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Pilot Weather Advisor

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Abstract

This report gives the results of the work performed by ViGYAN, Inc. to demonstrate the Pilot Weather Advisor cockpit weather data system using a broadcast satellite communication system. The Pilot Weather Advisor (developed under the NASA Langley Research Center Small Business Innovation Research Program 90-1, subtopic 03.02, Aircraft Severe Weather Environments) demonstrated that the technical problems involved with transmitting significant amounts of weather data to an aircraft in-flight or on-the-ground via satellite are solvable with today's technology. The Pilot Weather Advisor is an excellent solution for providing accurate and timely weather information for aircraft.

The purpose of the Pilot Weather Advisor is to improve the safety and utility of aircraft operations by providing automatic updates of the weather situation to the in-flight pilot in a form that is easily understood in terms of the planned mission. Current weather detection and dissemination systems for general aviation are not completely satisfactory. Airborne radar is expensive, often impractical for small single engine aircraft, has a relatively short range, and severe attenuation in heavy rain. Lightning detectors do not provide indications of precipitation and do not give accurate ranges for lightning activity. Radio contacts with ground sources to acquire weather data requires considerable effort; at times is impractical; and does not always provide an adequate representation to permit strategic flight planning. The Pilot Weather Advisor will overcome most of these disadvantages by automatically providing near real-time graphical depictions of weather information in the aircraft via satellite communications.

In Phase I the Pilot Weather Advisor collected NWS surface observations and WSI NOWRAD radar data four times each hour. These surface observations and radar data were encoded into a data stream by STX in Lanham, MD and then sent via telephone communications to the GTE satellite Earth Station in Grand Junction, CO for uplink to the GSTAR I communications satellite. The data stream was then broadcast covering the Continental United States area. This data stream was received by a Qualcomm satellite communications system provided by NIALL Enterprises of Belmont, WI on-board the aircraft. The data stream was processed and displayed on a PC/AT computer as a graphical depiction of the surface observations and radar data for a given geographical area using the software developed by STX in support of the FAA Pilot Advisor Weather Support System (PAWSS) program. These graphical depictions show the Visual Flight Rules/Instrument Flight Rules (VFR/IFR) status, the weather of reporting airports, and the current radar data for the area. The aircraft position is also displayed to enable the pilot to determine the best course of action in the presence of hazardous weather.

Abbreviations

ASCII	American Standard Code for Information Interchange
ATC	Air Traffic Control
CAT I	Category 1 Weather Conditons
COM	Serial Communication Port on a Personel Computer
DOS	Disk Operation System
FAA	Federal Aviation Adminstration
FSS	Flight Service Station
ID	Identitifcation
IFR	Instrument Flight Rules
LIFR	Low Instrument Flight Rules
MVFR	Marginal Visual Flight Rules
NASA	National Aeronautical and Space Adminstration
NOWRAD	Radar Data Product from WSI
NWS	National Weather Service
PAWSS	Pilot's Advisor Weather Support System
PC/AT	Personal Computer
PWxA	Pilot Weather Advisor
RAM	Radom Access Memory
RS	Record Special Airway Observation
SA	Surface Airway Observation
SP	Special Airway Observation
SBIR	Small Business Innovation Research
TV	Television
VGA	Video Graphics Array
VIP	Video Integrated Processor
VFR	Visual Flight Rules
WSI	commerical provider of weather data, subsidiary of Technical Application Science Corp.
Z	Zulu time

Introduction

This report gives the results of the work performed by ViGYAN, Inc. under contract NAS1-19250 as Phase I, of the NASA Langley Research Center Small Business Innovation Research (SBIR) program 90-1, subtopic 03.02, Aircraft Severe Weather Environment. This subtopic requested "Innovative concepts for an airborne weather monitoring and processing system that will accept data from various sensor units (airborne and ground based) to provide hazardous weather information to the pilot". In response to this request, ViGYAN proposed to apply the results of the Pilot Automated Weather Support System to develop the Pilot Weather Advisor. The Pilot Weather Advisor puts large amounts of weather data on-board aircraft using a satellite communications system and displays this data to the pilot in a suitable color graphic format.

The Phase I work was performed during January 1991 through September 1991 by ViGYAN and its subcontractors, and is reported herein. ViGYAN is now involved in the Phase II of the NASA SBIR program to develop and test a Pilot Weather Advisor system for commercial service.

PWxA System Description

The purpose of the Pilot Weather Advisor (PWxA) is to improve the safety and utility of aircraft operations. The PWxA system shown in figure 1 provides near real-time graphical depictions of weather information in the aircraft via satellite communications. The PWxA collects National Weather Service (NWS) Sequence Weather Reports (surface observations) and WSI NOWRAD radar data four times each hour. These surface observations and radar data are encoded into a broadcast data file and then sent via telephone communications to a satellite earth station for uplink to a communications satellite. The data file is then broadcast over the Continental United States. This data file is received by a satellite communications system on-board an aircraft. The data file is processed and displayed on a PC/AT computer as a graphical depiction of the surface observations and radar data for a given geographical area. These depictions show the VFR/IFR status and the weather elements of reporting stations and the current radar for the area. The aircraft position is also displayed to enable the pilot to determine the best course of action in the presence of hazardous weather.

The PWxA depictions are a subset of the depictions developed in the Pilot Automated Weather Support System (PAWSS) project. (Ref. 1) The depictions used by the PWxA included regional data for "Airport/Station Weather", (Airport Weather), and "Airport/Station Category", (Airport Category), a regional version of ground weather radar reflectivity "Mosaic Radar" (Radar), and Airport/Station Identification (Station ID). The Station ID depiction is a summary of the geographical region and is shown in figure 2. The Airport Category depiction shown in figure 3 is a graphical display of the VFR/IFR condition at specified observation stations. The Airport Weather depiction shown in figure 4 is a graphical display of the weather elements at specified observation stations. The Radar depiction shown in figure 5 is a mosaic of the current precipitation radar for a given geographical region. All the displays use color to differentiate the different conditions of Airport Weather, Airport Category, and Radar conditions.

Ground Data Processing System

The weather data acquisition and ground processing systems were constructed by ST Systems Corporation (STX) at its Lanham, MD facility using real-time weather data from the NWS and WSI. New concepts and designs for the real-time data processing software and broadcast data formats were developed for the PWxA, and operated in support of the SBIR Phase I effort.

Ground data processing was initiated to broadcast a final data file four times per hour on the quarter hour. The quarter hour intervals were defined as A, B, C, and D intervals with A being the first quarter hour. Processing for the Airport Weather and Airport Category during this SBIR Phase I effort was time consuming, and therefore started 10 minutes before the broadcast time.

Processing for the radar data was relatively rapid. However, the WSI NOWRAD radar for the quarter hour was not available to users until about 10 minutes after the time of observation, the delay in delivery ranged from 9 to 11 minutes.

An overall data flow diagram for the PWxA is shown in figure 6, identifying the major data stores at both the ground and aircraft processing segments.

Airport Weather and Airport Category Data

The PWxA Airport Weather and Airport Category data were obtained from the NWS Sequence Weather Reports (SA, SP, or RS) referred to as surface observations. The SA and RS reports are specific weather observations taken at designated reporting sites throughout the United States. These observations are usually made hourly at 50 minutes past the hour and are available within 15 minutes of the observation time. When the weather conditions are changing a special observation (SP) is made at any time during the hour.

The surface observations are available as ASCII data from the NWS data file and are acquired and stored "as is" in a file on an hourly basis, beginning ten minutes before broadcast time. The data file is "frozen" temporarily four times per hour to transfer all surface observation reports to the ground data processor. The PWxA ground data processor deciphers these SA, SP, and RS into a broadcast file format.

For Airport Weather, shown as a diamond, the given conditions are displayed in the PWxA depiction as the corresponding colors:

Condition	Color
no report	clear/clear
no weather, ceiling ≥ 3000 ft. or visibility ≥ 5 mi.	white/white
ceiling < 3000 ft.	green/green
rain or drizzle	blue/white
obstruction to vision	white/yellow
both rain or drizzle and obstruction to vision	blue/yellow
hazardous weather	red
winds > 20 kt.	white outline

For Airport Category, shown as a circle, the given conditions are displayed in the PWxA depiction as the corresponding colors:

Condition	Color
no report	clear/clear
ceiling > 3000 ft. or visibility ≥ 5 mi. (VFR)	white
ceiling ≤ 3000 ft. or visibility < 5 mi. (MVFR)	green
ceiling < 1000 ft. or visibility < 3 mi. (IFR)	blue
ceiling < 500 ft. or visibility < 1 mi. (LIFR)	yellow
ceiling < 200 ft. or visibility < 0.5 mi. (<CAT I)	red

Figure 7 shows the a typical SA for LSE (LaCrosse, WI) and how the PWxA ground processor deciphers an SA into Station ID, Airport Category, and Airport Weather. The colors for the PWxA depiction differentiate the flying conditions set by the FAA guideline. For the LSE SA shown in figure 7 the Airport Category (circle) color is white and the Airport Weather (diamond) color is all red. An additional feature not show in figure 7 is that if the winds are greater than 20 knots the weather symbol (diamond) is outlined in white instead of black.

Once the surface observations have been deciphered into Station ID, Airport Weather, and Airport Category, they are combined into a *.SFX file which will be merged with the Radar data file and then broadcast.

The Stations selected and used for the PWxA are set in the ground processing system for a given geographical region. The geographic regions for the PWxA SBIR Phase I was centered on Dubuque, IA (DBQ). The stations used for the DBQ geographical region are listed in Appendix A.

Radar Data

The PWxA Radar data are obtained from the WSI NOWRAD radar data. The radar data are acquired using the usual commercial access method supported by the WX-VIEW software of Robertson Software, Inc. The user downloads a regional mosaic radar at 320 by 240 resolution in six reflectivity levels, in the cylindrical equidistant map projection centered on the desired station site (for Phase I Dubuque, IA). The data are then displayed on a PC/AT at the 640 by 480 resolution, and written to a flat image file. The flat image file is then processed to create a Radar broadcast file (*.RX). The Radar broadcast file provides the WSI NOWRAD radar data as an 80 by 60 line grid with four reflectivities.

The Radar reflectivity levels are assigned the following values based on the Video Integrated Processor (VIP) assessments of the precipitation intensities for the given conditions and displayed as the corresponding colors:

Condition	Color
zero reflectivity	Clear (not drawn)
non-zero reflectivity, VIP levels 1 and 2	green
non-zero reflectivity, VIP levels 3 and 4	yellow
non-zero reflectivity, VIP levels 5 and 6	red

Once the Radar (*.RX) and Airport Weather/Category (*.SFX) broadcast files are generated they are merged together to create a final PWxA broadcast file (*.BX) A sample PWxA broadcast file including Radar, Airport Weather, Airport Category, and Station ID is shown as Appendix B.

Satellite Communications System

Communications satellites are positioned 22,300 miles above the equator and travel in an orbit that is synchronized with the rotation speed of the earth. The satellites that broadcast to North America are positioned along the equator between 55 and 140 west longitude. From there they cast a signal over the entire Continental United States.

Current communication satellites are made up of 16/24 transponders that are roughly similar to TV channels when used for television or other broadband distribution services. These channels are readily divided into much narrower bandwidth segments for data uses called Single Channel Per Carrier applications (the technology used for the PWxA).

To reach the satellite requires an earth station that uses a large, highly directional antenna system to avoid interfering with adjacent satellites. These earth stations are used to format the information for transmission to various transponders on satellites and to exercise the quality control function over the entire process.

NIALL Enterprises, Inc., Belmont WI, was operating a Piper Malibu aircraft in a test mode with a Qualcomm satellite communications system on-board. NIALL has developed a satellite communications data link for its own proof-of-concept use to deliver air traffic controllers' radar data to the cockpit to generate a cockpit display for collision avoidance purposes (Ref. 2). It was a relatively simple matter to deliver weather data on this data link instead of air traffic controllers' radar data. ViGYAN negotiated with NIALL to provide the use of this aircraft and satellite communications system for the PWxA test flights in the Wisconsin area. The PWxA test flights were successfully conducted using the satellite communications system described below.

For the series of test flights, the "satellite communications chain" of elements making up the communications system is shown in figure 8 and briefly described as follows:

1. The earth station and space segment were secured from GTE Spacenet on Ku band, (12 and 18 gigahertz), on the satellite GSTAR I located at 103 west longitude fed by a GTE Spacenet earth station at Grand Junction, CO.

2. The mobile satellite receive system mounted on the aircraft was a standard Qualcomm OMNITRACS system currently in use on over 14,000 semi-trailer trucks operating in North America. This system is a half duplex, two-way data (message) system using a patented mechanically steered antenna mounted on the mobile unit. The antenna tracks the satellite based on the received signal strength and internal software. The antenna was mounted on the nose of the aircraft as shown in figure 9.

3. The two-way OMNITRACS data system was modified to accommodate an additional satellite broadcast (one-way) data channel from transponder #12 on which the PWxA broadcast data file was carried at 9600 baud. Modulation and demodulation were accomplished with ComStream high speed VSAT data modems on each end of the satellite communications data link.

4. In the aircraft, the PWxA broadcast data were fed to the COM 1 port of an IBM PS/2 Model 30 computer for use by the PWxA airborne processing system.

5. PWxA broadcast data were delivered to the GTE Spacenet ground station at Grand Junction, CO from STX at Lanham, MD via dial up telephone modem at 2400 baud.

PWxA Airborne Processing System

The software for the airborne processing system of PWxA has been designed for the common PC/AT family of personal computers. This family of microprocessors provides a reliable and cost effective platform for the reception and display of the PWxA depictions. A serial data stream of the broadcast file is provided to the standard COM port 1 of the PC/AT at a standard baud rate. The user control of the PWxA is provided through a standard keyboard. The depictions developed for the PWxA by the PAWSS project are designed for a standard VGA video, which supports 16 programmable colors in a 640 by 480 display resolution.

The PWxA broadcast data files are received and processed to generate data stores and depictions as shown in figure 6. A complete byte-for-byte copy of the received data stream is collected into a quarter hourly series of files with the extension *.PCK. These data are subsequently scanned by a decoder to identify valid (error free) packets. Decoded data for the Airport Weather and Airport Category depictions are stored in a quarter hourly series of files with the extension *.SFM. Decoded data for the Radar depictions are stored in a quarter hourly series of files with the extension *.RAD.

The *.PCK, *.SFM and *.RAD series of quarter hourly files are uniquely identified by filenames. All data received during each quarter hour segment is logged into the latest (open) *.PCK file and is overwritten to the latest *.SFM and *.RAD files.

