the voice. The press-to-talk feature can often be heard when used and is recorded, causing odd sounds to be broadcast. No standard seems to exist for these

TABLE 3. TWEB NDB's NOT BEING FLIGHT-CHECKED AS OF MARCH 12, 1979

FAA Region	Facility Name	Nearest City/State	Identifier	Frequency (kHz)
Eastern	Elmira NDB	Elmira, N.Y.	ELM	375
Southwest	Oklahoma City NDB	Oklahoma City, Okla.	OKC	350
	Walker NDB	Roswell, N. Mex.	AKH	305
Rocky Mountain	Antelope NDB	Rock Springs, Wyo.	AOP	290
	Harford NDB	Casper, Wyo.	HAD	269
	Ogden NDB	Ogden, Utah	OGD	263
Northwest	Medford NDB	Medford, Oreg.	MFR	263
	Pendleton NDB	Pendleton, Oreg.	PDT	341
	Seattle NDB	Seattle, Wash.	SEA	362
Western	Blackjack NDB	Las Vegas, Nev.	BKJ	206
	East Bay NDB	Oakland, Calif.	EZB	362
	Inglewood NDB	Los Angeles, Calif.	IGB	332
	Proberta NDB	Red Bluff, Calif.	PBT	338

microphones, and sometimes they are just the choice of the local operator. The lack of a quiet area often allows high-level noise from teletypewriters, other voices, and sounds to be heard in the background of the broadcasts.

RECORDING EQUIPMENT. The various recorders themselves are cumbersome electromechanical devices which are difficult to adjust and maintain. The older recorder, the FA-5210, was manufactured many years ago and presumably to the state-of-the-art for its day. Most in use now have been refurbished and overhauled to keep them operating. However, they are still causing a constant maintenance problem with tape stretching, dirty tape heads, etc. The newer Sonicraft and Ampro 6P2 are somewhat better pieces of equipment, but essentially are latter day copies of the old FA-5210. Like the FA-5210 they are mechanically cumbersome and difficult to load. The Stancil-Hoffman TRC-89 recorder is an archaic piece of equipment that continues to have a reputation for unreliability and high downtime.

All the types of recording devices in use have several negative factors in common. They are difficult to operate. In order to update even one word on a tape unit the entire tape must be remade. The time required to do this can take up to 5 minutes without regard to time taken for rewinding, checking, etc. Editing of a complete TWEB message thus takes a substantial amount of time, since the TWEB message may take as long as 15 minutes and consist of a large number of recording cassettes. Training and expertise are required on the part of the operator in manning this equipment. Even an expert operator can have a slip of the tongue necessitating the entire message being rerecorded.

The Alaskan Region recently embarked on a TWEB program through its receipt of a Stancil-Hoffman TRC-89 recorder at Anchorage. Problems ensued, however, due to the 3-minute message-length limitation of this type of recorder and the region's actual need for greater message length to cover the route network of the lower Alaskan geographical area. In an attempt to provide an adequate message length capability, "half-speed" motors have been installed in the equipment. Although this modification has lengthened the message to 6 minutes, unfortunately, the audio response has been affected adversely. The resulting recording is distorted to the point that intelligibility is poor.

SPECIFICATIONS.

In all instances, the survey team assumed that the equipment operation met the prescribed specifications. It was stated many times by field personnel, when questioned, that "it meets the specs." While this may be so, it was quite obvious that the equipment was being operated over a wide range of modes at the various locations. When it is stated that "an equipment shall be operated with a voice modulation not to exceed 30 percent," it can meet the requirement with a modulation depth of only 3 percent. This will meet the specification, but result in an unsatisfactory operation for TWEB.

The International Civil Aviation Organization (ICAO) standards were examined to determine where such loopholes exist. There are many. One such requirement is Annex 10, Aeronautical Telecommunications, which states that the identifier (ID) signal of a VOR is to be sent at the rate of seven words per minute and shall be repeated at least once each 30 seconds. ICAO recommends that, when there is no voice, it be sent three times each 30 seconds. The depth of modulation of the ID is to be 10 percent except where voice is provided, in which case it may be 5 percent. Under a rule such as this, the ID may be sent each 10 seconds with modulation of the ID overriding the voice, thus making the TWEB virtually useless for a listener.

Many cases of interference between an outlet's coded identifier and the taped voice were observed. These ranged from "a slight problem" to a totally unusable broadcast due to the presence of the very annoying and overloud ID which repeated itself at intervals of 3 seconds from the tail of one ID chain to the start of the next. In this latter case a Sonicraft reproducer supplied audio input to the remnant antenna of an old four-course range station reduced to the status of a beacon. Aside from the audio problem, the signal of this system is receivable at distances of over 100 nmi during daylight hours.

We know that, compatible with ICAO technical requirements, it is possible to reduce ID repetition and to adjust modulation levels so that the TWEB function is enhanced. L/MF systems exist where such steps have been taken. The ID period was expanded to 30 seconds and the modulation depth reduced to the background. When these latter facilities were voice-modulated to the permissible depth, the results were very good. Upon reading the ICAO standards, it is quite clear that the intent in permitting variations is to allow good operation within the ranges cited. In paragraph 3.3.6.6.1, it is recommended that ID modulation should be 5 ±1 percent when voice modulation is used on the VOR.

The ICAO standards require monitoring of both the VOR and L/MF signals. In the case of the VOR, automatic monitoring is accomplished with the exception of voice monitoring. This monitoring includes accuracy of bearing, power out, and ID. Some locations require monitoring of the voice at each shift change. In no instance was the voice automatically monitored. Evidently the facility depended upon reports from pilots or others to determine when trouble existed. Again, no standards of quality checks existed for local monitoring of voice output. A check is provided by merely noting the existence or absence of the voice. In the case of the TWEB on L/MF, no automatic means of voice monitoring was found by the survey team.

BROADCAST MONITORING.

As the project group traveled about the country, sample airborne and ground tape recordings were made of TWEB outlets. The ground checks were made on a low-cost L/MF and VHF monitor-type receiver, which is available to the general aviation public in two of three competing models. They are surprisingly sensitive, but incapable of the performance generally obtained from the aircraft-grade electronic gear which was used for the airborne flight checks. The results reflect the varying quality of the receivers used and are considered to be a valid representation of what is actually in use in the field today. Of recordings made on the ground, one-third were judged adequate for use. The "rejects" ranged from broadcasts which were so poorly modulated that it was impossible to perceive the meaning of the words, to those which were usable with difficulty either because of distortion or the presence of an overloud, coded identifier. The "good" recordings were not perfect in all respects, but they were judged as generally good audio programs. There were two or three excellent samples which stood out from the others by virtue of their rarity. Of recordings made in the air, half were judged adequate for use. Here the rejects included: "no TWEB program heard," "too lightly modulated" (mainly VOR's), and "distorted audio" samples. Overloud identifiers were a typical problem which ranged from "vexing" to "obliterating words and phrases."

The range of the L/MF beacons varied considerably in the air and on the ground. L/MF ground ranges in some instances were less than 10 nmi. VOR ground ranges were sometimes found to be less than 1 nmi and rarely more than 5 nmi. Airborne checks of range varied on L/MF from 100 to 15 nmi and VOR from 80 to 0 nmi.

The audio quality seemed totally independent of the "newness" of the recording equipment being used. The variety of technical problems in the system (ancient transmitters, noisy telephone circuits, poor microphones, noisy recording environments, incorrect use of amplifiers and various gain settings) evidently caused this spread of performance. Problems ranged from loud hums on the carriers, to unreadable voice, to identification signals completely overriding the voice. Instances were also observed where a series of messages within a single broadcast varied in loudness. This was attributed to different speakers preparing different parts of the broadcast. Also observed was a case of extreme low-level modulation of a VOR outlet, such that the TWEB message could not be heard in flight or while taxiing, although a "good" receiver was being used. The voice modulation was not discernable until the engine was shutdown at a ground location near the transmitter site. In this case, a listener on the ground, without the aircraft engine, would erroneously assume the broadcast was adequate when, in fact, it was totally unusable to an airborne listener.

The lack of a requirement for "actual outlet quality monitoring" allows poor broadcasts to continue without corrective action. Most remote outlets are impossible of being monitored by the facility which prepares the TWEB broadcast and many local L/MF outlets are not monitored by use of a separate receiver. Regular facility monitors are rightly concerned with navigational operation. The presence of audio voice on the line to the station can be monitored, but there is rarely an opportunity to listen to the broadcast signal of the outlet for an actual receiving test.

COST ANALYSES

GENERAL.

As indicated earlier in this report, there is no "standard" TWEB configuration. Rather, the national TWEB network is comprised of a multiplicity of recorder-outlet configurations containing a diversity of recorder equipment, outlets, and landlines. Further, differences in equipment design, length of equipment in service, and actual operational and maintenance policies and practices act mutually as determinants to TWEB system performance and, consequently, interplay as contributors to overall systems costs.

As a direct adjunct, questions arise as to what is the total cost for the TWEB service, what are the specific constituents of overall systems costs, and how can they be assessed. To answer these types of questions, a comprehensive cost analysis was carried out to determine the dollar amount expended for operating and maintaining TWEB in its present national configuration.

Based on discussions with cognizant personnel of Systems Research and Development Service and Air Traffic Service, following the release of the Project Guidelines, agreement was reached that the study would additionally include a cost analysis for the mass weather dissemination services accessible by telephone. This cost analysis was carried out through a thorough and rigorous examination of each of the separate in-place services; i.e., a cost analysis of each of the national configurations for TEL-TWEB, PATWAS, and TABS dial-up services and, additionally, for the New Dimension Touch-Tone dial-up system at the Seattle FSS.

LIMITATIONS.

Details pertaining to the methodologies of approach, the various procedures and methods used in the cost analyses, and exhibits of the detailed tabular cost data appear in volume II of this report. Emphasis in this volume is primarily focused on the overall results stemming from the separate cost analyses of the TWEB radio service and the telephone accessible mass weather dissemination services for calendar year 1978.

With respect to comparison of TEL-TWEB and PATWAS usage data for those facilities having both services, only facilities having TEL-TWEB and "pure" PATWAS were considered. A facility having TEL-TWEB and TABS dial-up services was ruled out. TABS is not considered as PATWAS either by its designator or its format.

A comparison was also made for dual TEL-TWEB/PATWAS facilities in terms of service cost per call. The findings were quite revealing, and a summary of the results has been provided herein.

COST CATEGORIES.

As a framework for collecting and analyzing the various cost data elements associated with the TWEB radio service, the costing elements were partitioned into five major *cost categories*. These consisted of:

1. Operational direct work staffing (DWS) costs—those collective costs associated with all FSS operational work activities in composing, editing, preparing, verifying, and updating messages recorded for TWEB radio. Unfortunately, no measured field data exists on which to base current operational standards for TWEB and PATWAS staffing. As a result, these were based on subjective estimates arrived at through discussions with personnel in the facilities.

2. Maintenance DWS costs—all costs for maintaining the various FAA TWEB recorders at field sites, as well as those allocated costs for maintaining the L/MF and VHF transmitters for TWEB radio purposes.

3. Lease line and associated equipment costs—all lease services costs which were identifiable as costs directly related to the TWEB radio service. All lease services costs for lines from the TWEB FSS's to the outlets, or to other TWEB FSS's, were rigorously analyzed according to a set of costing criteria.

4. Provisioning and refurbishment costs—all costs for recorder replacement spare parts and recorder tapes, as well as costs for overhauling and repairing recorder units at the FAA Depot located at Oklahoma City, Oklahoma (Okla.).

5. Training costs—costs for training of facility personnel at the FAA Academy, Oklahoma City, Okla., in the operational use of the recorders.

For the telephone accessible mass weather dissemination services, two major cost categories were established for that cost analysis: (1) operational DWS costs and (2) lease line and associated equipment costs.

Two important points are in need of mention here. First, the TABS equipment exist in various configurations and have different operational uses. The TABS system configurations at Los Angeles, Oakland, and Roanoke FSS's have dual capabilities. The Los Angeles and Oakland TABS provide both en route and local area messages. The en route messages are broadcast over their respective outlets, and can be accessed by telephone as well, whereas their local area messages are only accessible by telephone. For Roanoke, the messages of this configuration are accessible both by radio and direct dial-in to the recording. As a consequence, operational DWS costing must account for these distinguishing features; and costs must be allocated according to the service being provided. Since the TABS configuration at the Washington, D.C., FSS can only be telephone-accessed, operational DWS costs are assignable strictly to this dial-up service.

The second point requiring explanation relates to TEL-TWEB. There is no assignable operational cost for the TEL-TWEB service. The rationale for this statement is that TEL-TWEB is a dial-in service to already prepared TWEB messages. Thus, all operational costs are assigned to the TWEB radio service itself. If the TEL-TWEB service were eliminated, the TWEB radio service would continue. Moreover, discontinuing any of the national TEL-TWEB services, or adding a TEL-TWEB service to any TWEB radio FSS facility, does not influence or change TWEB operational costs.

COST ANALYSIS RESULTS—TWEB RADIO SERVICE.

During calendar year 1978, the overall aggregate cost for the TWEB radio service was approximately 3.5 million dollars. Table 4 provides a breakout of the categorical costs stemming from the detailed investigation and analysis of each of the major costing categories. It is to be noted that no costs were incurred by the FAA for formal TWEB training during 1978. This was reported by the FAA Academy. As can be seen, the operational DWS staffing cost was the major cost contributor to total aggregate costs. The allocated operational DWS costs for production of TABS message broadcasts represented $45,250.70 of the total operational DWS costs shown in the table.

