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16. Abstract
This project will ultimately serve to supplement the manner in which Texas pilots receive weather data. This will be accomplished first by inventorying the sources used by pilots to get weather data. The reliability, and convenience, of these sources will be evaluated and the unmet needs enumerated.

The approach described above will be tailored to the needs of pilots with all levels of competency. This includes the weekend-only pilot interested in whether the local area will continue to have visual meteorological conditions (VMC) to those planning a cross-country routing in VMC, to the high time, instrument-rated pilot who will wonder about airframe icing on route or about low ceiling and visibility at the destination.

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TECHNOLOGY ADVANCES IN DELIVERING WEATHER DATA TO TEXAS PILOTS AND OTHER USERS

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Research Report 1799-2
Research Study Number 0-1799
Research Study Title: Integration of Weather Data from All Available Sources
To Enhance Aviation Weather Data Available in Texas

Sponsored by the
Texas Department of Transportation
In Cooperation with the
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Federal Highway Administration

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TEXAS TRANSPORTATION INSTITUTE
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IMPLEMENTATION STATEMENT

The results of research documented in this report clearly demonstrates that the collection of weather data is distinct and separate from its dissemination. There are relatively few primary weather data collection sources (e.g., NWS), while there are a multitude of intermediary processing and interpretation agencies and firms (e.g., commercial outlets). In addition, several collection and dissemination sources are in transition.

The numerous sensors and overlapping dissemination systems and networks within Texas demonstrate the potential for synergistic uses of the gathered data. The transportation, construction, agriculture, and energy industries, as well as the media, all have the need for improved weather data.

Low-cost sensing devices are on the near horizon and will allow the Texas Department of Transportation (TxDOT) to extend its weather data collection activities. Data from these advanced sensing and delivery systems will allow pilots to make better decisions before flight and while en-route. However, to access and effectively use these advanced systems, Texas pilots must become familiar with their operation. TxDOT can take the lead in this continuing education process by implementing advanced practices into pilot training and recurrent training programs. The availability of training on the use of advanced systems will help Texas pilots improve their skills and help them learn to make better decisions concerning flight into all types of weather.

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the opinions, findings, and conclusions presented herein. The contents do not necessarily reflect official views or policies of the Federal Highway Administration or the Texas Department of Transportation. This report does not constitute a standard, specification, or regulation. Additionally, this report is not intended for construction, bidding, or permit purposes. George B. Dresser, Ph.D., was the Research Supervisor for the project.

ACKNOWLEDGMENTS

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SUMMARY

Following a long, detailed study of weather sensors and distribution systems in Texas, one point becomes readily apparent. Many Texas pilots lack familiarity with, and the method to access many of the available sources. Major parts of the following recommendations concern continuing education for pilots, particularly instruction about the available high-tech resources.

One resource not well understood by most pilots is weather satellite imagery. These images show water as clouds, or vapor, in the atmosphere. The National Oceanic and Atmospheric Administration (NOAA) has two types of satellites that record these images: the GOES satellites and the POES satellites.

Scientists and forecasters develop mini movies using consecutive GOES images to study the movement of certain weather phenomenon during the preceding hours or days. The closer imaging by the POES has not proven as valuable to pilots as the views from GOES 8 and 10.

Satellites that scan the infrared (IR) wavelength actually measure cloud top temperatures rather than reflected light, as in visible satellite images. Because temperatures in the lower portion of the atmosphere are almost inevitably warmer than temperatures in the higher portions, high level clouds will appear whiter than lower level clouds. Low clouds and fog will appear as a light gray tint only. One advantage of the IR image is that the satellite can produce an IR image at night while visible images are not available at night.

A third type of image developed using the weather satellites is the Water Vapor Channel image. A part of the IR scanning range, called the “vapor channel,” produces the image. These images are also available at night. Vapor channel images are sensitive to water vapor, showing water vapor as shades of gray to white—the whiter the shade the more humid the air. Black indicates air containing virtually no water.

The Texas Department of Transportation Aviation Division is encouraged work with the Digital Users Access Terminal Service (DUATS) providers to obtain special features for Texas users. There are several ideas to consider, but one that seems most appropriate is to print out the airport layout, and other pertinent data, about the destination airport when a flight ends in Texas. This data is currently available in the Texas Airport Directory. DUATS providers might consider this as a desirable value added feature.

Other, and similar enhancements, could include a blank clearance form near any cross-country log or a format for recording Hobbs times, tach times, or clock times.

Inevitably other states and the FAA would note the desirability of these features and promptly begin to emulate them. By taking the initiative to suggest these enhancements, TxDOT and the state will strengthen its reputation as leaders in assisting pilots and general aviation in striving for safety.

The use of personal computers (PCs) has become an integral part of virtually everyone’s life. People use PCs for writing, accounting, filing, and calculating. Indeed users have not fully explored the full extent of the PC’s potential.

That statement is as true for aviation training as for any other field. It is becoming clear that the PC will become an increasingly valuable tool to the pilot and flight instructor, for both initial and recurrency training. Currently, one of the primary uses is the interactive CD-ROM and instructional discs, used as a ground school. Instructors are using the PC to administer virtually all knowledge tests. Obviously, practice tests using PCs are excellent methods to prepare for the knowledge tests and provide the flight instructor with an evaluation of the student’s progress.

Another use is to obtain pre-flight weather briefings via the DUATS. Other possible uses include adapting the PC to simulate flight, and flight problems, especially flight under IMC.

Recent advancements in technology are serving general aviation well by making it easier for pilots to obtain current weather information and weather forecasts that are more reliable. TxDOT has, and is, doing a good job in assuring that these advancements are widely and inexpensively available to Texas pilots. One area where the Department can improve its efforts is in educating Texas pilots, typically through the CFIs, about efficiently and safely using new weather sources to make better decisions and improve safety.

CHAPTER 1. INTRODUCTION

Tremendous advances in technology and understanding have characterized the past century of heavier than air aviation. Just less than 100 years ago, the Wright brothers made the first flight of an aircraft. Their endeavor, not without its controversies and critiques, proved to be a monumental step forward for a myriad of travelers and adventurers. It was an American step, and foreshadowed the great engineering accomplishments that characterized the subsequent era. These accomplishments included the winning of two World Wars, landing men on the moon, putting reliable personal vehicles in virtually every garage and a telephone system that links with every corner of the world. Virtually all of these technologies were applicable to aviation and have been directly applied to producing faster, more reliable aircraft, and a transportation system that can deliver a person to virtually anywhere, usually in only a fraction of a day.

Air transportation has also become safer. The graph in Figure 1 shows that since the mid-1970's both the number of aviation accidents and the number of aviation fatal accidents (per 100,000 flying hours) has consistently improved. The implications of these trends are important to everyone, from the airframe manufacturer to the insurer to the regulating government agencies. They suggest, almost demand, that everyone involved in aviation must work tirelessly to continue the great improvements in all aspects of flying to make it more convenient, economical, simple, and, most of all, safe.

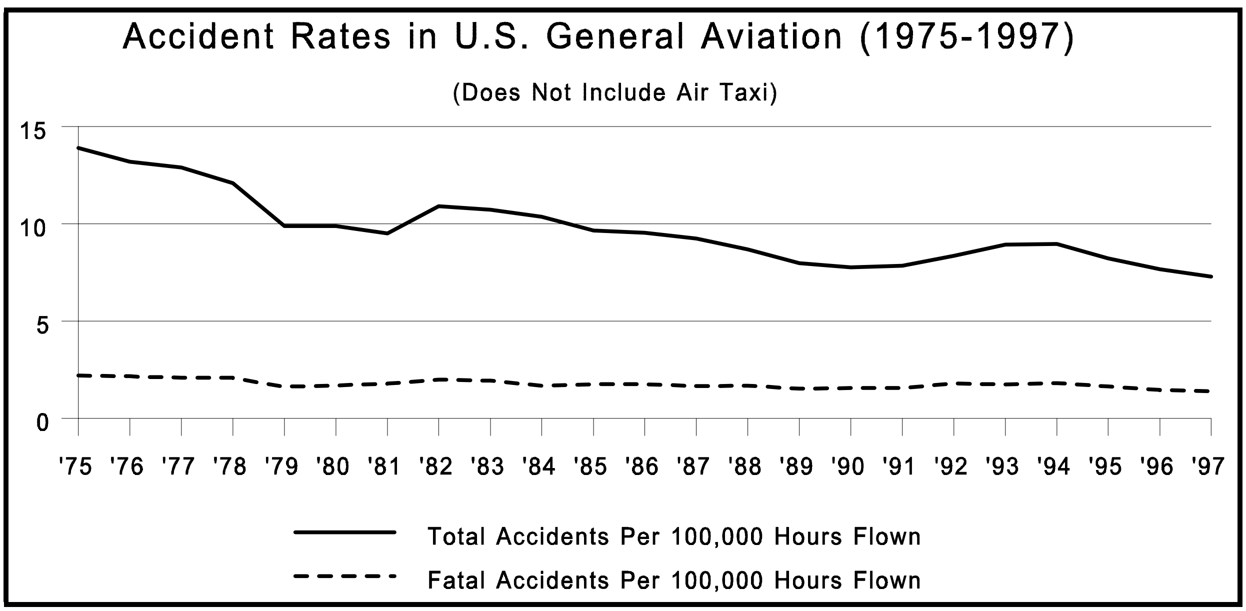


FIGURE 1. U.S. General Aviation Accident Rates

Whatever the reasons, and there are many, the performance and reliability of aircraft have continuously improved during the century. The first flight was indeed slow and undoubtedly tenuous. Now however, single flights may span thousands of miles at speeds reaching hundreds of miles per hour.

The progress in aircraft manufacturing accelerated by the development by large manufacturers of automated production lines that fabricate products with ever improving operating characteristics and reliability. The use of wind tunnels and huge computing capacities, by the large airframe manufacturers, has led to much of the technological progress.

Another area where technical gains have meant a lot to the aviation industry is the introduction of new materials and methods of fabricating airframes. The replacement of wood with metal, first for the airframe itself, but later for the outer skins of the fuselage and the wing and tail surfaces, proved to be a great improvement. Then the ability to tailor the strength and thickness of these skins and to make the metal resistant to heat and other corrosive elements was a step forward.

Currently, it appears the use of polymeric-based composites for aircraft surfaces is growing in popularity. This is because it is easy and inexpensive to tailor the strength and thickness, as needed, and to form smooth reduced-friction surfaces.

Since World War II, the basis for most airborne navigation was very-high-frequency omni-directional ranging stations that operate at frequencies between 108.00 and 117.95 MHz. Other, perhaps less important systems, have included the non-directional radio beacon (190 to 1020 kHz), the Long Range Navigation (LORAN) system (near 100 kHz), and the OMEGA system operating at very low frequencies. Others included the seemingly dormant Microwave Landing System (just over 5000 MHz), and inertial guidance systems that are entirely self-contained. All of these systems have worked well and have provided precise navigation in virtually all weather and circumstances. However, a new, less expensive, and more reliable satellite-based system, the global positioning system (GPS), has appeared. The U.S. Air Force developed this system primarily for worldwide weapons guidance.

GPS provides accurate position and velocity information and precise time on a continuous global basis to an unlimited number of users. The system is unaffected by weather and provides a worldwide common grid reference system. It is ideal for cross-country navigation from airport to airport. With the government expected to complete modifications and extensions in the near future, the system can provide the needed three-dimensional information necessary to fly precision and non-precision approaches. The economical availability of the GPS equipment appears is one of the most attractive features of the new system.

The ability to rapidly obtain information concerning the current weather at the origin, at en-route locations, and at the destination became easy and commonplace during the 20th century. While early in the century, people used local observations coupled with sailor-type rules of thumb to prognosticate weather conditions in the near term future. The advent of the practical aircraft provided for larger scale weather observations, but also highlighted the need for more meaningful weather forecasts.

In his recent book on the history of weather forecasting, Mark Monmonier, a professor of geography at Syracuse University, describes how the ability to map weather led to the ability to understand the governing physics and the transient behavior of weather. The position and movements of highs and lows, fronts, temperatures and, in turn, winds and precipitation, quickly proved to be of great value to farmers and fishermen as well as pilots (1).

Another factor accelerating the understanding and forecasting of weather was the rapid data collection and timely storm warnings facilitated by the electric telegraph. Additionally, the common acceptance of the government as having primary responsibility for being the official collector and disseminator of weather information helped. Consequently, the U. S. Weather Bureau began operating as a civilian agency in 1891.

At first, forecasting was primarily a cartographic art in that the Weather Bureau employees would plot weather phenomena, watch its geographic progress, and then extrapolate where it would go and how it would change in the future. Remembering how weather patterns moved and what conditions prevailed the day before was a big part of the mix, and those who could judge and remember proved to be the best, most reliable, forecasters. Remembering that the weather is a three-dimensional phenomenon aided the reliability of the process. Then came the advent of Doppler Radar, satellite photos, unmanned weather sensors and computers, all tools available to improve weather forecasts. These provide real data to input into the numerical models to account for thermal and mass migrations in the atmosphere. These programs can, when calibrated against actual weather, become ever more precise and meaningful forecasting tools.

Current weather conditions are essentially available anywhere at any time. One improvement for consideration in pilot education and training is ensuring that all pilots have the knowledge to easily access weather information and the knowledge how to access and comprehend this information while airborne.

The first century of aviation was one of tremendous progress and change. It has not been without its fits and starts. Wars and technological breakthroughs accelerated the process, while economic slumps, a litigious environment, and a perception of daring and danger has slowed it. For example the production of general aviation aircraft fell from 18,000 in 1978 to less than 1,000 in 1993. The average general aviation aircraft flying today is about 30 years old. Panel technologies currently in use, date back as late as the 1950's, and piston propulsion technologies have remained relatively unchanged for nearly 40 years. Regulatory restrictions and liability claims have also taken their toll driving up prices and forcing some businesses to fail. American general aviation manufacturers have spent $3 billion over the past 15 years on product liability claims alone.

With the dawn of a new millennium, there is evidence that this most recent downward trend is changing. New materials, technologies, weather data services, traffic (both airline and surface) congestion, and improved training techniques are all converging to encourage the development of a safer, faster, and cheaper general aviation transportation system. Many believe that the great popularity of the automobile is the freedom it affords the individual to tailor and complete his or her specific transportation needs. General aviation aircraft, of course, provide much the same advantage.

Much of the acceleration toward increased use of general aviation is due to government leadership provided by the NASA Langley Research Center through a consortium called Advanced General Aviation Transport Experiments (AGATE). This consortium, consisting of about 70 U.S. aviation-related entities including the Federal Aviation Administration (FAA), private industry, academia, and non-profit organizations, is working to promote this acceleration. These entities include 31 state governments. The purpose of AGATE is to become a facilitator for market growth of inter-city transportation in small aircraft. AGATE specifically aims to make single-pilot, light aircraft more safe, affordable, and available as a viable part of the nation's transportation system. In general, AGATE is targeting trips of 150 to 700-mile total distance, i.e., those trips too long to drive in a day and too short to efficiently use the hub and spoke system of the airlines.

AGATE promises to foster revenue and job creation in the areas of manufacturing, sales, training, service, support, and operations industries within the U.S. small airport infrastructure. The program focuses on the development of new general aviation technologies including bad weather flight and landing systems, complete with graphic displays of weather and guidance information, and emergency coping and avoidance measures that use on-board systems to support decision-making. The program also focuses on the development of traffic avoidance systems, systems that reduce the flight planning workload and enhance passenger safety, and systems designed to improve passenger comfort, aircraft performance, and efficiency. All of these aims are related, of course, to the goals sought by the research reported here. Increases in pilot population, flight hours, airport utilization, and new aircraft deliveries will determine the success of the AGATE program.

In speaking of this program, Dr. George F Donahue, FAA associate administrator for research and systems acquisition, said, "AGATE is in the right place at the right time to support modernization of the system for general aviation." There is every indication that we are beginning another go-go period in the development of general aviation.

This study enumerates the current, and changing, status of weather observing equipment, distribution equipment, how forecasts are formulated, and how these data can be used to make flying safer. Chapter 2 discusses new weather sensors and data delivery systems. Chapter 3 is a discussion of airborne weather decision-making. Chapter 4 presents information on the uses of high-tech weather sensors and list sources for obtaining weather information on the Internet. Chapter 5 discusses continuing education programs for pilots throughout the U.S. and Chapter 6 presents the findings, conclusions, and recommendations of this research study.

CHAPTER 2. NEW WEATHER SENSORS AND DATA DELIVERY SYSTEMS

The recent past presents a plethora of significant new weather sensing devices and weather data software. This has greatly changed the way pilots obtain weather information and has improved the quality of the aviation weather reports and forecasts.

Consequently, the National Weather Service (NWS) recently completed what might be termed a massive reorganization. The reorganization is a direct result of the new technologies that include:

- AWIPS (Advanced Weather Interactive Processing System);
- ASOS (Automated Surface Observation System);
- NEXRAD (WSR-88D Weather Surveillance Radar - Doppler);
- GOES (Geostationary Operational Environmental Satellite); and
- National Center Advanced Computer Systems.

The NWS continuously monitors the operation of these new technologies to ensure their optimal use and application.

ADVANCED WEATHER INTERACTIVE PROCESSING SYSTEM

The Advanced Weather Interactive Processing System (AWIPS) is an integrated suite of automated data-processing equipment that supports complex analysis, interactive processing, display of hydrometeorological data, and the rapid dissemination of warnings and forecasts in a highly reliable manner. AWIPS can:

- provide computational and display functions at operational NWS sites;
- provide open access, via NOAAPORT, a satellite based communications system, to extensive National Oceanic and Atmospheric Administration (NOAA) datasets that are centrally collected;
- acquire and process data from an array of meteorological sensors (e.g., Weather Surveillance Radar-88Doppler, Geostationary Operational Satellite, and Automated Surface Observation System) and local sources;
- provide an interactive communications system to interconnect NWS operations sites and to broadcast data to these sites; and
- disseminate warnings and forecasts in a rapid, highly reliable manner.

Each Weather Forecast Office (WFO) accommodates the data handling capability of the AWIPS. There are about 10 WFOs in Texas. Figure 2 illustrates the AWIPS located in the U.S.

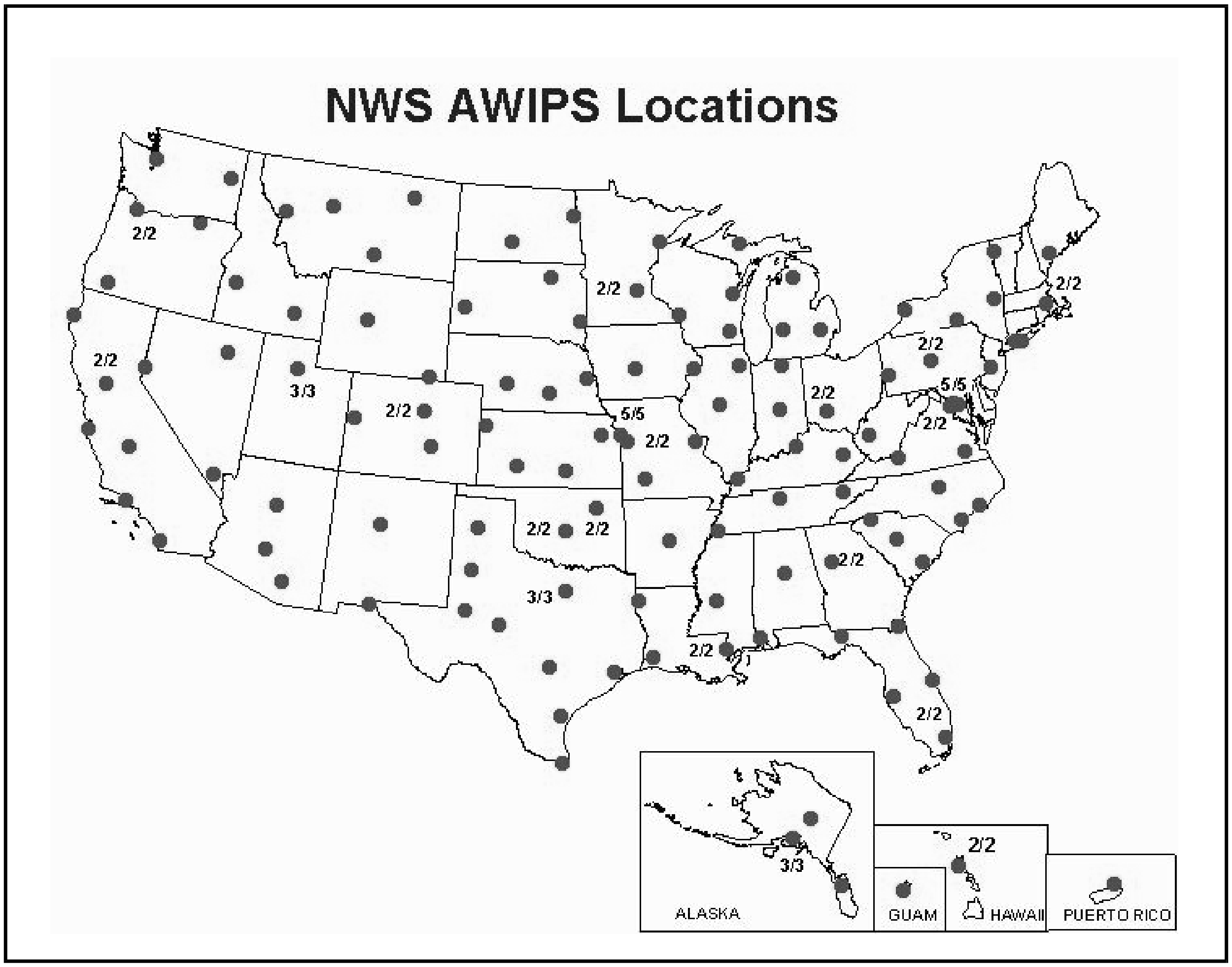


FIGURE 2. AWIPS Locations in the U.S.

AUTOMATED SURFACE OBSERVING SYSTEMS

The Automated Surface Observing Systems (ASOS) develop continuous unmanned weather observations. These systems, and the slightly less sophisticated Aviation Weather Observation Systems (AWOS), are located at many sites, mostly airports, across the nation. They have become, in effect, the primary surface weather observing system in the nation. They support weather forecast activities and aviation operations, and, at the same time, support the needs of the meteorological, hydrological, and climatological communities.

The installation of these ASOS is one of the advances helping provide improved weather information to pilots. The ASOS network has more than doubled the number of full-time surface weather observing locations. Obviously, this denser distribution of reporting points will inevitably help the NWS develop more accurate and timely forecasts and issue earlier warnings of inclement weather.

The ASOS obviously has strengths and weaknesses compared to the old system of using weather observers. Some of the strengths include the reduction in costs (which, in turn, provide for the installation of more sites), the ability to locate the points of observation near the airport runway touchdown zones, and the ability to collect continuous timely data.

The NWS distributes the data, hourly observations and special observations, via NWS networks to the national system of AWIPS. The special observations are automatically transmitted when conditions exceed a pre-selected threshold, e.g., the visibility decreases to less than three miles. In addition, ASOS routinely and automatically provide computer generated voice observations on published frequencies directly to aircraft near airports using FAA ground-to-air radio. These messages are also available via a local telephone number.

The basic weather element sensed by the ASOS include:

- sky condition: cloud height and amount (clear, scattered, broken, overcast) up to 12,000 feet;
- visibility (to at least 10 statute miles);
- basic present weather information: type and intensity for rain, snow, and freezing rain;
- obstructions to vision: fog, haze;
- pressure: sea-level pressure, altimeter setting;
- ambient temperature, dew point temperature;
- wind: direction, speed and character (gusts, squalls);
- precipitation accumulation; and
- selected significant remarks: variable cloud height, variable visibility, precipitation beginning/ending times, rapid pressure changes, pressure change tendency, wind shift, peak wind, etc.

Controlled Airspace

Controlled airspace is the different classes of airspace (Class A, Class B, Class C, Class D, and Class E) within which air traffic control (ATC) service is provided for Instrument Flight Rules (IFR) flights and to Visual Flight Rules (VFR) flights in accordance with the airspace classification. IFR operations imply that the pilot has filed an IFR flight plan and has received an appropriate ATC clearance. When a pilot files an IFR flight plan and receives clearance, the FAA assumes the responsibility for providing separation from other aircraft "operating under IFR". The implication of the more restrictive classes of controlled airspace is that a higher level of IFR activity is common. The pilot of the IFR flight must ensure that the weather forecast will meet requirements for a safe approach and completion of the flight.

Similarly, it is the responsibility of the VFR pilot to ensure that the appropriate weather minimums are prevalent prior to entering controlled airspace. Table 1 presents the basic weather minimum requirements. As shown in the table, these weather minimums are defined primarily in terms of flight visibility and distance (above, below and horizontal) from clouds. A competent VFR pilot must know the Class(es) of airspace in which he or she will be operating, the basic VFR minimums for that (those) Class(es), and what the weather situation will be at the time of the planned flight. This will allow the pilot to determine if he or she can legally complete the flight.

TABLE 1
Basic Weather Minimums

<table>
<tr><th colspan="3">Airspace</th><th>Flight Visibility</th><th>Distance From Clouds</th></tr>
<tr><td colspan="3">Class A</td><td>Not Applicable</td><td>Not Applicable</td></tr>
<tr><td colspan="3">Class B</td><td>3 statute miles</td><td>Clear of clouds</td></tr>
<tr><td colspan="3" rowspan="3">Class C</td><td rowspan="3">3 statute miles</td><td>500 feet below</td></tr>
<tr><td>1,000 feet above</td></tr>
<tr><td>2,000 feet horizontal</td></tr>
<tr><td colspan="3" rowspan="3">Class D</td><td rowspan="3">3 statute miles</td><td>500 feet below</td></tr>
<tr><td>1,000 feet above</td></tr>
<tr><td>2,000 feet horizontal</td></tr>
<tr><td rowspan="6">Class E</td><td colspan="2" rowspan="3">Less than 10,000 feet MSL</td><td rowspan="3">3 statute miles</td><td>500 feet below</td></tr>
<tr><td>1,000 feet above</td></tr>
<tr><td>2,000 feet horizontal</td></tr>
<tr><td colspan="2" rowspan="3">At or above 10,000 feet MSL</td><td rowspan="3">5 statute miles</td><td>1,000 feet below</td></tr>
<tr><td>1,000 feet above</td></tr>
<tr><td>1 statute mile</td></tr>
<tr><td rowspan="13">Class G</td><td rowspan="4">1,200 feet or less above the surface (regardless of MSL altitude)</td><td>Day, except as provided in section 91.155(b)</td><td>1 statute mile</td><td>Clear of clouds</td></tr>
<tr><td rowspan="3">Night, except as provide in section 91.155(b)</td><td rowspan="3">3 statute miles</td><td>500 feet below</td></tr>
<tr><td>1,000 feet above</td></tr>
<tr><td>2,000 feet horizontal</td></tr>
<tr><td rowspan="6">More that 1,200 feet above the surface but less than 10,000 MSL</td><td rowspan="3">Day</td><td rowspan="3">1 statute mile</td><td>500 feet below</td></tr>
<tr><td>1,000 feet above</td></tr>
<tr><td>2,000 feet horizontal</td></tr>
<tr><td rowspan="3">Night</td><td rowspan="3">3 statute miles</td><td>500 feet below</td></tr>
<tr><td>1,000 feet above</td></tr>
<tr><td>2,000 feet horizontal</td></tr>
<tr><td colspan="2" rowspan="3">More than 1,200 feet above the surface and at, or above, 10,000 feet MSL</td><td rowspan="3">5 statute miles</td><td>1,000 feet below</td></tr>
<tr><td>1,000 feet above</td></tr>
<tr><td>1 statute mile</td></tr>
</table>

Source: Adapted from Airman's Information Manual.