The PWxA requires, at a minimum, the following personal computer characteristics:

IBM PC/AT or compatible
VGA display (640 x 480) with at least 256 kByte video memory
640 kByte RAM memory
keyboard
system disk (DOS)

The system disk is prepared for the PWxA by creation of a directory (directory path and name are user's choice), plus two required subdirectories IMAGES and DATA with appropriate files.

The files in the ..\IMAGES subdirectory define the geographical map projection and list of valid Station Identifiers, respectively.

The *.PCK, *.SFM, *.RAD files are the stored PWxA data which are stored for playback and trend assessment of the depictions in the \DATA subdirectory.

The PWxA system is then executed running the PWxA executable:

PWXA.EXE

Users must follow the on-screen prompts to provide information on the parameters desired for COM port 1 (baud rate, parity and number of START and STOP bits). The PWxA will initialize, open COM port 1 for data acquisition, and start operations showing the initial PWxA introduction page. At this time, the PWxA is looking for valid user keypress or commands.

Test Aircraft

The aircraft utilized for the test flights was a Piper PA-46 Malibu, N711XL owned by Dave Stauffacher, President of EXCELL INNS, Inc. of Madison, WI. The aircraft was operated on all flights by Dave Stauffacher. A sketch of the aircraft showing the locations of the satellite communications equipment and the on-board PC is shown in figure 10. This equipment is not normally carried on the aircraft during flights.

Pertinent aircraft avionics include a Sperry Weather Radar, a Wx 1000 Storm Scope, an ARNAV 50i LORAN, a VOR/DME Area Navigation System, a VFIS Electronic Moving map, as well as the conventional VOR and NDB receivers.

Test Area

All test flight for the PWxA were conducted in the Wisconsin area as shown in figure 11. All test flights originated form Platteville, WI (PVB). Appendix A gives all the states and their stations included in the Wisconsin test area.

Preflight Test Scenario

Early in the day, available sources of weather information (commercial TV broadcast, Weather Channel, telephone FSS briefing) were utilized to formulate one or several flight test scenarios for the Wisconsin test area. The aircraft was then ferried from Madison to Grant County Airport near Platteville, WI (PVB). At PVB, the satellite communication equipment, PC, and display equipment were installed and checked out. The satellite communications were established and following execution of the PWxA software through the keyboard, the current PWxA depictions were displayed, reviewed, and compared with the previous knowledge of the weather situation. The flight test scenario for the day was then confirmed or modified, and the decision-to-go was made by the pilot.

Flight Test

Four complete test flights were flown with the PWxA system in June 1991. Each flight was documented with a video recorder, voice recorder, and the PWxA broadcast data and depictions. Because of the developmental nature of the PWxA system several changes were made to improve the PWxA system between flights. A detailed analysis was conducted for all the flights to determine the performance of the PWxA system. The June 25 and 26 flights were VFR; the June 27 flight was IFR, with the ATC Clearance obtained via telephone from PVB, and picked up in the air after a VFR takeoff. The last flight (June 27, 1991) is discussed in this report.

June 27, 1991 Flight

Summary: A morning IFR flight was conducted from Platteville, WI (PVB) to Minneapolis, MN (MSP) in Visual Meteorological Conditions with a landing at MSP, and a return flight later that afternoon. Takeoff from PVB was at 9:09 a.m. CDT, and landing at MSP at 10:39 a.m. CDT. The route of flight to MSP, takeoff, and landing times are shown in figure 11, along with a list of the PWxA depictions received during the flight. The aircraft path and position data shown herein were added after the flight.

Preflight: Information indicated a line of possibly severe convective weather was in the Wisconsin test area, stretching from southwestern through northern Minnesota. Cell movement was 25 to 35 kt along the line; the line itself was supposed to move slowly southeast. The MSP terminal forecast shown below, indicated a reasonable chance of success for the flight.

> MSP FT 270808 C 80 BKN 1812. 11Z 25 SCT C 80 BKN 1810 CHC C 25 OVC 3TRW. 15Z 50 SCT 100 SCT C 250 BKN 1915 CHC C 40 OVC 5TRW AFT 21Z. 02Z VFR TRW

This situation was confirmed with the first depictions (13B) which were received on the ground at about 1400Z, figure 12 and 13. VFR conditions existed along the route of flight with the line of convective activity positioned a little farther northwest than expected. It was decided to fly to MSP and land there if possible, using the PWxA system to monitor the development and movement of the convective weather line.

Enroute: After a VFR takeoff at 1409Z, the IFR clearance was received from Chicago Center to climb and maintain 8,000 feet via Rochester (RST) and then direct MSP. The Storm Scope showed lightning activity at about 80 and 100 miles at 11 to 12 o'clock positions, even though the aircraft was about 220 miles from the convective weather line.

The first depiction received in the air was 13C, figure 14, at about 1430Z. This 13C depiction showed a further spread of the storm into northern WI, and a yellow (level 3 or 4) cell northwest of MSP. Some yellow appeared at the southwest end of the line. The line was between MSP and Alexandria (AXN), just east of Brainerd (BRD). Some low level radar activity was noted in central Wisconsin that did not appear on the NWS Radar Summary reviewed after the flight.

Several times the aircraft position was manually entered into the system and shown on the display. This greatly reduced the effort to interpret the depiction. The approximate aircraft positions were determined and plotted after the flight on the figures in this report as an "X".

Just before 1445Z, the Storm Scope indicated lightning activity at about 125 miles, at the 12 o'clock position. This appeared to correlate with the position of the line on the (13C) Radar depiction, figure 14.

When the 13D depiction, figure 15, arrived on-board it showed the line about 50 miles northwest of MSP had 3 yellow squares (levels 3 and 4) whereas at 13C it had one yellow square. It was decided to monitor this development closely. Subsequently the Storm Scope showed lightning activity 30 degrees left to 20 degrees right of the airplane heading at 150 to 200 miles.

The 14A depiction, figure 16, showed the line directly northwest of MSP was thinning out, and was dividing into two parts, northeast and southwest of our line of flight, and had not come closer to MSP. No surface observations were shown with this depiction. (It was later found that the STX ground processor for the surface observations had failed.) The Storm Scope showed at that time the same indications of lightning activity at 15 degrees right at 160 miles and 25 degrees right at 120 miles, with no activity indicated dead ahead.

During the flight, the cloud layer on the horizon ahead was rising steadily, and after 1500Z it rose to approximately 30 degrees above the horizon. Soon after this at about 59 miles out and 12,000 feet altitude, MSP approach started vectoring the aircraft for descent into the MSP terminal area. At about 1516Z the aircraft was under a high overcast that extended to the horizon on the left, but above and out of the field of view to the right.

When the 14B depiction was received at about 1515Z, figure 17, it showed that the storm line was still 50 miles northwest of MSP, and that the yellow (levels 3 and 4) had moved northeast to a point directly north of MSP. Some yellow did appear down to the southwest end of the line in South Dakota. It appeared that the cells were moving along the line to the northeast, but the line was not moving toward MSP.

The 14B depiction continued to show the low level radar activity in central to eastern Wisconsin. The MSP Automated Terminal Information Service Kilo obtained at this time indicted CONVECTIVE SIGMETS 19C and 20C were current. MSP 1453Z weather was 9500 scattered, 15000 scattered, estimated ceiling 20,000 broken, visibility 12 miles, temperature 84 F, dew point 69 F, wind 200 at 14 knots with the altimeter at 29.83. Because of the proximity to landing and the active vectoring of approach control there was little opportunity to contact Flight Service to determine the content of the SIGMET advisory. The aircraft landed at MSP on runway 11R at 1539Z in Visual Meteorological Conditions.

After landing, the PWxA system remained on, and 14D depiction was received, figure 18, at about 1545Z. This showed that no immediate threat existed at MSP, although some red (levels 5 and 6) had appeared down to the southwest end of the line. The next depiction 15A was not sent by STX and therefore not received. The last depiction 15B, figure 19, was received on the ground at about 1615Z also without surface observations. This confirmed the overall trend, that MSP was "safe" and our flight route home to PVB showed no convective activity.

System Performance, June 27, 1991 Flight

For a complete analysis of the system performance, the flight was broken down into a discrete set of events from which it was possible to determine the errors in the system. Below is the procedure required to obtain a depiction in the aircraft as described earlier. This procedure is repeated every 15 minutes.

1. NWS Sequence Weather Reports are processed to obtain desired surface observations.

2. Surface observations are then assembled into Airport Weather and Airport Category for specified stations. (*.SFX files)

3. WSI NOWRAD radar data are assembled into Radar for the specified test area. (*.RX files)

4. The Surface observations and Radar files are then combined into a Broadcast file and broadcast to the aircraft. (*.BX files)

5. The Broadcast files are then received by the satellite receiver and sent to the on-board PC for processing. These Broadcast files when received are saved. (*.PCK files)

6. The Received files are then processed and Displayed on the PC monitor.

By comparing each step of the procedure an estimation of the system performance can be determined. This analysis cannot separate the system errors and possible human errors associated with each step in the procedure. The system performance analysis was conducted for this flight by comparing what was the original surface observation with what was displayed in the aircraft. The analysis is broken into the following steps and deals only with the surface observations:

1. Surface observations -- Broadcast (Ground Processing)

2. Broadcast -- Receive (Satellite Communications)

3. Receive -- Display (Airborne Processing)

4. Surface observation -- Display (Overall Performance)

The above steps cover all the aspects of the system which are the ground processing, satellite communications, airborne processing, and an overall performance.

Because this analysis only dealt with the surface observations, the analysis was performed only with data sets (broadcast files) that were complete with the surface observations and the radar data as shown in Appendix B.

For the flight on 6-27-91, PWxA Software Version 5, the analysis results are given below:

Display		Errors	%Errors
JUN27_13B	Surface Obs. -- Broadcast	10/49	20.4%
	Broadcast -- Receive	0/49	0.0%
	Receive -- Display	2/49	4.1%
	Overall Set Performance	**11/49**	**22.4%**
JUN27_13C	Surface Obs. -- Broadcast	9/49	18.4%
	Broadcast -- Receive	0/49	0.0%
	Receive -- Display	6/49	12.2%
	Overall Set Performance	**13/49**	**26.5%**
JUN27_13D	Surface Obs. -- Broadcast	9/49	18.4%
	Broadcast -- Receive	0/49	0.0%
	Receive -- Display	6/49	12.2%
	Overall Set Performance	**12/49**	**24.5%**
JUN27_14A	Surface Obs. -- Broadcast	10/49	20.4%
	Broadcast -- Receive	0/49	0.0%
	Receive -- Display	49/49	100.0%
	Overall Set Performance	**49/49**	**100.0%**
JUN27_14B	Surface Obs. -- Broadcast	10/49	20.4%
	Broadcast -- Receive	0/49	0.0%
	Receive -- Display	0/49	0.0%
	Overall Set Performance	**10/49**	**20.4%**

Overall Flight Surface Obs. -- Broadcast	19.6%
Overall Flight Broadcast -- Receive Error	0.0%
Overall Flight Receive -- Display Error	25.7%
Overall Flight Performance Error	**38.8%**

Several conclusions were drawn from the above analysis. The ground processing had some problems creating an accurate broadcast file. The process appeared to have specific problems with -X, -BKN, -OVC, double letters in the surface observations, problems with visibility at 5 miles, and stations reporting more than once during the hour.

The satellite communications were extremely reliable. The communications maintained a perfect score for these flight sets.

For this flight the airborne process experienced a complete software failure that caused a 100% error on the JUN27_14A display. This error could be attributed to several factors. The airborne software occasionally required a reboot of the on-board PC. This 100% error could have occurred during one of these reboots. If the 100% error is ignored from this analysis, the Overall Flight Receive -- Display Error is reduced to 7.1% and the Overall Flight Performance Error for this flight is 23.5%.

Overall performance of the PWxA system software for this flight was considered fair. This fair performance can be directly related to the ground processing software. The satellite and airborne processing software performed well if the 100% error of JUN27_14A is ignored as a possible human error. Automation of all the processes is required to avoid human errors and to provide a very low error system.

Flight Review and Data Comparison

This section contains available NWS weather data and maps pertinent to this flight. The maps were supplied by the FAA FSS at Patrick Henry Airport, VA (PHF), and the alphanumeric data were supplied by STX.

National Weather Depiction: The 16Z depiction, figure 20, indicated scattered to broken clouds along the route, with high bases (20,000 to 25,000 feet). West and north of MSP, there was overcast at 9,000 and 11,000 feet. The existence of the convective line northwest of MSP was not indicated. The 19Z depiction, figure 21, showed the route was VFR with scattered clouds at 4,000 feet visibility at DBQ. A stationary front was depicted northwest of MSP.

National Radar Summary: The 1335Z, 1435Z, 1535Z, and 1635Z data, figures 22, 23, 24, and 25, generally agree with the Radar depictions displayed on-board the aircraft. The location, intensity, and dynamic behavior as discussed earlier are well represented. However, the activity shown in the on-board depictions in central WI and southern IA are not shown on the National Radar Summaries.

Surface Observations: A complete listing of the surface observation for the flight are given in Appendix C. The performance of the PWxA system in depicting the surface observations was considered only fair because of software problems associated with the ground processing system as mentioned earlier in this report. The RWF and MSP observations are repeated below for 15Z, 16Z, and 17Z:

MSP SA 1453 95 SCT 150 SCT E200 BKN 12 095/84/69/1911/983/ 307 1078
RWF Missing

MSP SA 1553 100 SCT E200 BKN 12 098/83/70/1910/984/FEW ACCAS NW
RWF RS 1555 60 SCT E90 BKN 250 OVC 10 084/81/71/2212/980/TE40 MVD ENE OCNL LTGIC N

MSP SA 1652 100 SCT E150 BKN 200 OVC 10 093/88/71/1717G22/983
RWF SA 1651 55 SCT E95 BKN 250 OVC 10T 080/80/71/1912/979/TB17 OVHD-N MVG NE VIRGA W-N LTGICCG NW-NE

RWF SP 1730 55 SCT 95 SCT 250 -OVC 12 2309/982/TE15 MOVD NE DRK NE

The NWS Radar Summary supports the Radar depictions presented by the PWxA. The RWF SA 17Z indicates that thunder began at 1617Z overhead and to the north, and was moving northeast, with cloud-to-cloud and cloud-to-ground lightning to the northwest through the northeast. As noted from the other data types and the experience of the flight crew, the line of thunderstorms did not reach to MSP during this flight. For this flight the Airport Categories and Airport Weather depiction performance were considered only fair because of the errors associated with the ground processing as discussed earlier. In subsequent testing performed by the FAA PAWSS project in response to the errors found in using the PWxA system, several software changes were made by STX to improve the performance. These improvements reduce the performance error to less than 2% for the Airport Categories and Airport Weather depiction. If this performance capability for the PWxA system had existed during this flight, the overall performance error would have been about 2%. It is believed that this overall error can be reduced to significantly less than 1% in an operational system.