Maintenance DWS costs for the recorder units were considered to be smaller than expected, especially in light of FAA failure rate and downtime analysis results obtained through field surveys of Stancil-Hoffman TRC-89 equipment and FA-5210's. Nonetheless, this overall cost figure was arrived at through adhering to existing FAA maintenance staffing standards, guidelines, and discussions on this subject with FAA Headquarters personnel.

COST ANALYSIS RESULTS—TOTAL TELEPHONE ACCESSIBLE MASS WEATHER DISSEMINATION SERVICES.

For calendar year 1978, the total aggregate cost for all mass weather dissemination services accessible by telephone was found to be approximately 1.3 million dollars. Collectively, this consisted of all operational DWS costs and lease services costs expended for TEL-TWEB, TABS (as a dial-up service), the en route message telephone services of the New Dimension Touch-Tone System, and the PATWAS/AAWS services. A cost breakdown by type of service showing the categorical cost expenditures on a national basis appears in table 5.

TABLE 4. NATIONAL TWEB RADIO SERVICE COSTS—CY 1978

	Cost Category	Summary Cost Breakout	Total Costs
A.	Operational (DWS)		$2,479,560.10
B.	Maintenance (DWS)—FAA Recorders	$516,836.84	
	Maintenance (DWS)—Outlets	359,668.79	
	Maintenance (DWS)—Total		876,505.63
C.	Leased Lines and Associated Equipment		83,037.06
D.	Spares	46,597.50	
	Repair Costs	26,590.99	
	Provisioning and Refurbishment—Total		73,188.49
E.	Training		0
	Total Aggregate Costs		$3,512,291.28

TABLE 5. NATIONAL TELEPHONE--ACCESSED MASS WEATHER DISSEMINATION COSTS—CY 1978

Type of Service	Operational DWS Costs	Lease Services Costs	Total Costs
1. TEL-TWEB	0	$57,239.04	$57,239.04
2. TABS	$135,755.10	155,262.60	291,017.70
3 New Dimension System (Route Messages Only)	17,597.86	13,318.34	30,916.20
4. PATWAS/AAWS	581,310.30	361,126.36	942,436.66
Total Services	$734,663.26	$586,946.34	$1,321,609.20

At the close of 1978, there were 19 TWEB FSS facilities providing direct TEL-TWEB services, with one additional facility (Elmira, New York, FSS) providing a remoted TEL-TWEB dial-in service. Additionally, four FSS's afforded TABS dial-in services; only one offered sophisticated dial-in services to en route messages by means of the New Dimension Touch-Tone System. In terms of PATWAS/ AAWS within the 48 contiguous states, there were a total of 56 FSS's and 3 NWS facilities preparing these types of telephone accessible message services. To gain a more vivid impression of the various facilities preparing telephone accessible mass weather dissemination services and ones which also provide various types of multiple services, the reader is referred to the composite chart of figure B-1 of appendix B.

SAMPLE STATION TEL-TWEB/PATWAS USAGE RESULTS.

Based on an examination of facilities providing telephone access to mass weather dissemination messages, a total of six FSS's within the 48 states were identified as having both PATWAS and TEL-TWEB:

Philadelphia, Pennsylvania FSS
Teterboro, New Jersey FSS
Denver, Colorado FSS
Salt Lake City, Utah FSS
Las Vegas, Nevada FSS
Tucson, Arizona FSS

For data collection of call counts for calendar year 1978, each of the facilities was contacted and requested to provide count information for both local and foreign exchanges.

The reports received from these facilities disclosed that: Las Vegas FSS did not have any call counters for either of these services; Denver, Salt Lake, and Tucson had no foreign exchange services for PATWAS; and neither Salt Lake nor Tucson had foreign exchange services for TEL-TWEB. Further, an examination of the report for Teterboro revealed that PATWAS had only been in use for the last 4 months of 1978. Consequently, comparision of TEL-TWEB and PATWAS usage was thereby restricted to the same 4-month period for that facility.

Table 6 provides a presentation of tabular results of comparative call counts for the five FSS's having call counters for both PATWAS and TEL-TWEB. In addition, to arrive at the respective percentages of usage of these two services, total counts for both services are provided. Through an inspection of the percentage of use tabular data, it can be quickly noted that both Philadelphia and Teterboro have substantially higher use of PATWAS than TEL-TWEB, and that PATWAS/TEL-TWEB usage is nearly the same for Denver and Tucson. For Salt Lake City, a higher use of TEL-TWEB can be discerned over that of PATWAS.

Comparative costs for PATWAS and TEL-TWEB for the five facilities are presented in table 7. For PATWAS, these include both lease services costs and operational DWS costs. Since there are no operational DWS costs associated with the TEL-TWEB service, the lease services costs are the only contributor to total costs.

Finally, table 8 provides a summary of the call counts and respective costs for PATWAS and TEL-TWEB as extracted from tables 5 and 6. In addition, the cost-per-call count is exhibited for each of the two services for the five PATWAS/TEL-TWEB

TABLE 6. COMPARATIVE USAGE OF PATWAS AND TEL-TWEB—CY 1978

Flight Service Station	PATWAS Call Count	TEL-TWEB Call Count	Total Count Both Services	Percent Services Use PATWAS	Percent Services Use TEL-TWEB
Philadelphia, Pa.	39,998	19,763	59,761	67	33
Teterboro, N.J.*	12,816	5,265	18,081	71	29
Denver, Colo.	58,216	55,155	113,371	51	49
Salt Lake City, Utah	10,574	21,788	32,362	33	67
Tucson, Ariz.	10,677	9,829	20,506	52	48

*Counts for PATWAS and TEL-TWEB are for the period Sept. - Dec. 1978

TABLE 7. COMPARATIVE COSTS FOR PATWAS/TEL-TWEB SERVICES—CY 1978

	PATWAS			TEL-TWEB	
Flight Service Station	Lease Services Costs ($)	Operational DWS Cost ($)	Total Costs ($)	Lease Services Costs ($)	Total Costs ($)
Philadelphia, Pa.	12,681.72	4,641.20	17,322.92	242.28	242.28
Teterboro, N.J.*	8,890.64	4,641.20	13,531.84	2,989.96	2,989.96
Denver, Colo.	5,312.76	31,328.10	36,640.86	4,025.42	4,025.42
Salt Lake City, Utah	1,992.84	13,923.60	15,916.44	829.92	829.92
Tucson, Ariz.	2,656.56	9,282.40	11,938.96	234.84	234.84

*Costs for PATWAS and TEL-TWEB are for the period September - December 1978

TABLE 8. SUMMARY OF COMPARATIVE USAGE AND COSTS FOR PATWAS AND TEL-TWEB—CY 1978

Flight Service Station	PATWAS Call Count	PATWAS Total Cost ($)	PATWAS Cost/Call ($)	TEL-TWEB Call Count	TEL-TWEB Total Cost ($)	TEL-TWEB Cost/Call ($)
Philadelphia, Pa.	39,998	17,322.92	0.43	19,763	242.28	0.01
Teterboro, N.J.*	12,816	13,531.84	1.06	5,265	2,989.96	0.57
Denver, Colo.	58,216	36,640.86	0.63	55,155	4,025.42	0.07
Salt Lake City, Utah	10,574	15,916.44	1.51	21,788	829.92	0.04
Tucson, Ariz.	10,677	11,938.96	1.12	9,829	234.84	0.02

*Counts and Costs for PATWAS and TEL-TWEB are for the period September - December 1978

FSS's. As can be discerned upon examination of these results, the cost-per-call for PATWAS can be viewed as extremely, if not excessively, high as compared to TEL-TWEB.

DISCUSSION

METEOROLOGICAL CONTENT.

At the project's outset the assumption was made that all TWEB content was "good." This is to say that we did not feel charged with evaluating the meteorology contained in the TWEB format. It is apparent, however, that certain aspects of meteorology should be commented upon.

FAA briefing personnel view their NWS counterparts in a critical light. Whether justified or not, the feeling is that weather bureau personnel are not aviation oriented. FAA briefers feel that only they understand the needs of the aviator. The roots of this problem might lie in the differences in organizational (grade) structure between the two agencies involved. However, the interrelationship of the two organizations is very important to the mission of each.

Weather, stated for any type of user—soldier, sailor, aviator, or housepainter—is basically similar. Aviation weather, of course, is vitally concerned with wind, cloud heights, and visibility; with more precision required than for other users. But the differences which mark aviation weather as distinct from the rest are immediacy and accuracy. Here also, is the root of the problem that the specialist sees with TWEB. Meteorological information is retrieved from teletype circuits which, in the usual FSS, is one or more teleprinters, presently quite a bit slower than "modern" communication methods. The NWS is currently installing more rapid circuits, and the FAA is also looking closely at these shortcomings, but for now, TWEB is very dependent upon these slower weather circuits.

Good aviation weather, however, is current to the point of being almost real-time. The problem facing the aviation user is: how quickly can he retrieve the specific weather he needs; how can he be assured that it is correct; and how can he keep updated as changes occur. This is at the heart of the success of the En Route Flight Advisory Service (EFAS) Flightwatch Program, which is a live pilot/weather briefer communication service.

Real-time currency is beyond the intrinsic capabilities of the present voice operated TWEB system. It will remain beyond the capabilities of an enhanced TWEB system which does not depart from present methods. There are recommendations elsewhere in this report whereby a new TWEB could satisfy the stringent requirements for absolute currency. This is not to say that an enhanced present-day TWEB is of no value. A TWEB system containing basic synoptic weather information and reasonably current weather reports could be of high utility today if properly promoted and utilized. At least during stable weather periods, there is no reason why present-day TWEB could not entirely suffice for the pilot to make "go, no-go" decisions. This fact should be kept in mind during any interim period before a "modernized" new TWEB becomes available. In this sense, there is really no alternative for TWEB radio. Mass weather telephone disseminating services can never match the potential for wide, convenient dissemination and retrieval inherent in a radio broadcast.

TWEB CONTENT.

The briefer is oriented to "currently reported weather conditions." His mental weather picture is reinforced by pilot reports, special weather reports, and his own "out of the window" sense of what if going on. He probably has a local weather sense which the remote NWS forecaster cannot have. Because of the briefer's perception of the needs of the flying public with which he is dealing, he is probably overcritical of any averaged weather picture or forecast. So when he is charged with administering a TWEB service, he is apt to be frustrated by the generalities in the synoptic language used. He is acutely aware that for the TWEB messages an hourly sequence report is indeed history at its inception, and further frustrated by his inability to update the TWEB message to his own standards of real-time currency. Therefore, he tends to discount the TWEB system's value as a "prebriefing" device. Though he doesn't think anyone is listening, he would probably be happier if the TWEB would only operate in weather conditions which are relatively stable or only slowly changing. When there are localized meteorological conditions of a rapidly changing nature, he would shut down the TWEB entirely since he recognizes his inabilty to keep it updated.

Today's TWEB can never support a "mass briefing" system. A recorded voice message can never fill all the specific needs of flight operations and the crews. The best that TWEB (or PATWAS) can do is to be a "disseminator" of weather information. This opinion is supported by the often repeated concern of the FAA briefer specialist who worried about misleading the listener. He sees a danger in disseminating "incomplete" weather information. The extreme view can lead to condemnation of all TWEB broadcasting.

TWEB ENHANCEMENT.

Present-day procedures and phraseology for use by personnel providing flight assistance services are prescribed in Flight Services Handbook, FAA Order 7110.10D.

The FA-5210, the Ampro 6P2 RWB, the Sonicraft, and various TABS systems provide for a multisegment message. The introduction of the Stancil-Hoffman TRC-89, with its 3-minute message-length limitation, forces an adaptation of procedures and context to two different message formats. A summary of the sequence of TWEB on L/MF, as specified under paragraph 331, is as follows:

a. Introduction.

b. Synopsis.

c. Flight precautions—extracted from Significant Meteorological Information (SIGMET's) and Airman's Meteorological Information (AIRMET's).

d. TWEB route forecasts.

e. Outlook (optional).

f. Winds aloft forecast.

g. RADAR reports.

h. Surface weather reports—not more than 20 reports; except up to 25 reports are authorized for HH (above 1,000 watts) TWEB outlets serving overseas routes.

i. Pilot weather reports (PIREP's).

j. NOTAM's—Information not carried in the AIM received from locations within 100 nmi of the TWEB outlet(s) as follows:

(1) Include NOTAM's concerning airport conditions and NAVAID's in the remarks of the weather report.

(2) Include significant local NOTAM's.

(3) Do not eliminate weather reports from the broadcast to accommodate NOTAM information.

k. Include the statement "Check Density Altitude" in the text if the field elevation/temperature combination at any airport included in the surface weather reports meets a stated criteria.

l. Include a statement on Military Training Routes/Military Operations Area (MTR/MOA) activity.

The sequence and content of transcribed broadcasts provided over a VOR are prescribed in paragraph 336 as follows:

m. Introduction.

n. Broadcast the hourly weather for the parent station and for stations (maximum five) immediately adjacent using stated criteria. NOTAM information not carried in the AIM, significant local NOTAM's, and PIREP's concerning each location, shall follow each individual weather report.

o. Terminal forecast information for the parent station and for one more (facility option) adjacent hub locations. (Update sequence reports in paragraph n above and terminal forecasts when amended data is received.)

p. Flight precautions—broadcast SIGMET/AIRMET identification and a brief statement defining what the weather is and the areas affected.

q. Potentially hazardous conditions peculiar to the local area (e.g., mountains rise sharply west).

r. Include a statement on MTR/MOA activity.

s. Broadcast a density-altitude reminder, "Check Density Altitude," if the field elevation/temperature combination meets the stated criterion.