Airspace control is becoming more restrictive and pervasive. Figure 3 shows the two areas of Texas designated as Class B Airspace. VFR air traffic in these areas is severely controlled and pilots must not enter the airspace without hearing the word "cleared." Additionally, ATC may assign altitudes and headings while pilots are in the airspace. Interestingly, the VFR pilot is obliged only to stay "clear of clouds" in the airspace where the FAA exercises IFR-like control over altitude and routing. Both of these sites have AWOS-type capabilities

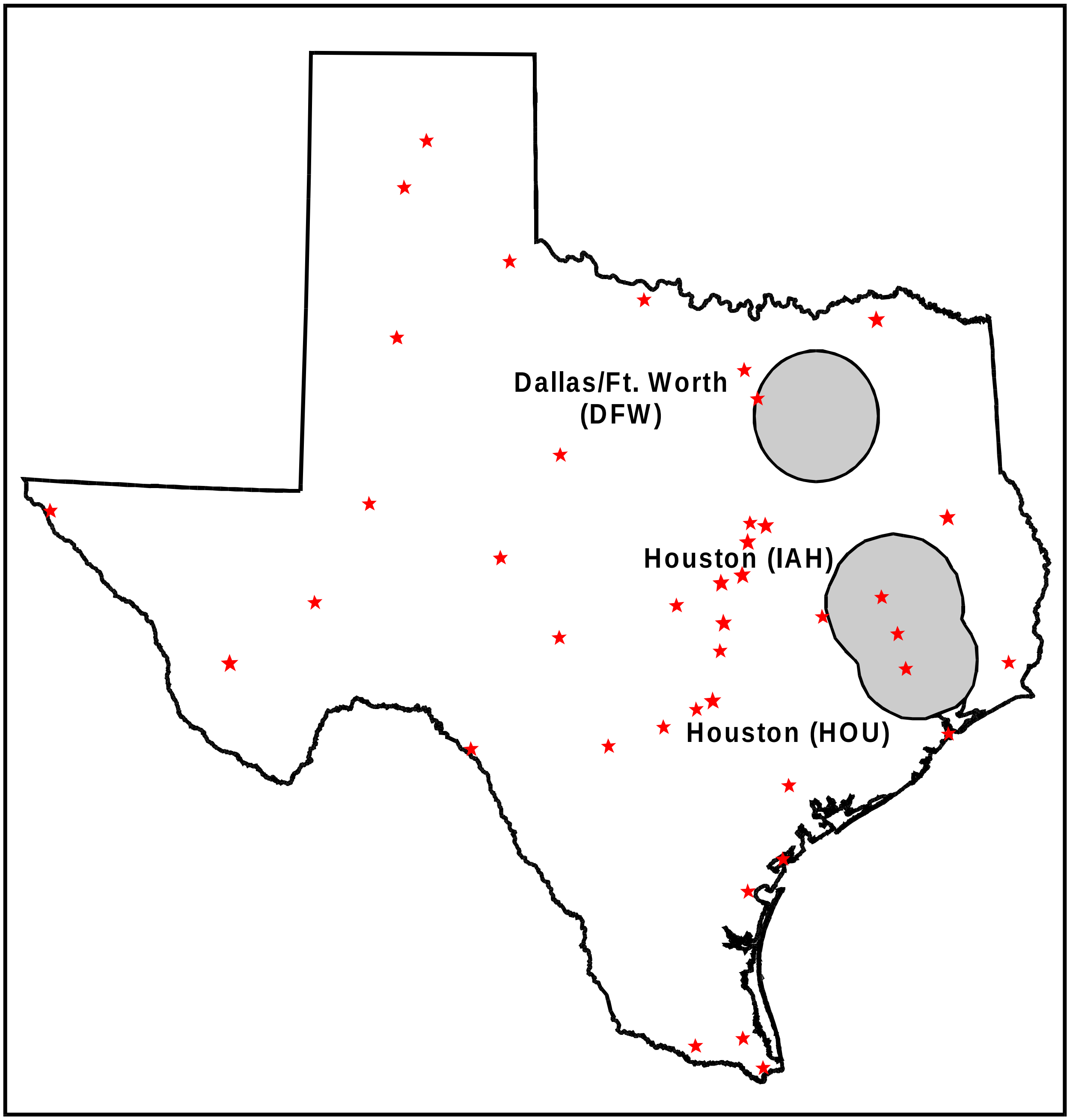


FIGURE 3. Class B Airspace in Texas with ASOS/AWOS Locations

Figure 4 shows the 11 areas designated as Class C airspace in Texas. Here control is not as severe, but the pilot must establish radio contact before entering the airspace and must use a radar transponder that indicates the altitude of the aircraft when operating in or above the airspace.

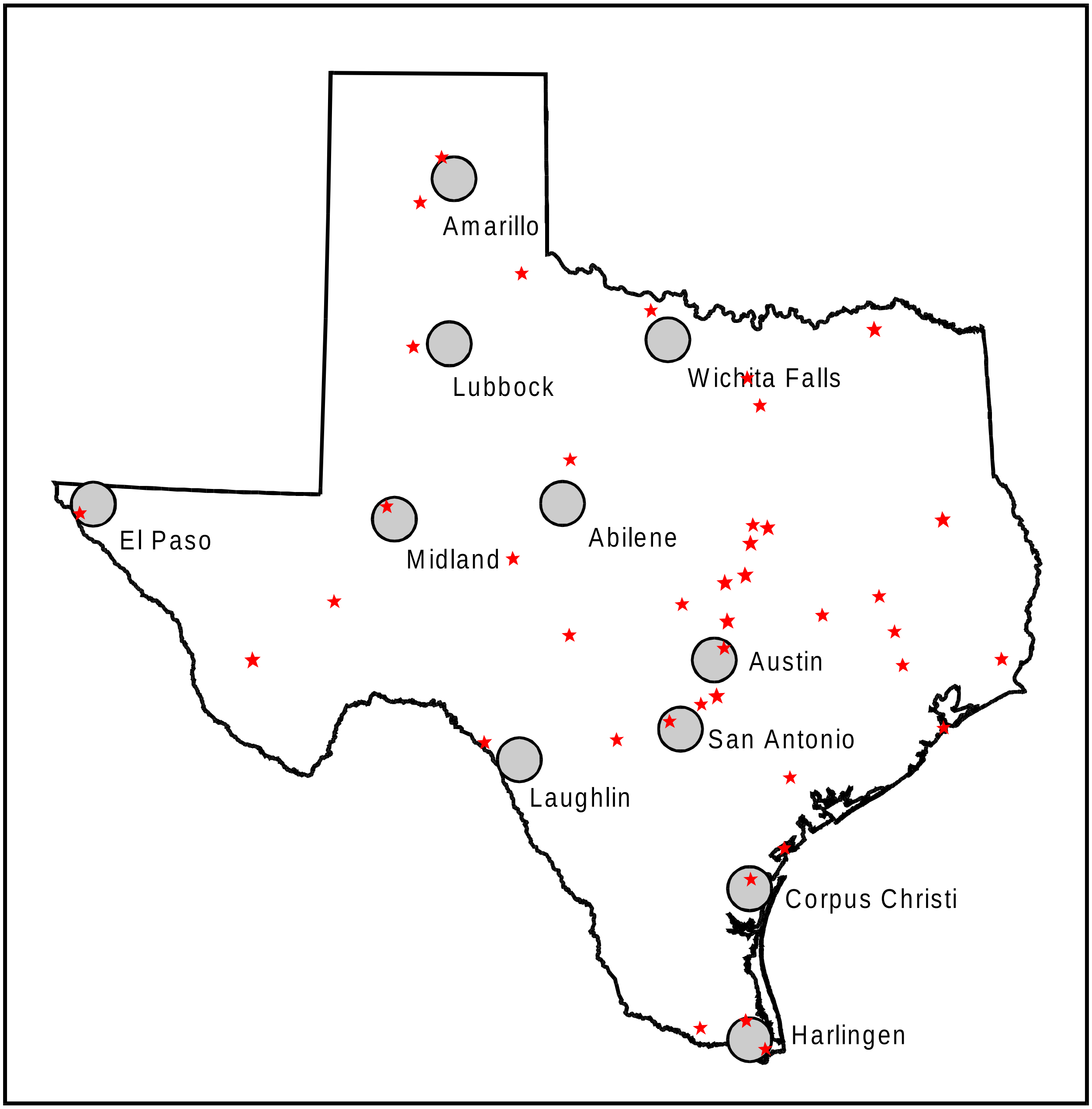


FIGURE 4. Class C Airspace in Texas with ASOS/AWOS Locations

Approximately 19 other Texas areas have the Class D airspace designation. These are primarily around airports that have operating control towers but are not Class B or Class C. Finally, many non-towered airports are designated to have Class E airspace that extends all the way to the ground near the airport. Figures 5 and 6 show designated Class D and Class E airspace in Texas. Typically, the surface is a five-statute mile radius around the primary airport.

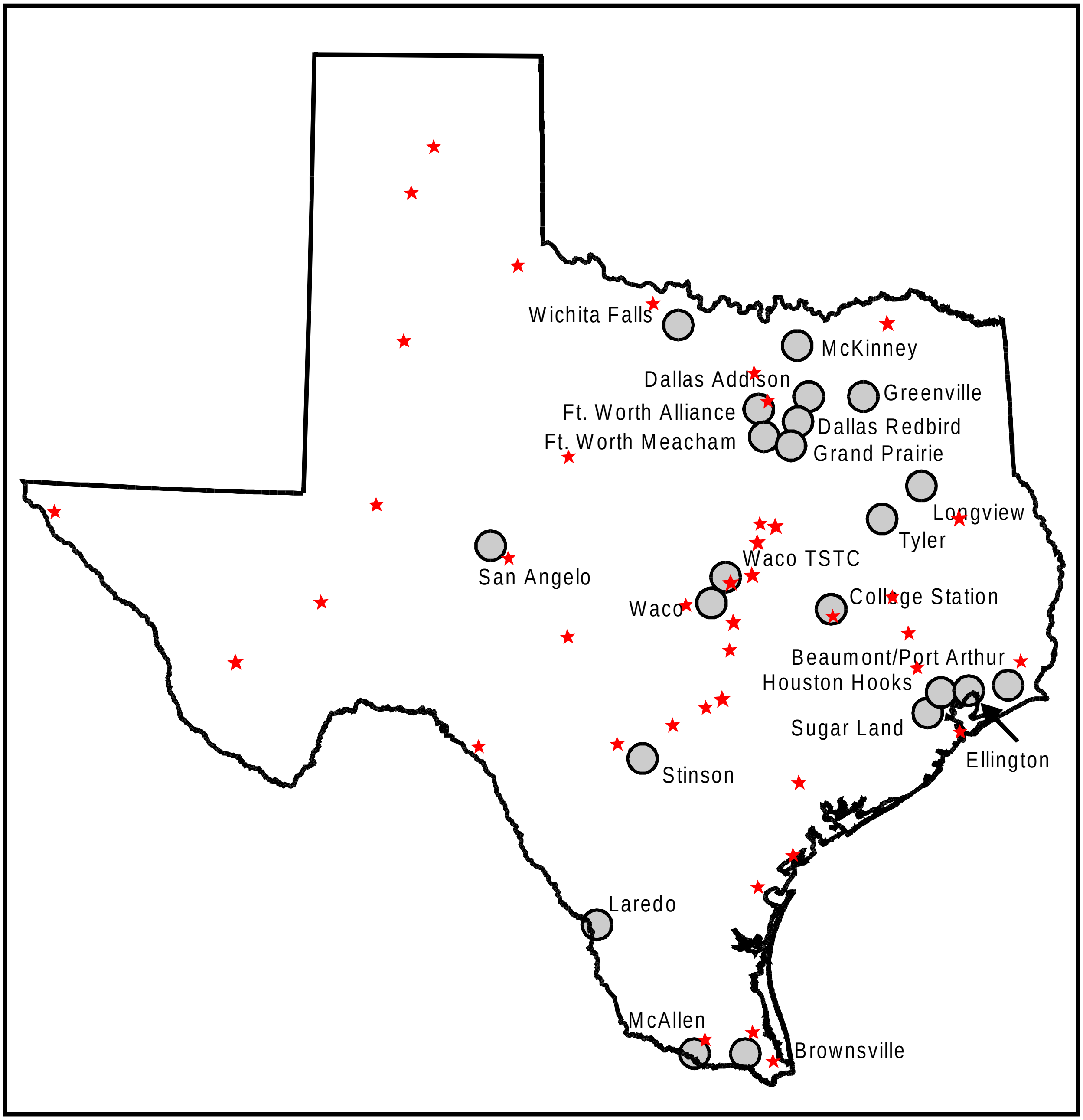


FIGURE 5. Class D Airspace in Texas with ASOS/AWOS Locations

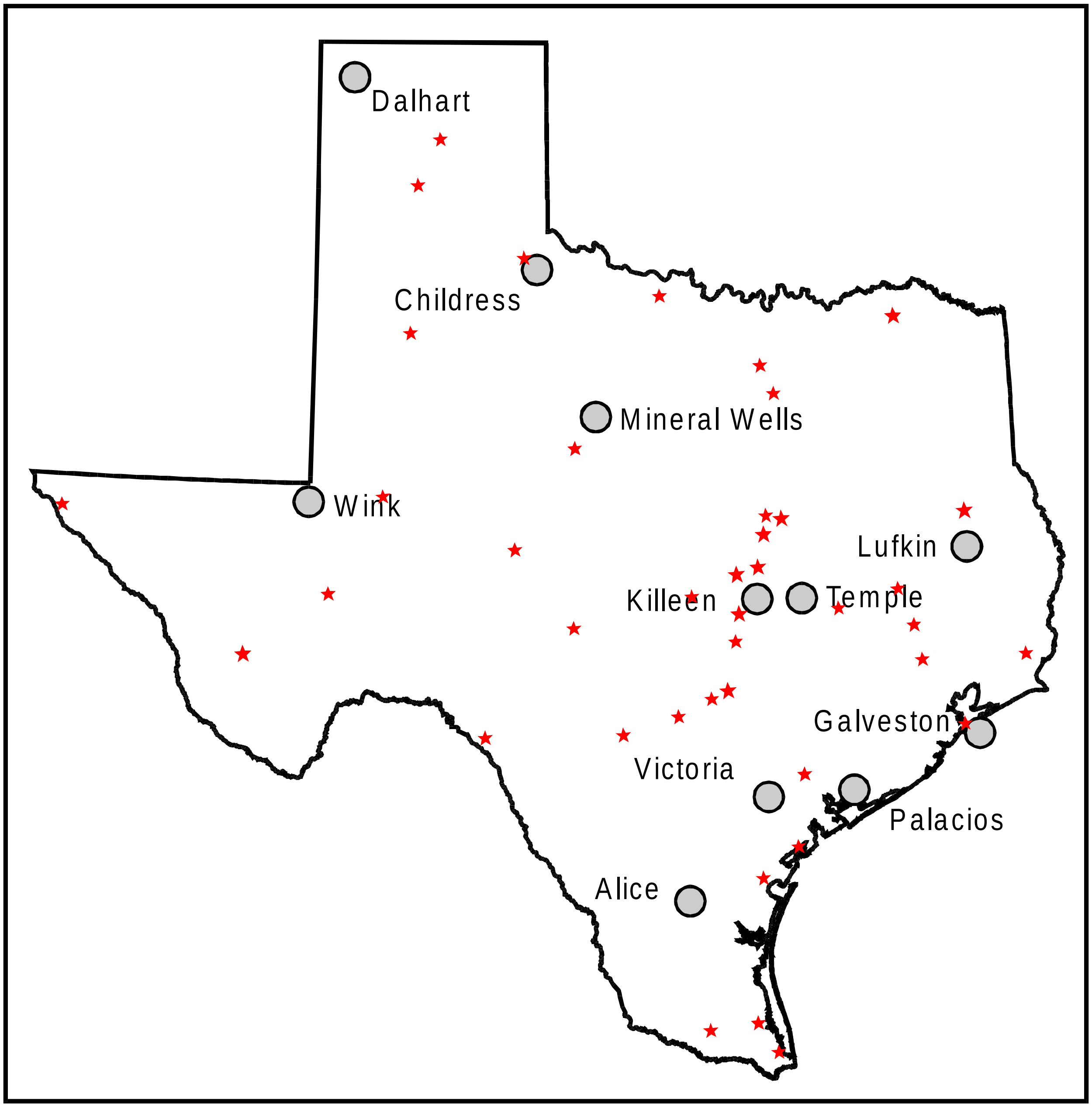


FIGURE 6. Class E Airspace in Texas with ASOS/AWOS Locations

For pilots to land aircraft under VFR at any of the airports in the so-called controlled airspace, the current reported weather at the airport must have a cloud ceiling of 1,000 feet or greater and/or the visibility must be one statute mile or greater. The implication here is, of course, that if automatic weather observing capabilities (or a qualified human observer) are not available, the VFR aircraft cannot land regardless of the weather. Figure 7 provides another graphical representation of the different airspace classes.

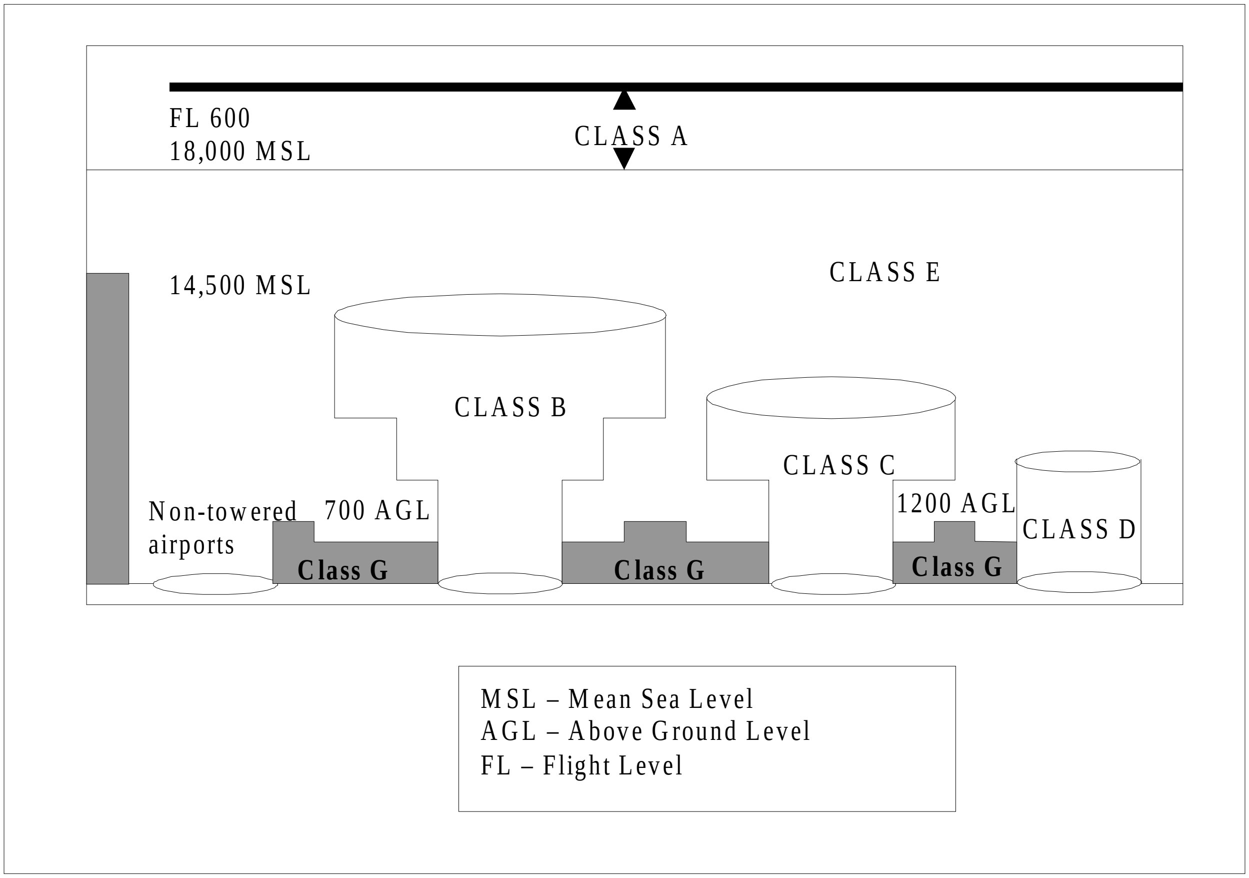


FIGURE 7. Airspace Classes

Uncontrolled Airspace
Class G airspace, uncontrolled airspace, is that portion of the airspace not designated as Class A, B, C, D, or E. Except near airports, most Texas surface area, up to 1,200 feet above ground level (AGL), is Class G. Some small areas in far West Texas are uncontrolled from the surface up to 14,500 feet mean sea level (MSL).

VFR flight in uncontrolled airspace less than 1,200-feet AGL requires the pilot to maintain one statute mile visibility and stay clear of clouds during the day (three statute miles visibility and 500 feet below, 1,000 feet above, and 2,000 feet horizontal from clouds at night). If pilots fly more than 1,200 feet AGL, the visibility requirement remains one statute mile during the day, but three statute miles at night while the minimum cloud clearances are 500 feet below, 1,000 feet above, and 2,000 feet horizontal both day and night. If pilots are more than 1,200 feet AGL and more than 10,000 feet MSL, the minimum visibility increases to five statute miles and the cloud clearances increase to 1,000 feet below, 1,000 feet above, and one statute mile horizontal.

The value of AWOS/ASOS sensors when planning a VFR flight is readily apparent. As the flight progresses, and especially if weather conditions deteriorate, the value of nearby observations becomes even greater.

Minimum IFR Weather Requirements

While the weather minimums for IFR flights are often much lower than those required for VFR, there are still minimums. While Federal Aviation Regulations (FAR) Part 91 allows for approaches to minimums to permit the pilot to take a look and see if the flight weather conditions will permit a safe landing, FAR Part 135, Operating Requirements: Commuter and On-Demand Operations, does not. Therefore, before a 135 flight can begin an approach, the pilot must obtain weather information at the airport and be flying above a prescribed minimum.

Unless the forecast weather at the destination is quite good (even better than VFR minimums), all IFR flight plans must incorporate a planned alternate airport to use when the weather at the destination airport does not permit a landing. Certain minimum weather visibility and cloud ceilings are required at the pilot's alternate airport. Therefore, ASOS observations at the destination and alternate airports are just as important to the IFR flight as they are to the VFR flight.

Table 2 lists all the Texas airports with instrument approaches including those with and without ASOS capabilities. Only three airports are located within controlled airspace without the automated observing capability. They are Houston Ellington, Dallas Addison, and Laredo International. Significantly, each of these have a manned control tower with weather observing capability and are located in near another airport with automated weather observing capability. However, there remain about 132 airports in Texas with instrument approaches, many of them precision approaches, without any weather data available on the field. And the number of airports with approved approaches is growing, almost daily, due to the addition of new GPS-based approaches. Some of these are precision approaches, allowing descents to lower ceiling and visibility minimums, as well.

TABLE 2
Texas Airports with Instrument Approaches

Associated City	Airport Name	Identifier	Weather Service	Airspace
Abilene	Abilene Regional	ABI	ASOS w/ATIS	Class C
Addison	Addison	ADS		Class D
Alice	Alice International	ALI	ASOS	
Alpine-Casparis	Alpine-Casparis Municipal	E38	AWOS	
Amarillo	Amarillo International	AMA	ASOS w/ATIS	Class C
Anahuac	Anahuac County	T00		
Andrews	Andrews County	E11		
Angleton/Lake Jackson	Angleton/Lake Jackson County	LBX	ASOS	
Arlington	Arlington Municipal	GKY	ASOS	
Athens	Athens Municipal	F44		
Atlanta	Atlanta Municipal	ATA		
Austin	Austin/Bergstrom International	AUS	ASOS w/ATIS	Class C
Austin	Lakeway Airpark	3R9		
Ballinger	Bruce Field	E30		
Bay City	Bay City Municipal	3R1		
Baytown	Baytown Airport	HPY		
Baytown	R.W.J. Airpark	54TX		
Beaumont	Beaumont Municipal	BMT		
Beaumont/Port Arthur	Beaumont/Port Arthur County	BPT	ASOS w/ATIS	Class D
Beeville	Beeville Municipal	3R0		
Big Lake	Reagan County	E41		
Big Spring	McMahon/Wrinkle	21XS		
Bonham	Jones Field	F00		
Borger	Hutchinson County	BGD	ASOS	
Bowie	Bowie Municipal	0F2		
Brady	Curtis Field	BBD	AWOS	
Breckenridge	Stephens County	BKD		
Brenham	Brenham Municipal	11R	AWOS	
Bridgeport	Bridgeport Municipal	1F9		
Brownfield	Terry County	Q26		

Associated City	Airport Name	Identifier	Weather Service	Airspace
Brownsville	Brownsville/South Padre Island International	BRO	ASOS w/ATIS	Class D
Brownwood	Brownwood Regional	BWD	AWOS	
Bryan	Coulter Field	CFD		
Burnet	Burnet Municipal Kate Craddock Field	BMQ	ASOS	
Caddo Mills	Caddo Mills Municipal	7F3		
Caldwell	Caldwell Municipal	14R		
Canadian	Hemphill County	HHF	AWOS	
Carrizo Springs	Dimmit County	CZT		
Carthage	Panola County-Sharpe Field	4F2		
Castroville	Castroville Municipal	T89		
Center	Center Municipal	F17		
Childress	Childress Municipal	CDS	ASOS	Class E
Cleburne	Cleburne Municipal	F18		
Cleveland	Cleveland Municipal	6R3		
Coleman	Coleman Municipal	COM		
College Station	Easterwood Field	CLL	ASOS w/ATIS	Class D
Commerce	Commerce Municipal	2F7		
Conroe	Montgomery County	CXO	ASOS	
Corpus Christi	Corpus Christi International	CRP	ASOS w/ATIS	Class C
Corsicana	C. David Campbell Field – Corsciana Municipal	CRS	ASOS	
Cotulla	Cotulla – La Salle County	COT	ASOS	
Crockett	Houston County	T56		
Crosbyton	Crosbyton Municipal	8F3		
Dalhart	Dalhart Municipal	DHT	ASOS	
Dallas	Dallas/Ft. Worth International	DFW	ASOS w/ATIS	Class B
Dallas	Love Field	DAL	ASOS w/ATIS	Class B
Dallas	Redbird	RDB	ASOS w/ATIS	Class D
Decatur	Decatur Municipal	8F7		
Del Rio	Del Rio International	DRT	ASOS	
Denton	Denton Municipal	DTO	ASOS	
Devine	Devine Municipal	23R		

Associated City	**Airport Name**	**Identifier**	**Weather Service**	**Airspace**
Dumas	Moore County	DUX		
Eagle Lake	Eagle Lake	ELA		
Eastland	Eastland Municipal	ETN		
Edna	Jackson County	26R		
El Paso	El Paso International	ELP	ASOS W/ATIS	Class C
El Paso	West Texas	TX04		
Ennis	Ennis Municipal	F41		
Falfurrias	Brooks County	T18		
Follett	Follett/Lipscomb County	TX80		
Ft. Stockton	Ft. Stockton-Pecos County	FST	ASOS	
Ft. Worth	Bourland Field	50F		
Ft. Worth	Alliance	AFW		Class D
Ft. Worth	Meacham International	FTW	ASOS x/ATIS	Class D
Ft. Worth	Ft. Worth Spinks	FWS		
Fredericksburg	Gillespie County	T82	AWOS	
Gainesville	Gainesville Municipal	GLE	AWOS	
Galveston	Municipal Airport	GLS	ASOS	Class E
Georgetown	Georgetown Municipal	GTU	AWOS	
George West	Live Oak County	8T6		
Giddings	Giddings-Lee County	62H		
Gilmer	Gilmer-Upshur County	4F4		
Gladewater	Gladewater Municipal	07F		
Graford	Possum Kingdom	F35		
Graham	Graham Municipal	E15		
Granbury	Granbury Municipal	F55		
Grand Prairie	Grand Prairie Municipal	GPM		
Greenville	Majors	GVT		
Gruver	Gruver Municipal	E19		
Hamilton	Hamilton Municipal	MNZ		
Harlingen	Rio Grand Valley International	HRL	ASOS w/ATIS	Class C
Haskell	Haskell Municipal	15F		
Hebronville	Jim Hogg County	03XS		
Henderson	Rusk County	F12		
Hereford	Hereford Municipal	HRX		