Pilot's Comments

The potential for the PWxA system became evident to the pilot, Dave Stauffacher. His comments included the following:

> "...It's great. The limitations on what we're doing is the quality and quantity of the data. It's that simple. Quality is the real-timeliness of it and the accurateness of it, because the older it gets, the less important it is. The ability

to get it into the airplane has been demonstrated. Software, we can do anything with, it's just a matter of how sophisticated you want to get. So it just boils down to what they're giving us on the other end, what the data stream looks like, and so its great what you're doing but we obviously have to refine that so they can turn data around very fast, because as we saw today, we had a tough time catching up with the weather sometimes..."

"Yeah...There's so much you can do! It was Good! OK. I'm just pleased, Good."

He indicated that the delay between getting the Radar depiction (approximately 15 minutes) was too long and he would like the option to see the actual surface observations in alphanumeric form.

He also indicated that the PWxA system set-up used in flight must be designed for minimum pilot workload and must be very reliable. He felt that if the display could be placed on the instrument panel, and possibly incorporated into the electronic moving map for navigation, it would reduce the overall workload and be very useful.

Conclusions

The PWxA system developed under the NASA SBIR program has demonstrated that the technical problems involved in transmitting significant amounts of weather data to a general aviation aircraft in-flight or on-the-ground via satellite are solvable with today's technology. The potential usefulness and need for the PWxA system concept was demonstrated to all those on-board the test flights. The Pilot Weather Advisor appears to be a viable solution for providing accurate and timely weather information for general aviation aircraft.

It must be noted that the usefulness of the Airport Category and Airport Weather depictions to flight management were not demonstrated due to the generally VFR weather encountered. Additional testing will be run under fall, winter, and spring conditions.

Future

ViGYAN Inc. has been awarded a Phase II SBIR from NASA to further develop the PWxA system into a commercial product. The future PWxA system will have many of the same features with additional improvements and more information.

Some of the improvements are:

1. Aircraft position automatically plotted on all depictions with a history of the aircraft track.

2. Better resolution in the Radar data block size (smaller than the 8 x 8 pixels per block).

3. A fast acting "looping" technique to permit quick trend assessment.

4. Complete automation of the ground processing of the PWxA system to improve accuracy and speed of the PWxA system.

5. Simplified control system.

6. Improved graphical depictions.

7. Automatic National Severe Storms Forecast Center "Watch Boxes" overlay on any depiction.

8. National/Regional geographical areas.

9. Improved aerodynamics and electronics of the satellite communications antenna.

10. Indication of Lightning activity on Radar depictions.

11. Trend assessment of specified airports.

This development will be a two year effort to provide a reliable and cost effective system of providing weather information to general aviation aircraft.

References

1. Dash, E.R.; Crabill, N.L.: The Pilot's Automated Support System Concept (PAWSS). Seventh International Conference Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology; American Meterological Society. January 1991.

2. Gates, H.M.; O'Neill, J.N.: Aeronautical Application for Reliable Mobile Satellite Services; IEEE Vehicular Technology Conference, Satellite Technology Session, May 11-13, 1992.

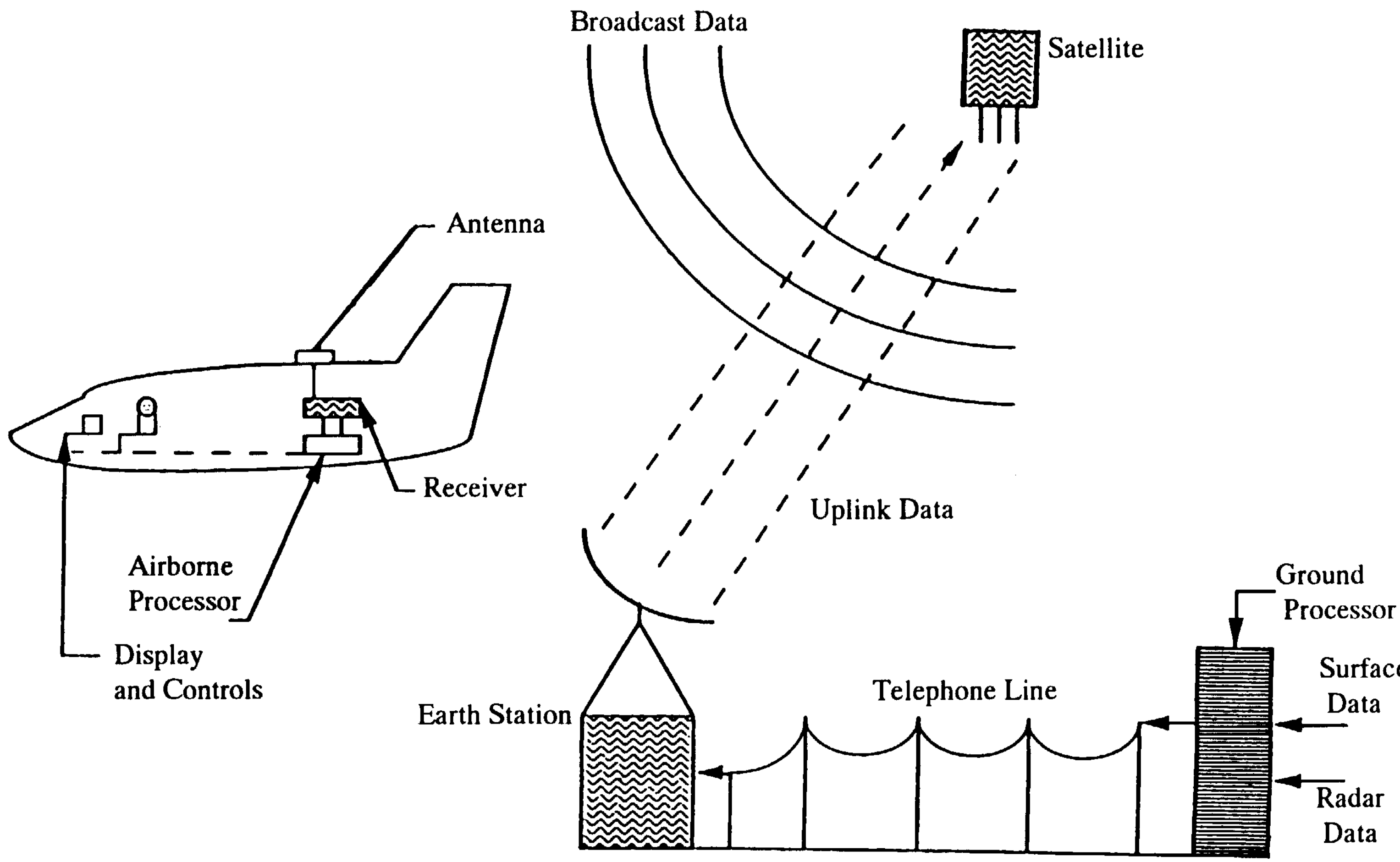


Figure 1. Pilot Weather Advisor System.

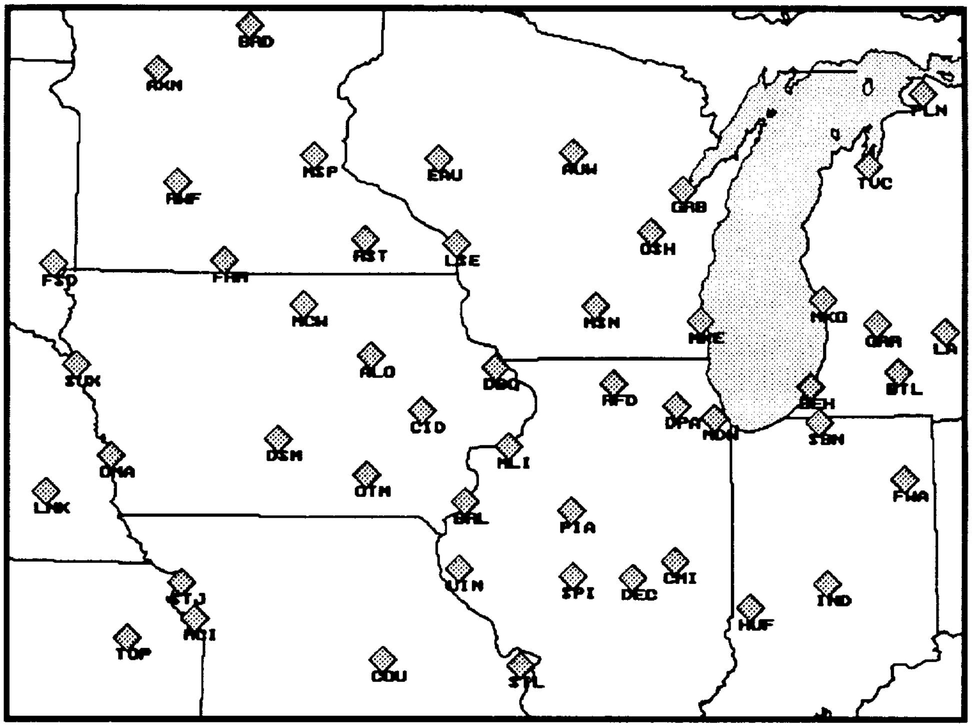


Figure 2. Airport/Station Identification Depiction.

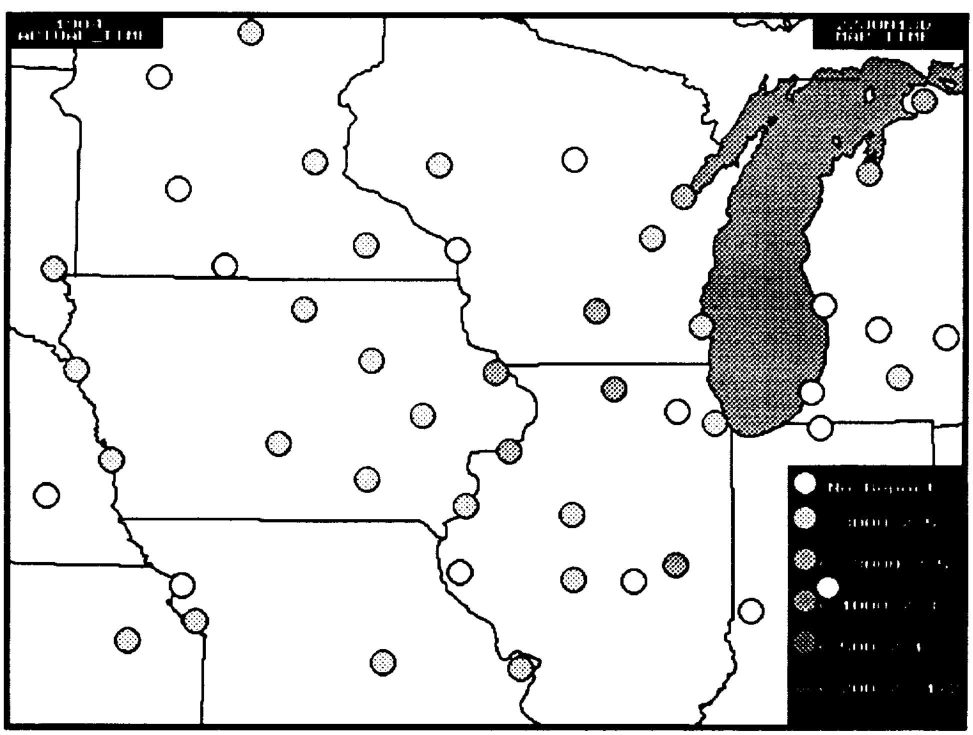


Figure 3. Airport Category Depiction.

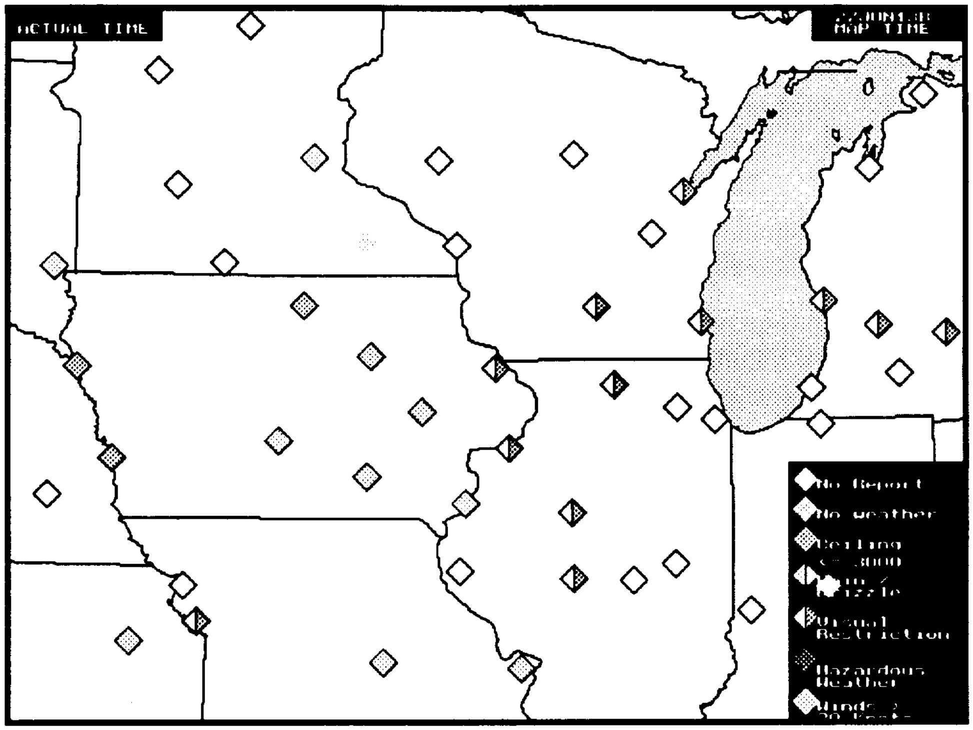


Figure 4. Airport Weather Depiction.