There may be a better format for TWEB broadcasting which would include the following:

a. A generalized systemic synopsis of a national character such as can be found on NOAA VHF-FM outlets but with aviation elements added. This national synopsis could be from a central office, the highly successful "AM WEATHER" group at the TV studio near Suitland, Maryland, might well compose and speak the national synoptic portion which could be accessed by telephone daily and made a part of all TWEB broadcasts;

b. An easily edited more local synopsis drawn from current briefer material and pilot report information;

c. Pertinent SIGMET's, PIREP's, and radar reports (RAREP's);

d. A selection of sequence reports known to be useful or needed at the specific outlet.

Each of these elements would be kept strictly up to date by inclusion of the latest specials and amendments issued. Winds aloft, in general terms, would be furnished in the synoptic analyses mentioned above. All other information would be disseminated elsewhere and not be included in this weather broadcast which would permit the broadcast to be as succinct as possible.

Since it is a weather broadcast, if the language was kept basic and plain and as free as possible of acronyms and specialized jargon, it would be more appealing to the less familiar aviation listener, the beginner. Even other casual listeners, farmers, contractors, etc, would find it of more value. The benefit to FAA's mission would be the resulting wider availability of receivers and added popularity of the service.

The whole broadcast would be reviewed for accuracy on a continuing basis and revisions included when needed. Except in stable or good weather, such a task is certainly full time; therefore, *station staffing would have to be reviewed in this light*. The caliber of the specialist who would compose the local synoptic portion of the TWEB would be of the best EFAS/briefer type available. He should be capable of short-term local forecasting. These local snyopses might be spoken at the nearest EFAS station, accessed by phone, and made a part of selected TWEB outlets.

In an enhanced TWEB, the main concern should be currency and accuracy. A recent Air Traffic Service Notice, N 7110.569, has addressed this with respect to PATWAS and "PATWAS accesses to TWEB systems." Notice the confusion which still exists over the definition of services. I suppose that "PATWAS accesses to TWEB systems" are "TEL-TWEB's." Additionally, the notice was not specifically addressed to "TWEB" *systems*. It is to be hoped that it does. Field personnel reacting to this notice are concerned with staffing. This is also what we have seen to be a requirement for an enhanced TWEB. The price of keeping TWEB current is dedicated attendance upon its accuracy and the speedy updating of all amended portions. The success of an enhanced TWEB, as well as the successful application of the notice cited above, also depends on the performance of the teletype circuits disseminating the weather and the timely *implementation of new dissemination circuits as they become available*.

The present state of the TWEB system—no audience perceived by FAA, poor equipment, tardy teletype reports, poor ground coverage, and low power outlets—indicates that the effort and expense of such an update would not be worth the small return to be expected. This effort would have to be a part of a general enhancement and promotion of the TWEB system which would include more powerful outlets, positive knowledge of ground coverage, and a rekindled desire on the part of the flying public to utilize this "new" system. Low-frequency receivers must also be easily available. VOR's, because of nonexistent ground coverage, would not figure in this new system. It has been suggested that VOR broadcasts could be converted to a flight hazard broadcast of which weather is only a part. Message content suggested was PIREP's, SIGMET's, field closings and hazards, military training area activity, and the like.

In the end, this modified system would still be the human voice, labor intensive, in a serial broadcast, an inefficient purveyor of meteorological information wherein the listener is forced to listen to a lengthy program and pick out the information he specifically requires. In other words—a perfectly enhanced and modified TWEB system operating under the concepts suggested, might still be regarded as an anachronism not suited to today's needs and not taking advantage of modern media capabilities, visuals, instantaneous updating, specificity, hardcopy output, etc. With the advent of Automation of Field Organization and Services (AFOS) and other automatic devices, it is conceivable that a display could be developed which would make the whole meteorological data base instantly available to the user in broadcast messages. A properly equipped audience could have their own self-briefing material constantly available.

PILOT BRIEFING.

The FAA's FSS pilot briefing mission, as of today, has a basic weakness. Its success is its own failure. The better it works, the more utility is expected of it. The telephone circuitry and the staff requirements are already badly strained or misapportioned.

Consider the pilot who receives an excellent telephone briefing from FSS personnel—an inspired and correct presentation of all the elements needed by the pilot and the happy circumstance of the weather doing just what the weather experts have forecast—and the additional happy circumstance of it being flyable weather for the particular pilot and aircraft involved. This pilot will think that there are sufficient numbers of FAA briefing personnel who can always solve all of his flight weather problems and who will immediately respond whenever he is in need of the service. The better this type of briefing becomes, the more this class of pilot will depend upon the briefer, even at the expense of allowing his own meteorological knowledge to decay or remain at primary level. Briefers report that this pilot is indeed present in today's system, and the existence of this type of pilot irritates another class of pilots who want more factual briefing material without benefit of paraphrase or briefer opinion. Therefore, there is a need for factual weather data dissemination. It can be argued that this concept of allowing the pilot to exercise his own judgment is healthier in the long run.

We must also consider that the concept of "briefing" pilots orginated in services which have more control over their subjects than does the FAA briefer. The military briefer or the airline dispatcher can cancel unfeasible operations. They are more related to the operational phases of their system than the FAA briefer is. The FAA briefer has no such authority and may tread on sensibilities if he suggests unfeasibilities or limitations to some of the more experienced pilots. The findings of the TWEB team suggests that meteorological expertise of the briefer and of the general aviator be more closely monitored to determine deficiencies or areas open to exploitation.

The following extract quotes from an early aviation publication, "Pilot-Meteorologist Relationship," which treats the problem of weather briefing, concurs with what has just been presented.

"The proper execution of a flight plan prior to departure is sound insurance against emergencies. Meteorology enters deeply into the flight plan, and pilots may have experienced difficulty in obtaining adequate information since war restrictions have been imposed. The amount of information available to properly identified pilots is limited, making it more important than ever to exercise judgment in the planning of flights wherever meteorological conditions of an unfavorable nature may be involved.

"Whether he flies for pleasure or for profit, the pilot is protected against weather hazards by an extensive organization designed to insure his safety. This protection is available for the asking, there being required only a normal amount of interest to obtain the information, then a normal amount of flying intelligence to use it effectively.

"The complaint is sometimes heard that meteorological information from forecasters is too vague. Were this same pilot to taxi to the gas pit and announce that he needed service, without specifying fuel, oil, or amount, he would hardly consider it unusual if the service proved to be unsatisfactory. Yet, it is quite usual for a pilot to request weather information and volunteer few or no basic details to guide the airways forecaster. The emphasis which the forecaster places upon certain features of the weather situation is governed largely by the type of flight contemplated, equipment used, pilot limitations, route, distance and time involved, and so forth. It is, therefore, obvious that unless this information is included in the request for a forecast, the meteorologist is at a disadvantage and must treat the matter in broad generalities."

The points made above in the second paragraph are especially apt. Today's pilot is indeed provided with an "extensive organization." With the continual increase in numbers of pilots, greater recognition of their needs and methods of meeting them, must be developed by the FAA to remain responsive.

This historic evidence indicates that the briefing and mass weather dissemination problem is not new at all but is related to flight planning and meteorology. The present-day overload of briefing capabilities clearly indicates the general acceptance of FAA's briefing service. But with the burgeoning demands upon the service running counter to plans for reducing FSS locations and staff, it is apparent that today's briefing methods can never hope to meet the needs of tomorrow.

BROADCAST EDITING DIFFICULTIES.

As noted earlier, the TWEB tape recording devices are generally outmoded and cumbersome. They suffer from technical difficulties which mar the effectiveness of the TWEB system. Operational shortcomings include the difficulties of preparing and updating the broadcast message without excessive repetition of data. Present policy and procedures establish a low priority for these activities. Due to the new priority, available manpower is frequently unable to perform timely preparation and update of TWEB messages. Thus, material is broadcast which is not current. Because of editing difficulties, some facilities do not insert special weather reports when received but wait for the hourly sequence to update the whole broadcast. Corrective proposals have been made to the regions for raising the priority of the TWEB and PATWAS tasks.

MULTIOUTLET DIFFICULTIES.

Present practice provides that some stations broadcast the TWEB message over several outlets. Some of these outlets are located hundreds of miles from the originating station. An inappropriate remote broadcast can result; one which has little meaning for the remote listener. The preparing station tends to prepare the TWEB message for local pilots and to forget the needs of the pilot at the remote outlet.

TWEB USAGE DIFFICULTIES.

The intended audience for TWEB is still open to question. Originally, when the TWEB service was established, it replaced certain scheduled weather broadcast on the L/MF ranges. Since the only users of the ranges were in-flight pilots, it can be inferred that the audience intended to be reached was in-flight pilots. The expansion of the TWEB service to a large number of VOR outlets seems to confirm this inference. The VOR is sited for the airborne user and its antenna system is not designed for ground coverage. The project team's experience with VOR ground coverage indicates that it is generally of very small radius and subject to complete masking by terrain.

However, the data being presented on TWEB is generally more suited to preflight briefings, which is also consistent with the FSS specialists' perception of the audience. Actually, most specialists seriously doubt that there are any listeners to their scheduled broadcasts, and this doubt extends to TWEB broadcasts. In fact, when consideration is given to how today's VOR navigation equipment is used, there is doubt that many listen to voice transmissions on the VOR while in flight. The audio level may only be briefly turned up in the cockpit (for identification) then immediately reduced, especially since the unit is tuned by reference to an exact digital readout. A reasonable directional indication and/or a distance measuring equipment (DME) readout suffices to confirm correct facility reception. Air route traffic control center (ARTCC) requests of FSS's to contact aircraft known to be navigating on certain facilities are largely futile.

There is presently no method of obtaining a count of the TWEB radio broadcast audience. Questionnaire-type polling surveys appear to hold the most promise for sampling the pilot population to determine the extent of TWEB usage and its effectiveness as a mass weather dissemination service. Preliminary checks of the pilot survey data collected by the Civil Air Patrol during the summer of 1978 indicate some usage. Some data confirm the team finding that the system is nonhomogenous. That is, usage is relatively high in some areas and almost nonexistant in others. In 1975, the AOPA conducted a sampling survey of its membership on behalf of the NWS. A statistical count of the responses indicated some degree of usage of the TWEB service. In addition, evidence of TWEB usage was obtained when an FSS broadcast's transmitted a notice to pilots of the future shutdown of a specific TWEB. This action elicited a "stack" of protests and testimonials directed to the FSS which indicated quite extensive use of the system. FSS specialists do acknowledge that users notify them when systems fail; however, they judge such notifications as coming from a very small audience: "the farmer down the road or that old retired pilot across town." Some FSS reports indicate that highly populated areas also make good use of the L/MF TWEB, especially where telephones might be expensive or overly busy. Though no substantive data were available, field specialists feel that a nonfunctioning TWEB system results in increased telephone briefs. They also report long distance telephone briefs from areas where local briefing lines are busy.

Sampling or questioning of potential users may present problems of data validity. There have been localized FSS surveys which indicate some confusion over what TWEB is. Some pilots have indicated this by making statements such as: "Oh yes, I listen to TWEB when it is broadcast at 15 and 45 minutes past the hour." Some facilities have counters attached to their TEL-TWEB lines, and there is an indication of usage here; but this information is of no real use to the specialist in effecting his briefing or motivating his TWEB preparation activities. Also, this usage indication has no bearing on who listens to TWEB radio broadcasts.

But if a briefer knew that a caller had heard a TWEB message, he might be able to shorten his briefing and thereby increase his productivity. It can be opined that if a specialist queried a caller about TWEB usage (e.g., "Have you listened to our TWEB on 300 kHz?") certain benefits would accrue, namely:

1. An affirmative reply would form the basis for the ensuing briefing. The briefing would be shorter.

2. An affirmative reply would provide feedback of immediate use to the specialists associated with administering the TWEB.

3. Any reply, yes or no, would have the effect of promoting the system. The caller would be reminded of the service or made aware of it.

Such a procedure could also apply to PATWAS messages. If such a method were made a part of a briefer's duties, it could form the basis for providing facility activity credits for the TWEB and PATWAS preparation tasks.

ALTERNATIVE POSSIBILITIES.

An examination of possible alternatives to TWEB quickly reveals that two classes of alternatives exist: (1) is the use of existing systems and the (2) is the building of new systems. The pro's and con's of the possible alternatives are examined below:

Existing Systems	Potential Systems
Telephone Systems	TV Broadcasts
NOAA Broadcast Systems	Satellite Systems
Short Term TWEB Enhancement	Teledata Systems
	Redesign of TWEB

1. Telephone Systems. (Includes the PATWAS, AAWAS, TABS, and New Dimension.)

Pro:

The systems exist and are quickly implementable where they do not exist.

A familiarity with the systems exists.

Systems utilization and effectiveness is easily determined.

Can be expanded to meet demand (within limits).

Can be configured to meet unique requirements.

Con:

Limited to ground use.

Expensive.

Unable to access if in use.

Weather data nonspecific.

Do not provide briefing in marginal or fast-changing conditions.

Difficult and time consuming to keep current.

Pilots live in places that can't access them.

Not suited for small audiences.

Voice limits the data that can be provided in a reasonable time.

2. NOAA.

Pro:

System exists.

Familiarity exists.

Receivers available at reasonable costs.

Con:

System forbidden to be used for broadcasting aviation weather (NOAA policy).