Associated City	Airport Name	Identifier	Weather Service	Airspace
Higgins	Higgins-Lipscomb County	1X1		
Hondo	Hondo Municipal	HDO	ASOS	
Houston	Clover Field	LVJ	ASOS	
Houston	David Wayne Hooks Memorial	DWH	ASOS w/ATIS	Class D
Houston	Ellington Field	EFD		Class D
Houston	Houston George Bush Intercontinental	IAH	ASOS w/ATIS	Class B
Houston	Houston Gulf	SPX		
Houston	Houston Southwest	AXH		
Houston	May	T51		
Houston	Weiser Air Park	EYQ		
Houston	West Houston	IWS		
Houston	William P. Hobby	HOU	ASOS w/ATIS	Class B
Huntsville	Huntsville Municipal	UTS	ASOS	
Jacksonville	Cherokee County	JSO		
Jasper	Jasper County – Bell Field	JAS	AWOS	
Junction	Kimble County	JCT	ASOS	
Kenedy	Karnes County	2R9		
Kerrville	Kerrville Municipal/Louis Schreiner Field	ERV	AWOS	
Killeen	Killeen Municipal	ILE	AWOS	Class E
Kingsville	Kleberg County	T80		
Kountze/Silsbee	Hawthorne Field	45R		
Lago Vista	Lago Vista TX – Rusty Allen	5R3		
La Grange	Fayette Regional Air Center	3T5	AWOS	
Lamesa	Lamesa Municipal	2F5		
Lampasas	Lampasas	T28	AWOS	
Lancaster	Lancaster	LNC		
La Porte	La Porte Municipal	T41		
Laredo	Laredo International	LRD		Class D
Levelland	Levelland Municipal	Q24		
Liberty	Liberty Municipal	T78		
Littlefield	Littlefield Municipal	Q00		
Livingston	Livingston Municipal	00R		

Associated City	Airport Name	Identifier	Weather Service	Airspace
Llano	Llano Municipal	6R9		
Lockhart	Lockhart Municipal	50R		
Longview	Gregg County	GGG	ASOS w/ATIS	Class D
Lubbock	Lubbock International	LBB	ASOS w/ATIS	Class C
Lufkin	Angelina County	LFK	ASOS	Class E
Madisonville	Madisonville Municipal	51R		
Marfa	Marfa Municipal	MRF	AWOS	
Marlin	Marlin	T15		
Marshall	Harrison County	ASL	AWOS	
Mason	Mason County	T92		
McAllen	McAllen Miller International	MFE	ASOS W/ATIS	Class D
McKinney	McKinney Municipal	TKI	ASOS	Class D
Mesquite	Mesquite Metro	HQZ		
Mexia	Mexia-Limestone County	TX06		
Midland	Midland Airpark	MDD		
Midland	Midland International	MAF	ASOS w/ATIS	Class C
Midlothian/ Waxahachie	Midlothian/Waxahachie Municipal	4T6		
Mineola	Mineola Wisener Field	3F9		
Mineola/Quitman	Mineola-Quitman	3T1		
Mineral Wells	Mineral Wells	MWL	ASOS	Class E
Monahans	Roy Hurd Memorial	E01		
Mt. Pleasant	Mt. Pleasant Municipal	MSA		
Muleshoe	Muleshoe Municipal	TA87		
Nacogdoches	A.L. Mangham Jr. Regional	OCH	AWOS	
Navasota	Navasota Municipal	60R		
New Braunfels	New Braunfels Municipal	BAZ	ASOS	
Odessa	Odessa-Schlemeyer Field	E02	ASOS	
Olney	Olney Municipal	ONY		
Orange	Orange County	ORG		
Ozona	Ozona Municipal	OZA		
Paducah	Dan E. Richards Municipal	3F6		
Palacios	Palacios Municipal	PSX	ASOS	
Palestine	Palestine Municipal	PSN	AWOS	

Associated City	Airport Name	Identifier	Weather Service	Airspace
Pampa	Perry Lefors Field	PPA		
Panhandle	Panhandle-Carson County	T45		
Paris	Cox Field	PRX	AWOS	
Pearsall	McKinley Field	T30		
Pecos	Pecos Municipal	PEQ		
Perryton	Perryton Ochiltree County	PYX		
Plainview	Hale County	PVW	AWOS	
Pleasanton	Pleasanton Municipal	PEZ		
Port Isabel	Port Isabel – Cameron County	PIL	ASOS	
Port Lavaca	Calhoun County	T97		
Robstown	Nueces County	T53		
Rockport	Aransas County	RKP	ASOS	
Rocksprings	Edwards County	69R		
Rockwall	Rockwall Municipal	F46		
San Angelo	Mathis Field	SJT	ASOS w/ATIS	Class D
San Antonio	San Antonio International	SAT	ASOS w/ATIS	Class C
San Antonio	Stinson	SSF	ASOS w/ATIS	Class D
San Marcos	San Marcos Municipal	HYI	AWOS	
San Saba	San Saba County Municipal	81R	AWOS	
Seminole	Gaines County	31F		
Seymour	Seymour Municipal	60F		
Sherman	Sherman Municipal	SWI		
Sherman/Denison	Grayson County	F39		
Sinton	San Patricio County	T69		
Snyder	Winston Field	SNK	AWOS	
Sonora	Sonora Municipal	E29		
Spearman	Spearman Municipal	E42		
Stamford	Arledge Field	F56		
Stephenville	Clark Field Municipal	SEP		
Stratford	Stratford Field	Q70		
Sugar Land	Sugar Land Municipal/Hull Field	SGR		
Sulphur Springs	Sulphur Springs Municipal	SLR		
Sweetwater	Avenger Field	SWW	AWOS	
Taylor	Taylor Municipal	T74		

Associated City	Airport Name	Identifier	Weather Service	Airspace
Temple	Draughon-Miller Central Texas Regional	TPL	AWOS	Class E
Terrell	Terrell Municipal	TRL	ASOS	
Tyler	Tyler Pounds Field	TYR	ASOS	Class D
Uvalde	Garner Field	UVA	AWOS	
Van Horn	Culberson County	VHN		
Vernon	Wilbarger County	F05	AWOS	
Victoria	Victoria Regional	VCT	ASOS	Class E
Waco	McGregor Municipal	PWG	AWOS	
Waco	Waco Regional	ACT	ASOS w/ATIS	Class D
Waco	TSTC Waco	CNW	AWOS	Class D
Weatherford	Parker County	WEA		
Weslaco	Mid Valley	T65		
Wharton	Wharton Municipal	5R5		
Wheeler	Wheeler Municipal	T59		
Wichita Falls	Kickapoo Downtown Airpark	T47		
Wichita Falls	Sheppard AFB/Wichita Falls Municipal	SPS	ASOS w/ATIS	Class D
Wichita Falls	Wichita Valley	F14		
Wink	Winkler County	INK	ASOS	Class E
Winnsboro	Winnsboro Municipal	F51		
Winters	Winters Municipal	77F		
Yoakum	Yoakum Municipal	T85		

Current Assessment of ASOS Installations in the U.S.

As previously mentioned, ASOS sensors are present across the U.S. Table 3 provides a breakdown of the number of ASOS sites for each state, as well as additional information for comparative purposes.

TABLE 3
ASOS Installations in the U.S.

State	Land Area X 1,000 miles (rank)	1997 Population Estimate (rank)	Number of ASOS (rank)	Area per ASOS (rank)	Radius (rank)	Population per ASOS (rank)
Alabama	51 (28)	4,322,113 (23)	18 (T-34)	2,833 (34)	30 (T-33)	240,117 (35)
Alaska	571 (1)	609,655 (47)	89 (2)	6,416 (46)	45 (T-45)	6,850 (1)
Arizona	113 (6)	4,553,249 (21)	25 (25)	4,520 (41)	38 (T-41)	182,130 (32)
Arkansas	52 (27)	2,523,186 (33)	24 (26)	2,166 (30)	26 (T-29)	105,130 (14)
California	156 (3)	32,182,118 (1)	97 (1)	1,608 (22)	23 (T-22)	331,774 (47)
Colorado	104 (8)	3,892,029 (25)	29 (T-19)	3,586 (39)	34 (T-38)	134,208 (24)
Connecticut	5 (47)	3,267,240 (28)	10 (45)	500 (3)	12.6 (3)	326,724 (46)
Delaware	2 (48)	735,143 (45)	3 (49)	666 (6)	14.6 (T-5)	245,048 (36)
Florida	54 (26)	14,677,181 (4)	57 (6)	947 (9)	17.4 (9)	257,494 (38)
Georgia	58 (21)	7,489,982 (10)	48 (8)	1,208 (18)	19.6 (18)	156,041 (26)
Idaho	83 (11)	1,208,865 (40)	18 (T-34)	4,611 (42)	38 (T-41)	67,159 (9)
Illinois	56 (T-23)	11,989,352 (6)	46 (11)	1,217 (19)	19.7 (19)	260,638 (39)
Indiana	36 (37)	5,864,847 (14)	19 (T-30)	1,895 (28)	25 (28)	308,676 (44)
Iowa	56 (T-23)	2,854,330 (30)	49 (7)	1,143 (16)	19.1 (16)	58,252 (6)
Kansas	82 (T-12)	2,601,437 (32)	26 (24)	3,153 (36)	32 (T-35)	100,055 (13)
Kentucky	40 (T-35)	3,910,366 (24)	31 (T-17)	1,654 (23)	23 (T-22)	126,141 (20)
Louisiana	45 (32)	4,353,646 (22)	27 (23)	1,666 (T-24)	23 (T-22)	161,246 (29)
Maine	31 (38)	1,241,895 (39)	17 (38)	1,823 (27)	24 (27)	73,053 (10)
Maryland	10 (42)	5,094,924 (19)	18 (T-34)	555 (4)	13.3 (4)	283,051 (42)
Massachusetts	8 (T-45)	6,114,440 (13)	19 (T-30)	421 (2)	11.6 (2)	321,813 (45)
Michigan	57 (22)	9,779,984 (8)	61 (5)	934 (8)	17.2 (8)	160,328 (28)
Minnesota	80 (14)	4,687,408 (20)	82 (3)	976 (10)	17.6 (10)	57,164 (5)
Mississippi	47 (31)	2,731,644 (31)	19 (T-30)	2,473 (32)	28 (T-31)	143,771 (25)
Missouri	69 (T-17)	5,408,455 (16)	22 (28)	3,136 (35)	32 (T-35)	245,839 (37)
Montana	146 (4)	878,730 (43)	21 (29)	6,952 (48)	47 (48)	41,844 (3)
Nebraska	77 (15)	1,657,009 (38)	28 (T-21)	2,750 (33)	30 (T-33)	59,179 (8)
Nevada	110 (7)	1,678,691 (37)	14 (T-41)	7,857 (49)	50 (49)	119,907 (18)
New Hampshire	9 (T-43)	1,172,140 (41)	9 (46)	1,000 (T-11)	17.8 (T-11)	130,238 (23)
New Jersey	8 (T-45)	8,058,384 (9)	13 (43)	615 (5)	14.6 (T-5)	619,876 (49)
New Mexico	122 (5)	1,723,965 (36)	19 (T-30)	6,421 (47)	45 (T-45)	90,735 (11)
New York	48 (30)	18,146,200 (3)	40 (T-14)	1,200 (17)	19.5 (17)	453,655 (48)
North Carolina	49 (29)	7,430,675 (11)	47 (T-9)	1,042 (13)	18.7 (14)	158,099 (27)
North Dakota	69 (T-17)	640,965 (46)	11 (44)	6,272 (45)	45 (T-45)	58,270 (7)
Ohio	41 (34)	11,192,932 (7)	38 (16)	1,078 (14)	18.5 (13)	294,551 (43)
Oklahoma	69 (T-17)	3,321,611 (27)	29 (T-19)	2,379 (31)	28 (T-31)	114,538 (16)

State	Land Area X 1,000 miles (rank)	1997 Population Estimate (rank)	Number of ASOS (rank)	Area per ASOS (rank)	Radius (rank)	Population per ASOS (rank)
Oregon	96 (10)	3,243,272 (29)	28 (T-21)	3,428 (37)	33 (37)	115,831 (17)
Pennsylvania	25 (40)	12,011,278 (5)	43 (12)	1,139 (15)	19 (15)	279,332 (41)
Rhode Island	1 (49)	987,263 (42)	5 (48)	200 (1)	8 (1)	197,453 (33)
South Carolina	30 (39)	3,788,119 (26)	18 (T-34)	1,666 (T-24)	23 (T-22)	210,451 (34)
South Dakota	76 (16)	737,755 (44)	16 (T-39)	4,750 (43)	39 (43)	46,110 (4)
Tennessee	42 (33)	5,371,693 (17)	47 (T-9)	894 (7)	16.9 (7)	114,291 (15)
Texas	263 (2)	19,385,699 (2)	74 (4)	3,554 (38)	34 (T-38)	261,969 (40)
Utah	82 (T-12)	2,065,001 (34)	16 (T-39)	5,125 (44)	40 (44)	129,063 (21)
Vermont	9 (T-43)	588,632 (48)	6 (47)	1,500 (21)	22 (21)	98,105 (12)
Virginia	40 (T-35)	6,737,489 (12)	40 (T-14)	1,000 (T-11)	17.8 (T-11)	168,437 (30)
Washington	67 (20)	5,614,151 (15)	31 (T-17)	2,161 (29)	26 (T-29)	181,102 (31)
West Virginia	24 (41)	1,815,231 (35)	14 (T-41)	1,714 (26)	23 (T-22)	129,659 (22)
Wisconsin	55 (25)	5,201,226 (18)	42 (13)	1,309 (20)	20 (20)	123,839 (19)
Wyoming	97 (9)	480,043 (49)	23 (27)	4,217 (40)	36 (40)	20,871 (2)

AWOS and ASOS Installations Planned in Texas

In the last two years the Texas Department of Transportation (TxDOT) has installed 16 AWOS III's around the state through an FAA Innovative Financing Program. These AWOS's were funded with 75% federal funds and 25% local funds, sited and managed by the aviation division of TxDOT. This program included five years of maintenance to be provided by the contractor, after which time the local communities will be responsible for all operating and maintenance costs.

The FAA has discontinued their Innovative Financing Program at this time. However, TxDOT plans to continue a similar program using state and local funds in the near future. Communities will be polled for volunteers as soon as funds can be identified.

There are no current plans by the FAA to install additional ASOS systems in the state. Installation is complete on all the systems the FAA purchased. The Air Traffic Division at the FAA plans to add 20-30 units nationwide, but it is undetermined if any are in Texas. There are approximately 15-20 sites in Texas that could warrant an ASOS. However, it costs the FAA approximately $250,000 per unit to install. This is significantly more than the units Texas recently installed. The units that the FAA installs are AWOS-4. The Air Traffic Division produces a list of possible ASOS sites, but technical or political reasons dictate actual site selection. Sugar Land is possibly the next ASOS site in Texas.

The NWS also has no plans to install additional ASOS units in Texas. Criteria for the location of ASOS sites are straightforward. The NWS installs an ASOS wherever there is a WSO at an airport collecting weather information, or at an airport collecting surface observations.

SUPER UNICOM
Super Unicom involves automatically transmitting local information via the Unicom frequency for pilots accessing the Unicom frequency as a common traffic advisory frequency (CTAF). This automated data might include ASOS weather information or information about traffic provided by a nearby traffic radar.

These features are associated with a procedure that is almost a standard practice at airports with an Automated Terminal Information Service (ATIS) and a control tower that closes at night. The common practice is to prepare an airport specific ATIS for the night followed by the current ASOS observation, both broadcast over the radio. This procedure greatly enhances the ability to safely fly an instrument approach at night after the tower is closed. Coordination with an Approach Control or and Air Route Traffic Control Center is required.

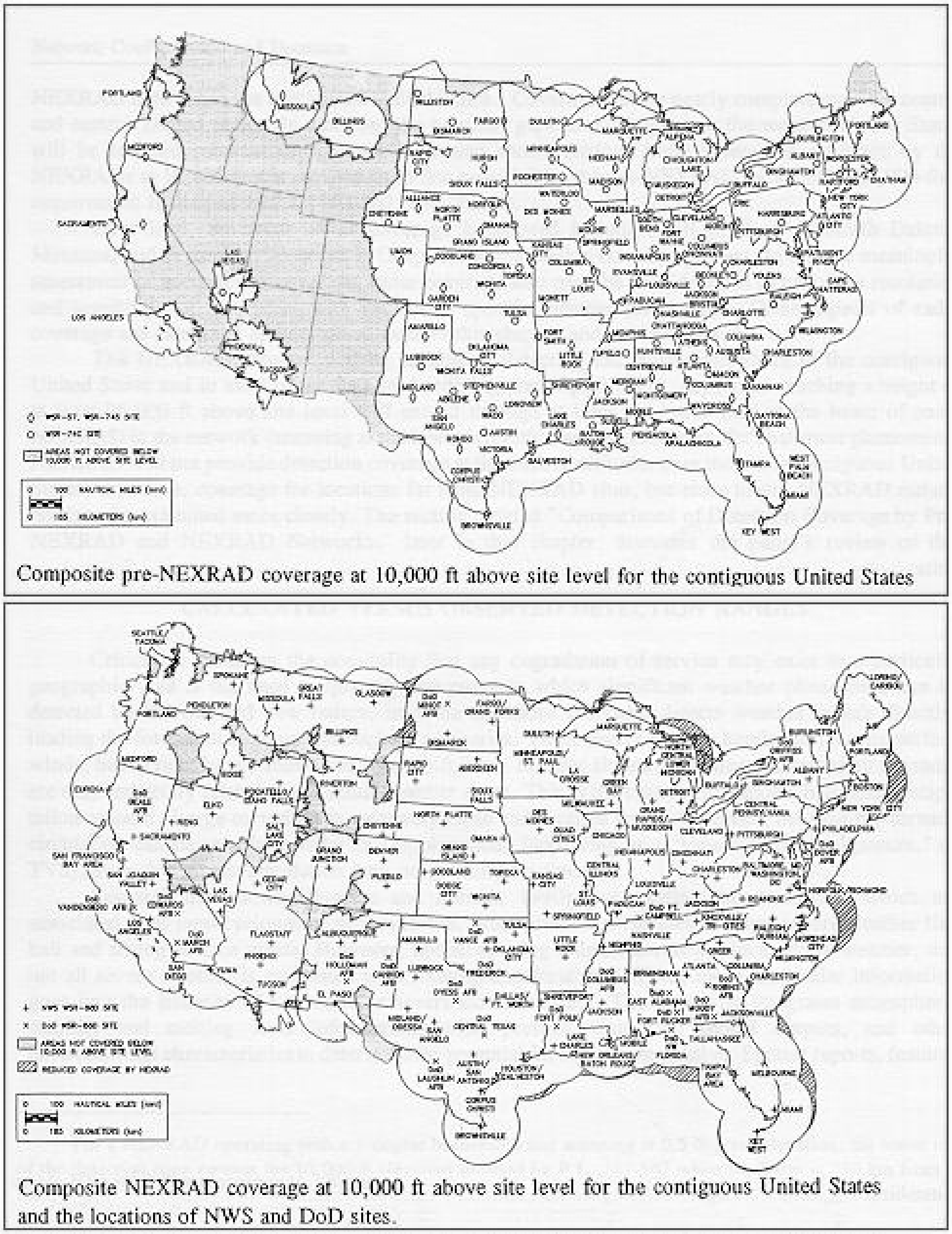
DOPPLER RADAR
Another staple in the new weather detection set of tools used by the NWS is the Doppler weather surveillance radar. These radar, that are mostly Model WSR-88D (also known as NEXRADs), monitor precipitation and observe the speed and direction of the wind. These radar also provide quantitative area precipitation measurements thus providing hydrological data of importance to agriculture and flood forecasters.

The WSR-88D uses Doppler radar technology to:

- substantially increase tornado warning lead-time;
- improve the detection and measurement of damaging winds, severe turbulence, wind shear, and hail storms;
- improve the forecast of the location and severity of thunderstorms;
- increase the accuracy of identifying areas that are threatened;
- substantially reduce the number of incorrect forecasts and false alarms;
- increase the accuracy of rainfall estimates for flash flood warnings; and
- improve water resource management and river flood forecasts.

The NWS feeds data from these radar, via NOAAPORT, into the AWIPS, thus providing local NEXRAD images for universal use.

There are 164 Doppler sites across the country, including the island territories from Guam to Puerto Rico, all linked to the NOAAPORT communication system. The Department of Defense and the FAA own some of the sites as does the NWS. There are more than 10 sites distributed across Texas. Figure 8 shows a representation of their coverage, at 10,000 feet, and contains a listing of the Texas NEXRAD sites.



Composite pre-NEXRAD coverage at 10,000 ft above site level for the contiguous United States

Composite NEXRAD coverage at 10,000 ft above site level for the contiguous United States and the locations of NWS and DoD sites.

Images from: Assessment of NEXRAD COVERAGE and ASSOCOATED WEATHER SERVICES; of the Commission on Engineering and Technical Systems. National Research Council

FIGURE 8. NEXRAD Coverage in the U.S.

WEATHER SATELLITES

There are two types of weather satellites currently used by the newly modernized and restructured NWS. These include the Geostationary Orbiting Environmental Satellites (GOES) and the much lower orbiting Polar-orbiting Operational Environmental Satellites (POES).

The NWS has two GOES satellites currently in geosyncronous orbit, GOES 8 and GOES 10. Each orbits about 22,240 miles above the earth exactly over the equator. GOES 8 continuously scans the eastern part of the U.S. (and the Atlantic Ocean) while GOES 10 continuously scans the western part of the U.S. (and the Pacific Ocean). Each satellite carries an on- board imager, sounder, and space environmental monitoring system. The imager, which collects visible images, and the sounder, which collects temperature profiles, moisture profiles, and cloudtop altitudes, are the primary tools used for weather sensing.

The POES satellites, orbiting at a much lower altitude, send back data that are more precise. However, since they are not geostationary, repetitive observations of a single point on earth have a long time lag.

PILOT TRAINING

One point quickly becomes clear when reviewing the list of sources and displays of weather data available to the general aviation pilot. If the pilot intends to use all the high technology available, the pilot must continually update his or her knowledge about the new equipment and procedures available. Even more importantly, pilots must realize the dire consequences resulting from misuse of the equipment and procedures. They must take the steps necessary to ensure proper operation of new equipment. Situational awareness and continuing updates will help to ensure against errors and misinterpretations.

All pilots, at all levels of experience and capability, have personal limitations for weather that they should not exceed. It seems obvious that this is more of a restriction on a private pilot, without an instrument rating, than on an airline transport pilot. However, setting the limits and then honoring them is equally important to pilots with all levels of ability and experience.

HIGH-TECH APPROACHES TO WEATHER DATA IN FLIGHT

Several versions and approaches toward providing timely, understandable weather information to the pilot while en-route are currently being pursued. In theory, this is a truly desirable goal if developers can accomplish this at a reasonable cost. Present indications are that this is possible.

For example, consider the “Capstone Demonstration Program” currently underway in southwestern Alaska. Figure 9 shows the general area included in the demonstration. The intent is to improve aviation safety and efficiency through the installation of government-furnished GPS-based avionics and data link communications suites in most general aviation aircraft serving the Yukon-Kuskokwim delta area. Plans call for equipping up to 200 aircraft and providing compatible ground systems, equipment, and services. The name “Capstone” comes from the program’s effect of drawing and holding together concepts and recommendations contained in various reports. These reports come from the Radio Telecommunications Conference of America (RTCA), the National Transportation Safety Board (NTSB), the Mitre Corporation’s Center for Advanced Aviation System Development (CAASD), and Alaskan aviation industry representatives. In addition to the avionics suites, Capstone will deploy a ground infrastructure for weather observation, data link communications, surveillance, and Flight Information Services (FIS) to improve safety and enable eventual implementation of new procedures. A successful Capstone demonstration will help reduce the FAA’s risks during the nationwide transition to the future National Airspace System (NAS) Architecture 4.0.

Aircraft selected for the Capstone program will receive:

- an IFR-certified GPS navigation receiver;
- Automatic Dependent Surveillance-Broadcast (ADS-B) transmitter/receiver;
- a moving map display with Traffic Information Service-Broadcasts (TIS-B) traffic and terrain advisory services;
- FIS providing weather maps, special use airspace status, wind shear alerts, NOTAM's, and PIREP's; and
- a multi-function color display.

The Anchorage Air Route Traffic Control Center (ARTCC) will house a ground broadcast server and a gateway processor to receive ADS-B aircraft position reports and data link messages from each remote site. The server and processor will interface with the existing Micro Enroute Automated Radar Tracking System (M-EARTS). The M-EARTS and related subsystems will depict the ADS-B targets on one or more air traffic controller displays fused with radar targets. Traffic Information Service-Broadcasts (TIS-B) will enable the pilot of a Capstone-equipped aircraft to see both ADS-B and radar targets on the multi-function display.

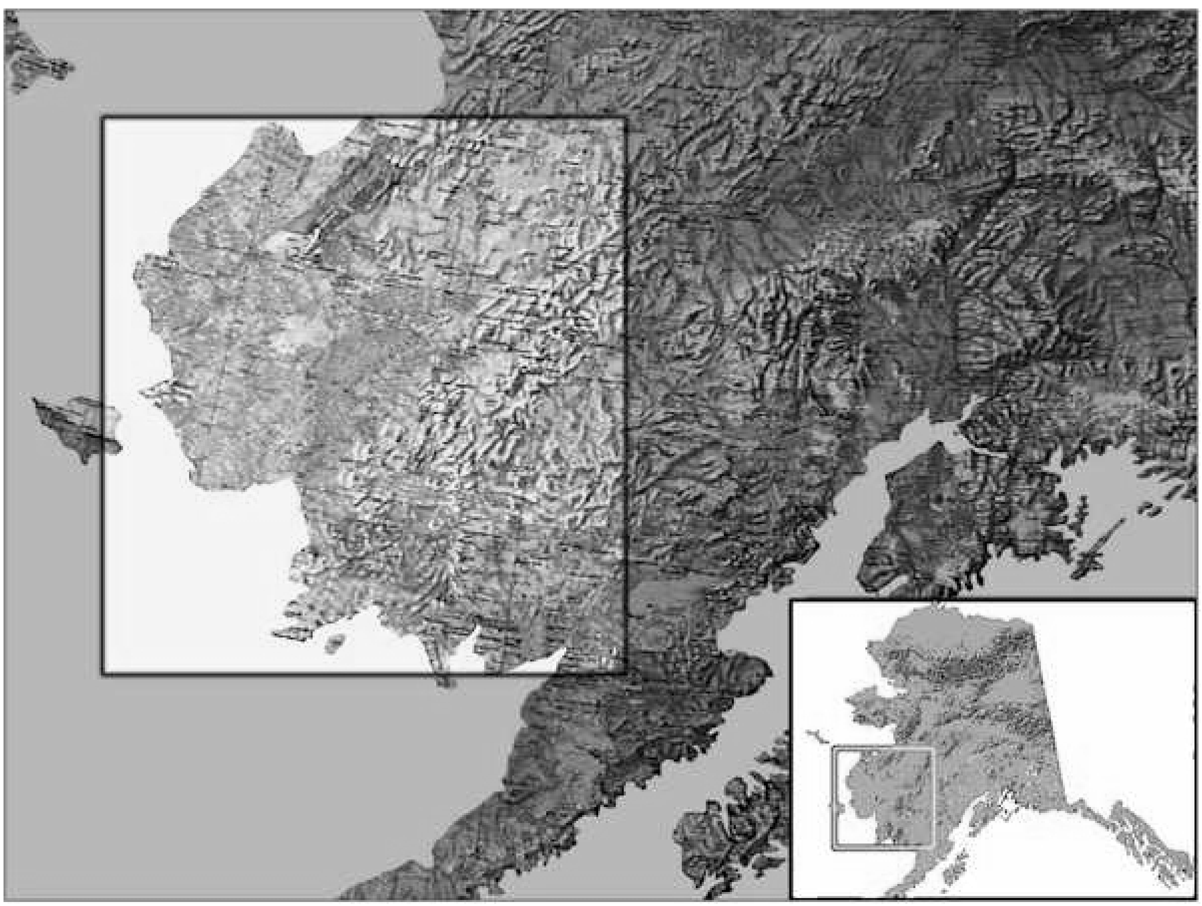


FIGURE 9. Capstone Region of Alaska

The Capstone program will enable delivery of improved weather products (text and graphics) to the pilot and test the GPS and data link technology as a “proof of concept” for the operational enhancements requested by RTCA. The program will also include training for pilots, operators, safety inspectors, air traffic control specialists, and technicians. The University of Alaska will conduct an independent evaluation of system safety improvements and document user benefits derived. Plans call for the safety evaluation to begin in January 2000.