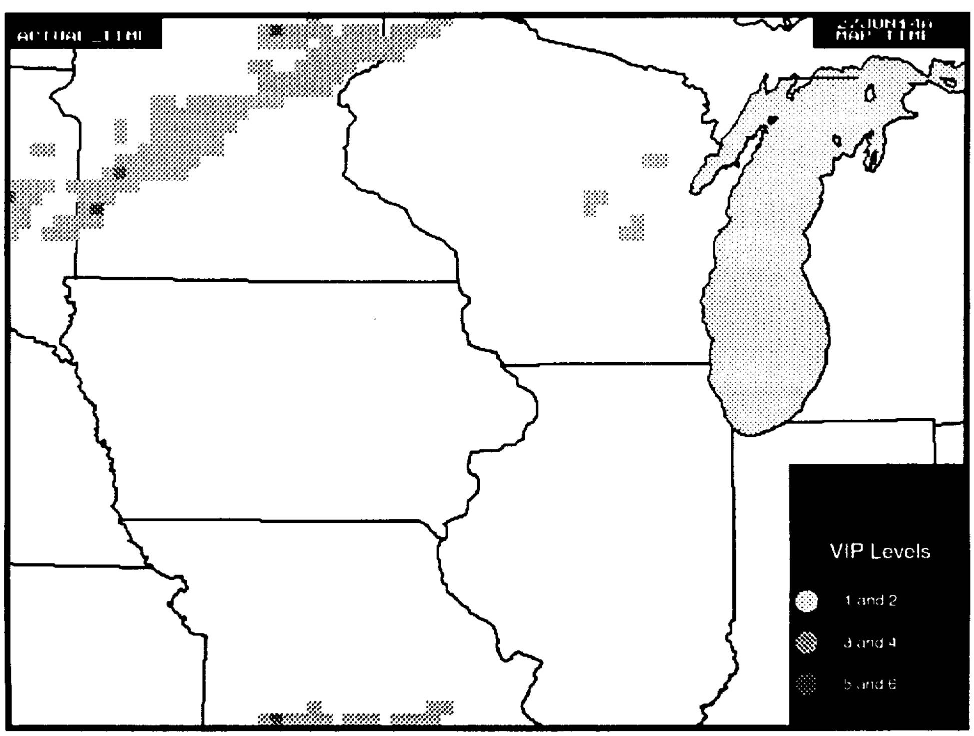


Figure 5. Radar Depiction.

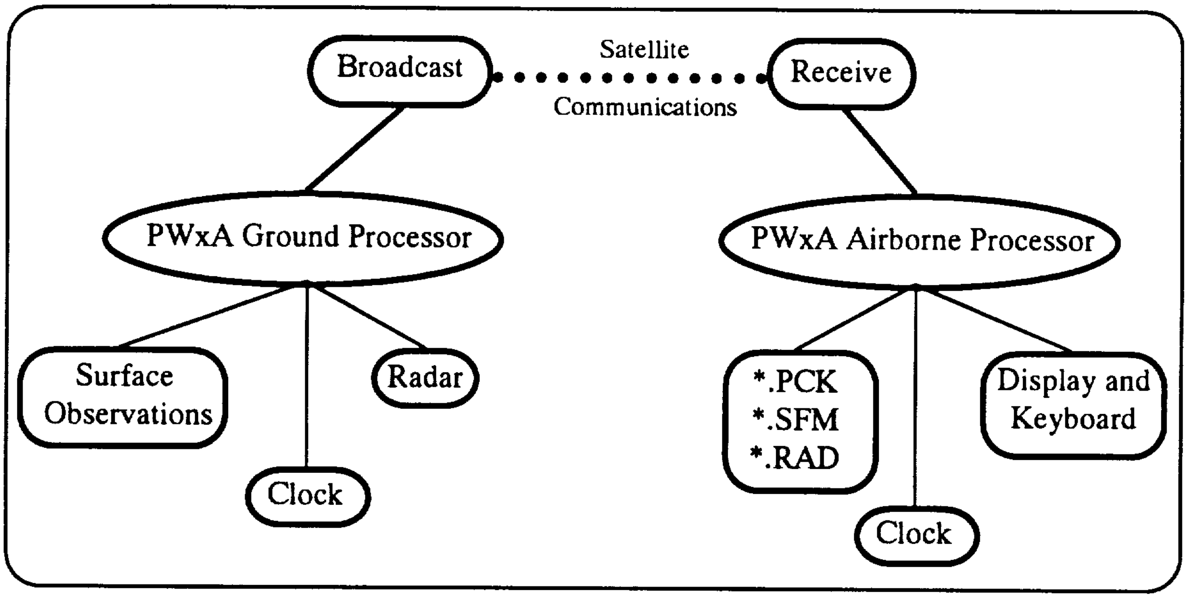
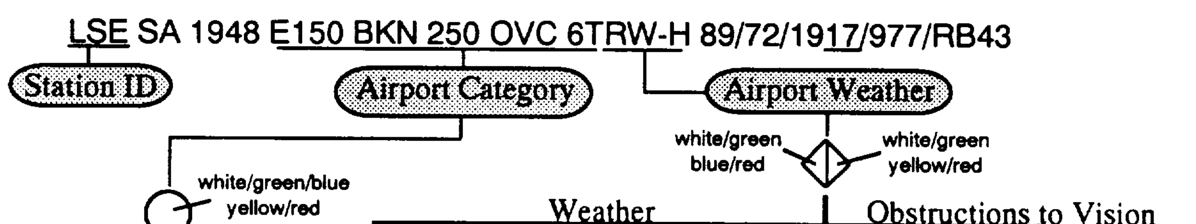


Figure 6. PWxA Data Flow Diagram



Category	Definition	Color
VFR	no ceiling visibility > 5 mi.	white
MVFR	ceiling < 3000 ft visibility < 5 mi.	green
IFR	ceiling < 1000 ft. visibility < 3 mi.	blue
LIFR	ceiling < 500 ft. visibility < 1 mi.	yellow
<CAT1	ceiling < 200 ft. visibility < 1/2 mi.	red

Weather

Symbol	Meaning	Color
Tornado	tornado	red
Funnel Cloud	funnel cloud	red
Waterspout	waterspout	red
T	thunderstorm	red
T+	sever thunderstorm	red
R	rain	blue
RW	rain shower	blue
L	drizzle	blue
ZR	frezzing rain	red
ZL	frezzing drizzle	red
A	hail	red
IP	ice pellets	red
IPW	ice pellets shower	red
S	snow	red
SW	snow shower	red
SP	snow pellets	red
SG	snow gains	red
IC	ice crystals	red

Obstructions to Vision

Symbol	Meaning	Color
BD	blowing dust	yellow
BN	blowing sand	yellow
BS	blowing snow	yellow
BY	blowing spray	yellow
D	dust	yellow
F	fog	yellow
GF	ground fog	yellow
H	haze	yellow
IF	ice fog	yellow
K	smoke	yellow

Note: If any red then all red. If no weather then all white.

Figure 7. Analysis of Surface Observations

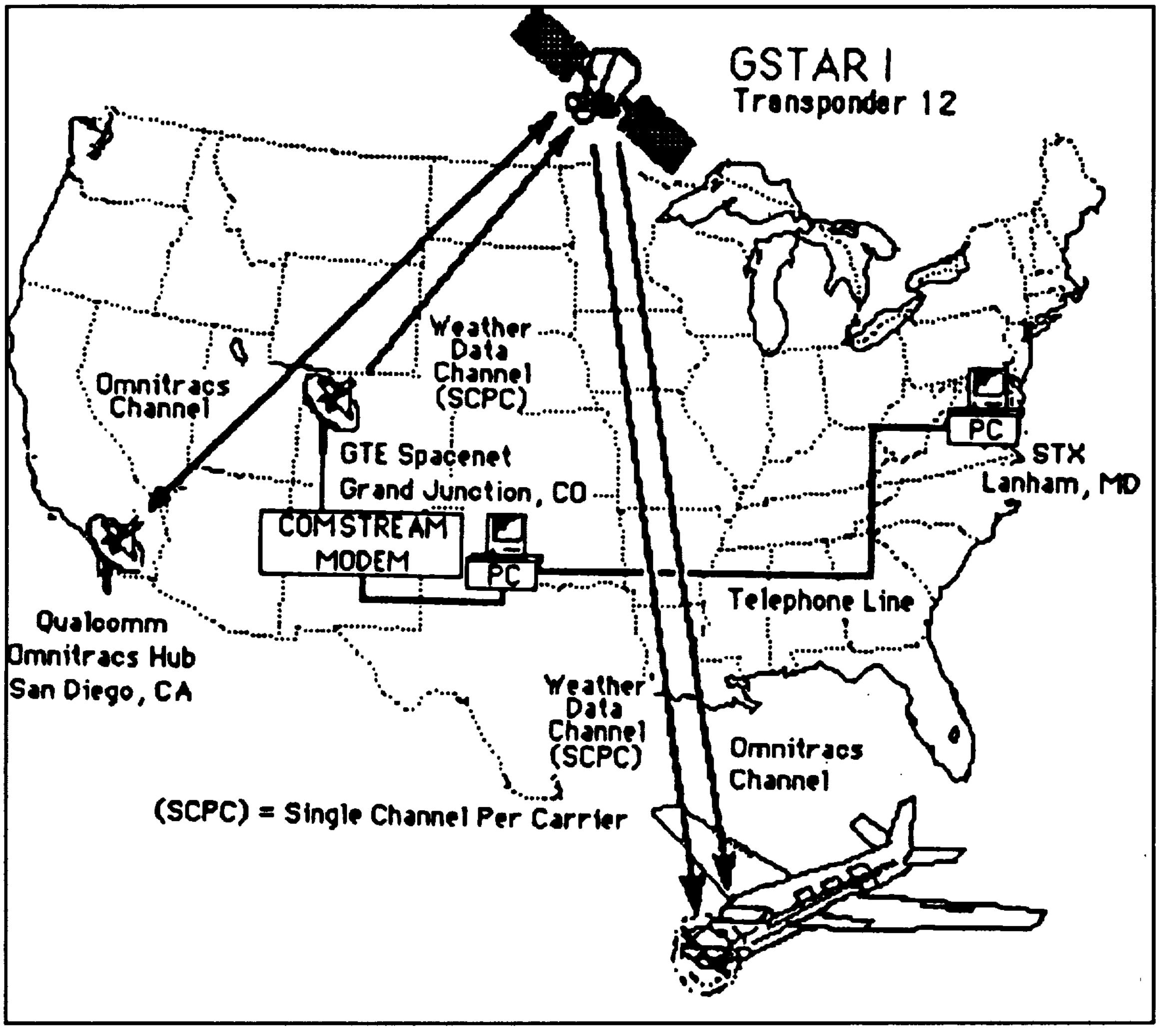


Figure 8. Satellite Communications System.

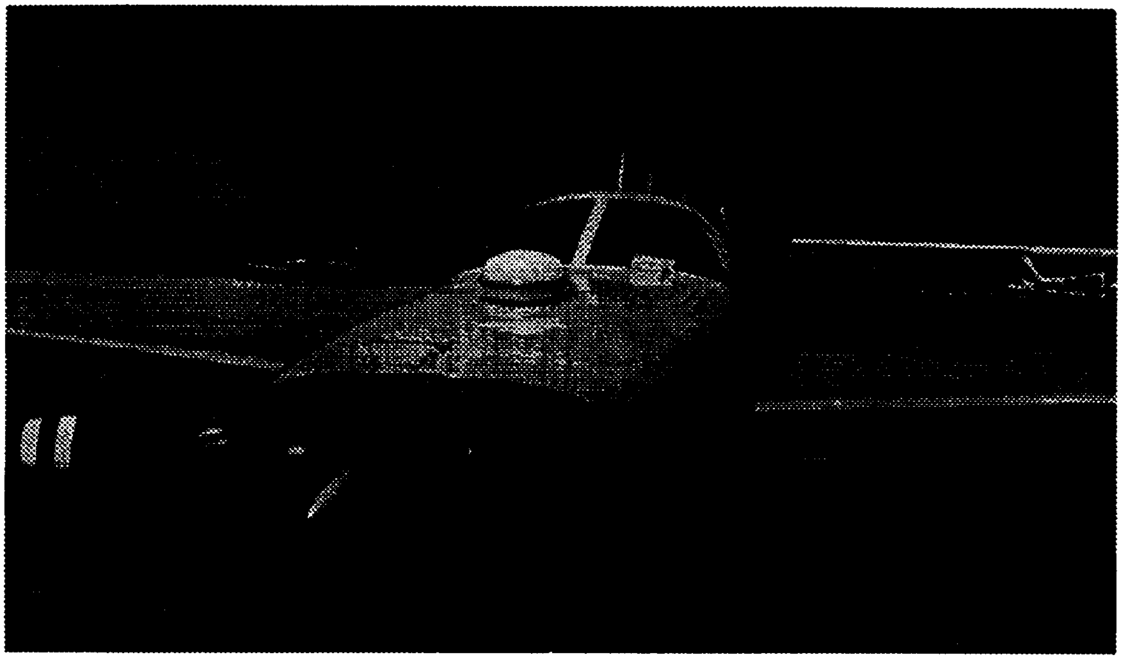


Figure 9. Piper Malibu Aircraft with Qualcomm Antenna Located on Nose.