Broadcast not long enough for aviation weather in its present form.

Ineffective due to voice limitations.

Expensive.

Weather data nonspecific.

Does not provide briefing in marginal or fast-changing conditions.

Difficult to keep current.

Equipment owned by NWS.

System modification required.

3. Limited TWEB Enhancement. (Repairing the shortcomings of the present-day system.)

Pro:

System exists.

Familiarity exists.

Problems are documented.

Costs are reasonable and controllable.

Can be done in orderly fashion leading to complete overhaul.

System would be operational even without further work.

Con:

Will not always provide a briefing.

Inherently lags real-time weather.

Tedious to listen to; loses audiences.

Still needs to be modernized to its potential.

Many inherent problems won't be addressed (e.g., lengthy voice messages).

Politically touchy to interfere with present program content.

Receiving equipment not easily available.

4. TV Broadcast.

Pro:

Good overall view of weather.

Easy to grasp.

Most users on the ground are equipped to receive it.

Professionally controlled content.

Easy to tie into.

Can be engineered for cockpit use.

Con:

Limited to ground use.

Too expensive for the FAA to create its own network.

Piggyback on educational TV limits the time and usage (half-hour per day not enough).

Not a specific briefing.

TV data are less specific than TWEB.

5. Satellite Systems.

Pro:

Universally useable.

Technology available.

Some systems exist.

Cost projections are reasonable.

Data compatible with projected communications systems.

Con:

Not immediately available.

Development necessary.

Startup costs expensive.

Operations plan necessary.

Multiple satellites necessary.

6. Complete Redesign of TWEB.

Pro:

Frequency band is already reserved for FAA use.

Economical coverage of the United States.

Numbers of transmitters can be reduced through engineering.

Likely to accommodate digital techniques.

Multiplexing can accommodate both voice and digital techniques.

Economical to operate and maintain.

Can be made redundant for emergency.

Could free frequencies for other use.

Automation of updating could make information current.

Digital data transmissions offer possibilities of data other than weather (NOTAM's, military training, etc.).

Compatible with FSS modernization.

Offers possibility of pilot self-briefing.

In-flight/ground use.

Digital system should be compatible.

Complete data base available.

Con:

L/MF TWEB is required to be combined with a NAVAID.

Lack of an operation plan.

Requires economic and engineering study.

Long-term plan.

Feasibility to be proven.

May require user education/acceptance.

ANALYSIS OF ALTERNATE POSSIBILITIES.

The question arises whether this difficult, problem-laden system should be terminated or should survive, changed in some fashion. The study team did much soul searching on these questions. If TWEB is to be terminated, the alternatives listed above for effecting the necessary mass dissemination of weather must be considered. It was recognized early in the analysis that tape recorded briefings en masse are self-limiting. If sufficient data are given serially on tape by voice for all pilots at any given location, the amount of data necessary becomes overwhelming. The present multichannel TWEB takes about 15 minutes for a minimum broadcast. If the listening pilot misses one significant word, he must suffer through a complete cycle to be exposed to it a second time. Also, he must listen to a great deal of data that have no bearing on his flight.

All voice systems studied had these drawbacks. However, at a number of PATWAS locations FSS's employ several recordings broken down by areas of interest available to calling pilots. The "New Dimension" system at Seattle and the "TABS" in other places do this. These are to reduce the amount of data a pilot must listen to. Typically, PATWAS evolves into five recordings: local, east, south, west, and north with a phone number for each. This helps but does not effect a complete cure (see TWEB Contents Enhancement above).

One solution is a new system of automatic mass weather dissemination. This dissemination can not be the same as today's concept of "briefings." It must be quickly retrievable and minutely detailed weather information of a character which is easily understood. (Alternatively, the uninitiated must be educated to a level where they can do their own briefings from the plethora of sophisticated material which exists even today.) Rapid means of acquiring weather information now exist, and high-speed telecommunications networks are operating which feed weather data displays and selective hard copiers at dazzling speeds. Aviation weather forecasting and amending should be accelerated to match this capability. Also available are new pictorials, obtained and structured from satellite and radar data. The new data dissemination methods should include the best of all the current information and be structured so that it is easily available to the "uninitiated" in terms of easy understanding and ease of acquisition, even though it adds to the amount of data to be distributed.

This system could be in consonance with other recommendations which have been made for weather dissemination improvements. Briefers see the need for real-time weather and short-term forecasting which are not even available to the present-day TWEB systems. All of these capabilities, if developed, would fit present-day concepts for TWEB. The "new TWEB" would have to be a data transfer system with visual readout, instant update, and broad data base capabilities. Much of the thinking necessary in specifying such a TWEB system is beyond the scope of this project, but it indicates that the immediate future of TWEB should be basic enhancement, thus reserving its function for ultimate conversion into rapid data transfer modes. This would include material appropriate for preflight briefing and specific realtime weather. Ultimately, it should be possible to access ground-based weather radar displays and even local wind shear information displays for use by a landing aircraft. Real-time turbulence or icing condition displays could exist in the cockpit of en route aircraft.

A system could conceivably be designed to blanket the nation with a digital program of the entire existing weather data base. It can be conjectured that such a system would have a greater capacity than parallel concepts envisioned in the future Discrete Address Beacon System (DABS), if implemented. It would be a transmit-only system and expandable to include other requirements, such as a NOTAM system, existing in its entirety on a cochannel. Therefore, pilot self-briefing could be a reality.

Appropriate techniques to accomplish such a design are contained in the literature. One such article is in the May 1979 issue of Popular Electronics, and another for using ordinary TV for displays is in the July 5, 1979, issue of Electronics Design. Coding techniques for display data are discussed in an article in the June issue of the Institute of Electrical and Electronic Engineers (IEEE) Spectrum. It is apparent that the electronic state-of-the-art is directed to just such systems as proposed. Some are already in use but not broadcast at such low frequency rates.

An engineering design study would entail, as a minimum, the following considerations:

1. Determination of a need and then an operations plan.

2. Determination of methods to achieve minimum bandwidth with maximum data rates in the L/MF band.

3. Display techniques and characteristics.

4. Transmitter power, coverage, frequency, location(s), and characteristics. (See DOT FAA Order 6050.19B.)

5. Antenna design.

6. Required Receiver Characteristics.

7. Availability of desired components.

8. Costs.

9. Schemes for encoding weather for transmission by computer.

10. A feasability model construction.

11. A report with an implementation scheme for all the above.

12. A determination of how this fits in with FAA automation plans.

CONCLUSIONS

It is concluded that:

1. There is neither an overall system design nor a system mission established for the Transcribed Weather Broadcast (TWEB) service. Further, there is no comprehensive national plan for mass weather dissemination which integrates the currently fragmented approaches to providing weather information service to pilots. There are no TWEB effectiveness standards.

2. The assumed (and probably true) lack of wide utilization of the TWEB services is directly related to the many deficiencies in the system which make it inadequate and inefficient as a mass weather briefing service. However, the desire for more weather information has been repeatedly expressed by pilots. Limited data indicates that there is a cadre of users that rely on TWEB, and also indicates that where TWEB is good, increased use follows to some unmeasured degree. Enhancements to the current TWEB system can be made to correct basic problems and produce a usable and adequate system. This will create increased demand and lay the base for a new modernized system.

3. The equipment currently used to provide TWEB service, from the microphones to the antennas, are generally old and presents reliability problems, maintenance difficulties, and problems in acquiring spare parts. Slow teletype circuits and the operating and updating difficulties of the recorders, including recently acquired recorders, contribute to the lack of currency of the broadcasts. Modern equipment could contribute to providing an adequate, reliable system if specifically designed to meet the operation.

4. The TWEB broadcast quality is frequently poor, or unusable, as a result of low voice modulation, identification signals overriding the voice, variable audio levels, and high background noise. There is no provision for actual output quality

monitoring, and neither air nor ground coverage of the voice output is available. The International Civil Aviation Organization (ICAO) standards are so flexible that unusable TWEB broadcasts can result. Changes, still within ICAO standards, have been made at some facilities which greatly improve system performance.

5. The priority associated with the preparation and broadcast of TWEB messages is too low in relation to other assigned duties. In addition, the classification system for assigning levels to Flight Service Station (FSS) facilities is based on the number of direct contacts with pilots, which the TWEB system is intended to decrease. Thus, the less effective TWEB is, the greater the facility level classification and, possibly, the grade level of the briefing specialists. The TWEB service thus seriously suffers from the neglect of management and the specialist.

6. The TWEB messages provided pilots are frequently out of date; not relevant to the location (remoted outlets); contains extraneous data not related to weather; contain confusing acronyms; and, in rapidly changing weather when needed most, broadcasts are frequently missing entirely.

7. There is no method of obtaining a current continuous count of the pilot audience listening to TWEB radio, nor of determining whether a pilot calling the FSS for weather briefing has actually listened to TWEB previously. Thus, the briefer is inclined to provide a complete briefing unless requested otherwise.

8. The TWEB radio service cannot meet the currency and accuracy needs of the airborne pilot. Further, TWEB radio cannot provide the specific information needed by each airborne pilot within range. Attempting to do so results in a message which is so long as to be virtually unusable by an airborne pilot. Such service can only be provided by direct pilot contact or, possibly, by providing the pilot the ability to select the specific information he desires from a very large and current data base; a capability not currently available via radio, but possible in the future.

9. Based on the preceding conclusion and the intrinsic limitations of omnidirectional ranges (VOR's)—virtually no ground coverage, limited voice modulation, usually ignored to in the cockpit, and 3-minute limit of recorders—VOR outlets are not suitable for TWEB, especially for preflight information.

10. The TWEB radio service is not, and cannot be, adequate for a pilot briefing service of the type provided by direct individual contact with the pilot, and should not be treated as such. Radio broadcasts are, however, a most efficient means of providing wide, mass dissemination of weather usable for making basic go/no-go decisions or a decision to get more information. Other systems of mass weather dissemination cannot match the capability provided by radio broadcasts. The potential existing in the L/MF band is so great that it cannot be ignored. It is a valuable asset highly suitable for this purpose and should be more effectively utilized. Using modern techniques it offers the promise of digital transmission that could make a full weather data base available to a user as a self-briefing system.

11. The L/MF sites used for TWEB service are sited for navigation aid (NAVAID) purposes, and not for the propagation of mass weather dissemination. Frequency conflicts with nondirectional beacons at small airports result in power reductions which further decrease their effectiveness.

Proper siting, regular ground coverage checks, and appropriate power settings could possibly improve their usefulness and decrease the number of facilitites required, thus relieving frequency management problems.

12. The Alaskan Region is an area which requires a good radio mass weather dissemination system. A properly designed and equipped TWEB system could meet that need even using existing L/MF facilities. The Stancil-Hoffman TRC-89 recorder delivered to the Anchorage FSS is unsatisfactory and does not meet the region's requirements.

13. Information on mass weather dissemination service published for pilot use is frequently incomplete, outdated, or inaccurate. Symbology used on charts is difficult to see and interpret. The many different names or acronyms used for various weather dissemination services (even those providing virtually identical services, from the pilots viewpoint) are confusing. Generally, the advertising given the TWEB service is extremely poor.

14. Current, accurate, and complete information on the TWEB and the Pilot Automatic Telephone Weather Advisory Service (PATWAS) national configuration is not available from any single source.

15. The TWEB radio service is not a reportable item in the Airways Facilities Service reporting system.

16. The lack of a standard TWEB configuration and the many differences in recorder-outlet configuration, landlines, daily use, number and types of recorders, and operational and maintenance policies which contribute to TWEB cost, make it inadvisable to estimate either average facility cost or total system cost, based on TWEB cost data from a few facilities.

17. The TWEB system suffers from a general lack of knowledge and control of the system at higher managerial levels. This is manifest in the lack of a managerial focal point, lack of direction for operating goals, poor procedures for updating documentation, poor record keeping, imposition of requirements without assurance that TWEB can meet them, and the lack of any penalty or reward system for performance.

18. Comparative costs of telephone access to TWEB (TEL-TWEB) and PATWAS, for five facilities which provide both services, shows that PATWAS costs per call are extremely high as compared to TEL-TWEB. Nevertheless, 34 TWEB radio facilities also provide PATWAS service rather than the much cheaper TEL-TWEB service.

RECOMMENDATIONS

Based on the conclusions of this report, it is recommended that:

1. A national plan for mass weather dissemination be established as rapidly as possible. Benefits of such a plan would afford uniform interagency guidance as to the missions, functional roles, and interfacing of preflight and in-flight mass weather information services, as well as influencing the direction for upgrading and modernizing the means for dispensing this information in an optimal, efficient, and cost-effective manner. Such a plan should account for the existing use and

inherent potential of the low/medium frequency (L/MF) frequency band, and its availability and value for providing radio broadcasts of mass weather information to pilots.

2. A pilot study be planned and developed for purposes of conducting experiments at one or more selected field sites to demonstrate technical improvements (developed in the study) to the Transcribed Weather Broadcast (TWEB) L/MF radio service and to determine pilot utilization when providing a vastly improved high quality product. The impact on telephone and in-person briefings will also be investigated. Operational enhancements would include increasing the priority of TWEB message preparation and updating; respecifying the TWEB message format to provide local and area, rather than route, weather information; reducing the use of acronyms, jargon, or abbreviations in the message; removing NOTAM's and other extraneous information; and reducing the message to 5- or 6-minutes in length. The objective would be for broadcasting the information for preflight planning use while allowing for telephone accessibility to the same data. Both the broadcast and telephone messages would be simultaneously prepared (see recommendation 6). Technical enhancements would include performing voice output ground coverage checks and making changes to transmitters, as necessary, to obtain the best coverage of the area to be served. Various state-of-the-art equipment for better recording and transmission would be tested to identify additional service improvements. In addition, other enhancements would include improving local promotion and advertising of the service, e.g., advertising in Letters to Airmen, newspapers, and telephone books; installing speakers and receivers to carry TWEB messages in the briefing areas. Finally, the information derived from the pilot study should provide a basis for establishing appropriate operations for best implementation and use of the enhanced TWEB L/MF service.