NATIONAL AERONAUTICAL AND SPACE ADMINISTRATION RESEARCH

For several years, the National Aeronautics and Space Administration (NASA) and the FAA in a consortium utilizing the resources of government, industry, and academia have worked to develop new methods to revive the general aviation industry. The consortium, AGATE, is attempting to stem an apparent decline in the general aviation industry by making travel by private aircraft safer, more reliable, and more affordable. The consortium consists of members from 31 states, 40 principle members from industry, 6 associate members from industry and universities, and 30 supporting members from universities, industry, and non-profit organizations.

The primary focus of AGATE is to promote single-pilot, light aircraft transportation. AGATE is targeting trips of 150 to 700 miles, round trips that are too long to complete in a day and too short to efficiently use the hub-and-spoke system.

System Features

Some of the features that the sponsors believe will promote the general aviation role include:

- graphical pilot interface for situational awareness;
- data link communications system;
- aircraft systems computer network;
- simplified automated flight controls and displays;
- simplified engine operations;
- engine health monitoring;
- improved structures and materials;
- crashworthiness;
- acoustics;
- ice sensing;
- ice protection;
- computer-based training;
- unified instrument-private curriculum;
- free-flight;
- advanced piston engines; and
- small advanced turbine engines.

With the exception of the two features pertaining to ice, the only features involving weather are the graphical pilot interface for situational awareness and the data link communications system.

Developers envision the graphical pilot interface for situational awareness as two flat panel displays: one a graphic primary flight display (PFD) and the other an integrated cockpit information system (ICIS). PFD depicts “highway in the sky” flight director graphics, while the ICIS integrates flight planning software with weather graphics and text including surface observations and visibility, NEXRAD mosaic, and turbulence and icing data. Further, the ICIS will display terrain cues and aircraft system status.

The data link communications system will include a digital radio for voice and data provided FIS, Traffic Information Service (TIS), Controller-Pilot Datalink Communication (CPDLC), and Commercial Information Services (CIS). FIS includes broadcast weather, NOTAM’s and AWOS sensing. The TIS includes GPS-based ADS-B for traffic and secondary surveillance radar for cockpit display of traffic information. CPDLC includes Air Traffic Control messaging between cockpit display and ATC displays. CIS includes emergency communications, Internet access to intermodal connections (food, lodging, fuel services), digital messaging, and airborne cellular services.

The services provide a national database of weather and aeronautical products as dictated by the contracting agency, the FAA. They both provide weather via the METAR/TAF format in plain language. In addition, they both provide weather graphics products, flight planning capabilities, and flight plan filing (either IFR or VFR). The flight planning feature stores the flight characteristics of aircraft including airspeeds, climb and descent rates, and fuel consumption rates to automatically calculate total flight times and total fuel usage.

CHAPTER 3. AIRBORNE WEATHER DECISION MAKING

Major elements in a pilot's "decision-making process" include weather, equipment, external situations, and the pilot him or herself. Modern weather sensing, analysis, and display have a significant influence on a pilot's ability to understand what is occurring and to complete a meaningful risk analysis prior to taking off. To a lessor extent, high-tech equipment improves other factors allowing pilots to make better decisions. However, the high-tech equipment also requires attention to produce the improved information, attention that should possibly be directed elsewhere. Everyone is becoming aware of the safety problems that cellular telephones are causing motorists. It is possible that the new high-tech equipment will also cause pilots the same problems. Making their operations simpler and more user friendly and providing training to make their operation more efficient are steps that will solve some of the problems.

MAKING DECISIONS

Just after 8:30 p.m. on Friday, July 16, 1999, John F. Kennedy, Jr., his wife Carolyn Bissette Kennedy and Carolyn's sister, Lauren Bissette, took off from the Fairfield, NJ, airport (Essex County, CDW) for an hour and a half flight to Martha's Vineyard (MVY), an airport on an island (with the same name) just south of Cape Cod, MA. He did not file a flight plan nor did he request flight following along the way. Apparently, Kennedy flew around the northern edge of the New York Class B airspace, then along the Connecticut shoreline, over the southwestern tip of Rhode Island, at which time, near 9:30 p.m., he turned out to sea toward Martha's Vineyard. The plane was at 5,600 feet when it headed out over the ocean. At 9:40 p.m., about 17 to 18 miles west of Martha's Vineyard, it was at 2,500 feet. When it was last detected, 29 seconds later, it was at 1,800 feet, about 16 ½ miles west of the island.

The NWS reported that haze cut visibility to near six miles at the Martha's Vineyard Airport, where Kennedy planned to drop Lauren Bissette before resuming the flight to Hyannis, on Cape Cod. Newspaper reports stated that Kennedy, 38, was a relatively inexperienced private pilot certified at the Flight Safety Academy in Vero Beach, FL, about 15 months prior to the accident. Apparently, he did not have an instrument rating.

Dr. Bob Arnot, chief medical correspondent for NBC, was flying nearby at about the same hour heading for the nearby island of Nantucket where he often vacations. He reported that he flew about three miles south of the Martha's Vineyard airport at about 9:00 p.m., and that it was very hazy. He said that he relied on his instruments to complete his flight and land. At the time this report is being prepared the actual (official) cause of the accident is unknown and may remain unknown. However, the known facts are instructive to consider.

Most believe that Kennedy intended to make a daytime VFR flight from Fairfield to Martha's Vineyard. It is believed that he was delayed, first when his sister-in-law could not leave work as early she had anticipated, and then when he apparently got slowed down in traffic as he drove west out of the city towards the airport. Another parameter in his decision-making process involved the recent removal, earlier in the week, of a cast, on his foot to help the healing of a wound suffered earlier in a para-gliding accident. Rumors were rampant that business changes involving his magazine, *GEORGE*, were under discussion with representatives of various other business entities. It seems likely that any judgements Kennedy made about the flight, he made under some stress.

It appears that this accident, like so many before, was a result of making decisions, under pressure that are inconsistent with the weather, the equipment, and the pilot's capability at the time. This accident, like so many, will probably be found to be the result of not one, but a chain of events, and judgements, that led to the fateful conclusion.

DECISIONS FOR VFR PILOTS

VFR pilots, especially VFR "only" pilots, must frequently make decisions about whether to proceed, land, or turn back. This is because of minimum weather requirements, mandated by the regulations, primarily to protect IFR traffic. VFR aircraft must stay in weather where separation from other aircraft is easily possible using the see-and-be-seen rules. However, pilots must also bring personal capabilities into the decision-making equation. The pilot must consider his or her own experience and competence as well as consider the equipment available to accommodate the weather and other risk factors.

Judgement Training

Several years ago the FAA recognized the importance of pilot judgements. Consequently, they attempted to determine how instructors could best teach pilots how to make better decisions. They funded a significant amount of research to help identify the principles of sound decision-making for pilots, and methods for incorporating those principles into recurrent training. This research resulted in a myriad of reports, training suggestions, and an Advisory Circular (AC 60-22, dated 12/31/91). Most practicing flight instructors are aware of the concepts suggested in these documents. They are best summarized by the diagram (Figure 10), that represents a mental process.

To consistently determine the best course of action under the circumstances, pilots typically use the systematic approach described in Figure 10. The FAA terms this the Aviation Decision-Making (ADM) approach. It consists of several mental steps including:

- consider the pilot, aircraft, environment and mission;
- mentally meld these parameters to select the possible courses of action;
- consider the consequences of each course of action;
- select a course of action; and
- pursue it deliberately, but always remain alert for changes in the parameters that may dictate a change in the decision.

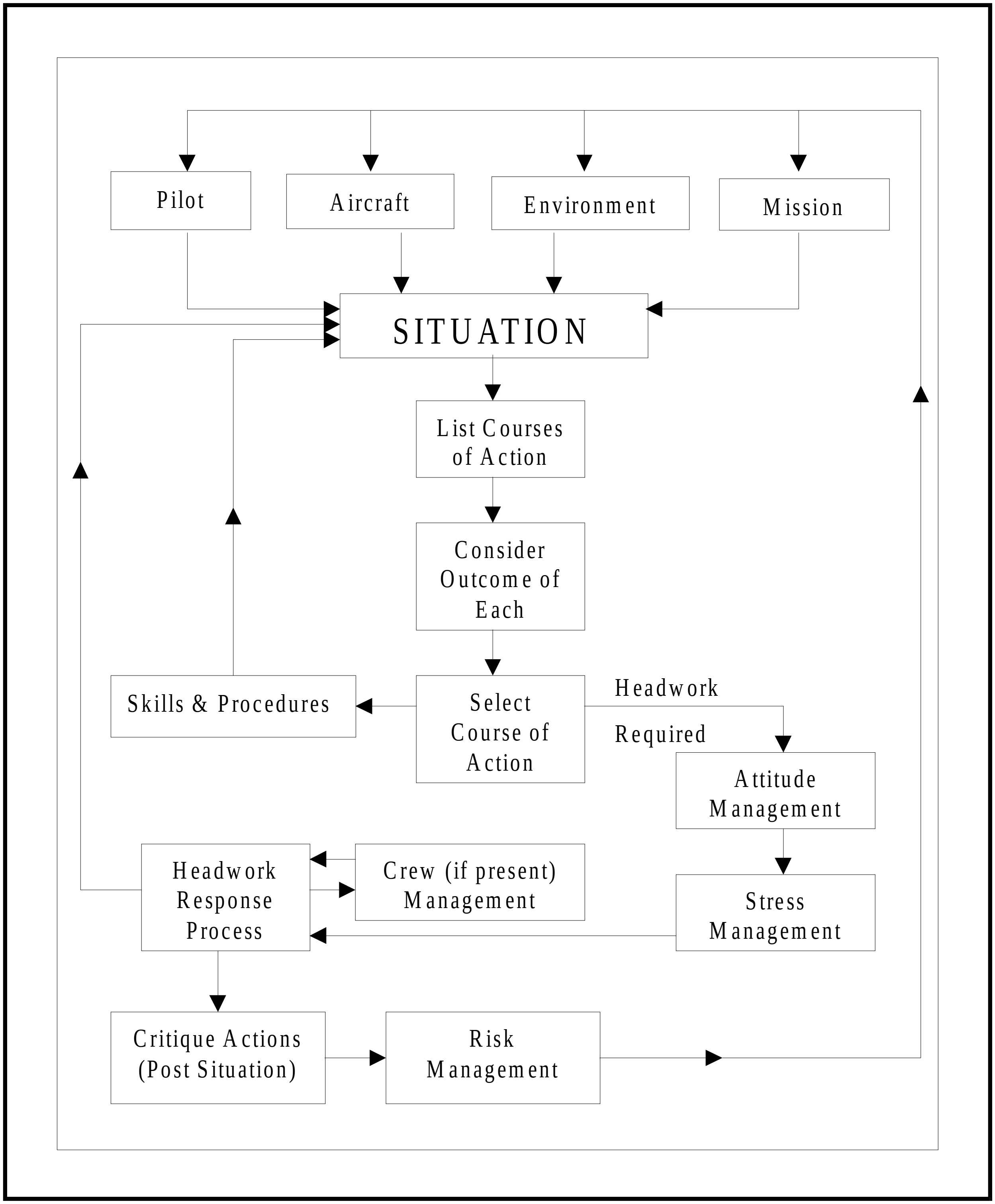


FIGURE 10. Aeronautical Decision Making Process

The FAA's research not only enumerated these steps, but also evaluated each seeking methods to teach pilots to identify and avoid pitfalls that others may have made. Again, the goal of this research and evaluation is to help the pilots develop the skills required to make sensible, risk-minimizing judgements, and, at the same time, utilize equipment and skills to the greatest extent.

FAR has always (at least for many years) implicitly required a pre-flight consideration of the conditions and environment present along a planned route. In fact, FAR 91.103 dictates that:

> Each pilot in command shall, before beginning a flight, become familiar with all available information concerning that flight. This information must include–
>
> (a) For a flight under IFR or a flight not in the vicinity of an airport, weather reports and forecasts, fuel requirements, alternatives available if the planned flight cannot be completed and any known traffic delays of which the pilot in command has been advised by ATC.

The primary reason for describing the pre-flight decision-making process here is to clarify the importance of the availability of reliable, easily understood weather sensing data and forecasts to making sensible decisions. This fact is primarily a direct result of the high-tech advances of the past several years. If the pilot does not have better, more reliable, more convenient, and more precise weather data, he or she is negligent or has fallen behind the times.

Operational Pitfalls

Pilots have fallen into a number of classic behavioral traps. Pilots, particularly those with considerable experience, as a rule try to complete a flight as planned, please the passengers, meet schedules, and generally demonstrate that they have the "right stuff." The FAA believes that the much talked about "right stuff" is a fragile image. They think that the basic drive to demonstrate the "right stuff" can have an adverse effect on safety and can impose an unrealistic assessment of piloting skills under stressful conditions. Such tendencies ultimately may lead to practices that are dangerous and often illegal, and may lead to a mishap. All experienced pilots have fallen prey, or been tempted, by one or more of these tendencies or behavior patterns, which have been identified by the FAA's studies. They include:

- *Peer Pressure.* Poor decision making based upon emotional response to peers rather than evaluating the situation objectively.
- *Mind Set.* The inability to recognize and cope with changes in the situation making the situation different from what the pilot anticipated and planned.
- *Get-There-Itis.* This tendency, common among pilots, clouds the vision and impairs the judgement by causing a fixation on the original goal or destination combined with a total disregard for any alternative course of action,
- *Duck-Under-Syndrome.* The tendency to *sneak-a-peek* by descending below designated minimums during an approach. Based on a belief that there is always a built-in "fudge" factor for use, or on an unwillingness to admit defeat and fly the published missed approach.
- *Scud Running.* This is a behavior where the pilot pushes his or her capabilities

and the capabilities of the aircraft to the limits by trying to maintain visual contact with the terrain while trying to avoid physical contact with the terrain. There is an old pilot's joke that characterizes this attitude: "If it's too bad to go IFR, we'll go VFR."

- *Continuing VFR* into instrument meteorological conditions often leads to spatial disorientation or collision with the ground or obstacles. It is even more dangerous if the pilot is not instrument rated or current.
- *Getting Behind the Aircraft.* This behavior allows events or the situation to control actions rather than taking actions to control the events or situations. Characterized by a constant state of surprise by what happens next.
- *Loss of Positional or Situational Awareness.* Another case of getting behind the aircraft that results in not knowing where you are, an inability to recognize deteriorating circumstances, and/or the miss-judgement of the rate of deterioration.
- *Operating Without Adequate Fuel Reserves.* Ignoring minimum fuel reserve requirements, either VFR or IFR, is generally the result of overconfidence, lack of flight planning, and ignoring the regulatory requirements.
- *Descent Below the Minimum En-Route Altitude.* The duck-under syndrome (mentioned above) manifesting itself during the en-route portion of and IFR flight.
- *Flying Outside the Envelope.* Unjustified reliance on the (usually mistaken) belief that the aircraft's high performance capability meets the demands imposed by the pilot's (usually overestimated) flying skills.
- *Neglect of Flight Planning, Pre-Flight Inspections, Checklists, Etc.* Unjustified reliance on the pilot's short and long-term memory, regular flying skills, repetitive and familiar routes, etc.

Advisors suggested several procedures to the FAA about minimizing the influence of these pitfalls on practicing pilots. "I-M-SAFE" and "Please Be Careful (P-B-CFL)" are a couple of examples. The first mnemonic refers to the evaluation of the pilot (Figure 10) prior to a flight. It reminds the pilot to review these aspects of his or her person:

I	Illness. Is the pilot healthy?
M	Medication. Has the pilot taken medication that might effect his or her ability to fly safely?
S	Stress. Is the pilot being subjected to undue stress?
A	Alcohol. Is the pilot free of the effects of alcohol?
F	Fatigue. Is the pilot too tired to fly?
E	Eating. Is the pilot excessively hungry?

The second mnemonic also refers to the pilot but is more a review of the paperwork requirements:

P Physical. This refers to the pilot having a current and correct class of aeromedical exam for the type of flying planned.

B Biennial flight review-completed within the preceding 24-calendar months.

C Currency implies three takeoffs and landings within 90-days if carrying passengers.

F Flight endorsements-tailwheel/complex/high performance/hight altitude, as required.

L License implies a pilot's certificate with the correct category and class for the flight planned.

ARROW and EATS

The following mnemonics both refer to the aircraft and whether or not it is ready, legal, and safe. ARROW, a widely known and used memory aid, refers primarily to paperwork.

A Airworthiness certificate.

R Radio station license. This license is no longer required when operating within the U.S.

R Registration certificate indicating the current owner.

O Operating limitations. Aircraft manufactured since 1976 must have an FAA Approved flight manual in the plane. All aircraft must have limitations posted either on placards or marked inside the aircraft.

W Weight and balance data. This document(s) must show the empty weight and balance information about the empty aircraft as well as the limiting (loaded) weights and balance data and methods to calculate the weights.

The second mnemonic refers to required inspections for the aircraft.

E Emergency locator transmitter inspection required and completed annually.

A Annual inspection required every 12 calendar months. (The FAA requires 100-hour inspections if the aircraft is carrying persons for hire.)

T Transponder inspections required every 24-calendar months. This inspection includes the altitude-encoding device (if installed).

S Static system and altimeter inspection required every 24-calendar months if the pilot operates the aircraft under IFR.

ENVIRONMENT

The recognition and enunciation of these decision-making pitfalls and some of the memory aids for overcoming them is the basis for a great deal of the current practice for continuing education for pilots. Except for the aspects involved in the collection and use of pertinent weather data, the remainder of this report will not focus on the above-mentioned decision-making process. However, new procedures and technologies have made the determination of the weather an altogether different procedure from what it was at the time the decision-making studies were conducted.

HEADWORK RESPONSE PROCESS

The availability of weather information in the cockpit used for assessing risk and making decisions should have greatly advanced in the last decade or two. However, the reality is that in most general aviation aircraft it has not. Pilots, in flight, still rely on verbal communications with air traffic controllers or flight service station personnel to obtain information on recent weather changes and trends and to determine how the changes influence the original go/no-go decision.

One recent incident involves the new owner of an Aero-Commander 500B conducting a flight from the San Marcos Municipal airport to the Lufkin, Angelina County, airport. The AC50 had neither radar nor a strike-finder, and the pilot received reports that several Level 3 thunderstorms were in the area. Before boarding at San Marcos, the pilot and his passengers studied the DTN video looking for the best route to Lufkin. The radar showed a line of showers from northeast to southwest extending from just north of College Station to near Shreveport, LA, moving to the southeast toward Lufkin. (Figure 11)

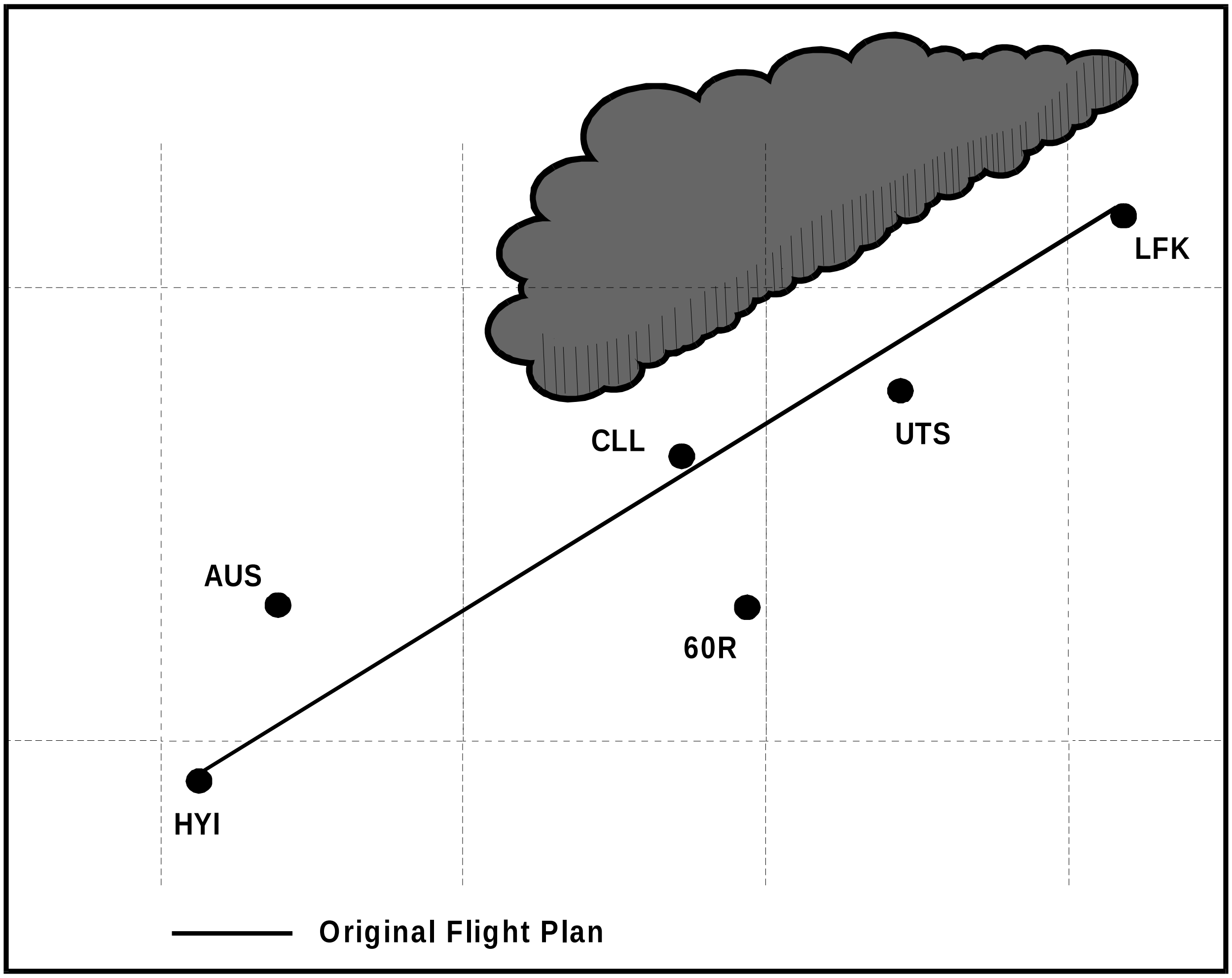


FIGURE 11. Original Flight Plan Showing an Approaching Line of Thunderstorms

However, when operators looped the screen (show recent historical motion), the line of showers appeared to be dissipating in the area near Nacogdoches, just to the northwest of Lufkin. The last version of the radar images seen by the pilot just before his departure looked something like that shown in Figure 12. The pilot therefore decided to fly well south of the direct course, and, after passing Woodville, southeast of Lufkin, to turn north and fly through the (expected) gap in the weather system to the destination.

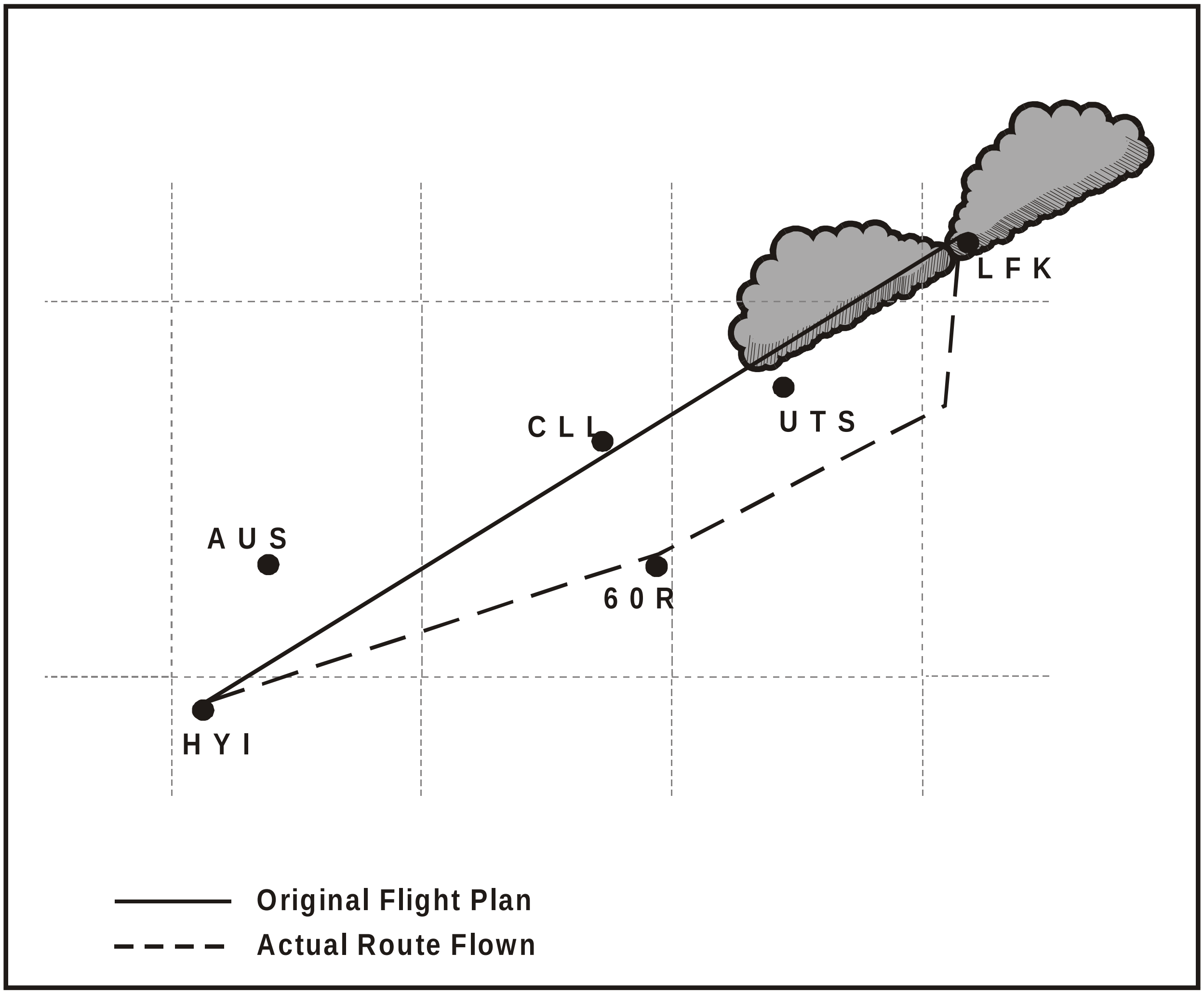


FIGURE 12. Position of Thunderstorm at Time of Departure

As the flight neared the mid-point, near the Navasota VOR, ARTCC advised the pilot of a better route. The ARTCC told the pilot to turn north for a few miles, and then turn southeast, and arrive at Lufkin from the northwest behind the line of showers. Figure 13 shows this route. However, the pilot remembered the heavy radar echoes he had seen on the DTN, and he looked at the ominous clouds out the left cockpit window, and elected to follow his original plan.