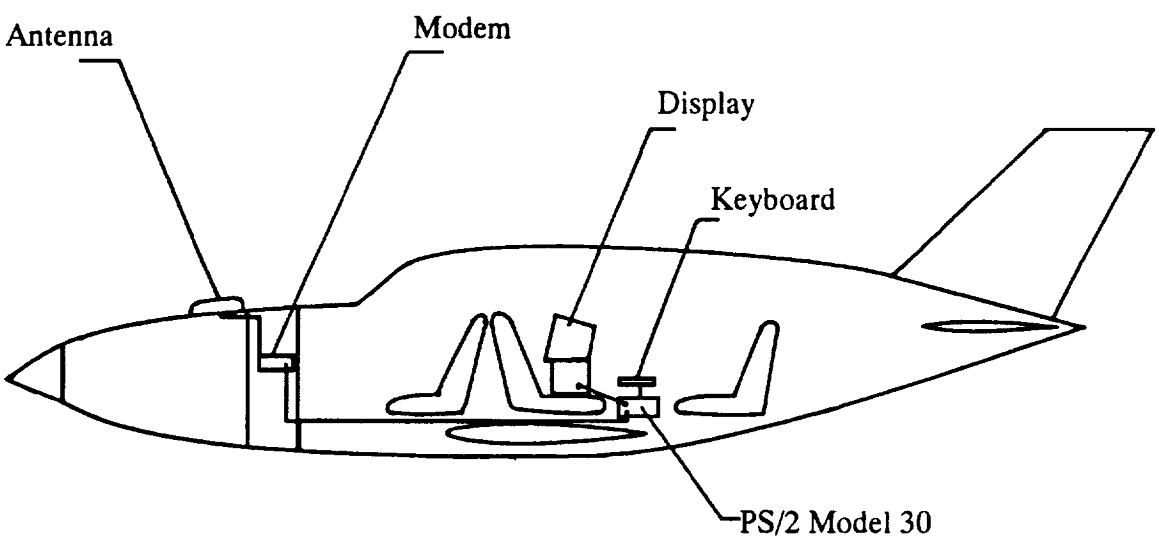
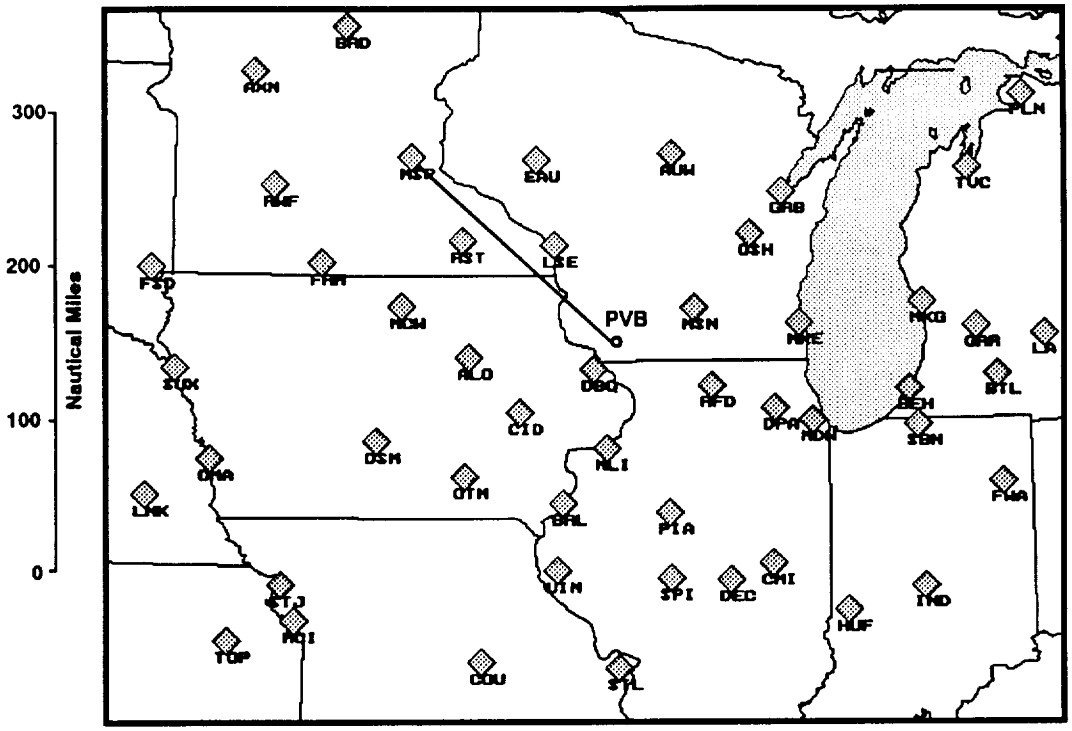


Figure 10. Schematic of Aircraft Showing Equipment Location.



Flight Times		**Depictions Received**
Takeoff @ PVB	1409Z = 9:09CDT	13B 1400Z
		13C 1430Z
		13D 1445Z
		14A 1500Z
		14B 1515Z
Landing @ MSP	1539Z = 10:39CDT	14C Not Received
		14D 1545Z
		15A Not recieved
		15B 1615Z

Figure 11. Wisconsin Test Area, June 27, 1991 Flight.

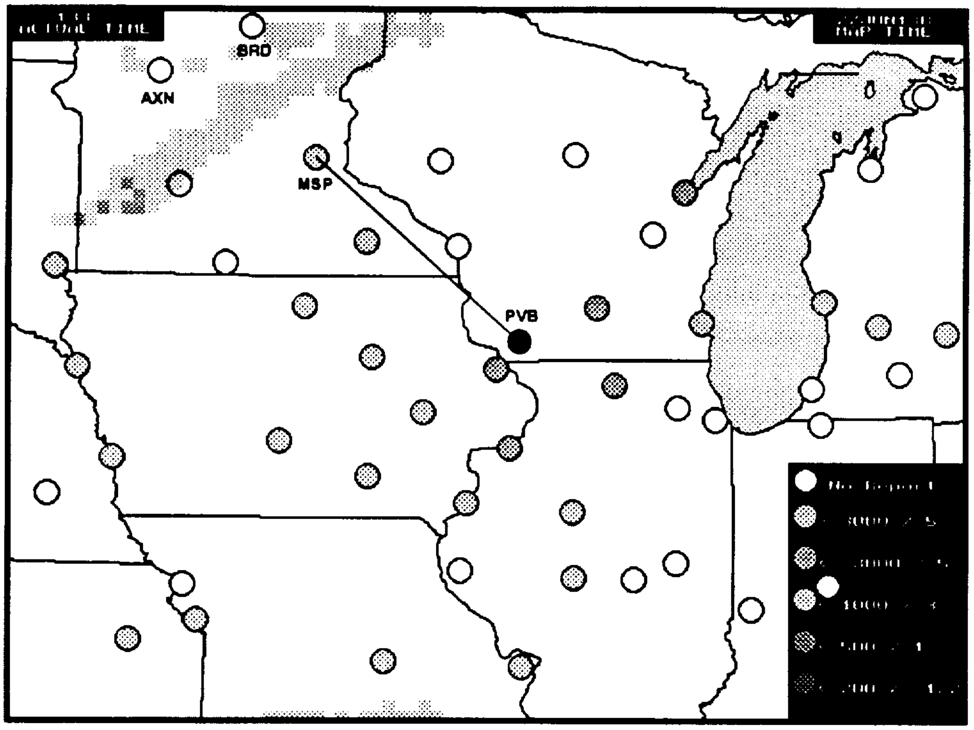


Figure 12. 27JUN13B, Airport Category and Radar Depiction, 1400Z.

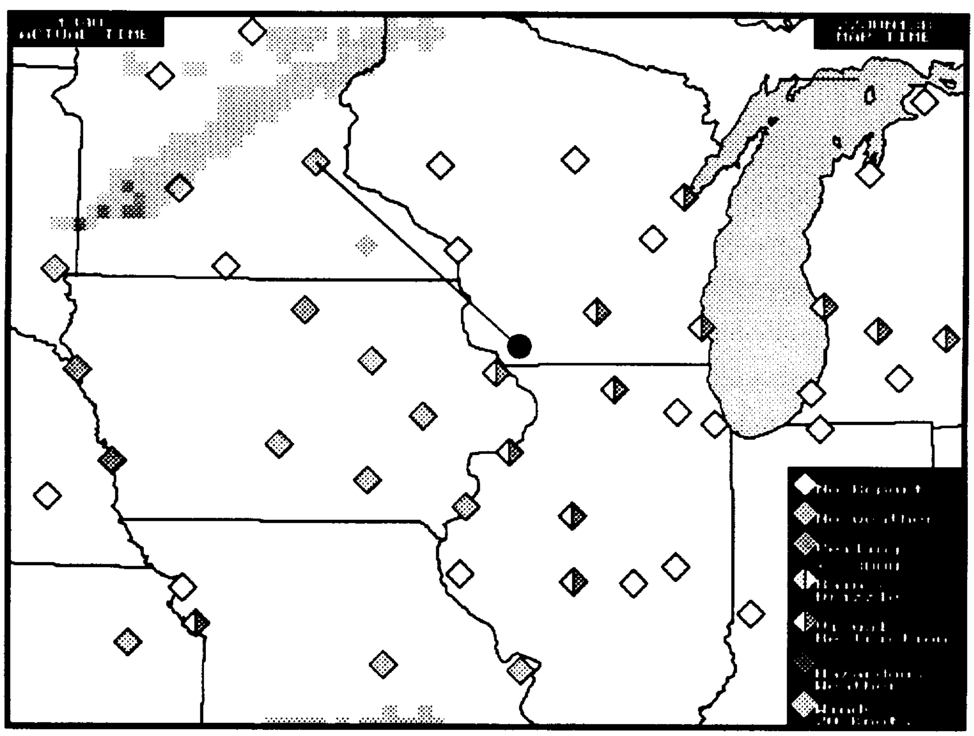


Figure 13. 27JUN13B, Airport Weather and Radar Depiction, 1400Z.

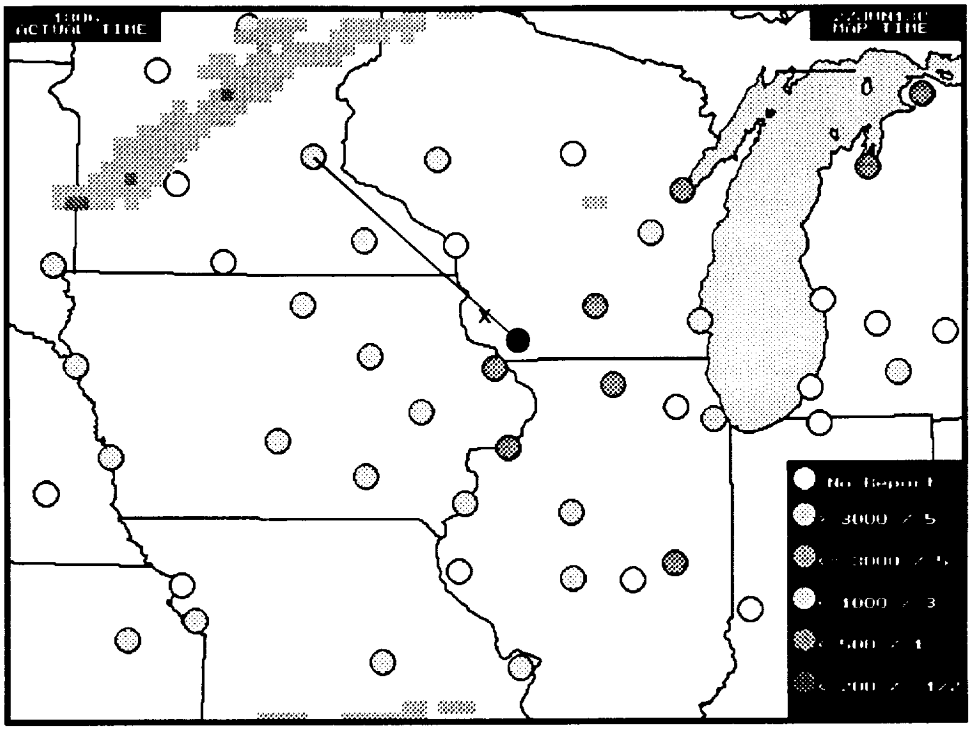


Figure 14. 27JUN13C, Airport Category and Radar Depiction, 1430Z.

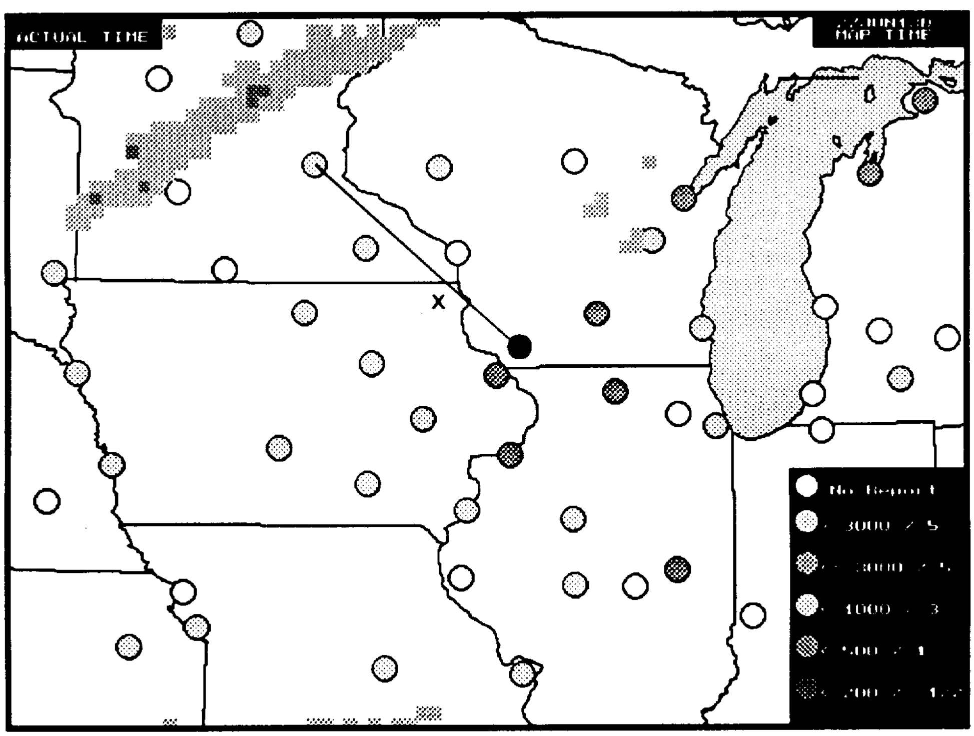


Figure 15. 27JUN13D, Airport Category and Radar Depiction, 1445Z.