3. As a direct follow-on to recommendation 4, an engineering program be established for in-service TWEB improvement. This program would be aware of the requirements stemming from the operations plan and thereby be able to accommodate for state-of-the-art improvements to be added as conditions permit. One such improvement would be the development of a voice-lost monitoring alarm. Another to be considered would be the development of a weather alert signal similar to the National Oceanic and Atmospheric Administration (NOAA) alert system. A coded signal could be broadcast on TWEB L/MF outlets which receivers could automatically detect, and thereby alert pilots that critical messages were being broadcast.

4. While awaiting the results of the pilot study in item 2 above, the TWEB radio service currently employed for disseminating mass weather information to pilots over L/MF outlets should undergo moderate immediate enhancements to improve its operation at field sites. Enhancements include the incorporation of sound proof rooms or booths, and microphones that do not impose extraneous noises, for the preparation of all voice recordings made for transmission to the public; setting voice levels of the broadcasts as close to 95 percent modulation as practicable; and for the identification signals, setting repetition intervals to 30 seconds and modulation to background levels, with the provision that when the voice is lost, the identification signal can be quickly changed to 95-percent modulation at 10 second intervals. Periodic monitoring of the live broadcast from a receiver, remoted if necessary, is essential. It is further recommended that this TWEB L/MF service, with these enhancements, be implemented in the Alaskan Region as rapidly as possible. The Stancil-Hoffman TRC-89 recorder at the Anchorage FSS should be replaced immediately with a Sonicraft or Ampro 6P2 RWB, or equivalent, until new recording capability is available (the FA-5210 is not recommended).

5. Current Flight Service Station (FSS) production and transmission of TWEB information over VHF omnidirectional range (VOR) outlets be discontinued. During the near term, emphasis should be directed to the planning and development of a new flight hazard very-high-frequency-omnidirectional Radio Range (VOR) broadcast service designed for in-flight use by the general aviation pilot in which critical alert, weather warning information is only a part. As constituents, message content should include pilot reports (PIREP's), significant meteorological information (SIGMET's), field closings and hazards, military training routes (MTR's), and military operations area activities (MOA's). Additionally, message length should be on the order of 5 or 6 minutes, thereby requiring technical determination of a suitable recording device for preparation and updating of messages. Following the planning and development phase, a pilot program should then be conducted at one or more selected field sites to determine pilot reaction to this service. Assuming its success, an operations plan would be required to include (but not limited to) defining this service and delineating policies and procedures for implementation at specified FSS field locations.

6. A single briefing message be specified for all mass weather dissemination for preflight briefings, whether broadcast via radio (as recommended above for L/MF TWEB message broadcast) or made available for telephone access. A single recording session would then produce, or update, both recordings. The additional operational costs currently incurred to produce separate/different messages would be eliminated. Such a message could cover the various quadrants (areas) successively so that all are broadcast, but each quadrant would be accessible separately by telephone. At TWEB radio facilities, telephone access should be through the TEL-TWEB capability rather than the much more costly PATWAS.

7. Classification rating standards be modified to permit TWEB operational duties to be rated on their own merits and receive some reasonable form of credit, as are other operational duties.

8. Publications and advertising circulated to the public, be reviewed immediately to correct errors and omissions. A regular procedure for reviewing and maintaining the accuracy of such publications should be implemented and enforced. A single name should be established for references to telephone accessible mass weather dissemination services, regardless of the devices used to produce them. Similarly, radio broadcasts of mass weather should also be referenced by a single name.

9. Actions be taken to review existing Federal Aviation Administration (FAA) procedures and standards pertaining to the role, duties, and responsibilities at the FSS, regional, and headquarters levels for collecting, accounting, auditing, documenting, and reporting on mass weather dissemination capabilities. Where specific information is lacking, procedures should be updated to insure that the system provides adequate and accurate information in a timely manner. A repository should be created where suggestions, complaints, and incidents relative to the mass weather dissemination service can be recorded, disseminated to responsible parties, and resolved.

10. The TWEB service be included as a reportable item in the Airway Facilities Service reporting system and in the list of facilities of appendix 1 of Order 1380.40.

11. New automated capabilities for digital transmission, selection, recording and selective updating of data, and generation of voice output as planned for the modernized FSS voice response system (VRS) be implemented for TWEB services as soon as possible. Work on this should start immediately.

12. Near term program planning be started and funding be provided to carry out investigatory work in exploring concepts for modernizing the TWEB system through redesign. An idealized system for long term use would make the entire data base instantly available to all, and would enable a user to make use of any part of it quickly. This would then be a self-briefing system. Assuming these requirements, and that the minimums of the previous near-term recommendations are met, modernization planning should include:

a. An operations plan which requires the entire data base be broadcast digitally with the intent to display the data to users. This plan would include the formats and message content of the various groups of data. Grouping the data in "pages" similar to the TELETEXT would be one way.

b. A design study to determine optimum methods for accomplishing the digital transmission. The design study should have a feasibility model built to confirm the study findings and to provide the basis for an engineering requirement for a more advanced model. From what can presently be forseen, only two broadcast media are available which can satisfy the requirements of universal and immediate availability to users. These would be broadcast over the L/MF band or the use of satellites. Of the two, the L/MF appears to be the most promising due to ease of implementation, availability, and the costs involved. Therefore, unless disadvantages prove to be overwhelming, the L/MF band digital broadcast is recommended.

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APPENDIX A

QUESTIONS SUBMITTED TO THE AOPA ON JULY 14, 1978 FOR USE IN THEIR OVERALL SURVEY

I BACKGROUND INFORMATION ABOUT YOU

A. Where do you currently live? (Please complete all lines below. Street address is not required.)

City/Town ______________ State ________

County ______________ Zip Code ☐☐☐☐☐

B. What pilot certificate do you hold?

(1) Student ☐ (3) Commercial ☐

(2) Private ☐ (4) Airline Transport ☐

C. Do you hold a current Instrument Rating?

(1) Yes ☐ (2) No ☐

D. What is your age group?

(1) 14 - 19 ☐ (6) 40 - 44 ☐

(2) 20 - 24 ☐ (7) 45 - 49 ☐

(3) 25 - 29 ☐ (8) 50 - 54 ☐

(4) 30 - 34 ☐ (9) 55 - 59 ☐

(5) 35 - 39 ☐ (10) 60 or over ☐

E. What total number of flying hours do you have as a pilot?

________ Hours

F. How many hours of General Aviation flying did you perform during the last 12 months?

(1) None ☐ (4) 51 - 100 ☐

(2) 1 - 24 ☐ (5) 101 - 200 ☐

(3) 25 - 50 ☐ (6) Over 200 ☐

80-6-A-1

II. WEATHER INFORMATION SOURCES AND SERVICES

A. To what extent do you use each of the 12 Sources/Services listed below for weather information? Read the 5 headings and for each Source/Service, place a check mark in the block that best answers this question.

Weather Information Sources and Services Other Than FSS Briefings	(1) Not Familiar With This - Don't Use It	(2) Familiar With This But Don't Use It	(3) Use This Rarely	(4) Use This Moderately	(5) Use This Most of The Time
1. Local Media (Radio/TV/Newspaper)	☐	☐	☐	☐	☐
2. National Weather Service (NWS) Briefing	☐	☐	☐	☐	☐
3. Self-Briefing at Private or Government Meteorological Office	☐	☐	☐	☐	☐
4. Transcribed Weather Broadcast (TWEB) by Radio	☐	☐	☐	☐	☐
5. Telephone Dial-up to a Transcribed Weather Broadcast (TELE-TWEB)	☐	☐	☐	☐	☐
6. Pilot's Automatic Telephone Weather Answering Service (PATWAS)	☐	☐	☐	☐	☐
7. National Oceanic and Atmospheric Administration (NOAA) Weather Broadcast - VHF FM Radio	☐	☐	☐	☐	☐
8. Corporate, Military, Private or Airline Meteorological Service	☐	☐	☐	☐	☐
9. Enroute Flight Advisory Service (EFAS) "Flight Watch"	☐	☐	☐	☐	☐
10. FSS Scheduled Hourly Broadcast (Quarter Past the Hour)	☐	☐	☐	☐	☐
11. Automatic Terminal Information Service (ATIS)	☐	☐	☐	☐	☐
12. Center or Tower Radio Communication	☐	☐	☐	☐	☐

80-6-A-2

II. <u>WEATHER INFORMATION SOURCES AND SERVICES</u>

B. For each of those Sources/Services which you indicated using (checked boxes 3, 4, or 5 in Part IIA above), please continue below by answering the following: HOW WOULD YOU RATE EACH OF THOSE SOURCES/SERVICES IN TERMS OF ITS USEFULNESS TO YOU? Read the 5 headings and place a check mark in the block that best answers that question.

Weather Information Sources and Services **Other Than FSS Briefings**	(1) Not Really Useful To Me	(2) I Use This but It Does Not Shorten Detailed FSS Briefings	(3) This is of Moderate Value In That It Reduces The Length Of FSS Briefings	(4) Overall This is Great And Sometimes It Eliminates FSS Briefings	(5) This is My Main Source/Service For Weather And I Rarely Require FSS Briefings
1. Local Media (Radio/TV/Newspaper)	☐	☐	☐	☐	☐
2. National Weather Service (NWS) Briefing	☐	☐	☐	☐	☐
3. Self-Briefing at Private or Government Meteorological Office	☐	☐	☐	☐	☐
4. Transcribed Weather Broadcast (TWEB) by Radio	☐	☐	☐	☐	☐
5. Telephone Dial-up to a Transcribed Weather Broadcast (TELE-TWEB)	☐	☐	☐	☐	☐
6. Pilot's Automatic Telephone Weather Answering Service (PATWAS)	☐	☐	☐	☐	☐
7. National Oceanic and Atmospheric Administration (NOAA) Weather Broadcast - VHF FM Radio	☐	☐	☐	☐	☐
8. Corporate, Military, Private or Airline Meteorological Service	☐	☐	☐	☐	☐
9. Enroute Flight Advisory Service (EFAS) "Flight Watch"	☐	☐	☐	☐	☐
10. FSS Scheduled Hourly Broadcast (Quarter Past the Hour)	☐	☐	☐	☐	☐
11. Automatic Terminal Information Service (ATIS)	☐	☐	☐	☐	☐
12. Center or Tower Radio Communication	☐	☐	☐	☐	☐

80-6-A-3

NOTE: IN PART II A, IF YOU INDICATED USE OF THE TWEB RADIO SERVICE, PLEASE ANSWER QUESTIONS A AND B ONLY OF PART III BELOW. IF YOU DID NOT INDICATE USE OF THIS SERVICE, BUT AT ONE TIME YOU DID USE IT, PLEASE ANSWER QUESTION C ONLY OF PART III.

III. TRANSCRIBED WEATHER BROADCAST (TWEB) RADIO SERVICE

A. Based on your most recent experience in listening to TWEB in the immediate local area where you live/fly, rate each of the characteristics listed in the left hand column. For each characteristic, it is suggested that you review the 5 possible choices, for the rating scales are different. Then place a check mark in that block which best describes your opinion.

(1) Broadcast Reception	☐ Excellent	☐ Good	☐ Fair	☐ Poor	☐ Unsatisfactory
(2) Facility Identifier Overriding Message	☐ No Problem	☐ Marginal Effect	☐ Sometimes an Effect	☐ Considerable Effect	☐ Always A Problem
(3) Message Length	☐ Excessively Short	☐ Short	☐ Just Right	☐ Long	☐ Excessively Long
(4) Message Format	☐ Excellent	☐ Good	☐ Fair	☐ Poor	☐ Unsatisfactory
(5) Speaker's Enunciation	☐ Excellent	☐ Good	☐ Fair	☐ Poor	☐ Unsatisfactory
(6) Speech Rate	☐ Too Slow	☐ Slow	☐ Just Right	☐ Fast	☐ Too Fast
(7) Message Currency and Accuracy	☐ Excellent	☐ Good	☐ Fair	☐ Poor	☐ Unsatisfactory
(8) Ability to Comprehend Message	☐ Very Easy	☐ Easy	☐ Sometimes Difficult	☐ Difficult	☐ Very Difficult

80-6-A-4

III. <u>TRANSCRIBED WEATHER BROADCAST (TWEB) RADIO SERVICE</u>

B. When you listen to TWEB, is it:

(1) On the Ground <u>Only</u> ☐

(2) In Flight <u>Only</u> ☐

(3) <u>Both</u> On the Ground and In Flight ☐

C. Since you at one time used the TWEB radio service but stopped using it, was it because of:

(1) Unsatisfactory Message Content ☐

(2) Unintelligible Broadcasts ☐

(3) Service became unavailable ☐

(4) Other Services Met Your Needs Better ☐

(5) Other Reasons Not Indicated Above ☐

80-6-A-5

APPENDIX B

CHARTS DEPICTING THE REGIONAL TWEB CONFIGURATIONS

LIST OF ILLUSTRATIONS

The purpose of this appendix is to provide the reader with a vivid insight into the diversity and complexity of the various FSS recorder/outlet configurations existing throughout the national TWEB network.