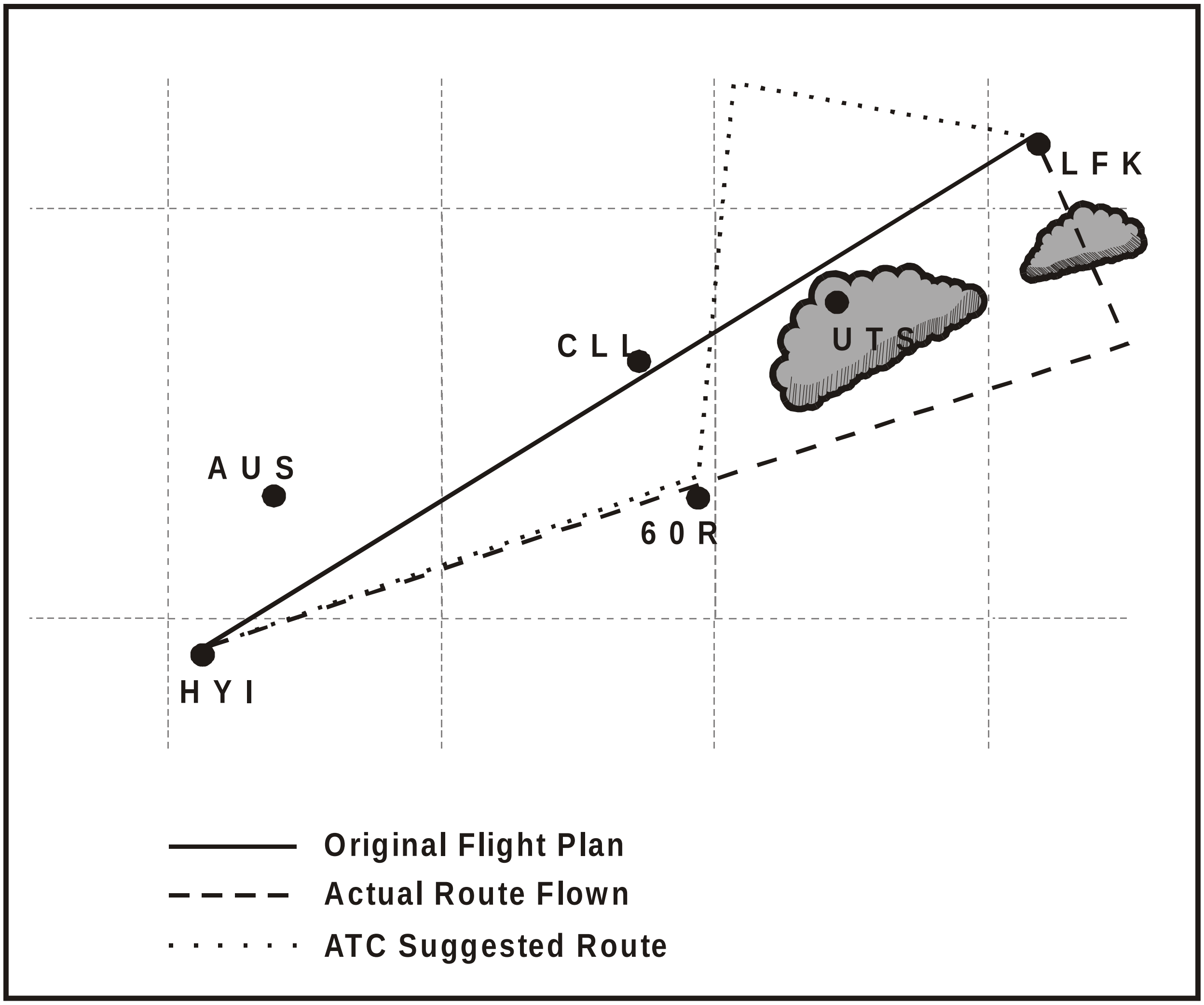


FIGURE 13. Flight Route Flown

Because he disregarded the advice of the ARTCC, and relied on his original decision, the pilot flew through the middle of a small thunderstorm cell. This is an example of a decision based on what the pilot had seen versus what a controller had told him. Many pilots have this bias. It is a result of experience with controllers and briefers who are often ultra conservative. It explains why pilots greatly prefer airborne instruments to verbal assistance from the ground. Another example is the popularity of the instrument landing system (ILS), using panel-based instruments, rather than the ground control approach (GCA). This is a situation where a controller, looking at radar, directs the pilot left or right, or up and down as he or she flies to the end of the runway.

In the post-flight assessment of these airborne decisions, it seems likely that the Aero Commander pilot will pay more attention to suggestions by the ATC, and not be so dogmatic with respect to modifying pre-flight weather decisions.

ATTITUDES
When making decisions concerning a flight, a proper mental and emotional attitude will promote a safe outcome. The FAA, in reviewing such decisions, determined that at least five hazardous attitudes might lead to disaster. These include:

- invulnerability;
- anti-authority;
- impulsivity;
- Mr. Macho; and
- resignation.

Investigators can usually trace the chain of events leading to aviation accidents back to one or more of these attitudes.

Howard Fried, a long time-flight instructor who works for Avweb, tells the story of a skillful pilot, a superb aircraft manipulator who lacked mature judgement. He was consistently an unnecessary risk-taker. In addition to being a "Mr. Macho" and feeling "invulnerable," he also had the "anti-authority" attitude. When he died he was descending through a cloud deck without an instrument clearance (although he was instrument-rated and could have easily called for a clearance) and flew into the side of a mountain.

People around the airport regarded this individual as an excellent pilot because of his skill at controlling an aircraft, so nobody felt comfortable attempting to counsel him regarding taking chances. Many times this type of pilot is incapable of accepting criticism.

RISK MANAGEMENT
In an attempt to make flying more "structured," many, if not most, flight instructors teach pilots to set personal limits on weather conditions into which they will fly. For example, a beginner might say to him or herself, "I will not fly if the observed or forecast ceiling is less than 2,000 feet, visibility is less than five miles or the wind is greater than 15 knots." Then, as he or she gains experience, they can relax the minimums. Similarly, a beginning instrument rated pilot might say, "I will not fly unless the observed and forecast ceiling is 500 feet or more and the observed and forecast visibility is two miles or more". Again, as the pilot's experience widens, the pilot can reduce these personal minimums. These types of "absolute" criteria help make the decision-making process easier. However, they do not always guarantee that the pilot will make the correct decision.

On a foggy January morning, a Learjet 25B took off from Houston Hobby Airport, bound for Houston Bush Intercontinental (IAH). At IAH, charter passengers were to board the aircraft and then continue on to Fargo, ND. Only the Captain and First Officer were on board as they flew the short Hobby to Intercontinental leg. The crew received radar vectors as they approached the ILS 26 Localizer from the south. The crew flew over the outer marker before intercepting the localizer, but it soon grazed the localizer centerline. At about this time the Captain realized he was getting a false nav display, and he said aloud, "I got a compass flag." So they turned away from the approach, back to the southeast, and began a climb. Quickly ATR (the tower had already changed them back to the Approach Control frequency) assigned them a heading of 120 degrees and cleared them to climb to 3,000 feet.

During this climb, the cockpit voice recorder (CVR) indicated that the crew was resetting circuit breakers in a frantic attempt to diagnose the problems. One of the reasons that so much is known about this accident is that the aircraft contained a CVR and the recorder was working during the entire flight.

At this point in the flight the Captain said, “Well, lets go back to Hobby. We can’t do a trip like this.” However, moments later, the Captain, while expressing second thoughts about his decision, asked the First Officer about the weather in North Dakota. The First Officer responded that the weather in Fargo was “severe clear.” “Uh, lets go on and try Intercontinental again,” commanded the Captain. The crew set up their radios for the ILS and the First Officer told ATC they wanted another approach into IAH. The cockpit conversation indicated that the crew would try to use the autopilot to fly a coupled approach.

With the weather deteriorating from that present during the first approach, the crew received the following weather update, “The wind three five zero at six. The uh, weather is less than a quarter mile visibility, light rain and uh, mist. 200 uh, measured ceiling 200 broken, 600 overcast. The runway two six RVR’s more than 6,000.”

After the Captain reported that the autopilot did not capture, and believing that the First Officer's localizer and glide slope were working properly, the Captain relinquishe d control of the aircraft to him. This change occurred well inside of the outer marker. Soon, both the Captain and the First Officer noted that the glide slope was indicating to descend. Following this indication, it was less than one-minute before the First Officer had flown the Learjet into the ground. Both of the crewmembers died in the crash.

There were many errors made by several parties that led to this fatal crash. Some involved radios, navigation equipment maintenance, and piloting procedures. Prefacing them all was the Captain’s deliberate decision, undoubtedly under great stress, to complete the mission by delivering the passengers to Fargo. The First Officer’s pronouncement that the weather there was “severe clear” only increased that pressure. In the end, the risk of trying the second approach into IAH was probably under-evaluated and the pilot should have returned to the Hobby airport.

Pilots should not underestimate the risk of blindly believing and following the indications of high-tech equipment and the equipment should undergo constant analysis and cross checking

RELIABILITY OF NEW WEATHER SENSING TECHNOLOGY

Planners spared no expense in designing the Chek Lap Kok Airport, built in Hong Kong during the mid-1990’s, to provide the finest weather instrumentation for controllers and pilots. The airport is near the open sea, but surrounded on two sides by mountainous terrain. The locale is famous for violent typhoons and rainstorms.

Consequently, Chek Lap Kok has one of the most modern and elaborate Integrated Terminal Weather Systems (ITWS) in existence. It includes a nearby Doppler Weather Radar, a Low Level Wind Shear Alert System and many other supplemental sensor systems. Most importantly, the ITWS is the software necessary to process data from the many three-dimensional sensors and uses the resulting information to help the ATCT and the pilot understand the erratic wind behavior characteristic of the locale.

On the afternoon of August 22, 1999, a China Air Lines Flight CI 642 was approaching Hong Kong. The eye of Typhoon “Sam” was less than 15 miles away when the flight touched down on Runway 25L at the nearly new airport. Throughout the afternoon, the nearby yacht basin flew a gale warning flag indicating the presence of winds greater than 39 mph. The flight originated in Bangkok and piloted by a 52-year-old Italian Captain and a 37-year old Taiwanese co-pilot. It was about 6:45 p.m. on August 22, not yet dark on the Sunday afternoon.

As the flight approached the new airport with two huge parallel runways, the Captain reviewed the conditions. China Air Lines had a rule for MD-11's that they were not to land in crosswinds exceeding 24 knots. The wind was varying, but roughly from 300 degrees at 39 knots. The Captain asked the co-pilot to calculate the crosswind component. The co-pilot made a quick calculation and announced with authority that it was 22.7 knots. The Captain quickly decided to land, as scheduled at Chek Lap Kok, before proceeding onward to Taiwan.

While landing in the gusting crosswind, the left wing touched the ground and the aircraft almost instantly burst into flame. The MD-11 left the runway, flipped upside down, and broke into three major pieces. Amazingly only three people among the 315 on board (300-passengers, 15 crew) died. One reason for the good fortune was the prompt action by the Air Rescue and Fire Fighting (ARFF) units who were at the crash site within a minute.

A calculation of the crosswind component after the accident indicated that the actual crosswind component was nearer to 26 knots. Investigators may never determine the exact origin of the error. In any event, China Air Lines announced a change in policy. From that time forward, MD-11's may not land when the crosswind component is more than 20 knots.

A question that the investigation will likely answer is why the ITWS did not answer the Captain’s query of, “What is the cross-wind component?”

PERSONAL MINIMUMS

Figures 14 and 15 show a Personal Minimums Checklist, published by the FAA, encouraging pilots, especially those with limited experience, to consider, set, and then follow personal minimums, especially with respect to weather. The newer, and more reliable, weather reporting and forecasting capabilities of the NWS and FAA have removed much of the fuzziness from the weather briefing the pilot receives. This has reduced the sting from the pilot’s complaint that the briefer is “crying wolf” too often when announcing that they are not recommending a VFR flight.

Personal minimums are more important, and the idea is more valid, than ever. Pilots should thoughtfully define the minimums in an environment devoid of the pressures usually associated with whether or not to make a particular flight. Then, once defined, pilots should follow these minimums meticulously.

Then, as the pilot’s experience grows, and additional ratings and capabilities are available, the pilot can lower the personal minimums. However, pilots should always consider the importance of other factors such as equipment limitations, fuel reserves, the physical condition of the pilot, and whether the flight will occur during the day or night.

EXTERNAL PRESSURES

Trip Planning

Allowance for delays........... ________ minutes

Diversion or Cancellation Alternate Plans

Notification of person(s) you are meeting

Passengers briefed on diversion or cancellation plans and alternatives

Modification or cancellation of car rental, restaurant, or hotel reservations

Arrangement of alternative transportation (airline, car, etc.)

Personal Equipment

Credit card and telephone numbers available for alternate plans

Appropriate clothing or personal needs (eye wear, medication…) in the event of an unexpected stay

► ______________________________

____

____

____

____

____

Importance of Trip

The more important the trip, the more tendency there is to compromise your personal minimums, and the more important it becomes to have alternate plans.

Your Personal Minimums Checklist—

- An easy-to-use, personal tool, tailored to your level of skill, knowledge, and ability
- Helps you control and manage risk by identifying even subtle risk factors
- Lets you fly with less stress and less risk

Practice "Conservatism Without Guilt"

Each item provides you with either a space to complete a personal minimum or a checklist item to think about. Spend some quiet time completing each blank and consider other items that apply to your personal minimums. Give yourself permission to choose higher minimums than those specified in the regulations, aircraft flight manuals, or other rules.

How To Use Your Checklist

Use this checklist just as you would one for your aircraft. Carry the checklist in your flight kit. Use it at home as you start planning a flight and again just before you make your final decision to fly.

Be wary if you have an item that's marginal in any single risk factor category. But if you have items in more than one category, you may be headed for trouble.

If you have marginal items in two or more risk factors/categories, don't go!

Periodically review and revise your checklist as your personal circumstances change, such as your proficiency, recency, or training. You should never make your minimums less restrictive unless a significant positive event has occurred. However, it is okay to make your minimums more restrictive at any time. Never make your minimums less restrictive when you are planning a specific flight, or else external pressures will influence you.

Have a fun and safe flight!

Federal Aviation Administration Aviation Safety Program

http://www.faa.gov/avr/news/ppams.htm

The Ohio State University

King Schools

PERSONAL MINIMUMS CHECKLIST

Think…

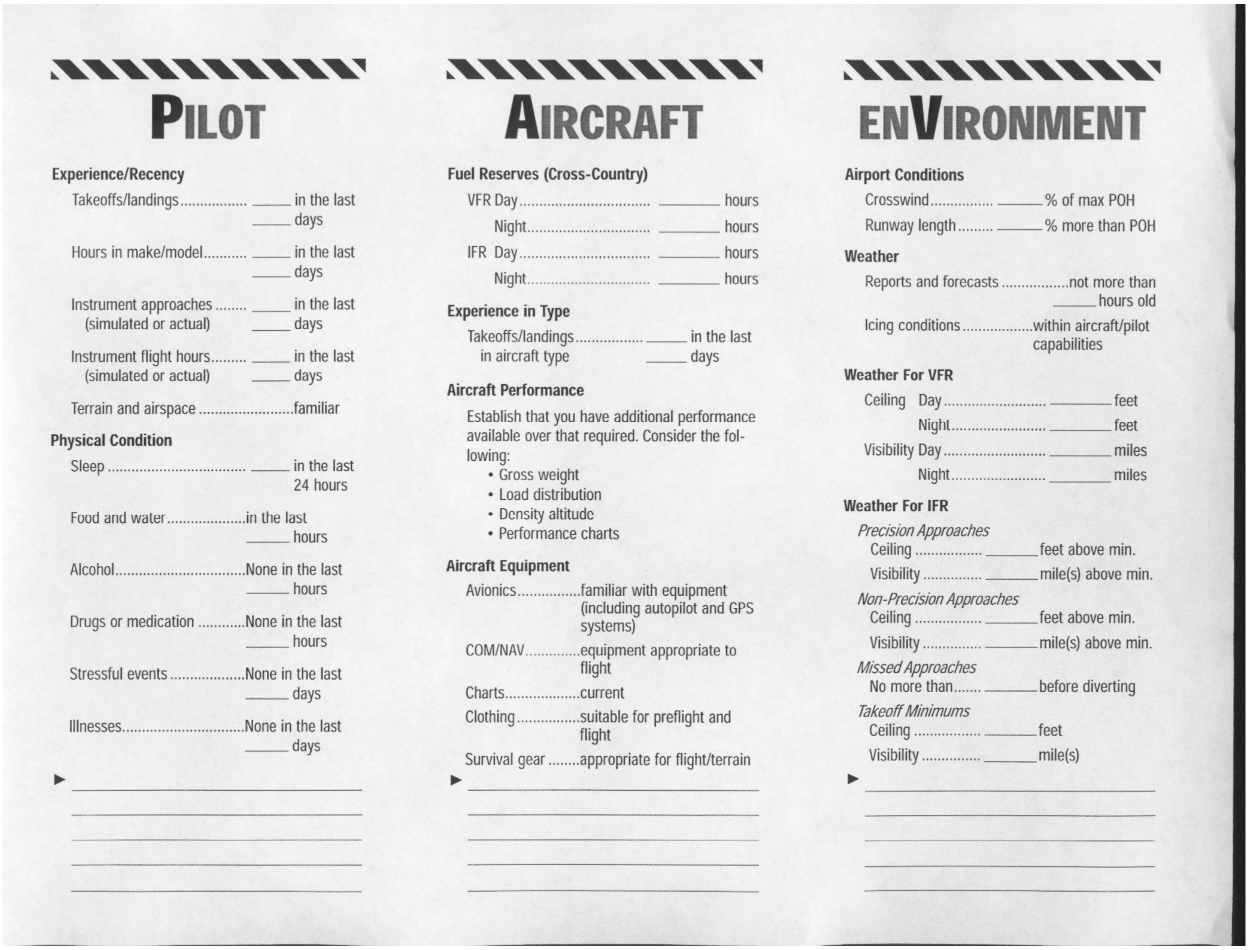
Pilot: ______________________

Date Revised: ______________________

Reviewed with: ______________________
(if applicable)

FAA-P-8740-56
AFS-810(1996)

FIGURE 14. Personal Minimums Checklist



PILOT

Experience/Recency

Takeoffs/landings .... ____ in the last ____ days

Hours in make/model .... ____ in the last ____ days

Instrument approaches (simulated or actual) .... ____ in the last ____ days

Instrument flight hours (simulated or actual) .... ____ in the last ____ days

Terrain and airspace .... familiar

Physical Condition

Sleep .... ____ in the last 24 hours

Food and water .... in the last ____ hours

Alcohol .... None in the last ____ hours

Drugs or medication .... None in the last ____ hours

Stressful events .... None in the last ____ days

Illnesses .... None in the last ____ days

► ______________________

AIRCRAFT

Fuel Reserves (Cross-Country)

VFR Day .... ____ hours

Night .... ____ hours

IFR Day .... ____ hours

Night .... ____ hours

Experience in Type

Takeoffs/landings in aircraft type .... ____ in the last ____ days

Aircraft Performance

Establish that you have additional performance available over that required. Consider the following:

- Gross weight
- Load distribution
- Density altitude
- Performance charts

Aircraft Equipment

Avionics .... familiar with equipment (including autopilot and GPS systems)

COM/NAV .... equipment appropriate to flight

Charts .... current

Clothing .... suitable for preflight and flight

Survival gear .... appropriate for flight/terrain

► ______________________

ENVIRONMENT

Airport Conditions

Crosswind .... ____% of max POH

Runway length .... ____% more than POH

Weather

Reports and forecasts .... not more than ____ hours old

Icing conditions .... within aircraft/pilot capabilities

Weather For VFR

Ceiling Day .... ____ feet

Night .... ____ feet

Visibility Day .... ____ miles

Night .... ____ miles

Weather For IFR

Precision Approaches

Ceiling .... ____ feet above min.

Visibility .... ____ mile(s) above min.

Non-Precision Approaches

Ceiling .... ____ feet above min.

Visibility .... ____ mile(s) above min.

Missed Approaches

No more than .... ____ before diverting

Takeoff Minimums

Ceiling .... ____ feet

Visibility .... ____ mile(s)

► ______________________

FIGURE 15. Personal Minimums Checklist (continued)

SUMMARY

During an April 1998 news conference, Jane Garvey, the FAA Administrator, and Vice President Al Gore announced the adoption of a new safety program entitled, *Safer Skies - A Focused Agenda*. The stated objective of the five-year program is to concentrate on the most prevalent causes of accidents and focus on reducing the root causes in a way that will bring about a five-fold reduction in fatal accidents.

Figure 16, a slide used in the news conference, shows two of the points of attention that directly relate to general aviation—weather and pilot decision-making.

FIGURE 16. FAA Safety Program

Their comments concerning weather were that weather-related accidents most often involve VFR flights into Instrument Meteorological Conditions (IMC). This situation results in controlled flight into terrain or other objects, or loss of control due to spatial disorientation or structural failure of the aircraft. Accidents also involve weather as a contributing factor, such as improper IFR approaches and crosswinds and tailwinds during landings. Weather is the number one cause/factor cited in general aviation accidents and was the greatest contributor to the fatality rate. Numerous FAA/industry partnership initiatives are underway to ensure more complete, more accurate, and more timely weather information, including the National Aviation Weather Strategic Plan and the Aviation Safety Program's educational programs for pilots.

The program is expected to provide more accurate, current, and affordable weather information in a format that is clearly understood by pilots and to provide products in educating pilots about aviation weather.

Garvey and Vice President Gore further suggested that pilot decision-making is often a fundamental element in accident causal chains, where a pilot did not make the best safety decision about a flying or non-flying situation. Estimates show that about 75% of all fatal general aviation accidents are attributable to pilot performance. Pilots must work to improve communications between maintenance and controller personnel to gain more information in an effort to avoid an accident. Numerous FAA/Industry partnership initiatives to develop new material and explore new ways to reach pilots are underway.

Another expected outcome of the program is to provide new decision aids, educational training, and enhance the appropriate existing guidance material.

It is clear that Garvey is attempting to build synergistic partnerships between the FAA, the states, and the aviation industry to capitalize on the rapid development in software tools and data processing to make aviation as safe as possible.

CHAPTER 4. USE OF DATA FROM HIGH-TECH WEATHER SENSORS AND OTHER SOURCES

In the roughest terms, there are four categories of general aviation pilots. They include pilots who:

- fly only on a sunny, quiet Saturday afternoons;
- fly extensively, but only VFR;
- are IFR rated, but use the rating sparingly, often to descend through an undercast or to climb out through a fog layer local to the airport; and
- use their ratings and equipment to the maximum to complete as many missions as possible.

The type of weather information required by each of these is different, but each needs access to a pre-flight weather briefing to ensure successful completion of a flight in accordance with the rules as stated in FAR 91.103 mentioned previously. The “see and avoid” rule applies to all facets of flying and all pilots must be on the outlook for other traffic. FAR 91.113(b) states:

> “When weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules, vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft”

A primary difference between IFR and VFR operations is that the VFR flight must remain in weather conditions that permit the visual sighting of other aircraft with the time to take evasive action if a conflict is likely. The IFR flight is not so restricted. The concept of classes of airspace and the VFR weather minimums associated with them provides structure to the way the VFR pilot studies the weather prior to a flight. For example, in Class B, C, D, or E airspace, a pilot must have a minimum of three statute miles and flight visibility to operate VFR day or night. In order to land, a pilot must have, in general, a ceiling of 1,000 feet.

Meanwhile, the IFR pilot must evaluate the possibility of flying into unmanageable turbulence, hail, or icing and have the ability to safely approach the destination airport with the ceiling and visibility lower than VFR requirements. Further, the pilot must consider and select a suitable alternate airport and decide whether or not there is sufficient fuel to fly to that alternate and still have the required reserve.

It appears that as pilots become more sophisticated and experienced, the average general aviation aircraft and its onboard equipment becomes more advanced. At the same time, the support systems, especially weather information gathering systems and navigation systems, are growing in complexity and capability.

The June 7, 1999 issue of *Aviation Week and Space Technology* magazine includes a photograph of the panel of the new Boeing 717, a 106-passenger, medium range jet, currently under development (Figure 17). There are six 8" x 8" liquid crystal displays on the panel, and there are very few dials and meters outside of the screens. It appears that in a short time, in terms of aviation evolution, panels on general aviation aircraft will look much the same.

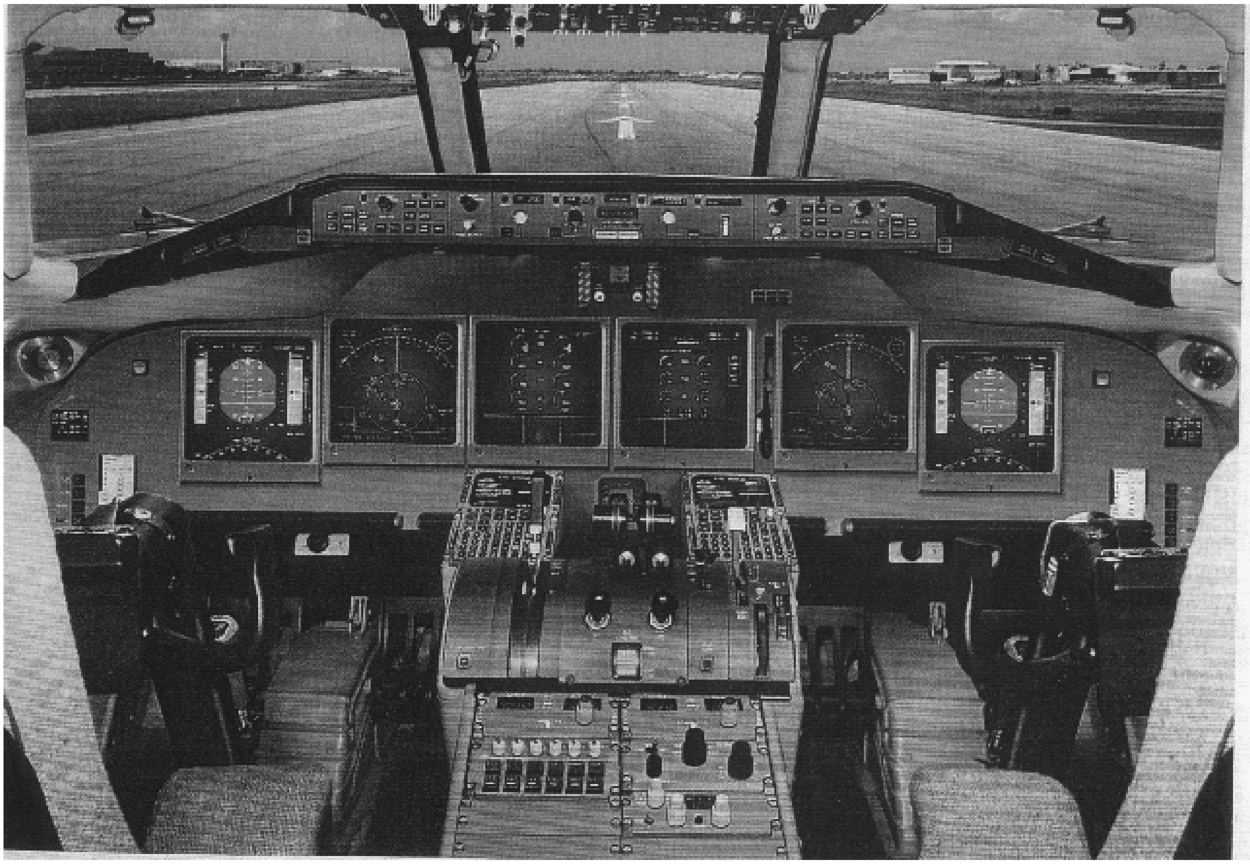


FIGURE 17. Panel of a New Boeing 717

THE BIG PICTURE

As the time for a flight approaches most pilots begin watching the weather news (the Weather Channel, the weather section of the newspaper, or the weather portion of the evening news) to understand the big picture. This means that pilots are following the elements that drive weather conditions—lows and highs, fronts, winds aloft—on a nationwide basis. Pilots call this synoptic weather.