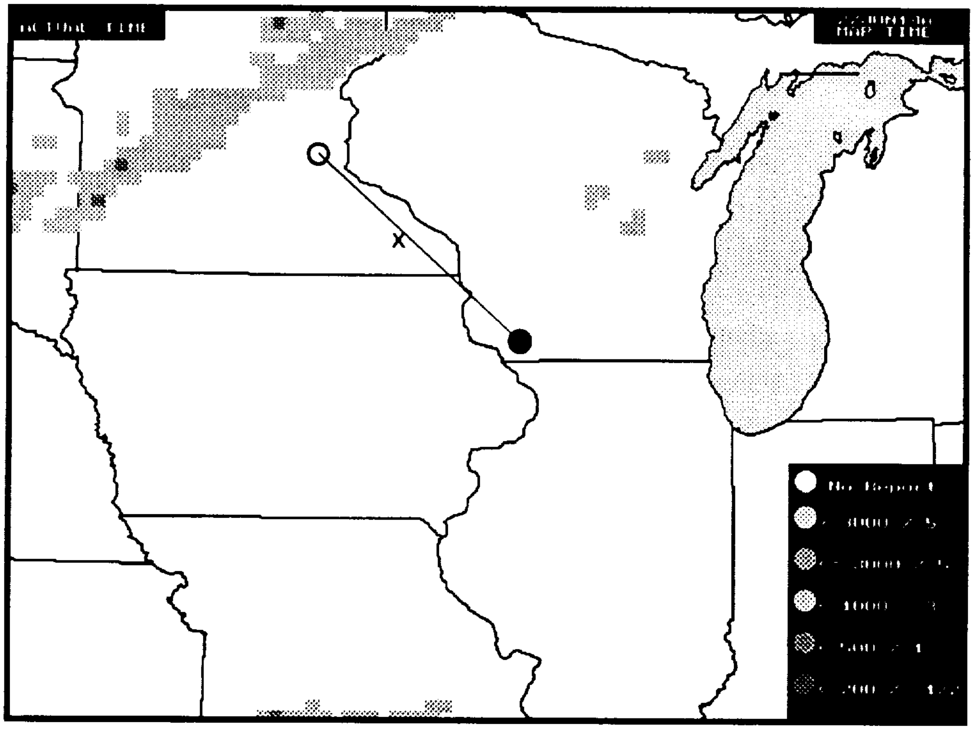


Figure 16. 27JUN14A, Airport Category and Radar Depiction, 1500Z.

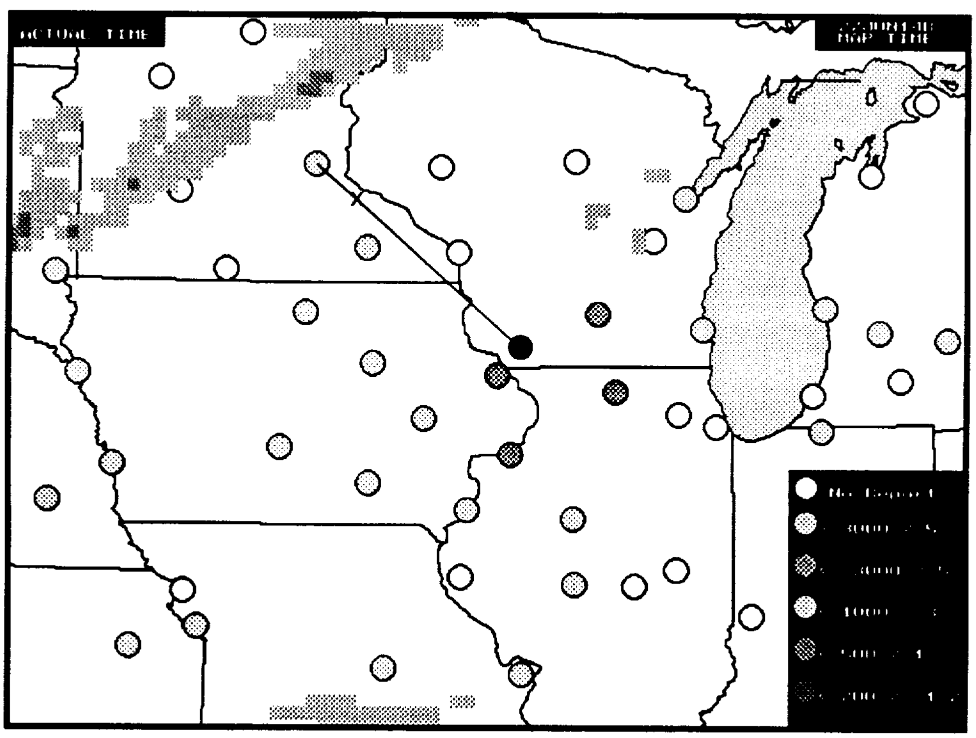


Figure 17. 27JUN14B, Airport Category and Radar Depiction, 1515Z.

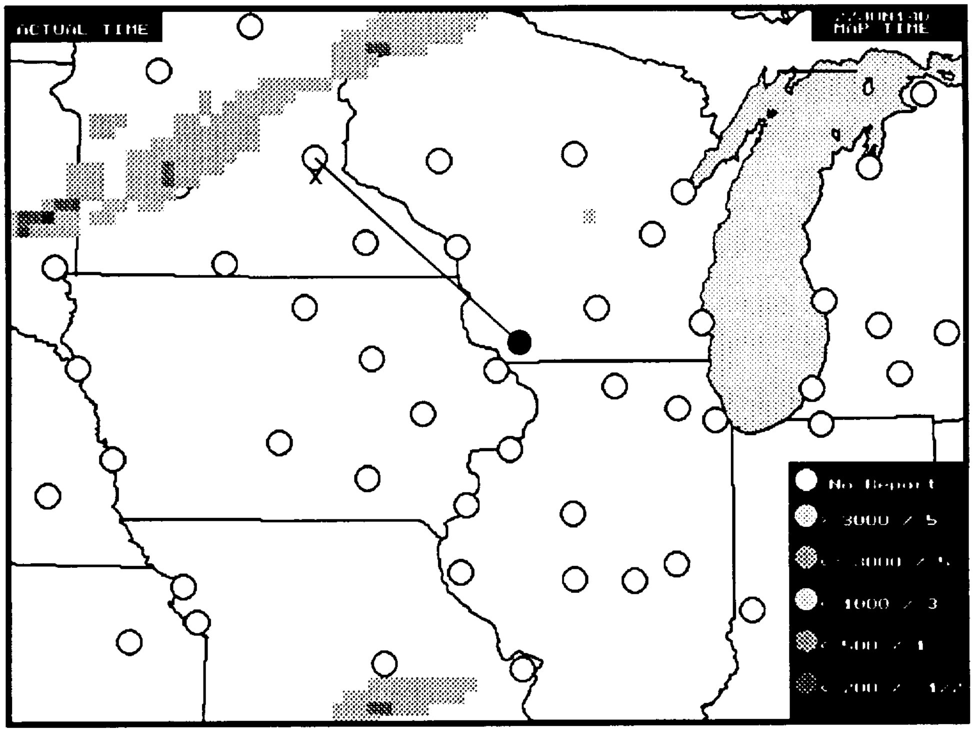


Figure 18. 27JUN14D, Airport Category and Radar Depiction, 1545Z.

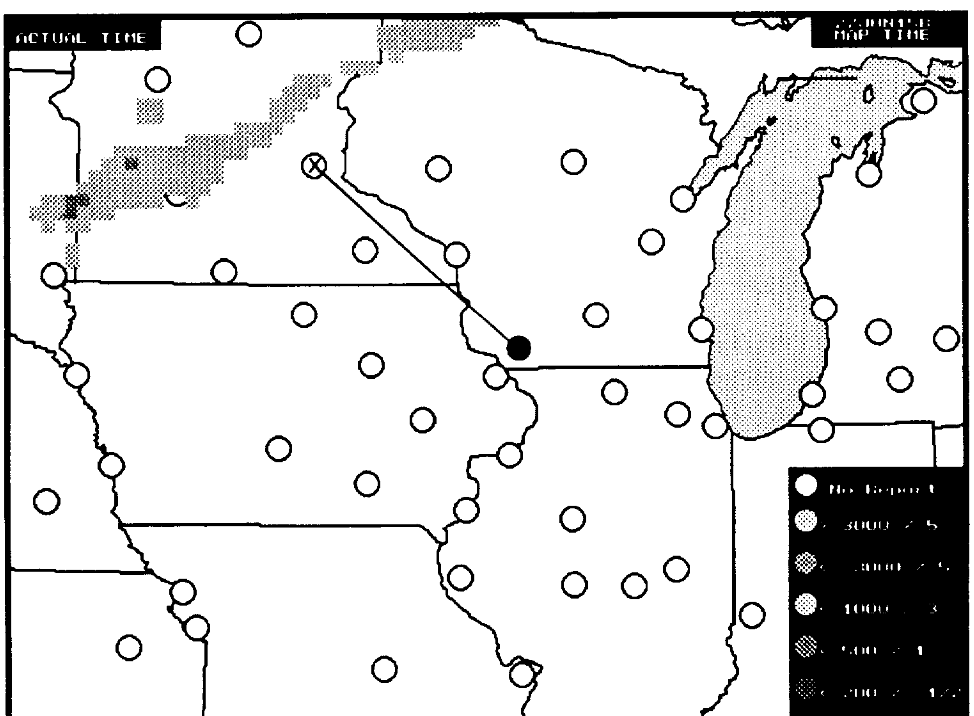


Figure 19. 27JUN15B, Airport Category and Radar Depiction, 1615Z.

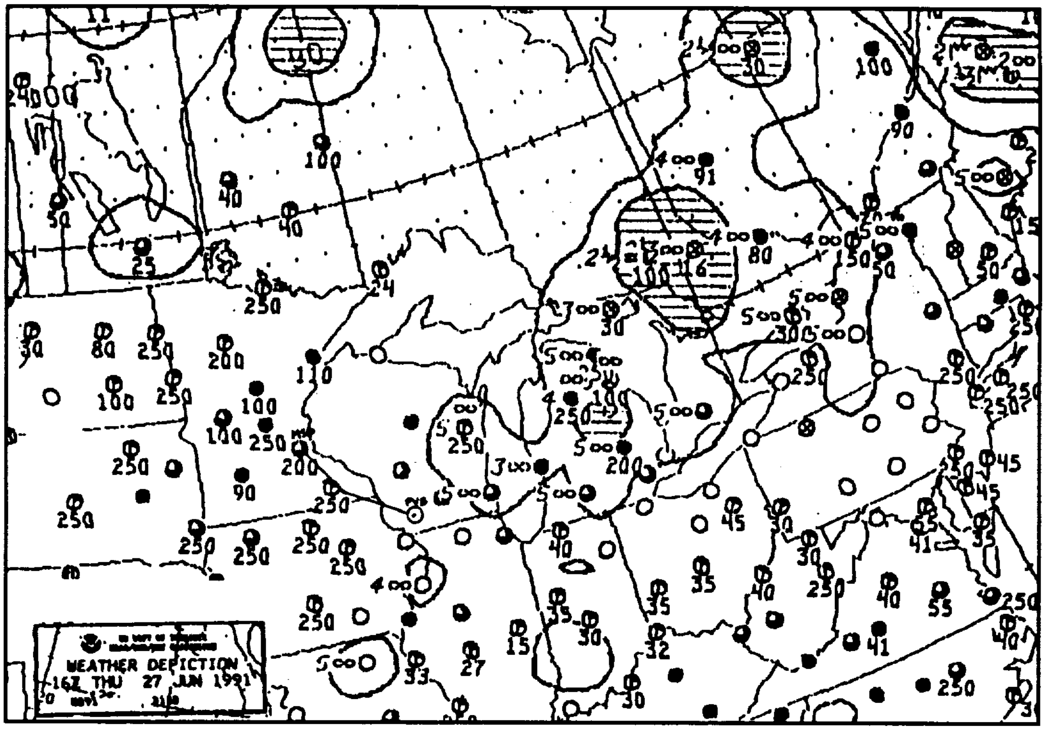


Figure 20. Weather Depiction 16Z 27 JUN 1991.

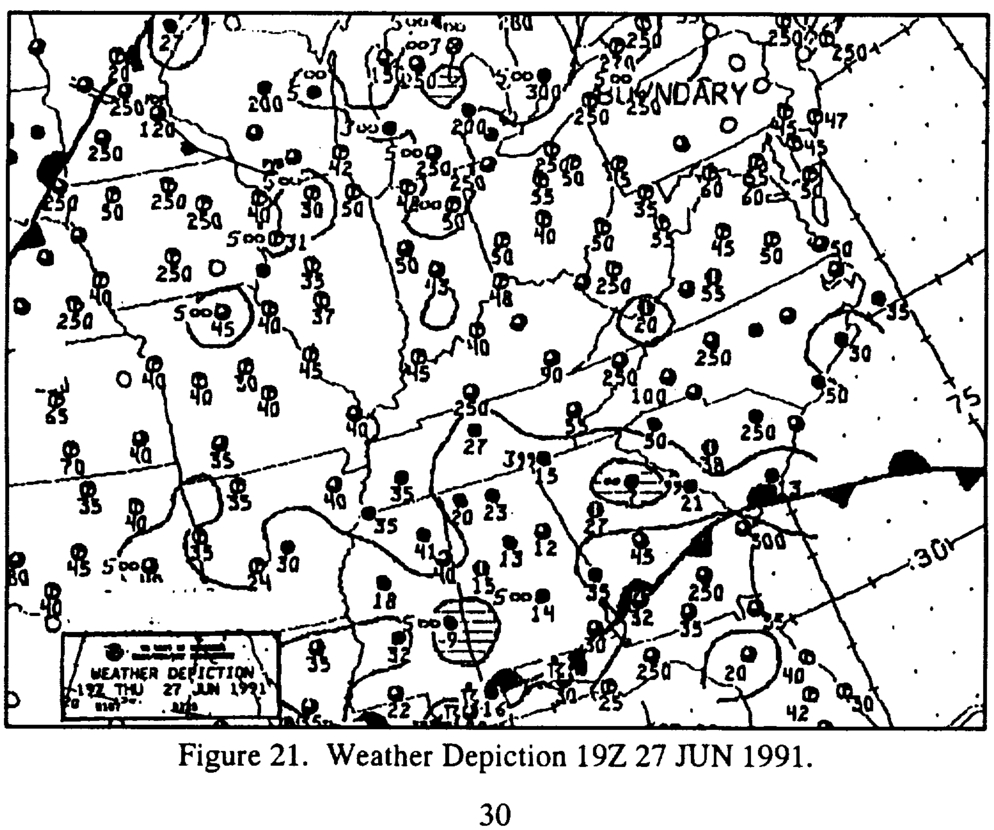


Figure 21. Weather Depiction 19Z 27 JUN 1991.