For illustrative purposes, this information appears in regional chart form in figures A-1 through A-9 and is based on data collected and verified by the project team through August 1979.

Each chart shows the respective TWEB FSS's comprising that region, the type(s) of recorder equipment each TWEB FSS employs, and the associated TWEB FSS's outlet configuration. Lines joining the TWEB FSS to the outlet(s) are not to be construed as the actual landline hookups, rather their intent is to depict the operational flow of TWEB transmissions to the outlets.

Concerning the charts, some additional comments are in order. The TWEB outlets are depicted soley by nearest city and not actual locations. Instances where certain TWEB FSS's remote messages to outlets in an adjoining region are shown. Further depicted are instances where the reverse situation occurs; namely, where TWEB FSS's in an adjacent region remotes messages to one or more outlets contained in the primary region of concern.

While the initial aim of accurately depicting the national TWEB configuration was intended as an aid for the project team, the importance of its other practical applicational uses became apparent. For example, the charts were instrumental as aids in the cost analysis of the national TWEB configuration. Moreover, since no charts on earlier configurations of TWEB were ever found in documentation received by the project team, the consensus was that these charts should be published as part of this report.

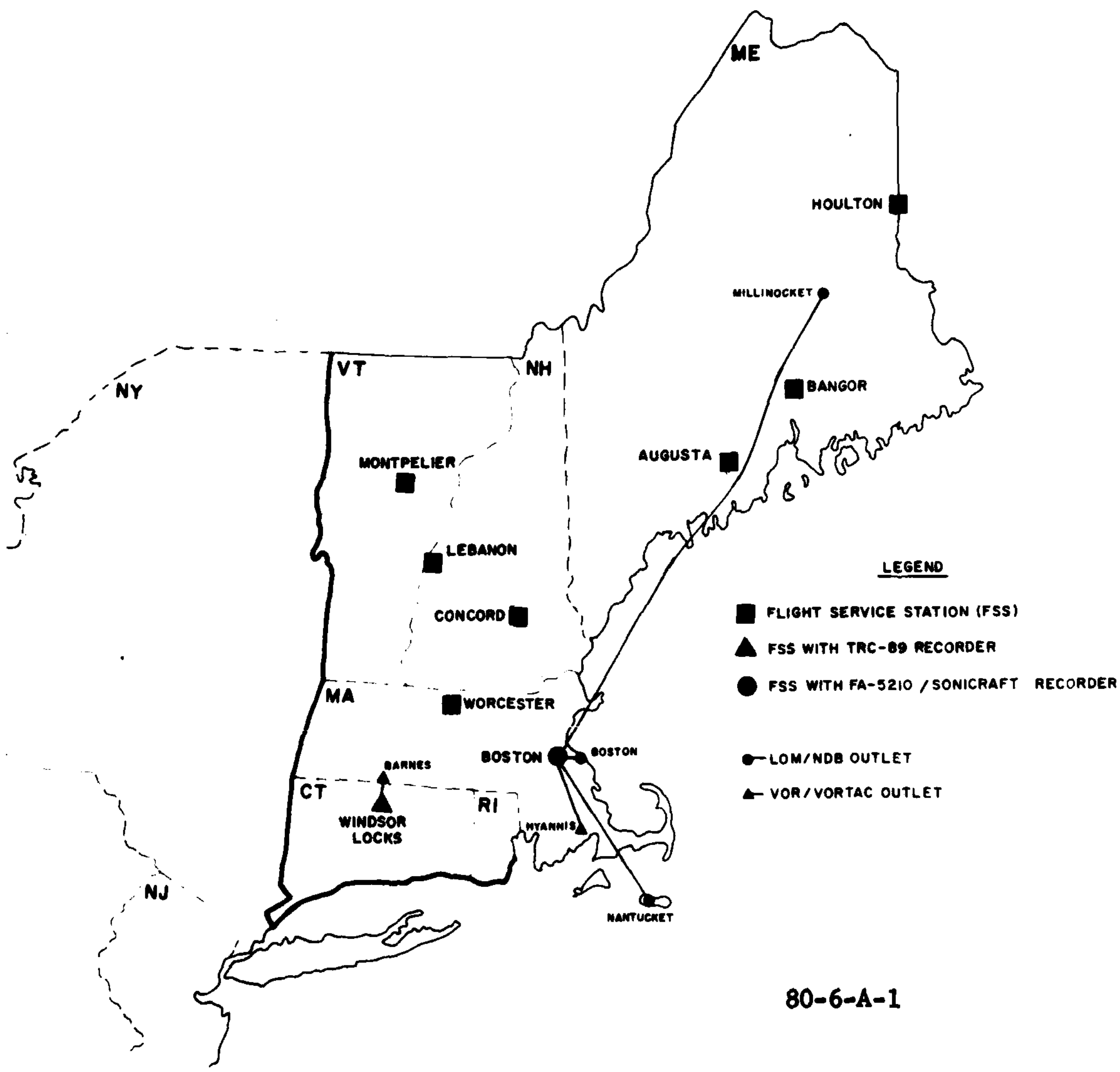
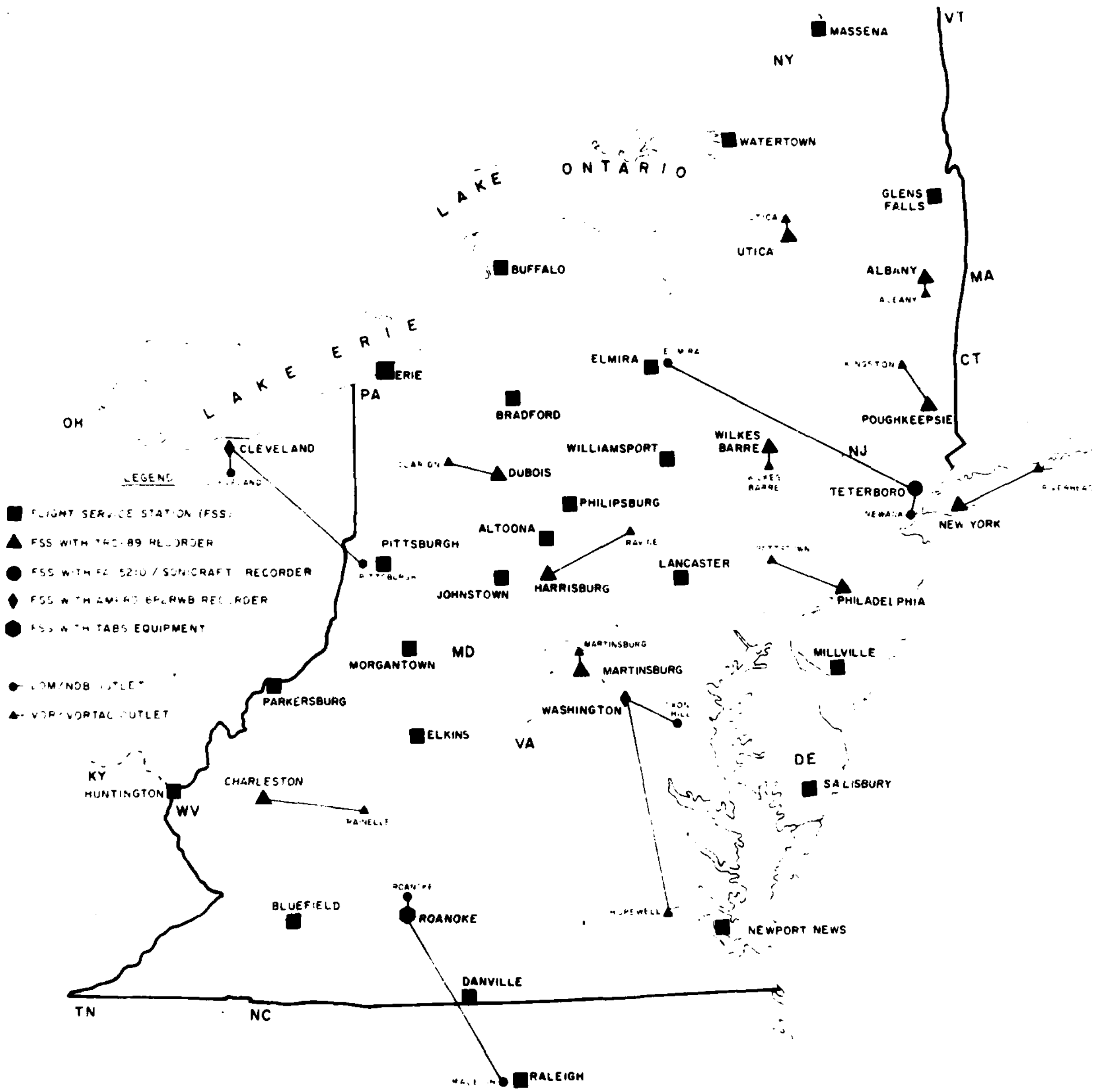