Aviation Weather Graphics

As the interest in the flight weather becomes more detailed, another weather data source is often available at most airports and fixed base operations (FBO). This is a weather graphics service offered via video screens at the airport or FBO. The provider, on a periodic basis, typically contracts these services. The equipment includes a video screen and control box with some type of menu for requesting specific information. The contractor then feeds, typically by satellite (with a dish), the data the user needs. Figure 18 shows a typical screen and dish.

FIGURE 18. Standard Video Display and Satellite Dish

Standard or Primary Weather Briefing

The two most common methods of obtaining weather information currently used by pilots are the classical telephone briefings by Flight Service Station personnel and the Direct Users Access Terminal Service (DUATS) using a digital computer. The latter system has only been in use for about 10 years and is gradually growing in importance as the primary method of obtaining weather information. It offers the tremendous advantage of providing text output that the pilot can print out and take along in the aircraft. Both methods leave a record with the FAA that a flight weather briefing was requested and received, an important factor, especially for the pilot, following any kind of incident or accident.

There are three Automated Flight Service Stations (AFSS) located in Texas and serving Texas pilots. They are the Montgomery County Flight Service Station, the San Angelo Flight Service Station, and the Ft. Worth Flight Service Station. The AFSS in Albuquerque, NM serves a small area of Texas, near and including El Paso. When a pilot dials 1-800-WX BRIEF, the pilot automatically connects to the AFSS serving the area where the call originated. This is true nationwide, as well as across Texas. More often than not, the pilot pays little attention to which AFSS is providing the briefing.

Classical Telephone Briefing

Many longtime pilots still prefer the one-on-one personal briefing obtained when telephoning the AFSS. Current estimates (mid-1999) show that oral briefings via the telephone comprise about one-half of all pre-flight weather briefings. The same proportion is true for filing flight plans. Whether the pilot should file the flight plan before or after the weather briefing is always a point of some contention, but in general, the times, altitudes, type of flight plan (IFR or VFR) and destination depend upon the weather. Therefore, the pilot will often wait until he or she completes the weather briefing to file the flight plan. Indeed, it is common for pilots to obtain the weather briefing in one telephone call and file the flight plan in another.

Typically, the thoughtful pilot will preface the request for a briefing with some background information. This information can include:

- type of flight - IFR or VFR;
- aircraft identification (tail number);
- type of aircraft - and equipment if IFR;
- departure point and destination - using airport identifiers;
- route of flight;
- planned altitude - or desired winds aloft levels;
- estimated time of departure (ETD);
- estimated time en-route (ETE); and
- type of briefing - standard, abbreviated or outlook.

Both the telephone briefing and the digital computer briefing are similar in that they are one of three types according to the detail provided. The types are: (1) Standard, (2) Abbreviated, and (3) Outlook. The Standard briefing, usually requested when a pilot is planning a flight and has not received an earlier briefing, will include the following items:

- adverse conditions;
- VFR flight not recommended;
- synopsis;
- current conditions;
- en-route forecast;
- destination forecast;
- winds aloft;
- notices to airmen (NOTAMs);
- ATC delays; and
- other information as requested.

Abbreviated briefings are requested when a pilot receives and earlier briefing or a briefing from a different source. The pilot may request either an update or specific items. Outlook briefings provide pilots with weather forecasts 18 hours in the future. The last item on the list is a catchall item and means that the AFSS people will attempt to help with any flying problem that the caller may have.

METAR/TAF Format
Typically, briefers and meteorologists think and communicate using symbols, abbreviations, and formats referred to as the METAR/TAF Format. METAR refers to the Aviation Routine Weather Report and TAF is the Terminal Aerodrome Forecast. Descriptions of these formats are available in many places, including:

www.nws.noaa.gov/oso/oso1/oso12/document/guide.shtml, or

www.nws.noaa.gov/oso/oso1/oso12/images/qkcard.gif.

Both of the DUATS contractors will, if requested, print out the weather briefing in plain language, thus bypassing a need to fully understand the METAR/TAF format.

Interestingly, the DUATS weather briefings are available in the same three basic types as the telephone briefings, described above, and will include the same data. Whether by telephone or by digital computer, DUATS provides all surface observations in the METAR format and the terminal forecasts in the TAF format.

En-Route Flight Advisory Service
As noted earlier, a dedicated frequency (and FAA briefer), on 122.00 MHz is available for describing and discussing weather information. The briefer sits at a video terminal displaying a Doppler radar image and discusses the weather with pilots flying near and around nearby weather. Pilots can obtain a great deal of information by monitoring the en-route flight advisory service (EFAS) frequency when threatening weather is near.

Other AFSS Services
Other helpful information is available through the FSS. They provide a useful service by providing pilots with weather information pertinent to the intended route as the flight progresses. They also manage the filing, opening, and closing of VFR flight plans using the universal FSS frequency of 122.20 MHz or other frequencies unique to the locale.

GTE AND DTC DUATS
The FAA provides DUATS for the convenience of pilots allowing them to access detailed aviation weather reports and forecasts using typical personal computers. The services, currently provided by two contractors, GTE and DTC, are available 24 hours a day, seven days a week, with no direct charge to the user. The FAA pays the costs of the services that include listings of NOTAMS, and flight plan filing and encoding/decoding.

The services provide a national database of weather and aeronautical products as dictated by the contracting agency, the FAA. They both provide weather via the METAR/TAF format and in plain language. In addition, they both provide weather graphics products, flight planning capabilities, and flight plan filing (either IFR or VFR). The flight planning feature stores the flight characteristics of the aircraft, including airspeeds, climb and descent rates, and fuel consumption rates, so that total flight times and total fuel usage are automatically calculated.

Free access to either DUATS contractor is available to U. S. pilots and student pilots who hold current medical certificates.

GTE DUATS

For access, dial	1-800-767-9989
For assistance, dial	1-800-345-3828

GTE DUATS is also available on the Internet at:

www.duats.com

DTC DUATS

For access, dial	1-800-245-3828
For assistance, dial	1-800-243-3828

DTC DUATS is also available on the Internet at:

www.duat.com

Another text-based, prompt-response, computer terminal access service is available through the Internet via any telnet client. Almost every modern PC and operating system has some sort of telnet client that will allow access to either GTE DUATS or DTC DUATS. Once connected to the Internet, the pilot can connect to either the GTE DUATS or the DTC DUATS with the same interface described above.

The two DUATS sites are different, but require and provide similar information. Figure 19 shows the main menu for the GTE DUATS. Several types of requests for weather are available as is a flight planner; an automatic capability to file flight plans, either VFR or IFR, and a service that will encode or decode location identifiers (or FAA contractions). The site also includes a help link, a CIRRUS information link, and a feedback address for asking questions and making comments. The services offered by both contractors are similar and parallel to the services received when calling the AFSS on the telephone.

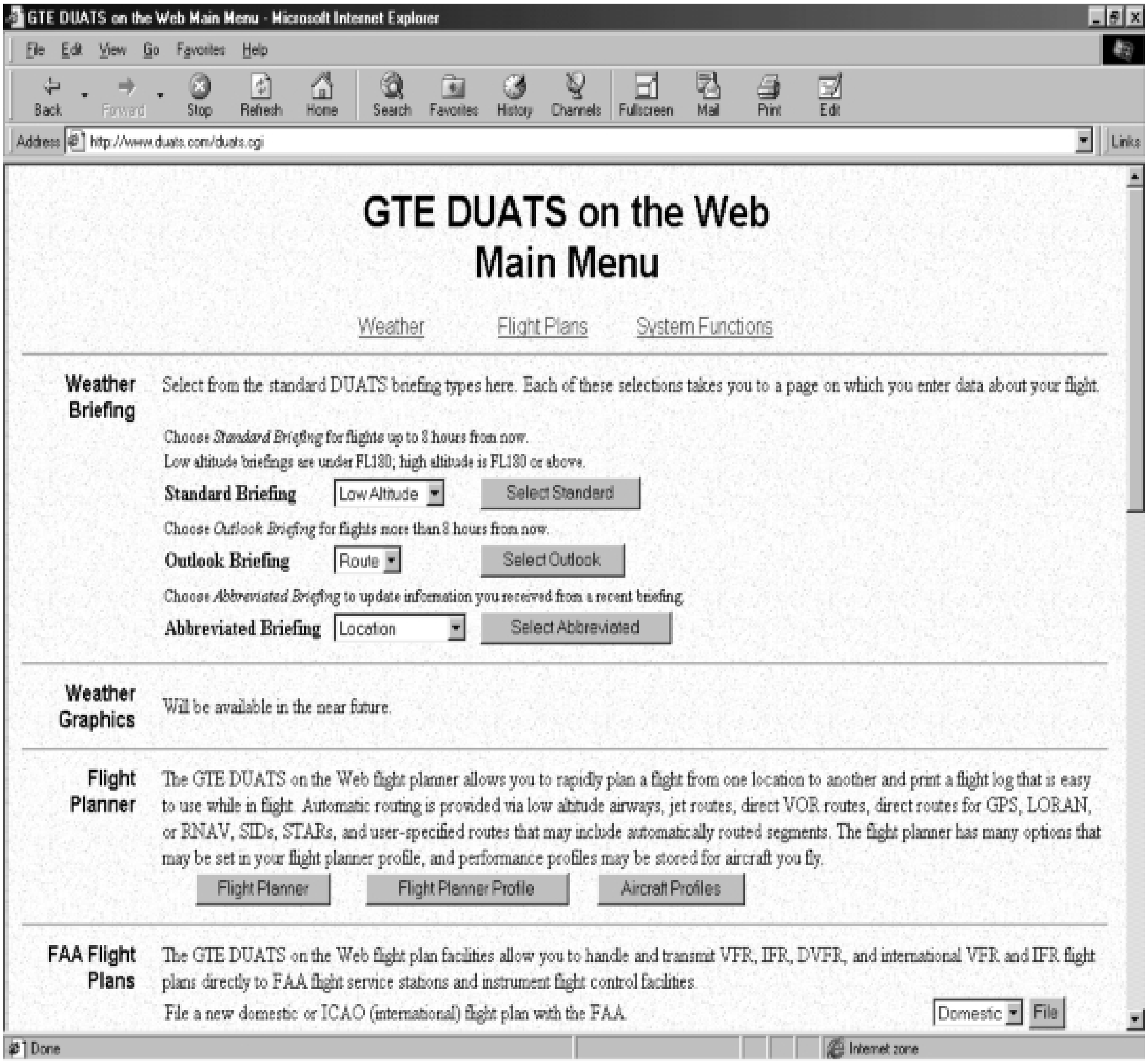


FIGURE 19. GTE DUATS Main Menu

Initial Registration

In preparation to register with either DUATS provider, the pilot will need to have a pencil handy to take notes and his or her pilots certificate. Figure 20 shows the GTE DUATS initial registration form as it appears on the Internet. The interactive registration process provides the pilot with an access code and a password that the pilot will need for subsequent use. Pilots who are not familiar with the on-line system should either seek guidance from a pilot who is familiar with the process or be patient and carefully work through the process.

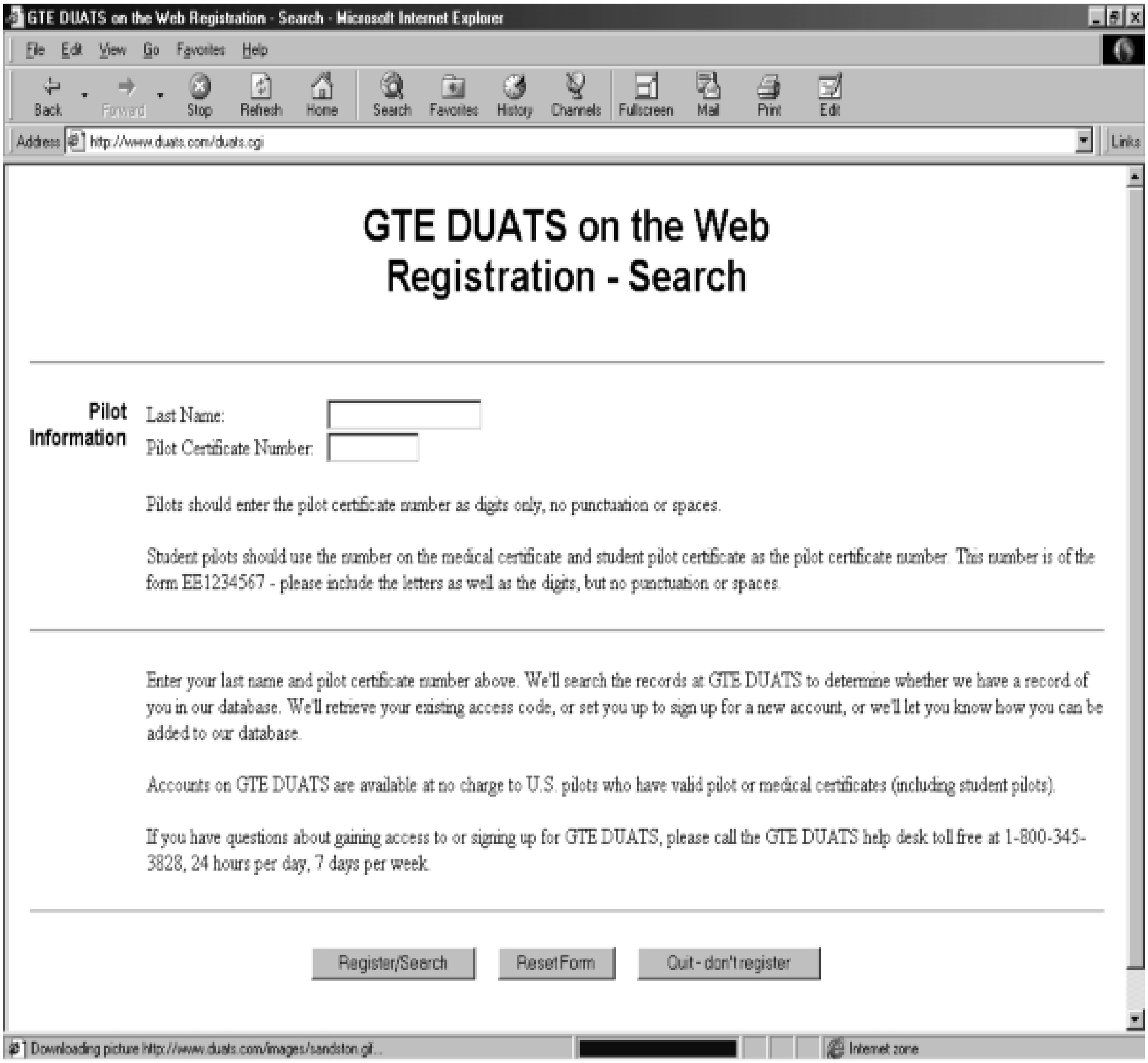


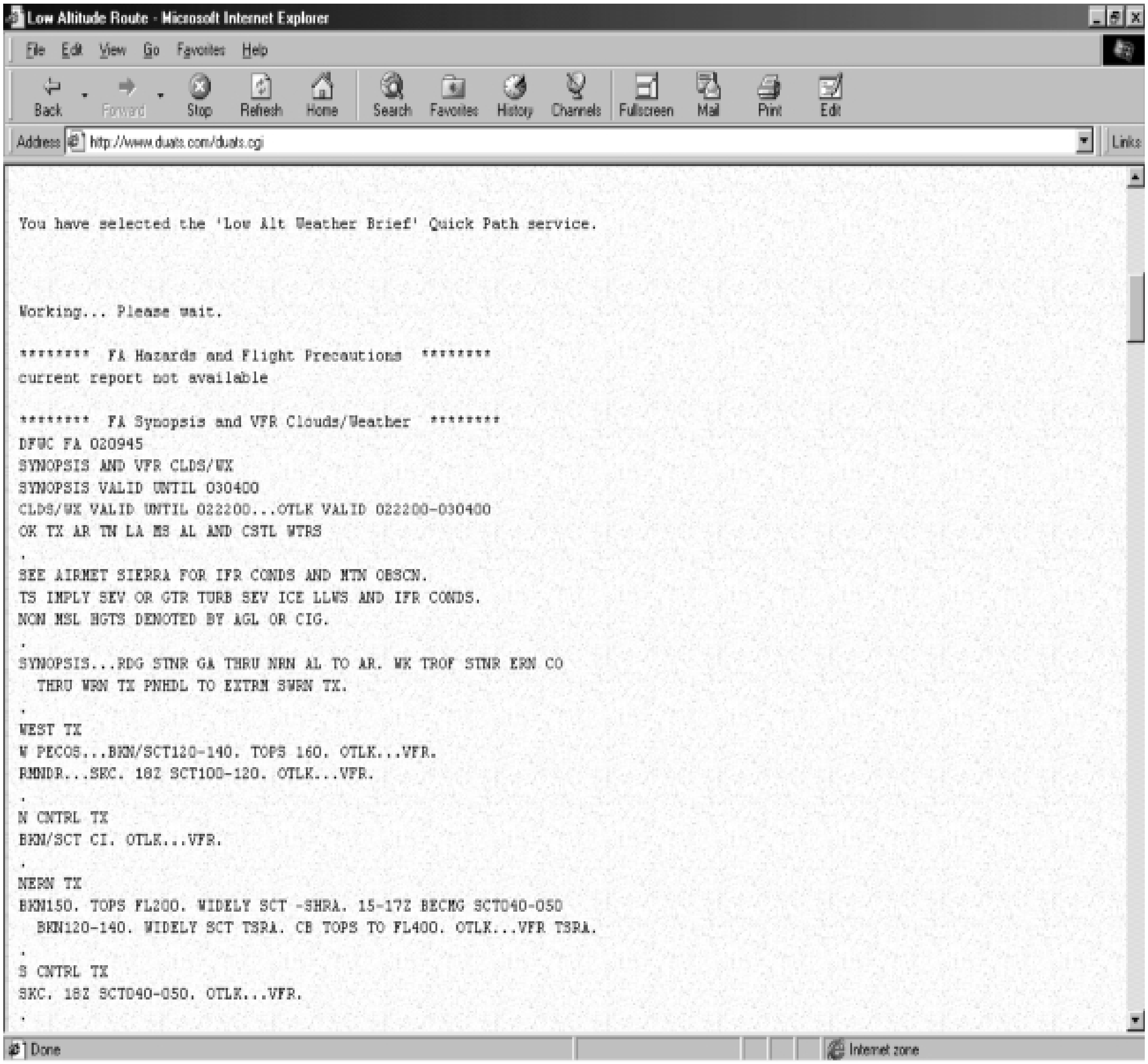
FIGURE 20. GTE DUATS Registration Screen

Weather Briefing

Figure 21 is an excerpt from a standard, low altitude route weather briefing for a flight planned from College Station, Easterwood Airport, to IAH in a Cessna 152 via the CUGAR (a five letter designation for an airborne intersection) intersection. The organization of the report for the one-hour flight includes:

- Hazards and Flight Precautions in the area forecast;
- Synopsis and VFR Clouds/Weather in the area forecast;

- Severe Weather Warnings;
- Significant Meteorological Information (SIGMETS);
- Convective SIGMETS;
- Center Weather Advisory;
- In-flight Weather Advisories (AIRMETS);
- Surface Observations;
- Pilot Reports (PIREPS);
- Radar Summaries;
- Terminal Forecasts;
- Winds Aloft Forecast; and
- NOTAMs.



You have selected the 'Low Alt Weather Brief' Quick Path service.

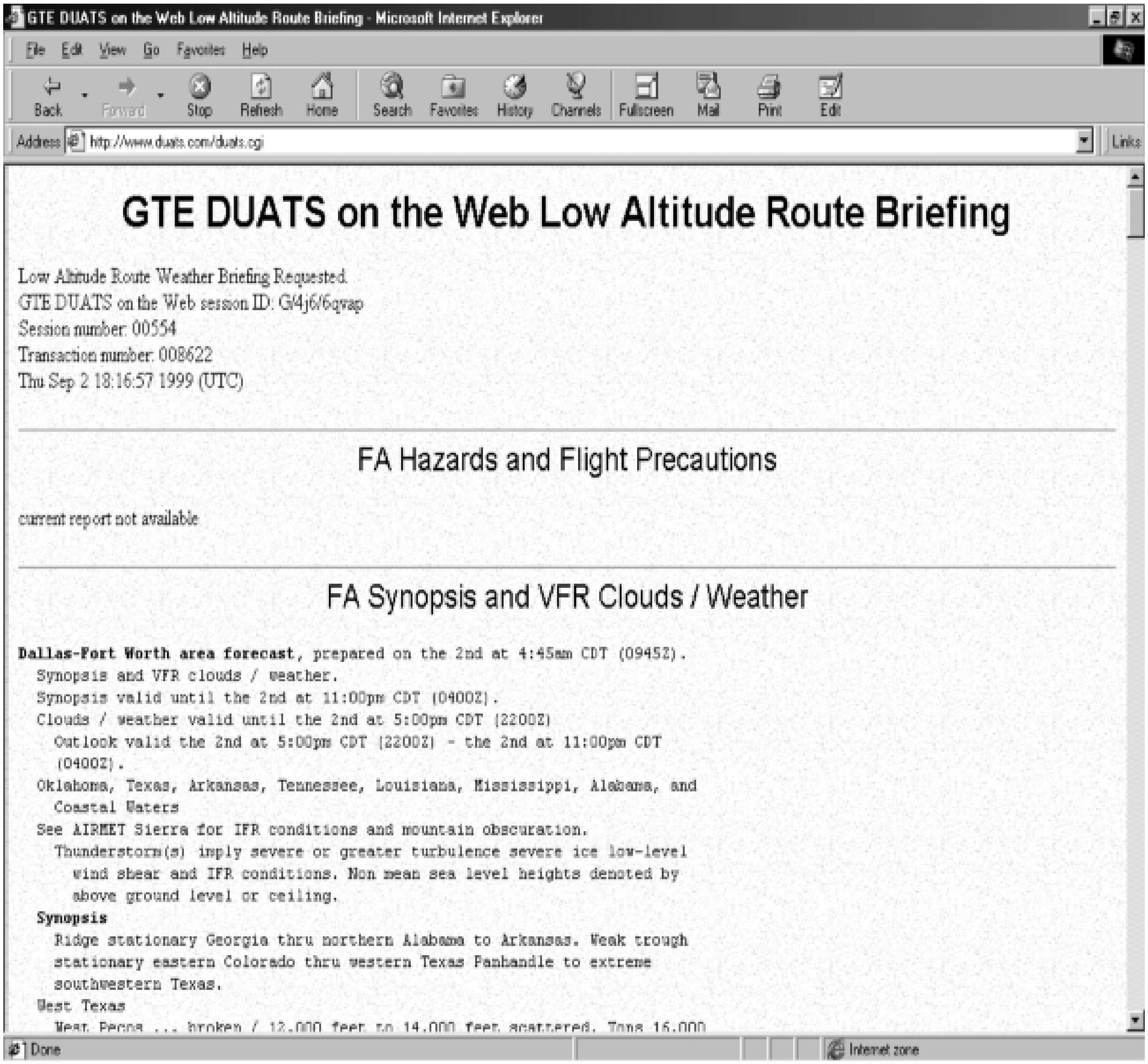
Working... Please wait.

******** FA Hazards and Flight Precautions ********
current report not available

******** FA Synopsis and VFR Clouds/Weather ********
DFWC FA 020945
SYNOPSIS AND VFR CLDS/WX
SYNOPSIS VALID UNTIL 030400
CLDS/WX VALID UNTIL 022200...OTLK VALID 022200-030400
OK TX AR TN LA MS AL AND CSTL WTRS
.
SEE AIRMET SIERRA FOR IFR CONDS AND MTN OBSCN.
TS IMPLY SEV OR GTR TURB SEV ICE LLWS AND IFR CONDS.
NON MSL HGTS DENOTED BY AGL OR CIG.
.
SYNOPSIS...RDG STNR GA THRU NRN AL TO AR. WK TROF STNR ERN CO
THRU WRN TX PNHDL TO EXTRM SWRN TX.
.
WEST TX
W PECOS...BKN/SCT120-140. TOPS 160. OTLK...VFR.
RMNDR...SKC. 18Z SCT100-120. OTLK...VFR.
.
N CNTRL TX
BKN/SCT CI. OTLK...VFR.
.
NERN TX
BKN150. TOPS FL200. WIDELY SCT -SHRA. 15-17Z BECMG SCT040-050
BKN120-140. WIDELY SCT TSRA. CB TOPS TO FL400. OTLK...VFR TSRA.
.
S CNTRL TX
SKC. 18Z SCT040-050. OTLK...VFR.
.

FIGURE 21. Low Altitude Weather Briefing

The report is presented primarily in the METAR/TAF format. Figure 22 contains an excerpt of the same information presented in plain language. The latter is what a pilot would expect to hear the briefer report if he or she had called the AFSS for a standard weather briefing for the same flight. The pilot could request either an outlook briefing, for flights beginning more than eight hours later, or and abbreviated briefing, to update a previously received standard briefing. The pilot can request specific weather items, and locales, for an abbreviated briefing.



GTE DUATS on the Web Low Altitude Route Briefing

Low Altitude Route Weather Briefing Requested.
GTE DUATS on the Web session ID: G/4j6/6qvap
Session number: 00554
Transaction number: 008622
Thu Sep 2 18:16:57 1999 (UTC)

FA Hazards and Flight Precautions

current report not available

FA Synopsis and VFR Clouds / Weather

```
Dallas-Fort Worth area forecast, prepared on the 2nd at 4:45am CDT (0945Z).
  Synopsis and VFR clouds / weather.
  Synopsis valid until the 2nd at 11:00pm CDT (0400Z).
  Clouds / weather valid until the 2nd at 5:00pm CDT (2200Z)
    Outlook valid the 2nd at 5:00pm CDT (2200Z) - the 2nd at 11:00pm CDT
    (0400Z).
  Oklahoma, Texas, Arkansas, Tennessee, Louisiana, Mississippi, Alabama, and
    Coastal Waters
  See AIRMET Sierra for IFR conditions and mountain obscuration.
    Thunderstorm(s) imply severe or greater turbulence severe ice low-level
      wind shear and IFR conditions. Non mean sea level heights denoted by
      above ground level or ceiling.
  Synopsis
    Ridge stationary Georgia thru northern Alabama to Arkansas. Weak trough
    stationary eastern Colorado thru western Texas Panhandle to extreme
    southwestern Texas.
  West Texas
    West Pecos ... broken / 12,000 feet to 14,000 feet scattered. Tops 16,000
```

FIGURE 22. Low Altitude Weather Briefing in Plain Language

Weather Graphics

One well-received feature of the DUATS service is the addition of graphical weather data. These charts are similar to those that hang on the walls of the old FSS's. They include weather depiction, surface analysis, radar summary, and various forecast-type charts. Pilots who found these types of charts useful were happy when they became available as a part of the DUATS weather briefing. Figures 23-26 provide some examples of the data. Figure 23 shows the current version of the old Surface Analysis Chart (SAC) with highs, lows, fronts and areas of significant weather. Figure 24, the Weather Depiction Chart (WDC), delineates the areas where the surface is IFR (visibility is less than three statute miles and/or the ceiling is less than 1,000 feet), and areas where the surface is MVFR (visibility between three and five statute miles and/or the ceiling between 1,000 and 3,000 feet). Figure 25 shows a Radar Summary Chart, depicting various intensities of precipitation using different colors. Figure 26 is the Lifted Index Analysis Chart that glider pilots use to evaluate the propensity for areas of thermal lifts that assists in keeping their gliders aloft. Figure 27 is a key to symbols used in the graphical weather presentations described above.