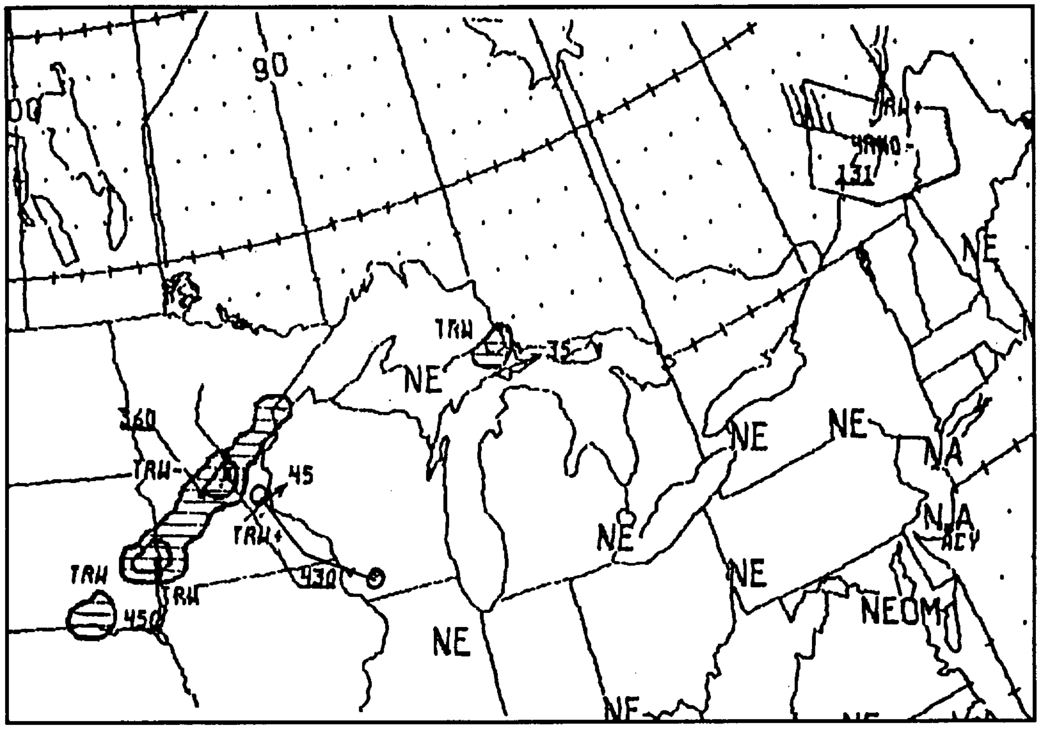


Figure 22. Radar Summary, 1335Z 27 JUN 1991.

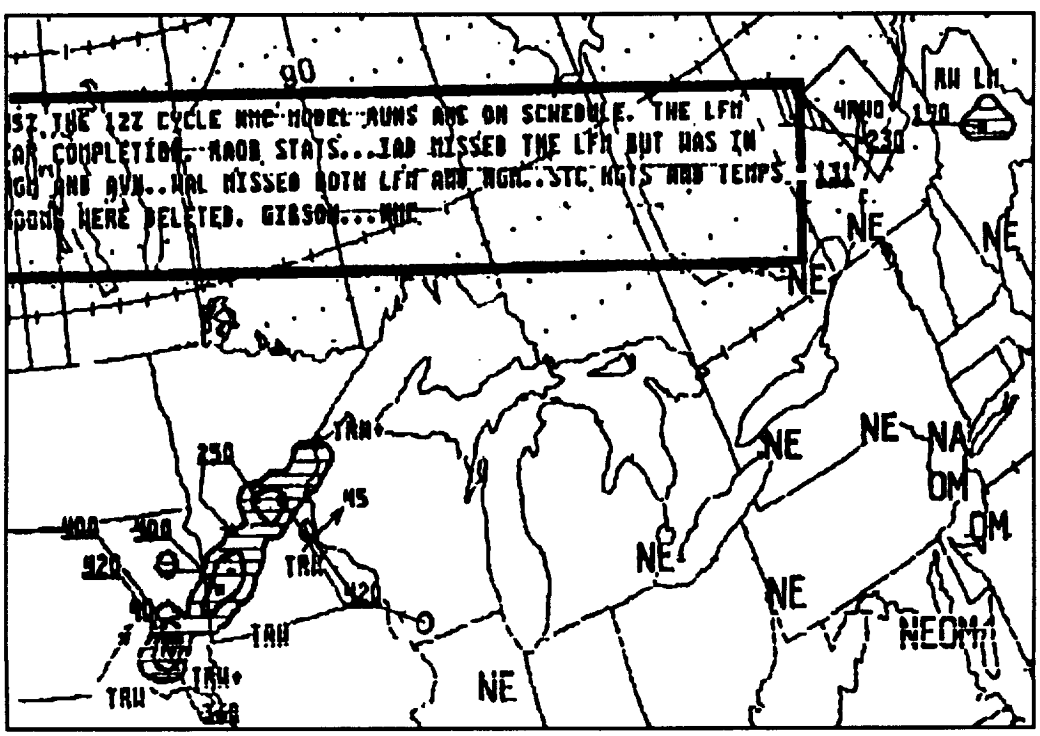


Figure 23. Radar Summary, 1435Z 27 JUN 1991.

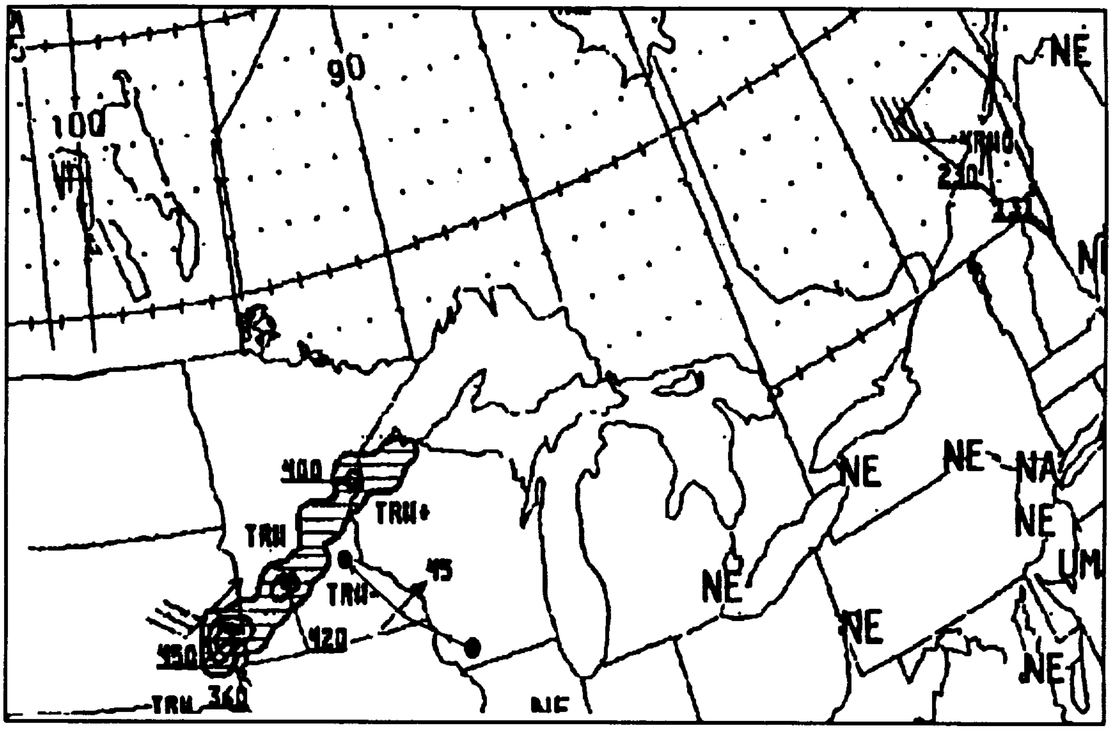


Figure 24. Radar Summary, 1535Z 27 JUN 1991.

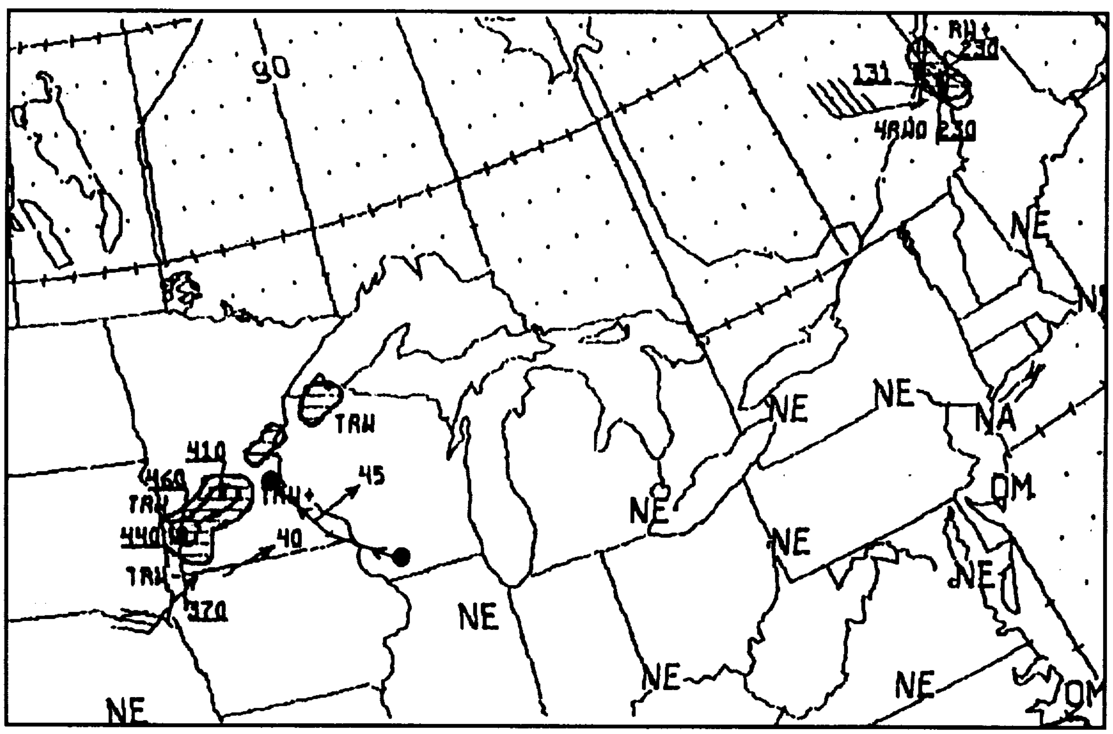


Figure 25. Radar Summary, 1635Z 27 JUN 1991.

Appendix A

Station Identifiers for those stations included in Wisconsin test area, centered on the Dubuque, Iowa radar site (DBQ).

Illinois
CMI=Champaign
DEC=Decator
DPA=Dupage
MDW=Midway
MLI=Quad City
PIA=Peoria
RFD=Rockford
SPI=Springfield
UIN=Quincy

Indiana
FWA=Ft. Wayne
HUF=Terre Haute
IND=Indianapolis
SBN=South Bend

Iowa
ALO=Waterloo
BRL=Burlington
CID=Ceder Rapids
DBQ=Dubuque
DSM=Des Moines
MCW=Mason City
OTM=Ottumwa
SUX=Sioux City

Kansas
TOP=Topeka

Nebraska
LNK=Lincoln
OMA=Omaha

Michigan
BEH=Benton Harbor
BTL=Battle Creek
GRR=Grand Rapids
LAN=Lansing
MKG=Muskegon
PLN=Pellston
TVC=Traverse City

Minnesota
AXN=Alexandria
BRD=Brainerd
FRM=Fairmont
MSP=Minn./St. Paul
RST=Rochester
RWF=Red Wood Falls

Missouri
COU=Columbia
MCI=Kansas City
STJ=St. Joseph
STL=St. Louis

South Dakota
FSD=Sioux Falls

Wisconsin
AWU=Wausaw
EAU=Eau Claire
GRB=Green Bay
LSE=LaCrosse
MKE=Milwaukee
MSN=Madsion
OSH=Oshkosh

Appendix B

PWxA broadcast "062714C.BX" on 27 JUN 91.

s300340021440C8xs30113001111002101001101001101002146056xs302250081470D3xs3032
30091480D4xs304190021010081500F6xs305180091530D6xs306200021014031540F3xs30719
0011024021560FDxs308160041014021570FExs309150061590DAxs310120071610C9xs31110
0071630CAxs3121000140616305Fxs313110041380011260F6xs314090051660D6xs315070041
014011670FCxs3160600110140413700113001Exs317050031400021300F1xs318050021730D1
xs319520011270D2xs320510021270CAxs321800A1xs322800A2xs323800A3xs324800A4xs325
800A5xs326800A6xs327800A7xs328800A8xs329800A9xs330800A1xs331800A2xs332800A3xs
333800A4xs334800A5xs335800A6xs336800A7xs337800A8xs338800A9xs339800AAxs340800A
2xs341800A3xs342800A4xs343800A5xs344800A6xs345800A7xs346800A8xs347800A9xs3488
00AAxs349800ABxs350800A3xs351800A4xs352800A5xs353800A6xs354800A7xs355800A8xs3
56800A9xs357800AAxs358800ABxs359800ACxs2ALO 011568xs2AUW 000072xs2AXN
00006Cxs2BEH 000054xs2BRD 011564xs2BRL 01156Cxs2BTL 041571xs2CID 01155Cxs2CMI
041669xs2COU 011573xs2DBQ 041667xs2DEC 000051xs2DPA 00005Axs2DSM
011570xs2EAU 011567xs2FRM 00006Axs2FSD 011569xs2FWA 000063xs2GRB
04166Bxs2GRR 041584xs2HUF 04167Exs2IND 04168Exs2LAN 041574xs2LNK 011578xs2LSE
000069xs2MCI 041568xs2MCW 021574xs2MDW 041577xs2MKE 04156Cxs2MKG
041578xs2MLI 041672xs2MSN 04167Exs2MSP 01157Cxs2OMA 02156Axs2OSH
041579xs2OTM 01157Cxs2PIA 041569xs2PLN 0E168Bxs2RFD 04166Cxs2RST
0B1596xs2RWF 000074xs2SBN 000068xs2SPI 04157Bxs2STJ 000076xs2STL 01157Fxs2SUX
02158Dxs2TOP 01157Fxs2TVC 04167Dxs2UIN 000071x