FIGURE B-1. TWEB CONFIGURATION, NEW ENGLAND REGION



80-6-A-2

FIGURE B-2. TWEB CONFIGURATION, EASTERN REGION

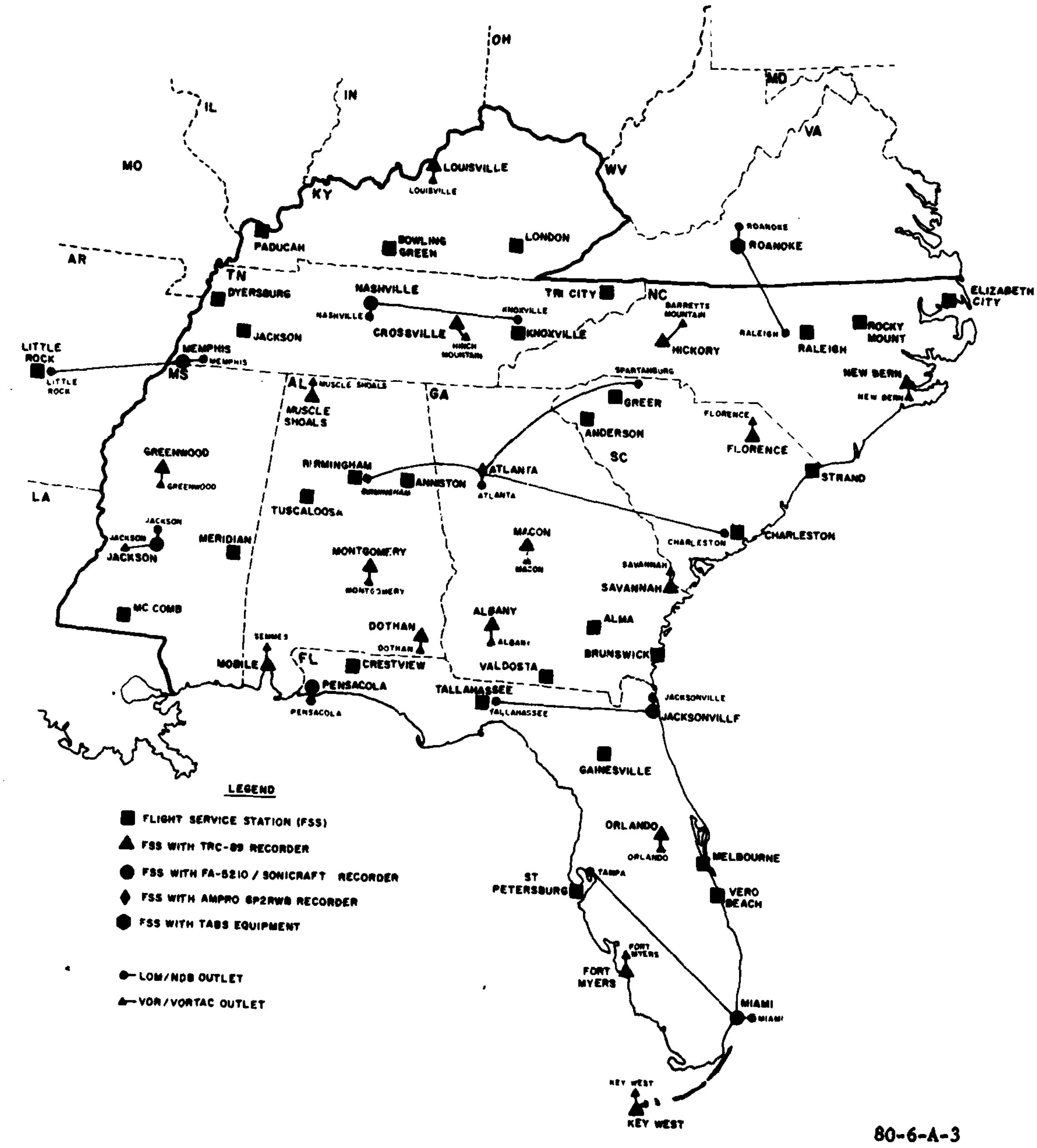


FIGURE B-3. TWEB CONFIGURATION, SOUTHERN REGION

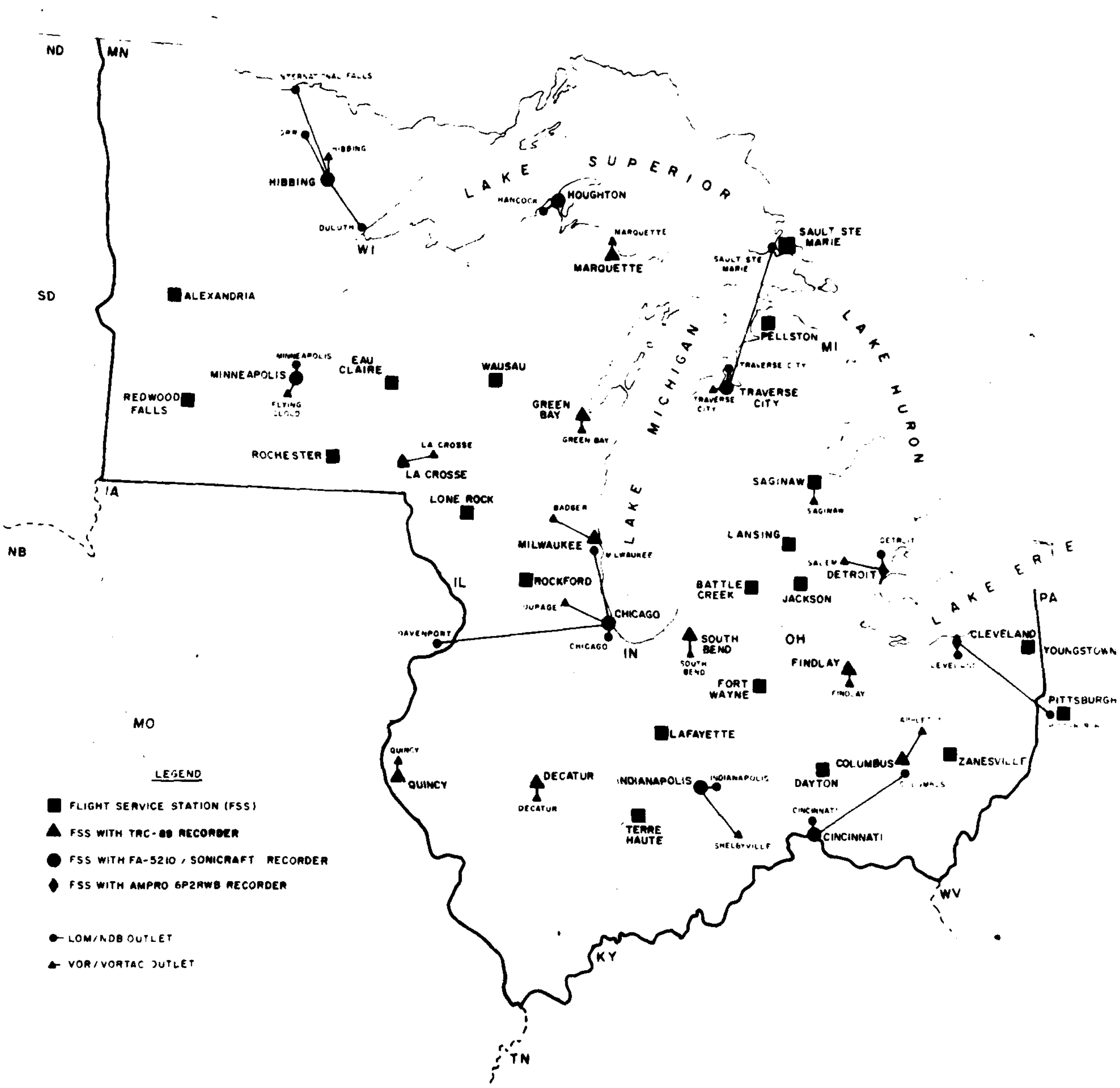


FIGURE B-4. TWEB CONFIGURATION, GREAT LAKES REGION

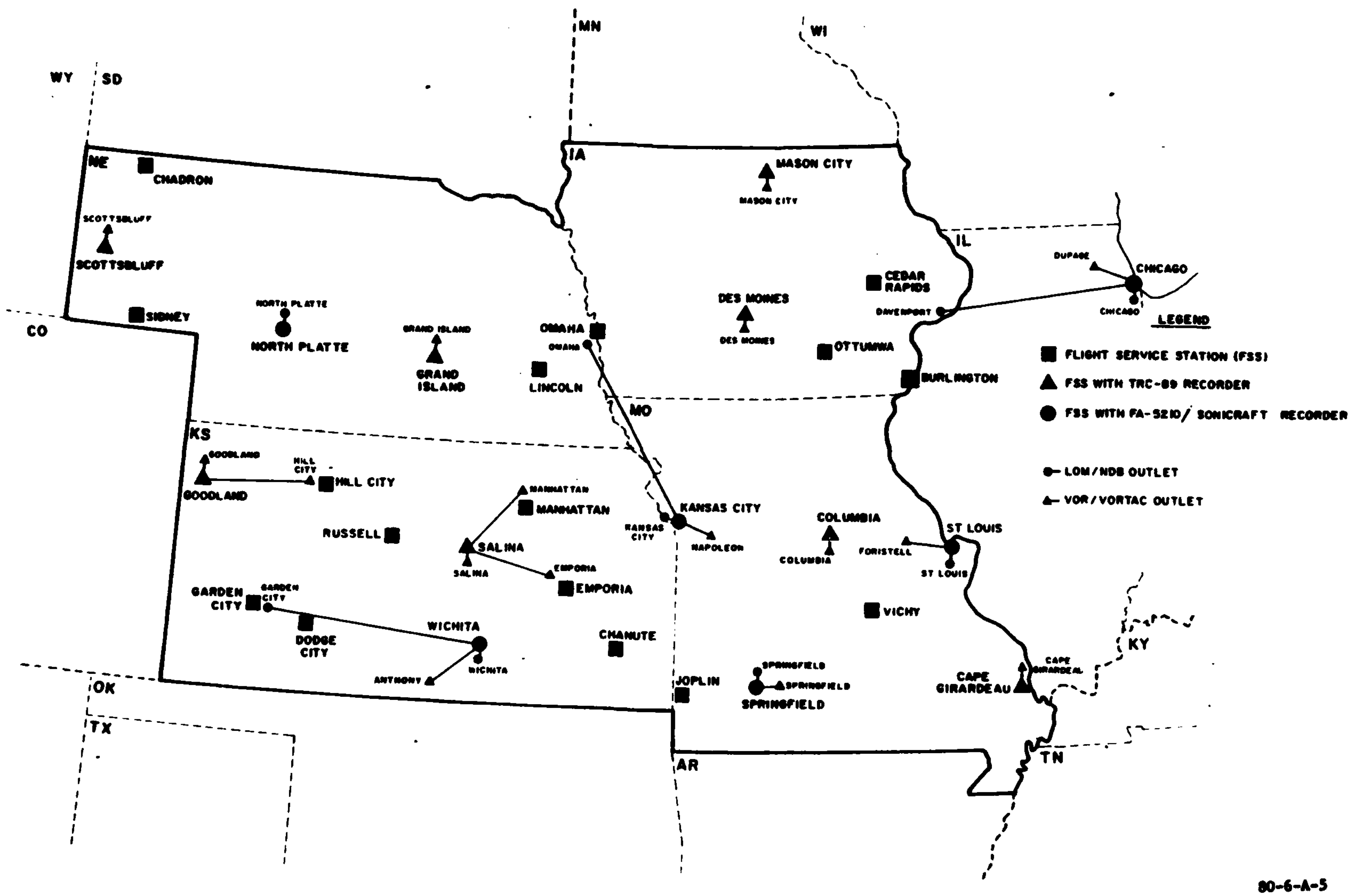


FIGURE B-5. TWEB CONFIGURATION, CENTRAL REGION

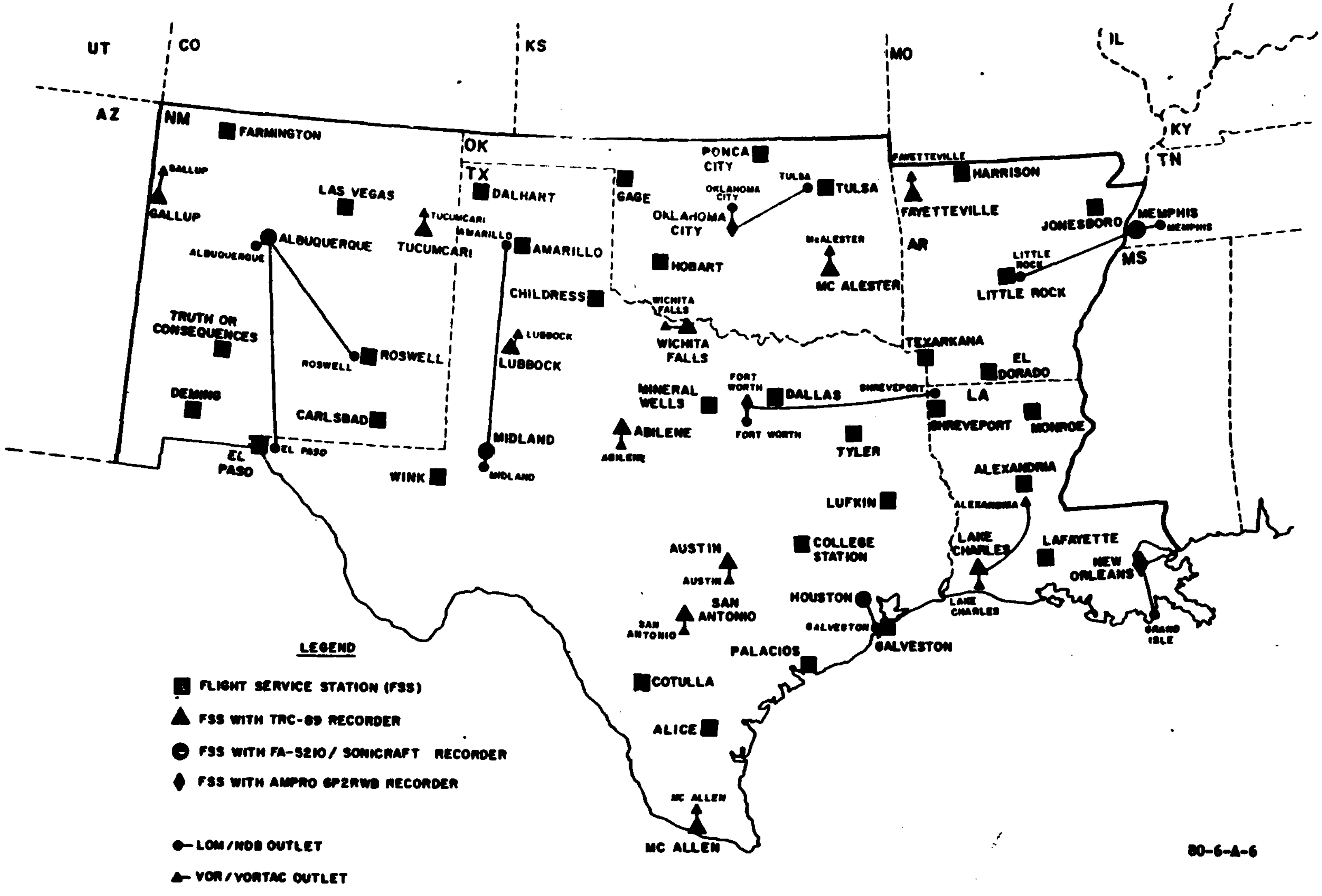


FIGURE B-6. TWEB CONFIGURATION, SOUTHWEST REGION