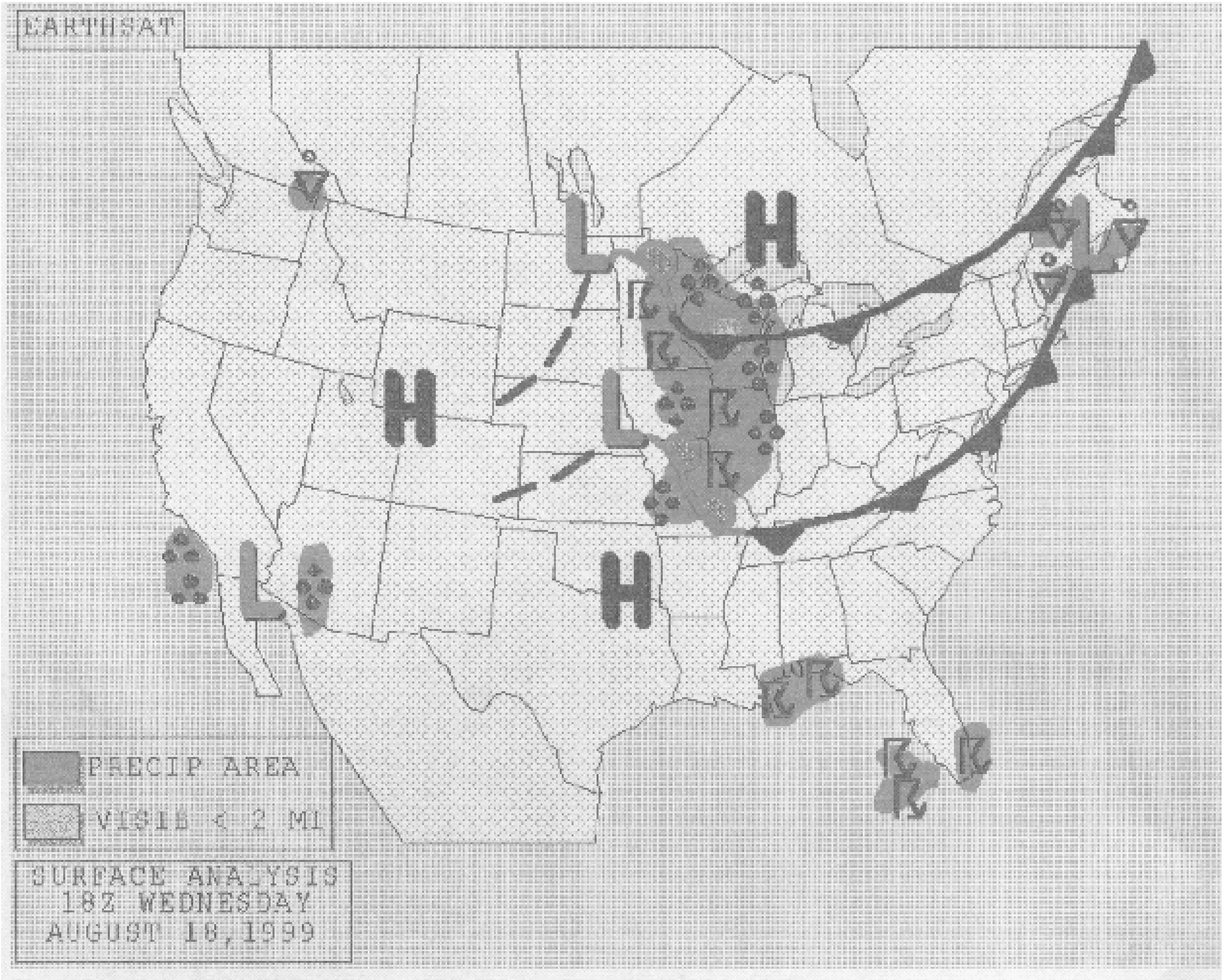


FIGURE 23. Surface Analysis Chart

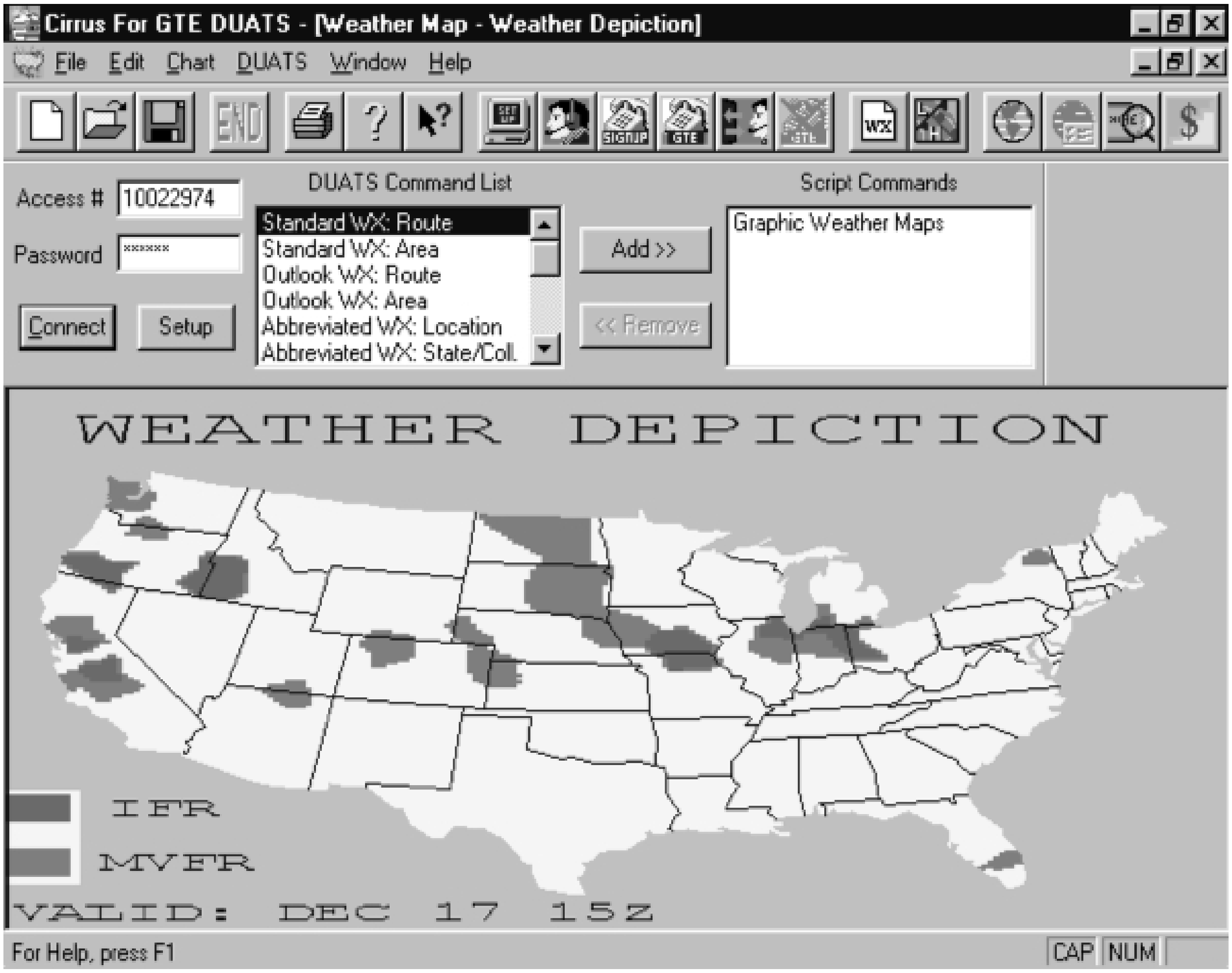


FIGURE 24. Weather Depiction Chart

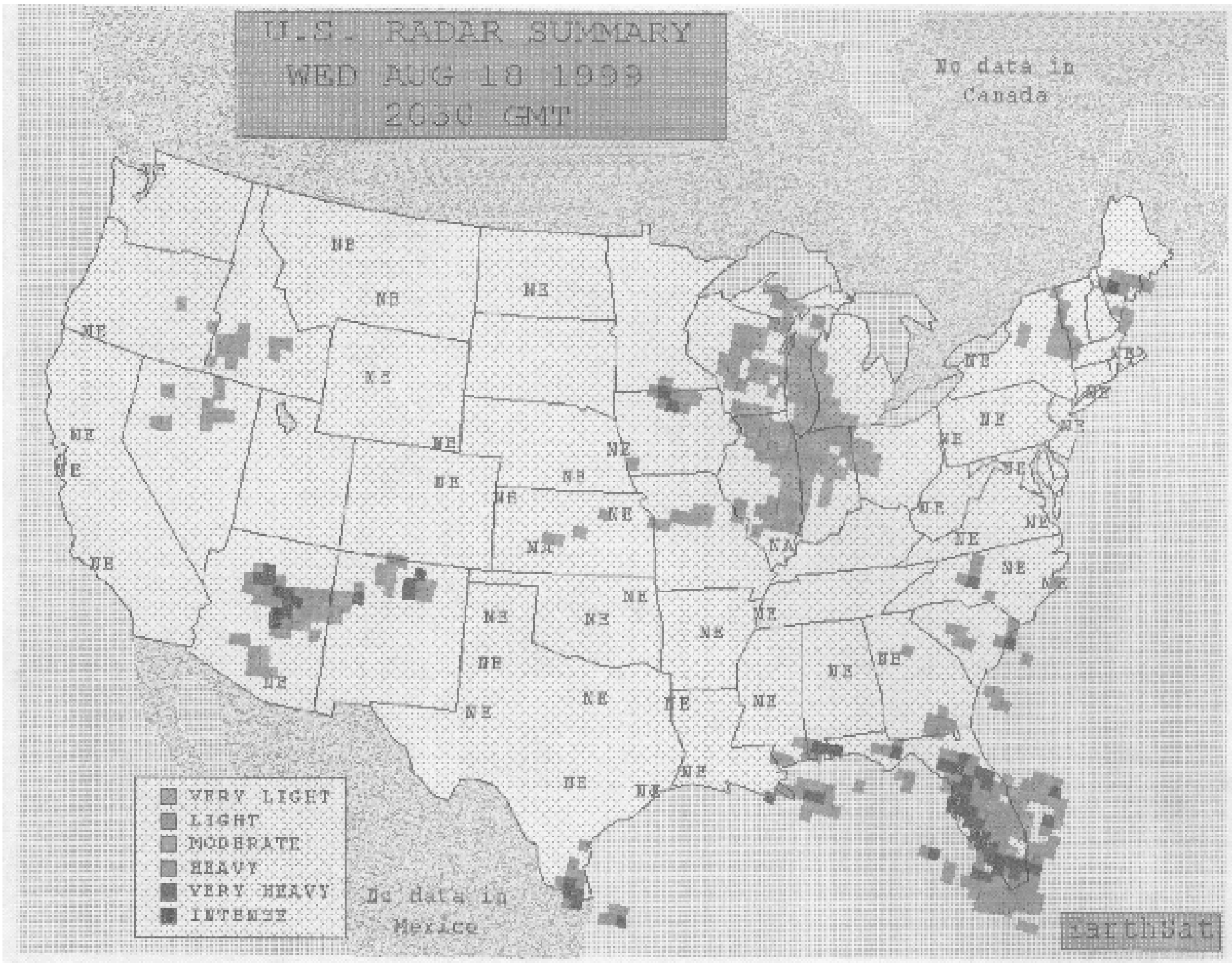


FIGURE 25. Radar Summary Chart

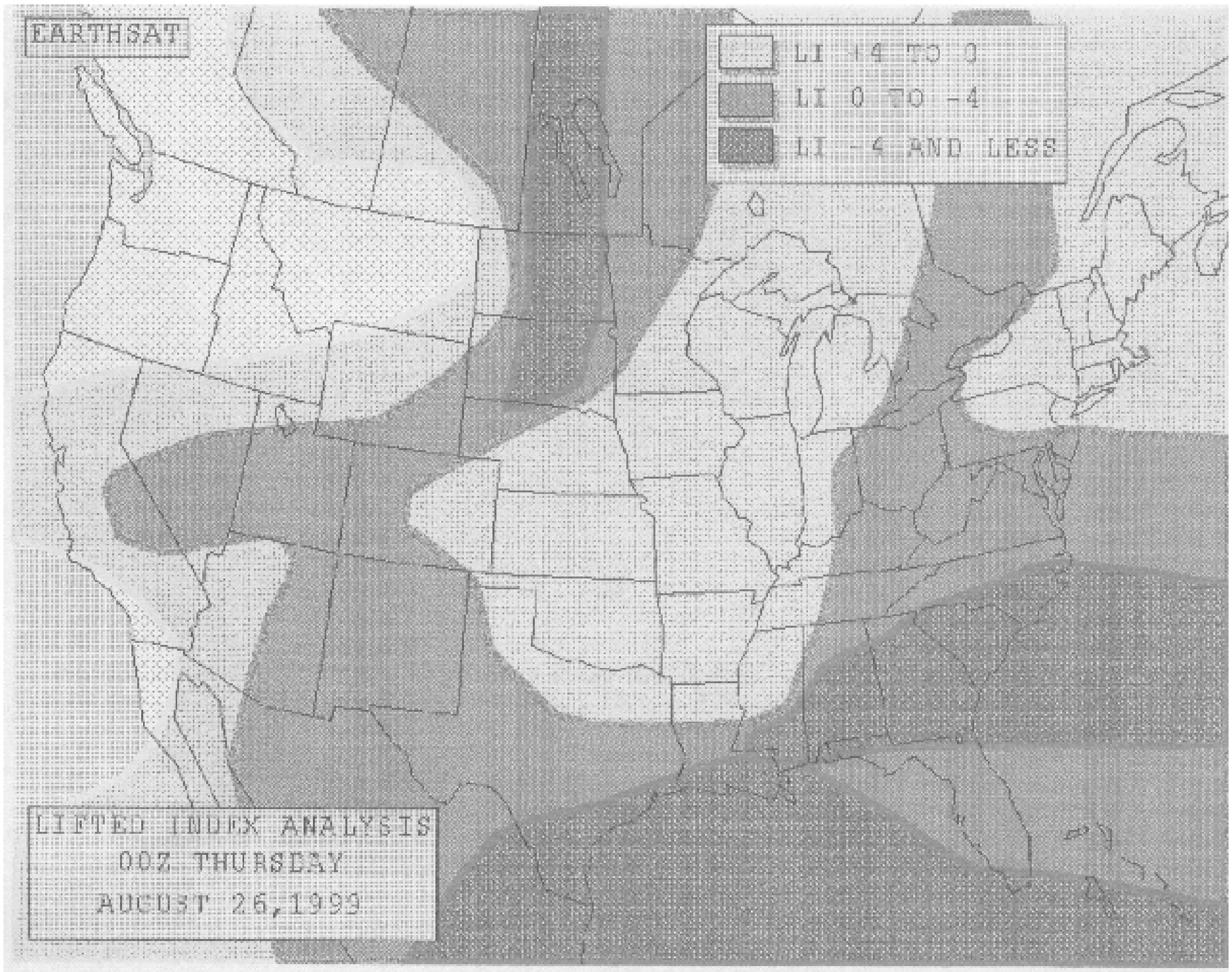


FIGURE 26. Lifted Index Analysis Chart

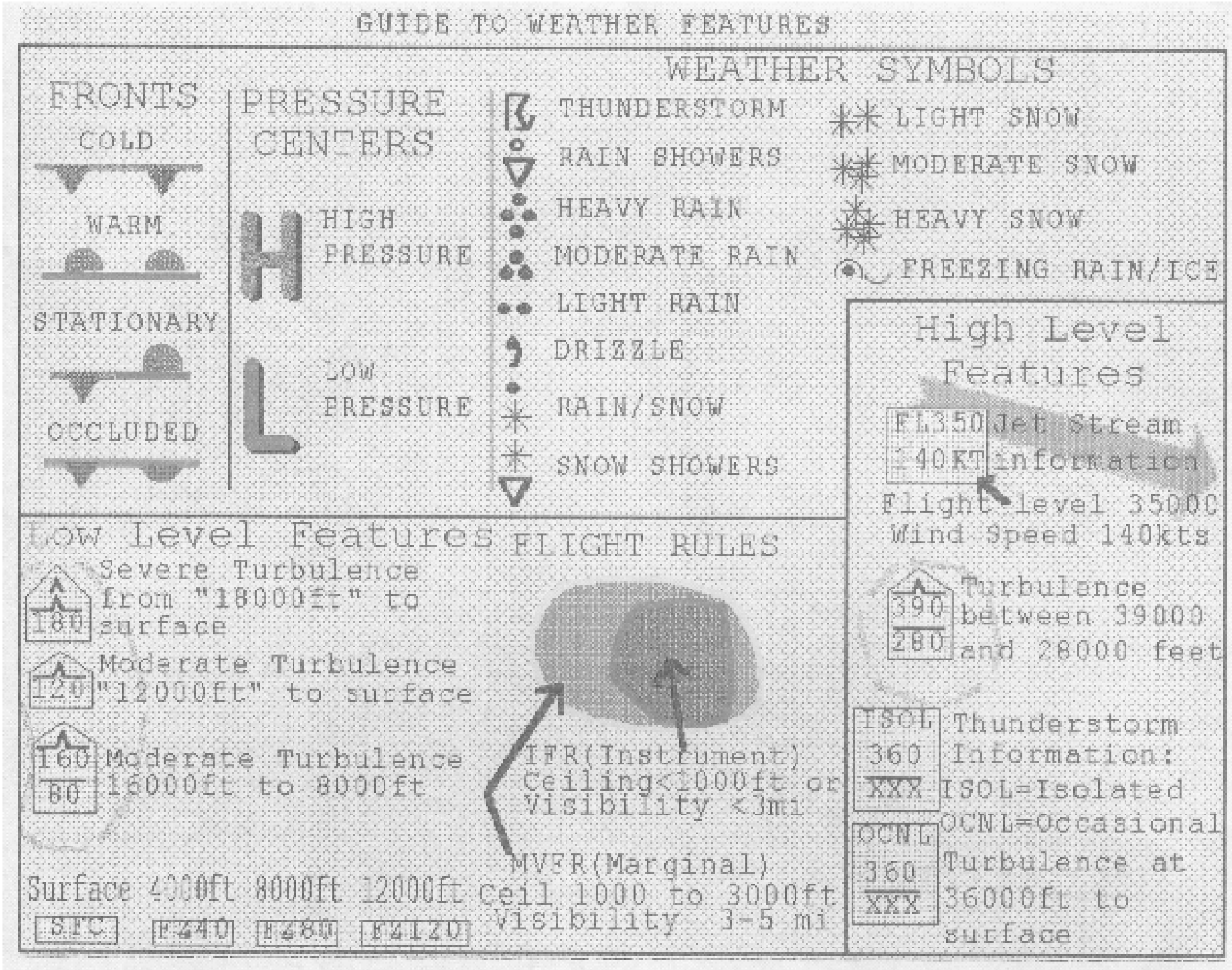


FIGURE 27. Guide to Symbols

Flight Data Center NOTAMS

The standard briefing includes extensive Flight Data Center (FDC) NOTAMS. However, there is an option of requesting only those FDC NOTAMS referring to one of the airports named in the weather- briefing request.

CIRRUS Software

CIRRUS for GTE DUATS is a software program developed for GTE by MentorPlus Software to supplement and support the original DUATS concept. CIRRUS works with Windows to select most of the DUATS features off-line (prior to making the actual telephone call). Then, after choosing a flight route by pointing and clicking on a databased map, the pilot dials (or connects to the Internet) GTE to download the required information automatically, usually without further pilot intervention. This downloading process moves rapidly and takes but a few moments to complete a flight log and file a flight plan for the specified trip. The conventional DUATS service now includes many of the CIRRUS features.

Pilots can download the CIRRUS software from the Internet or obtain the software free on a disk by mail. Then, about every 56 days, users can update the database using the Internet. This update will include new, or different, airports and navaids. Figure 28 shows an example of the CIRRUS software. The software stores the properties of the aircraft—climb rate and airspeed, cruise airspeed, and descent rate and airspeed—as well as the fuel consumption rate during each phase of flight.

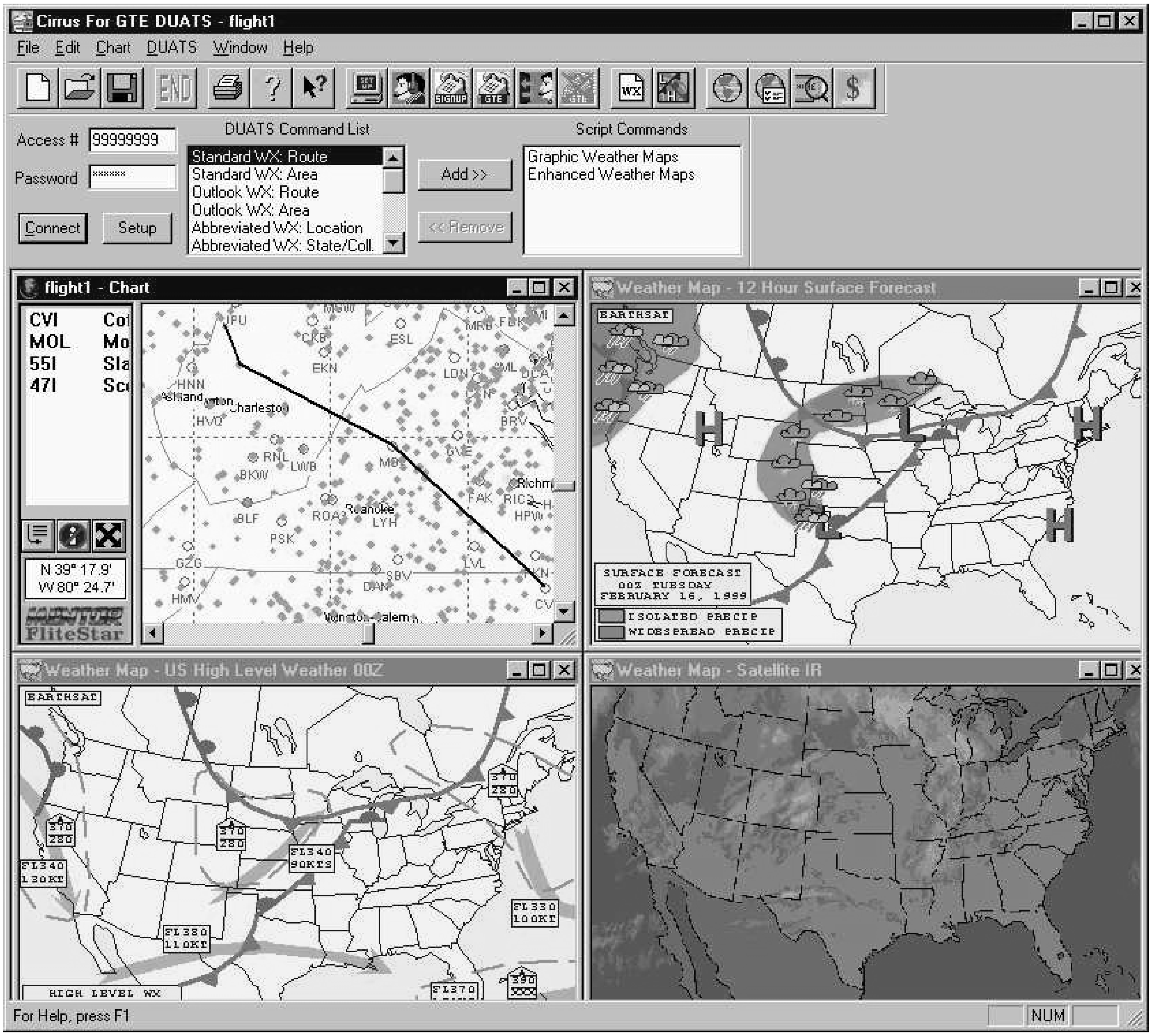


FIGURE 28. Example of CIRRUS Software

When a pilot prescribes a time and route, CIRRUS will prepare and print a pre-flight log, accounting for climbs, descents, and forecast of winds aloft, that the pilot can expect for the aircraft properties stored in the file. Figure 29 shows an example of defining the route, using information stored in a database; in this instance for a flight in a Cessna 152 from College Station, TX (Easterwood Airport), to Vicksburg, MS. Figure 30 shows the calculated flight log with check points at the Lufkin VOR and the Nacogdoches Airport. Figure 30 also shows the properties of the aircraft, as well as the winds aloft.