Appendix C

Surface Observations collected for 1400Z, 6-27-91

ALO SA 1351 250 -SCT 12 141/81/72/2011G19/997
BRD SA 1350 20 SCT E100 BKN 250 BKN 10 70/64/0000/979
BRL SA 1350 100 SCT 250 -BKN 7 180/78/71/2108/008/HAZY
BTL SA 1345 250 -BKN 4H 80/68/2212/015
CID SA 1353 CLR 7 155/80/73/1812/001/HAZY
CMI SA 1345 CLR 5H 77/69/2010/014
COU SA 1350 30 -SCT 250 -SCT 7 180/77/69/1809/009
DBQ SA 1352 250 SCT 5H 164/79/72/2112/004
DSM SA 1351 CLR 7 143/80/71/1913/998/FEW STFRA AND FEW CI
EAU SA 1352 200 SCT 15 104/83/69/1908/986
FSD SA 1350 110 SCT 250 -OVC 15 075/80/69/1915/979/ACCAS SW-NW-NE
GRB SA 1350 150 SCT 250 -OVC 4H 135/82/72/2116G21/994
GRR RS 1350 250 -OVC 5H 193/79/68/2211/012
HUF SA 1359 30 SCT 5FH 77/71/2307/019
IND SA 1352 CLR 5H 220/78/68/2003/020/VSBY LWR E-SE
LAN SA 1352 250 -OVC 3H 201/79/69/2112/015
LNK SA 1350 150 SCT 250 -SCT 15 106/81/70/2015G24/988/WND 18V24
MCI SA 1350 CLR 6H 158/80/73/1814/003/FEW CU N
MCW SA 1350 250 -BKN 12 124/81/69/1920/993
MDW SA 1345 200 -BKN 6H 79/68/2311/013
MKE SA 1353 250 -OVC 4H 161/83/71/2012/002
MKG SA 1350 250 -OVC 3H 190/75/68/1711/010
MLI SA 1350 CLR 3H 175/80/72/2211G15/006/FEW CI SFC VSBY 5
MSN SA 1355 270 -SCT 4H 153/81/72/2216/000
MSP SA 1354 E150 BKN 250 OVC 12 084/83/69/2020/980/ACCAS FRMG W-NW
OMA SA 1350 250 -BKN 8 108/79/71/1916/988/HAZY
OSH SA 1355 200 -BKN 4H 83/71/2210/997
OTM SA 1350 CLR 8 164/81/71/1912/004
PIA RS 1350 250 -OVC 5H 197/77/71/1809/013
PLN SA 1350 120 SCT E180 OVC 4H 138/81/70/2322G30/994
RFD SA 1353 250 -SCT 3H 184/80/71/1913/009
RST SA 1352 250 -SCT 10 105/82/69/2121G31/987
SPI SA 1350 250 -SCT 6H 198/77/69/1810/013
STL SA 1351 250 -SCT 7 195/79/68/2010/012/FEW CU NE-S AND W
SUX SA 1350 250 -BKN 20 093/81/71/1814/983
TOP SA 1350 CLR 10 154/79/73/1910/001
TVC SA 1349 E150 OVC 4H 83/70/2515G21/998/BINOVC

Surface Observations collected for 1500Z, 6-27-91

ALO SA 1450 250 -SCT 10 137/84/72/1912/996/FEW AC/ 803 1032
BRL SA 1450 250 -BKN 10 180/81/70/1910/008/ 110 1008
BTL SA 1445 250 -BKN 5H 82/68/2212/015
CID SA 1450 CLR 7 155/83/74/1913/001/HAZY FEW CI E/ 400 1001
CMI SA 1445 15 SCT 8 80/69/2108/015
COU SA 1450 55 SCT 10 183/80/68/1614/010/ 115 1500
DBQ SA 1451 250 SCT 5H 164/82/73/2110/004/ 003 1008
DSM SA 1452 250 -SCT 8 141/83/72/2014G20/997/ 002 1001
EAU SA 1450 150 SCT 15 101/86/69/2113/985/ 803
FSD SA 1450 110 SCT E250 OVC 15 077/81/69/2115/979/ACCAS ALQDS/ 107 1081
FWA SA 1450 CLR 7 221/82/65/2307/020/FEW CU/ 003 1100
GRB SA 1452 250 -BKN 4H 135/85/72/2216/994/FEW AC E/ 603 1037
GRR SA 1450 250 -OVC 5H 190/82/68/2212/011/ 003 1001
HUF SA 1445 E20 BKN 6H 79/72/2108/019
HUF SP 1530 M10 OVC 2F 3520/980/PHASE III TEST
IND SA 1451 CLR 6H 222/80/69/2407/020/CU FRMG E/ 114 1100
LAN SA 1453 250 -OVC 4H 200/81/69/2413/014/ 003 1007
LNK SA 1450 150 SCT 250 -SCT 15 107/85/71/2115G20/989/WND 18V24/ 207 1081
LSE SA 1446 250 -SCT 8 88/71/1922/990
MCI SA 1450 CLR 6H 158/82/73/1913G21/003/FEW CU/ 110 1100
MKE SA 1450 250 -OVC 5H 157/85/71/2313G18/001/ 000 1007
MKG SA 1450 250 -OVC 3H 187/77/68/1810/009/ 007 1007
MLI SA 1450 55 SCT 3H 173/81/72/1812G17/005/SFC VSBY 5/ 005 1500
MSN SA 1455 250 -SCT 5H 153/83/73/1812/000/ 603 1001
MSP SA 1453 95 SCT 150 SCT E200 BKN 12 095/84/69/1911/983/ 307 1078
OMA SA 1450 250 -BKN 8 112/83/72/1915/989/HAZY/ 207 1004
OTM SA 1450 CLR 8 164/83/71/1915/004/ 103
PIA SA 1450 250 -BKN 8 195/82/71/2010/012/ 108 1001
PLN SA 1450 40 SCT E150 OVC 4H 147/81/69/2711/997/ 314
RFD SA 1450 250 -SCT 5H 180/82/71/1914/008/ 000 1001
RST SA 1453 250 -SCT 10 112/85/69/2222G28/990/ 503 1008
SBN SA 1450 250 -SCT 6H 200/82/68/2314/014/FEW CU/ 803 1101
SPI SA 1450 250 -SCT 6H 198/79/70/1911/013/FEW CU/ 115 1106
STL SA 1453 250 -SCT 10 197/82/66/1807/013/CU NW-N/ 117 1101
SUX SA 1450 250 -BKN 15 092/84/71/1918G23/983/ 103 1006
TOP SA 1450 CLR 10 141/83/73/1915G23/997/ 203
TVC SA 1445 E150 BKN 5H 84/70/2515G24/998

Surface Observations collected for 1600Z, 6-27-91

ALO SA 1551 250 -SCT 12 137/86/72/2012G21/996
AUW SA 1550 250 -OVC 7 123/84/71/2212/992
AXN SA 1546 E100 BKN 250 BKN 15 080/75/67/2707/978
BEH SA 1559 40 SCT 6H 86/71/2310G16/012
BRD SA 1445 20 SCT E100 BKN 250 OVC 10 71/67/0000/979
BRL SA 1550 100 SCT 250 -OVC 10 180/83/71/1808/008/FEW CU
BTL SA 1545 100 SCT 250 -BKN 5H 84/67/2410/015
CID SA 1552 25 SCT 7 155/86/75/1910/001/HAZY
CMI SA 1545 15 SCT 10 82/68/2212/014
COU SA 1550 M60 BKN 10 183/81/69/1913/010
DBQ SA 1555 CLR 6H 162/85/72/2212/003
DEC SA 1545 50 SCT 6H 84/70/2010G15/015
DPA SA 1545 -X 250 SCT 4H M/M/2311G18/008/H2
DSM SA 1551 250 -SCT 8 141/85/72/1815G21/997/FEW CU E
FSD SA 1550 110 SCT E250 BKN 12 081/84/70/2115G22/981/ACCAS ALQDS
FWA SA 1550 CLR 7 218/83/65/2106/019/FEW CU HAZY
GRB SA 1551 250 -SCT 5H 133/88/73/2216/994
GRR SA 1550 50 SCT 250 -OVC 6H 188/84/69/2315/010
HUF SA 1545 M20 BKN 7 81/72/2010/018
IND SA 1554 30 SCT 6H 218/83/68/2306/019/TCU ALQDS
LAN SA 1550 250 -OVC 4H 196/83/69/2114/013
MCI SA 1550 CLR 6H 155/85/73/1915/002/FEW CU
MCW SA 1550 250 SCT 12 121/86/69/2018G26/992
MDW SA 1545 200 SCT 6H 85/68/2315/010
MKE SA 1551 120 SCT 250 -BKN 5H 156/88/72/2113/001
MKG SA 1550 250 -OVC 3H 187/79/69/1810/009
MLI SA 1550 CLR 4H 171/85/73/1909G14/005/FEW AC
MSN SA 1551 250 -BKN 6H 153/86/73/2013/000
MSP SA 1553 100 SCT E200 BKN 12 098/83/70/1910/984/FEW ACCAS NW
PIA SA 1550 250 -BKN 9 194/84/69/2010/012/FEW CU
RFD SA 1550 CLR 6H 176/84/73/2014/007/FEW CU
RST SA 1552 250 SCT 10 115/88/70/2319/990
RWF RS 1555 60 SCT E90 BKN 250 OVC 10 084/81/71/2212/980/TE40 MVD ENE OCNL L TGIC N
SBN SA 1550 40 SCT 6H 199/85/67/1914/013
STJ SA 1555 35 SCT 7 86/72/1915/999
STL SA 1551 250 SCT 10 195/83/66/1608/012/FEW CU WND 12V18
SPI SA 1550 27 SCT 250 -SCT 8 196/81/69/1811/013/HAZY
SUX SA 1550 250 -OVC 15 092/86/72/2115/984/ACCAS DSNT N
TOP SA 1550 CLR 10 141/84/74/1914G22/997/FEW STFRA
UIN SA 1547 33 SCT 250 SCT 6H 184/82/67/1812G16/010
OMA SA 1550 250 -BKN 10 107/86/73/1815/988/SML CU E
OTM SA 1550 CLR 10 163/87/73/1913/004
OSH SA 1545 CLR 5H 88/72/2013/996

Surface Observations collected for 1700Z, 6-27-91

ALO SA 1650 CLR 12 137/88/71/1916G21/996/FEW CI
AUW SA 1650 250 -OVC 7 127/86/70/2310/993
AXN SA 1646 60 SCT E100 BKN 250 BKN 15 085/77/67/3107/980
BEH SA 1655 40 SCT 200 -BKN 6H 87/69/2208/012
BRD SA 1655 20 SCT E100 BKN 15 76/68/2703/980
BRL SA 1650 250 -OVC 10 177/84/72/2210/007/FEW CU
BTL SA 1645 40 SCT 250 -BKN 5H 87/68/2210/013
CID SA 1652 30 SCT 8 155/87/74/1913/001/HAZY
CMI SA 1645 E25 BKN 10 82/69/2108/012
COU SA 1650 33 -SCT 7 183/84/70/1412/010
DBQ SA 1652 CLR 7 162/86/73/2010/003/FEW SC AC
DEC SA 1645 50 SCT 7 87/71/2012/013
DPA SA 1645 250 -SCT 4H M/M/2511G18/008
DSM SA 1652 250 -SCT 8 140/87/72/2016G20/997/FEW CUFRA NW-N
EAU SA 1650 E150 BKN 15 106/90/71/2210/987
FSD SA 1650 110 SCT E250 BKN 12 084/86/70/2315G19/982/ACCAS W-NE
FWA SA 1650 40 SCT 7 214/87/65/2210/018
GRB SA 1650 250 -SCT 5H 133/89/72/2117G24/994
GRR SA 1650 50 SCT 250 -OVC 6H 187/87/67/2216/010
HUF SA 1646 -X 35 -SCT 150 -SCT 200 -BKN 300 -OVC 7 85/72/0000/002/TEST PHII I AB
HUF SA C05/069
HUF SA 1700 E20 BKN 7 84/73/1510/016
IND SA 1653 34 SCT 6H 215/85/69/2009/019/FEW MDT CU
LAN SA 1652 E250 OVC 5H 198/85/68/2313/014/FEW CU CIG PTLY THN
LNK SA 1650 250 -SCT 15 103/92/70/1917G25/988/WND 16V21=
LSE SA 1645 250 -SCT 8 93/71/1922/990
MCI SA 1650 45 SCT 6H 154/87/74/1915/002
MCW SA 1650 250 SCT 12 121/89/69/1922G28/992
MDW SA 1650 40 SCT 6H 88/67/2314/010
MKE SA 1651 120 SCT 250 -SCT 6H 156/89/71/2014G20/001/FEW CU
MKG SA 1650 250 -OVC 3H 187/79/68/2113/009
MLI SA 1653 27 SCT 4H 168/86/74/2207G16/004
MSN SA 1653 250 -BKN 7 153/88/73/2213/000
MSP SA 1652 100 SCT E150 BKN 200 OVC 10 093/88/71/1717G22/983
OMA SA 1650 250 -SCT 10 107/89/73/1916/988/SML CU OVR BLUFFS E
OSH SA 1645 200 SCT 5H 91/72/2115/996
OTM SA 1650 CLR 10 160/89/71/1914/003/CU ALQDS
PIA SA 1650 250 -SCT 9 190/85/69/2214/011/FEW CU
PLN SA 1653 E250 OVC 5H 141/87/70/2313/995
RFD SA 1650 50 SCT 5H 176/86/73/2116/007
RST SA 1655 250 -BKN 10 115/91/69/2219G25/990
RWF SA 1651 55 SCT E95 BKN 250 OVC 10T 080/80/71/1912/979/TB17 OVHD-N
MVG NE VIRGA W-N LTGICCG NW-NE
RWF SP 1730 55 SCT 95 SCT 250 -OVC 12 2309/982/TE15 MOVD NE DRK NE
SBN SA 1650 38 SCT 250 -SCT 6H 194/87/66/2414/012
SPI SA 1650 33 SCT 250 SCT 8 191/83/68/2013/011/HAZY
STJ SA 1645 35 SCT 7 88/73/1913/998
STL SA 1652 40 SCT 250 SCT 10 191/85/66/1513/011
SUX SA 1650 250 -OVC 15 092/90/72/2313G23/984
TOP SA 1650 CLR 10 140/86/75/1912G21/997/FEW SC
TVC SA 1645 E150 BKN 5H 91/70/2612G22/996
UIN SA 1650 35 SCT 55 SCT 220 SCT 6H 180/85/68/1711G17/008

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13. ABSTRACT *(Maximum 200 words)*

This report gives the results of the work performed by ViGYAN, Inc. to demonstrate the Pilot Weather Advisor cockpit weather data system using a broadcast satellite communication system. The Pilot Weather Advisor (developed under the NASA Langley Research Center Small Business Innovation Research Program 90-1, subtopic 03.02, Aircraft Severe Weather Environments) demonstrated that the technical problems involved with transmitting significant amount of weather data to an aircraft in-flight or on-the-ground via satellite are solvable with today's technology. The Pilot Weather Advisor appears to be a viable solution for providing accurate and timely weather information for general aviation aircraft.

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