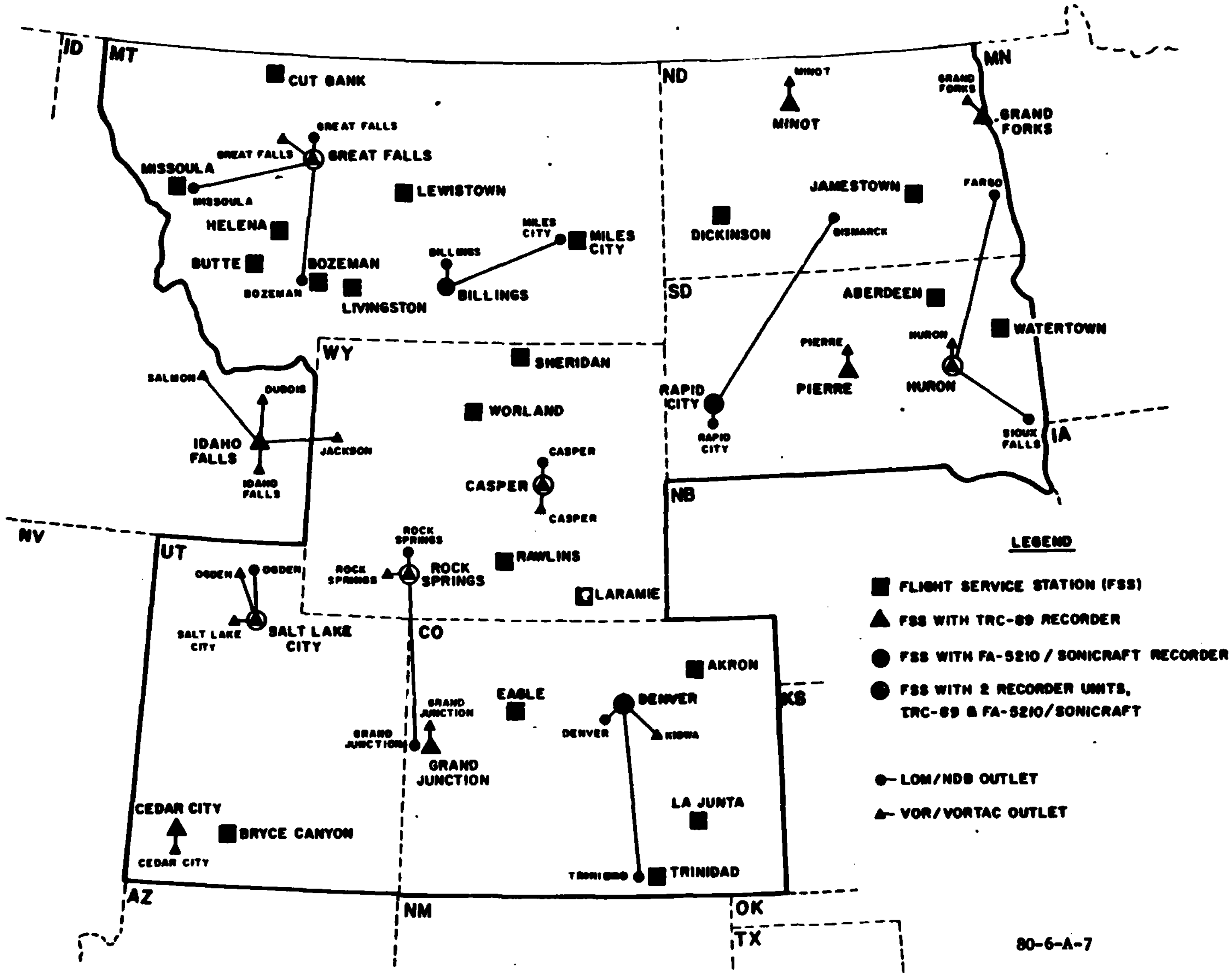


FIGURE B-7. TWEB CONFIGURATION, ROCKY MOUNTAIN REGION

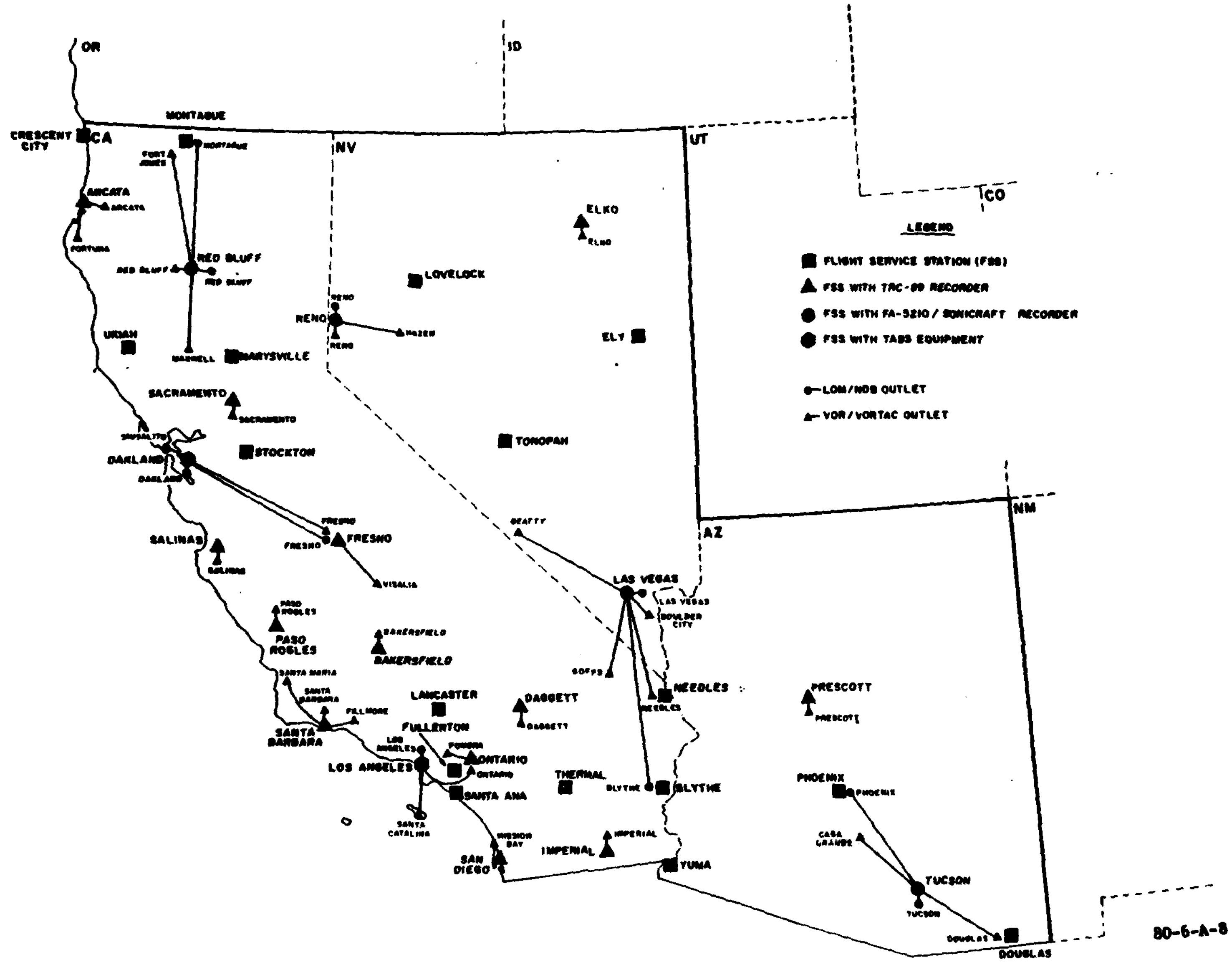


FIGURE B-8. TWEB CONFIGURATION, WESTERN REGION

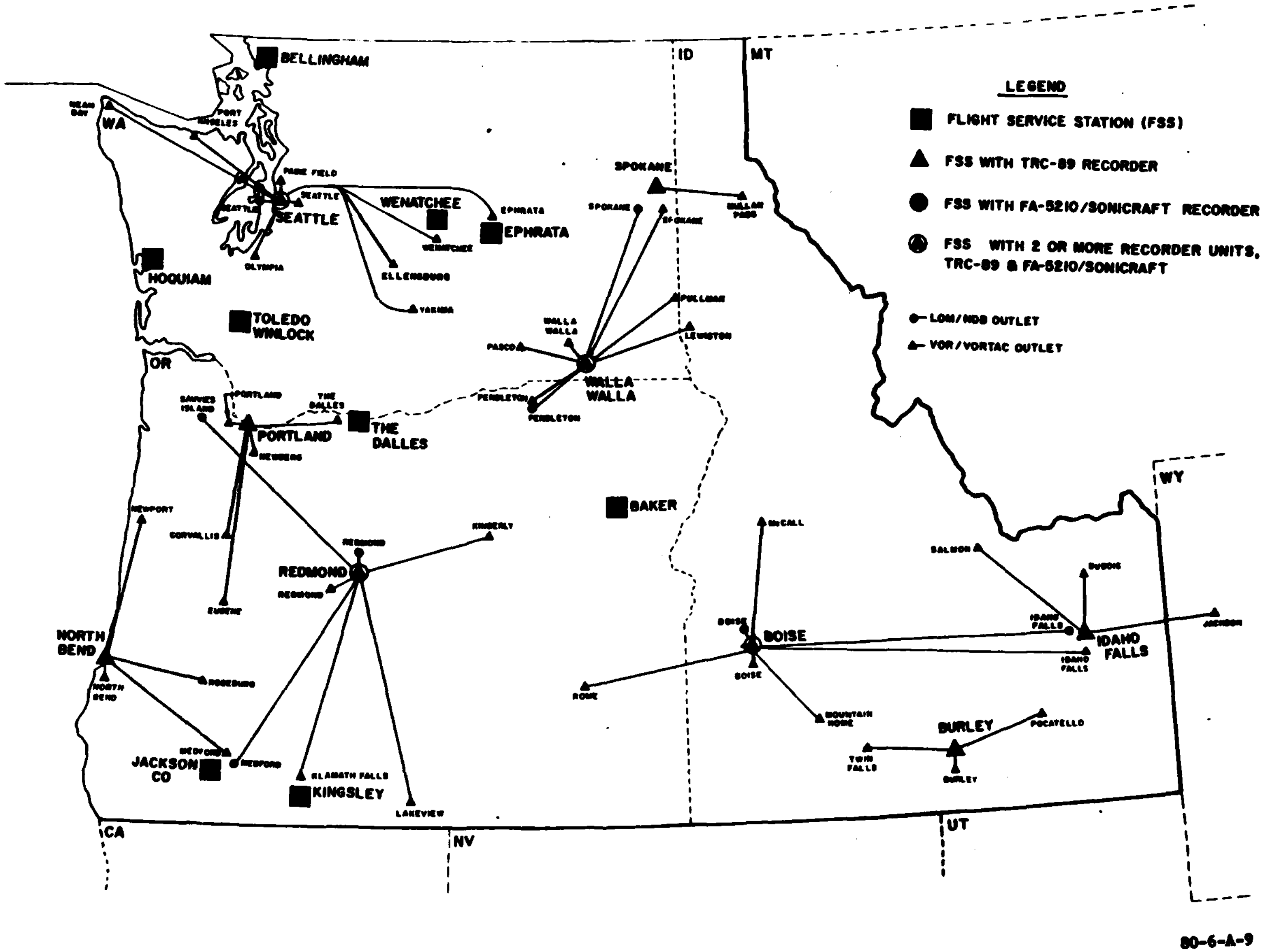


FIGURE B-9. TWEB CONFIGURATION, NORTHWEST REGION

APPENDIX C

FACILITIES FURNISHING TELEPHONE ACCESSIBLE MASS WEATHER DISSEMINATION SERVICES

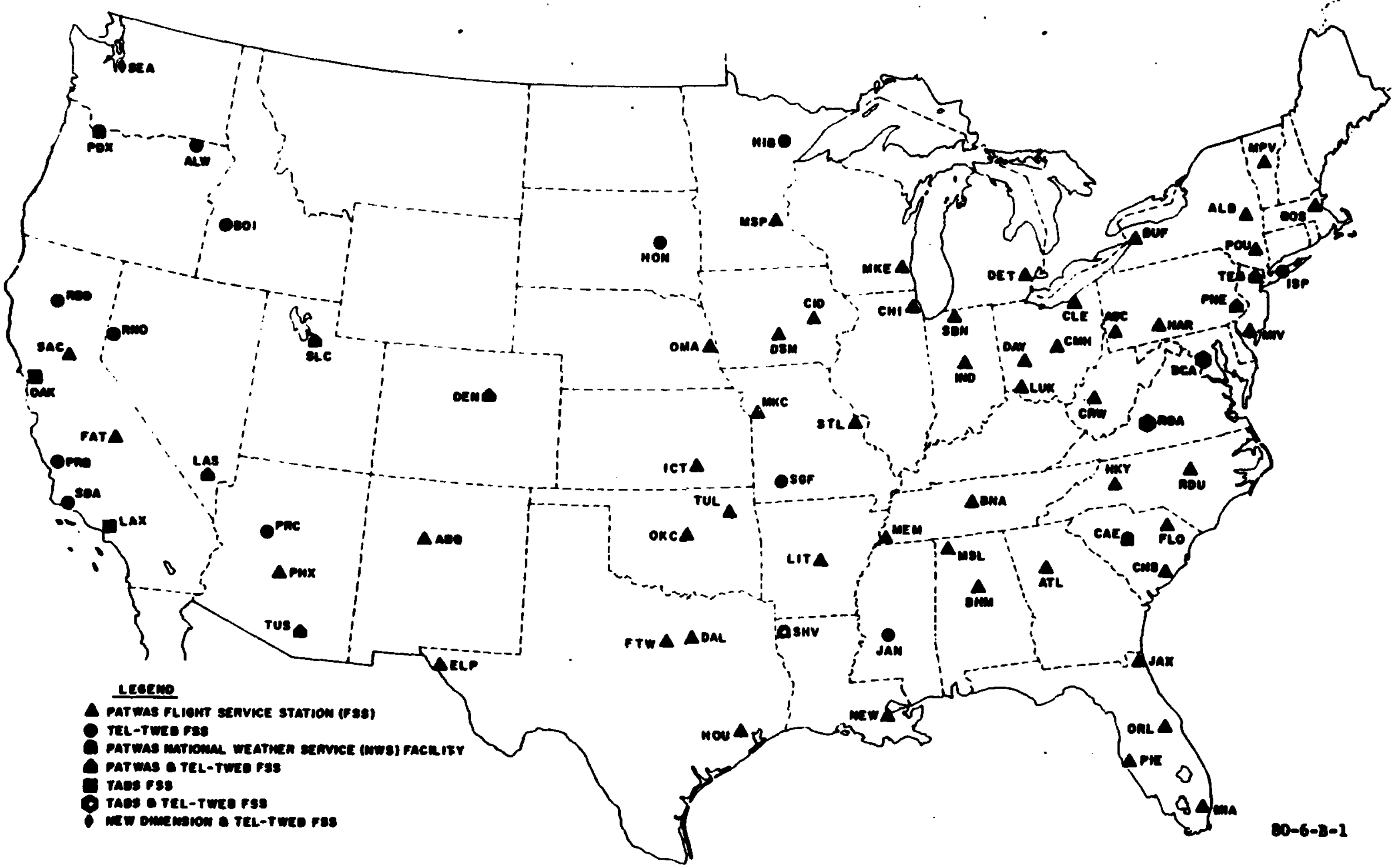


FIGURE C-1. FACILITIES PREPARING TELEPHONE ACCESSIBLE MASS WEATHER DISSEMINATION SERVICES