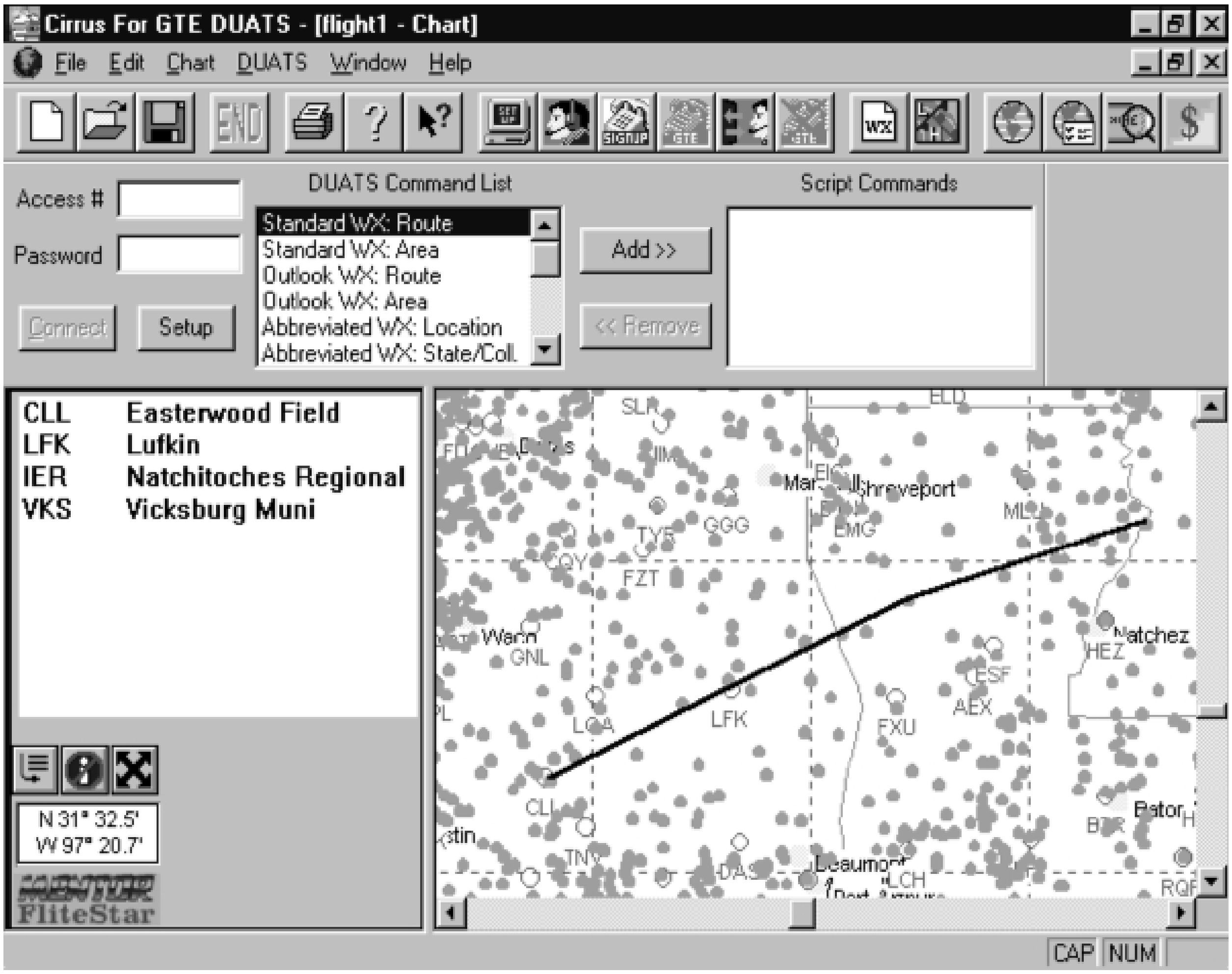


FIGURE 29. Flight Routing Using CIRRUS Software

```
                 GTE DUATS on the Web
              Flight Plan     CLL-VKS

From: KCLL -- College Station TX (Easterwood Field)
To:   KVKS -- Vicksburg MS
Alt.: 5,500 ft.  Profile: C152
Time: Fri Dec 17 23:00 (UTC)

Routing options selected:  Direct.
Flight plan route:
 LFK IER
Flight totals: fuel: 15 gallons, time: 2:55, distance 295.7 nm.

  Ident  Type/Morse Code      |                              |Fuel
  Name or Fix/radial/dist     |                              |Time
  Latitude Longitude Alt.     |Route  Mag  KTS Fuel          |Dist
---+--------+---------+---------|Winds  Crs TAS  Time         |------
 1. KCLL   Apt.               |Temp   Hdg  GS  Dist          | 0.0
  College Station TX ( Eas    |--------+----+---+------------|0:00
  30:35:18  96:21:49   3      |Direct         4.9            | 296
---+--------+---------+---------|200/18  061  88  0:55        |------
 2. LFK   .-..  ..-.  -.-     |+13C   070  100   92          | 4.9
  d112.1 Lufkin               |--------+----+---+------------|0:55
  31:09:44  94:43:01   55     |Direct         4.2            | 204
---+--------+---------+---------|226/19  062  90  0:50        |------
 3. IER    Apt.               |+7 C   066  108   89          | 9.1
  Natchitoches LA             |--------+----+---+------------|1:45
  31:44:08  93:05:56   55     |Direct         5.8            | 115
---+--------+---------+---------|191/13  070  93  1:10        |------
 4. KVKS   Apt.               |+11C   077  98  115           |14.9
  Vicksburg MS                |--------+----+---+------------|2:55
  32:14:21  90:55:42   1      |                              |  0
---+--------+---------+---------|                              |------

NOTE: fuel calculations do not include required reserves.
Flight totals: fuel: 15 gallons, time: 2:55, distance 295.7 nm.
Average groundspeed 101 knots.
Great circle distance is 295.4 nm -- this route is 0% longer.

------------------------------------------------------------------------



------------------------------------------------------------------------
 Copyright ⌐ 1997-1999 ENFLIGHT    $Id:  form_planner.c,v 1.22 1999/07/10
 All rights reserved.                     06:17:57 geoff Exp $
```

FIGURE 30. Calculated Flight Log

In conjunction with preparing the flight log, CIRRUS automatically files a flight plan, either VFR or IFR, with the AFSS. The pilot can print the flight plan as filed with the AFSS and then carry it on the flight. Figure 31 shows an example of the flight plan from College Station to Vicksburg, in this case a VFR flight plan. Notice that CIRRUS automatically files the flight plan with the appropriate FSS.

```
                         FAA Flight Plan Filed

 1  Type of flight plan:              VFR
 2  Aircraft tail number:             N49785
 3  Acft type/special equip:          C152/U
 4  True airspeed:                    90
 5  Departure point:                  CLL
 6  Departure time:(UTC)              Fri Dec 17 23:00
 7  Altitude:                         55
 8  Route of flight:                  LFK IER
 9  Destination:                      VKS
10  Estimated time enroute:           0255
11  Remarks:
12  Fuel on board:                    0400
13  Alternate destination(s):
14  Pilot's name:                     JOE S PILOT
     Address:                         707 TEXAS AVE COLLEGE STATION TX 77840
     Phone no.:                       409 111 2345
    Aircraft home base:               CLL
15  Number aboard:                    1
16  Color of aircraft:                MAROON/WHITE
17  Dest contact name:
     Phone no.:

Flight plan accepted by GTE Contel DUAT service and will be filed
with CXO on Fri Dec 17 22:00 (UTC).

---------------------------------------------------------------------------



---------------------------------------------------------------------------
 Copyright ⌐ 1997-1999 ENFLIGHT      $Id:  duats_cmd.c,v 1.9 1999/09/09
 All rights reserved.                 04:15:38 geoff Exp $
```

FIGURE 31. Flight Plan

A feature of the CIRRUS program is the capability of furnishing weather graphs and enhanced satellite images giving the pilot a quick synoptic view of the weather. This gives a quick overview of the weather trends, and, in an emergency, where to fly for better weather conditions. Figure 32 provides an example of a WDC showing areas of Instrument Meteorological Conditions (IMC) and Marginal Instrument Meteorological Conditions (MIMC).

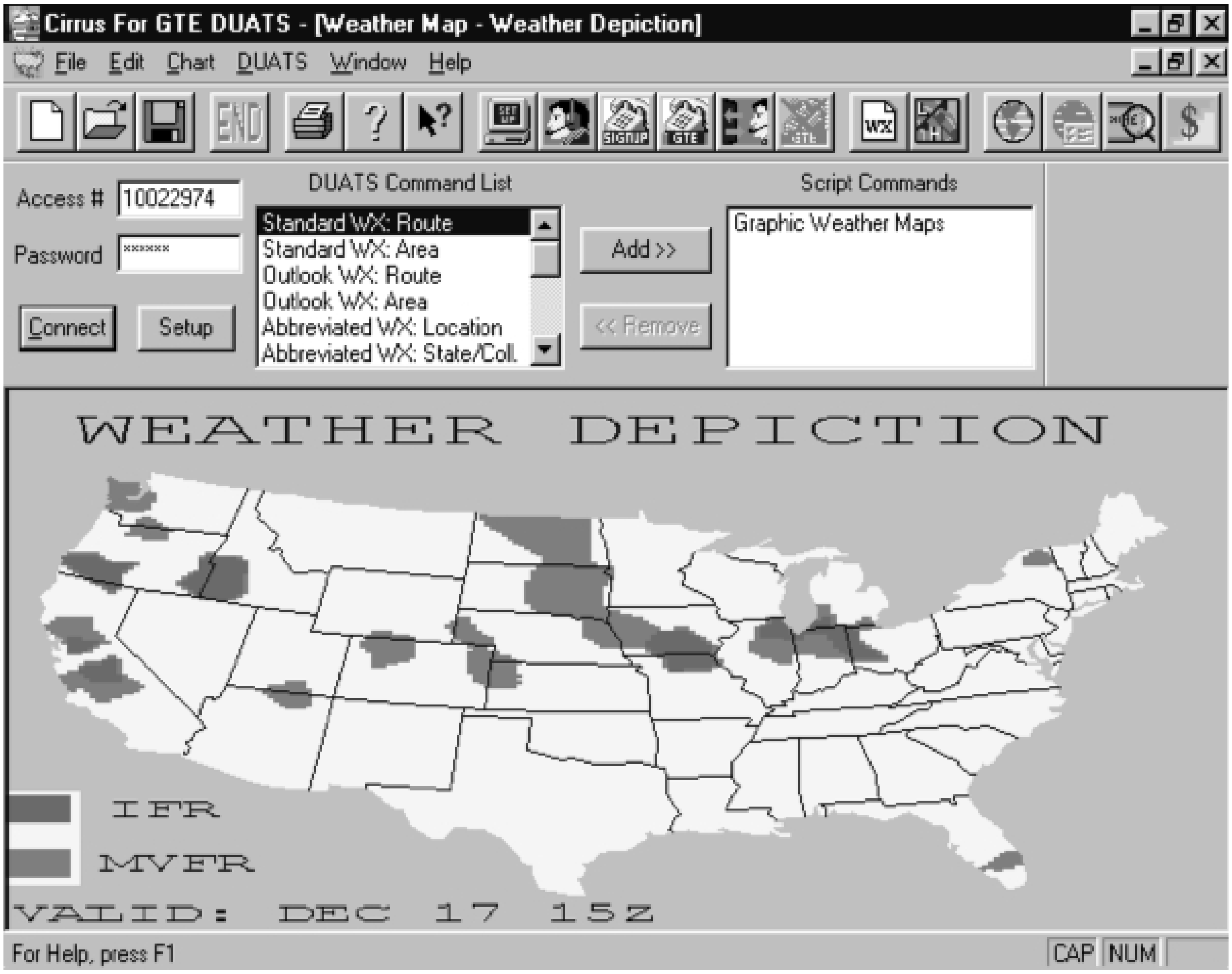


FIGURE 32. Weather Depiction Chart Developed Using CIRRUS Software

AVIATION WEATHER SOURCES ON THE INTERNET

The expansion of the Internet provides pilots an abundance of sources to obtain specialized weather-related information. The following provides a few of the sites that provide aviation weather information as well as a brief description of the site.

One particular site, Aviation Digital Data Service (ADDS), supplies weather data in a format favored by pilots. The service plots areas of turbulence, convective activity, icing, and IMC, customarily been accomplished by defining boundaries in terms of VOR's, in chart form. An example AIRMETS and SIGMETS plot is shown in Figure 33 Similar plots of PIREPS, one concerning turbulence and the other concerning icing, are shown in Figures 34 and 35, respectively. The site began as an experiment, but it is wildly popular with pilots and many expect the site to become a mainstream conduit for distributing weather information.

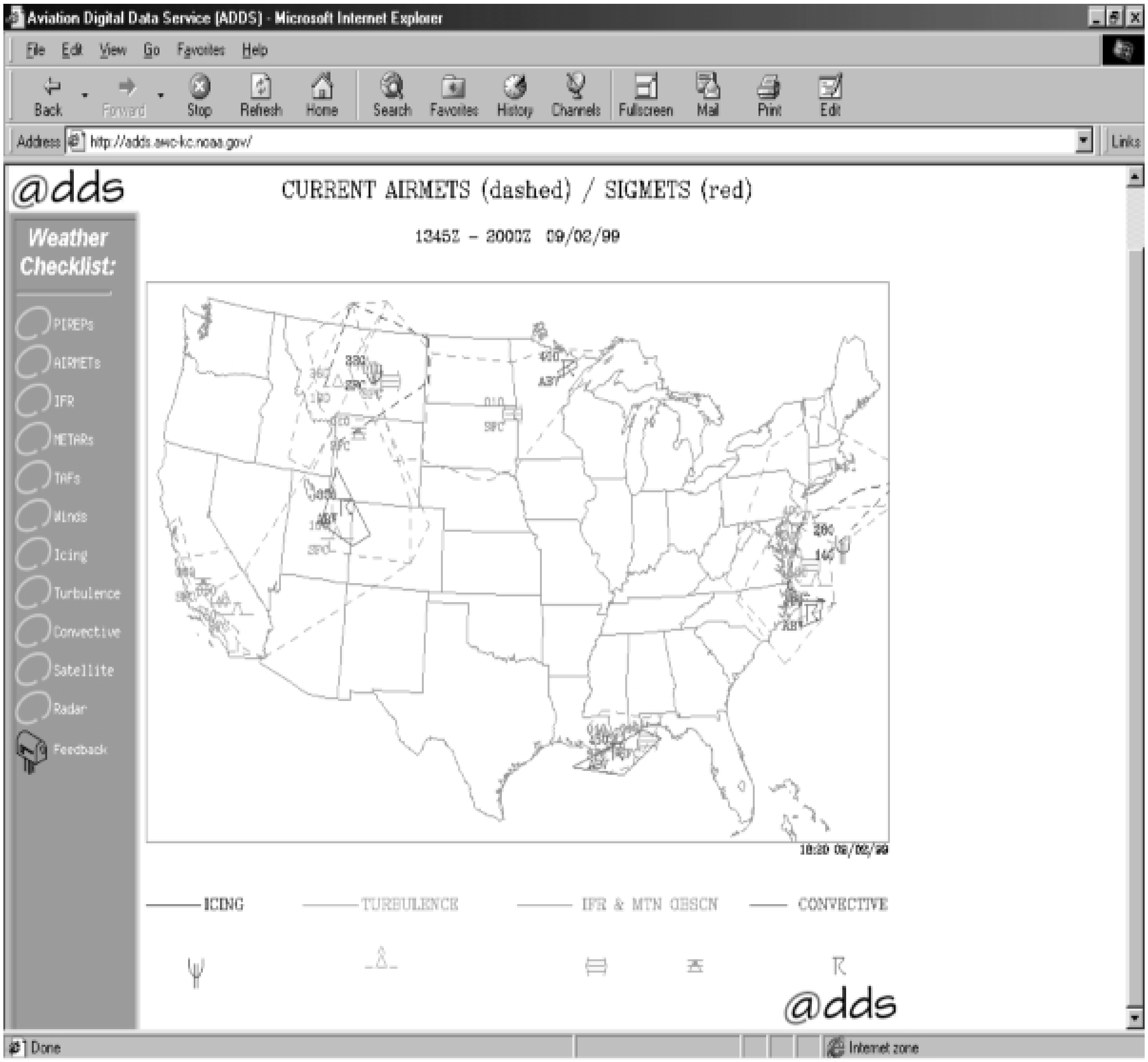


FIGURE 33. ADDS AIRMETS and SIGMETS

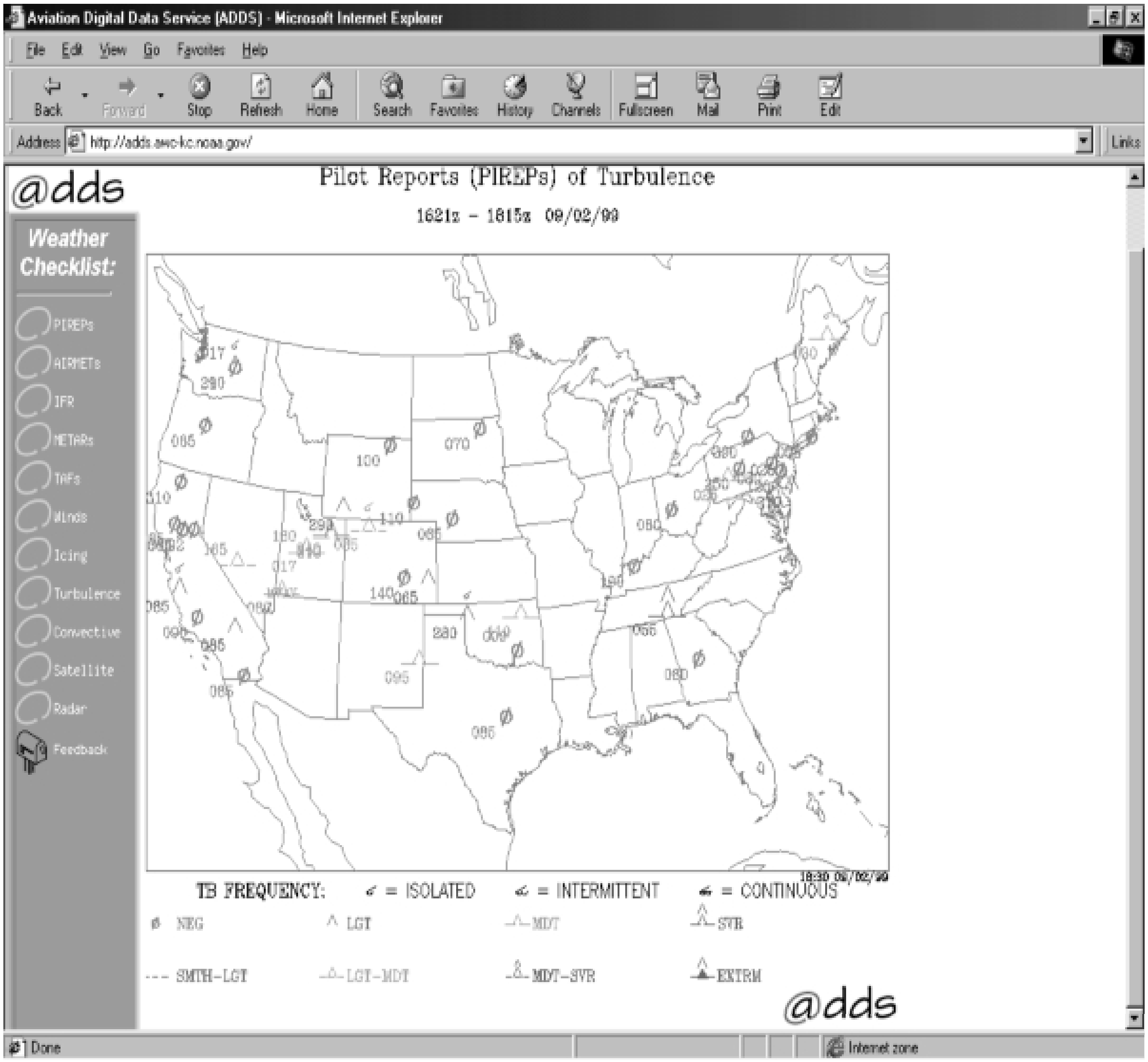


FIGURE 34. ADDS PIREPS of Turbulence

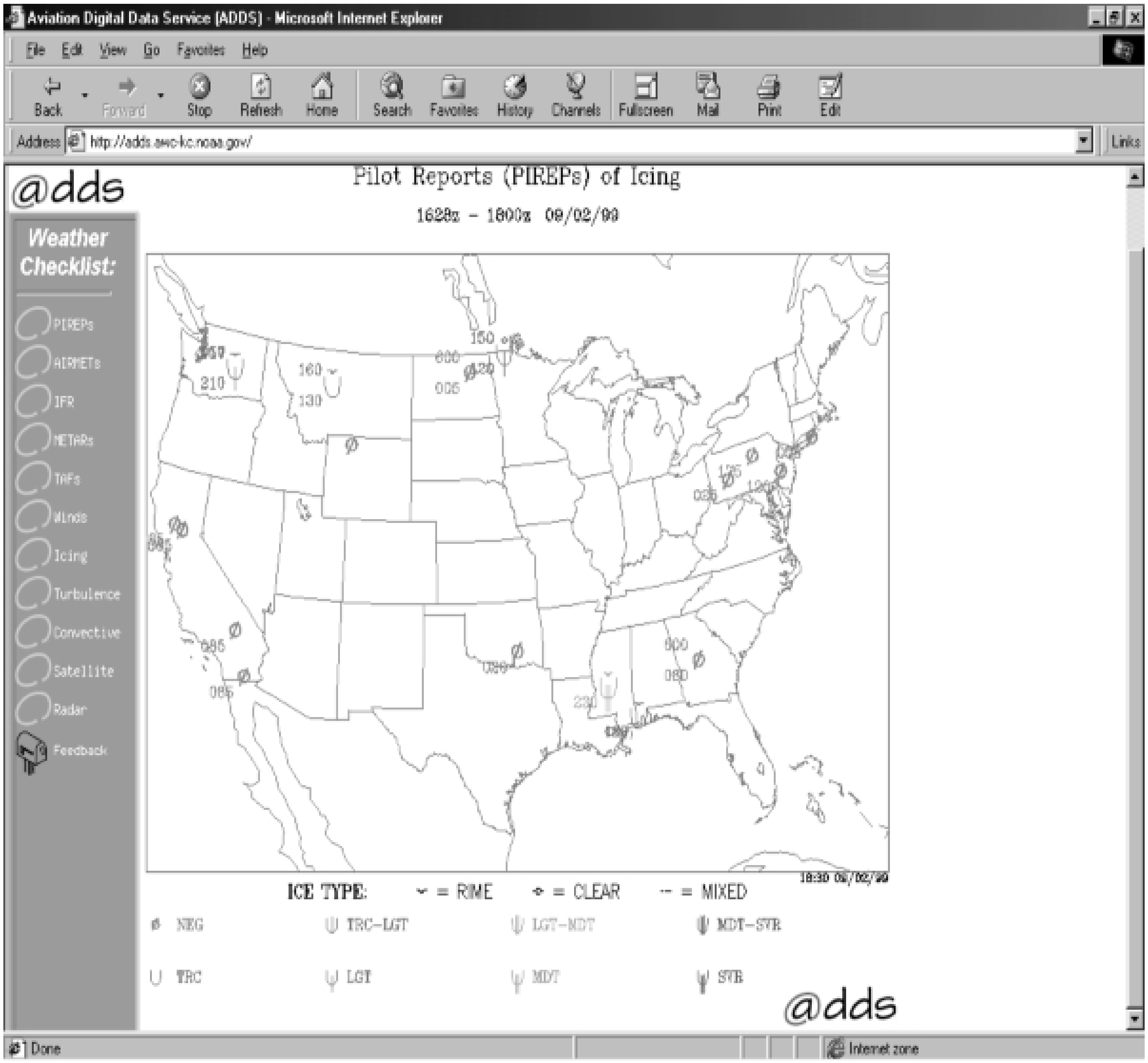


FIGURE 35. ADDS PIREPS of Icing

One valuable feature is that the ADDS site presents PIREP's (of all types, but mainly those concerning weather) in graphical form. For example, the chart of Figure 36 represents the METAR's reported from Texas airports.

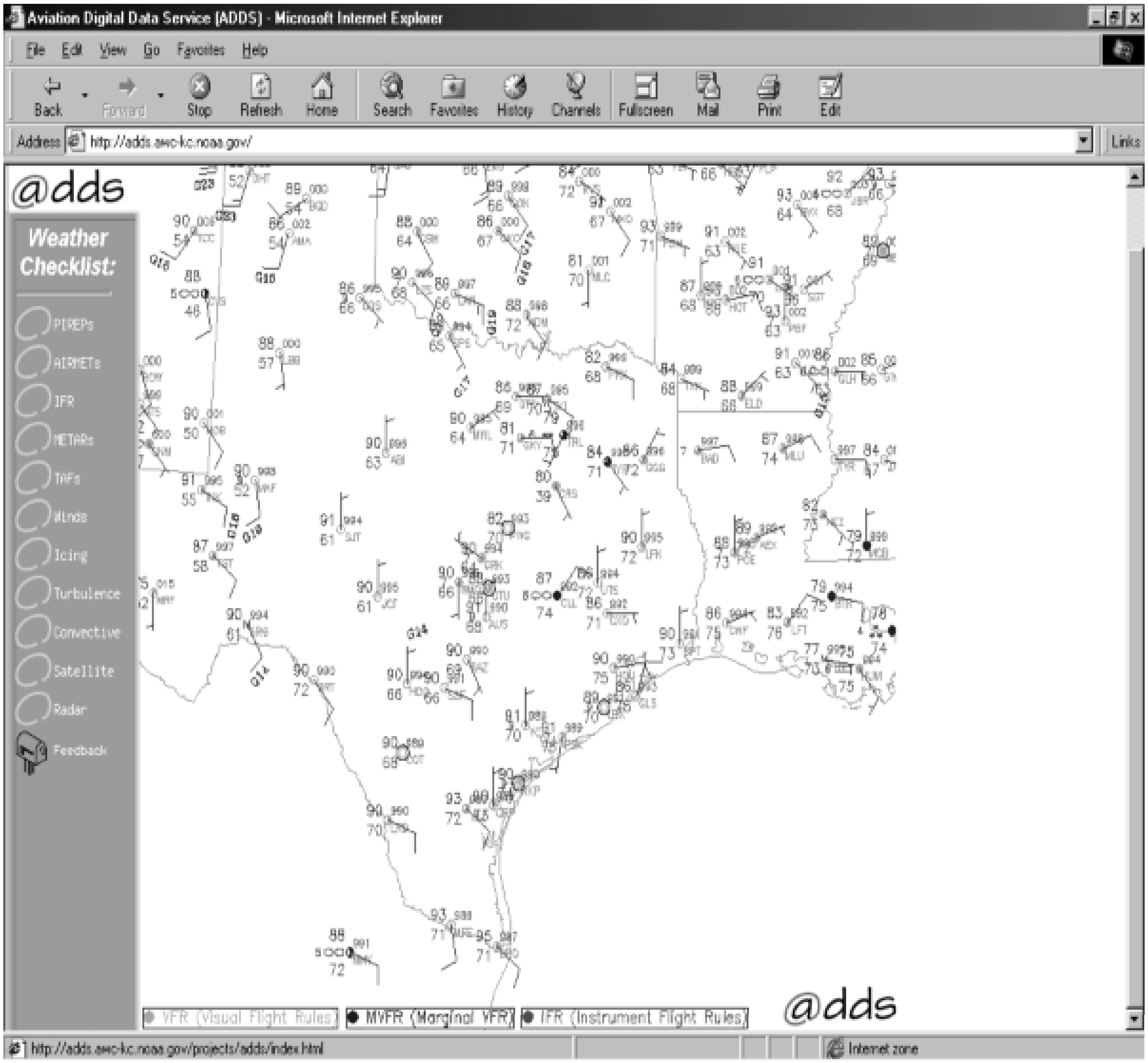


FIGURE 36. Weather METARs

Table 4 lists several other sites for obtaining weather data. Exploration shows that each is valuable for specific uses. The table also presents a brief description of the strengths of each site.

TABLE 4
Aviation Weather Internet Sites

Site	Description
Http://www.intellicast.com	This site, provided by Intellicast, is especially good for displaying local radar and visible satellite photos.
Http://cirrus.sprl.umich.edu/wxnet	This site, maintained by the University of Michigan, is a particularly good source of NEXRAD graphs for specific locations around the nation.
http://www.eas.purdue.edu/wxp	This joint site, run by Purdue University and Unisys, is extremely valuable to the pilot from several standpoints. It displays a series of forecasts based on different computer models. The pilot has the information required to see how the models differ and which models best portray the future weather. A useful feature of this site is the looping graph of the current and preceding weather.
Http://www.weather.com/aviation	This site, maintained by The Weather Channel, provides a quick look at the location of the jet stream.
Http://www.usatoday.com/weather/wfront.htm	This site, maintained by USA Today, provides weather data worldwide. The radar images at the local level provide a looping sequence as well as county outlines. This information is useful for determining exactly where the weather is located.
Http://www.usatoday.com/weather/radpic/Wrhoust1.htm	This site is an example of the looping radar for the Houston, TX, area.
Www.rap.ucar.edu/weather/aviation.html	This site, sponsored by the National Center for Atmospheric Research, provides both an overview and a local, detailed look at current and forecast weather for pilots.
http://aviationweather.noaa.gov	Sponsored by the National Weather Service, this site provides for distributing aviation weather products. It is an especially good source of new and experimental graphical presentations. Pilots find the satellite photos, with the current station observations (IFR, MVFR, VFR) superposed upon them, particularly convenient.
Www.aviationweather.com	This is one of the best sites for obtaining aviation weather, and contains a disclaimer that pilots should not use the Internet for operational purposes.
http://adds.aviationweather.noaa.gov	This site, called the ADDS, is a joint effort of the NWS' Aviation Weather Center and the FAA.
Http://emwin.hcad.org/lightning/lgtiahtx.gif	This site, sponsored by the Emergency Managers Weather Information Network, is helpful for pilots flying near Houston because it reveals the presence of lightning strikes in the locale.

Aviation Weather and Flight Planning
Another Internet site, especially useful as a starting point, is the Aviation Weather and Flight Planning site sponsored by Sport Flyers. Pilots can find the site at:

http://sportflyer.com/weather.htm.

Here pilots can find links to DUATS and other weather sources as well as supplementary cross-country planning aids.

Texas A&M University Meteorology Site
The Meteorology Department at Texas A&M University developed an Internet site providing data not found at many of the other sites (Figure 37). Here, users can access NEXRAD radar images, including precipitation and wind direction, from the several NEXRAD sites across the state. The site includes two other interesting features—the superposition of radar images on satellite photos, and lightning strikes. These are all informative features for pilots planning cross-country flights.

More importantly, the site includes a display of lightning strikes sequenced in time. This shows the movement and growth, or shrinkage, of the area of turbulent activity. Figure 38 presents an example of this color display. One cautionary note is in order. Pilots should always check the time and date of the display of the image they are accessing.

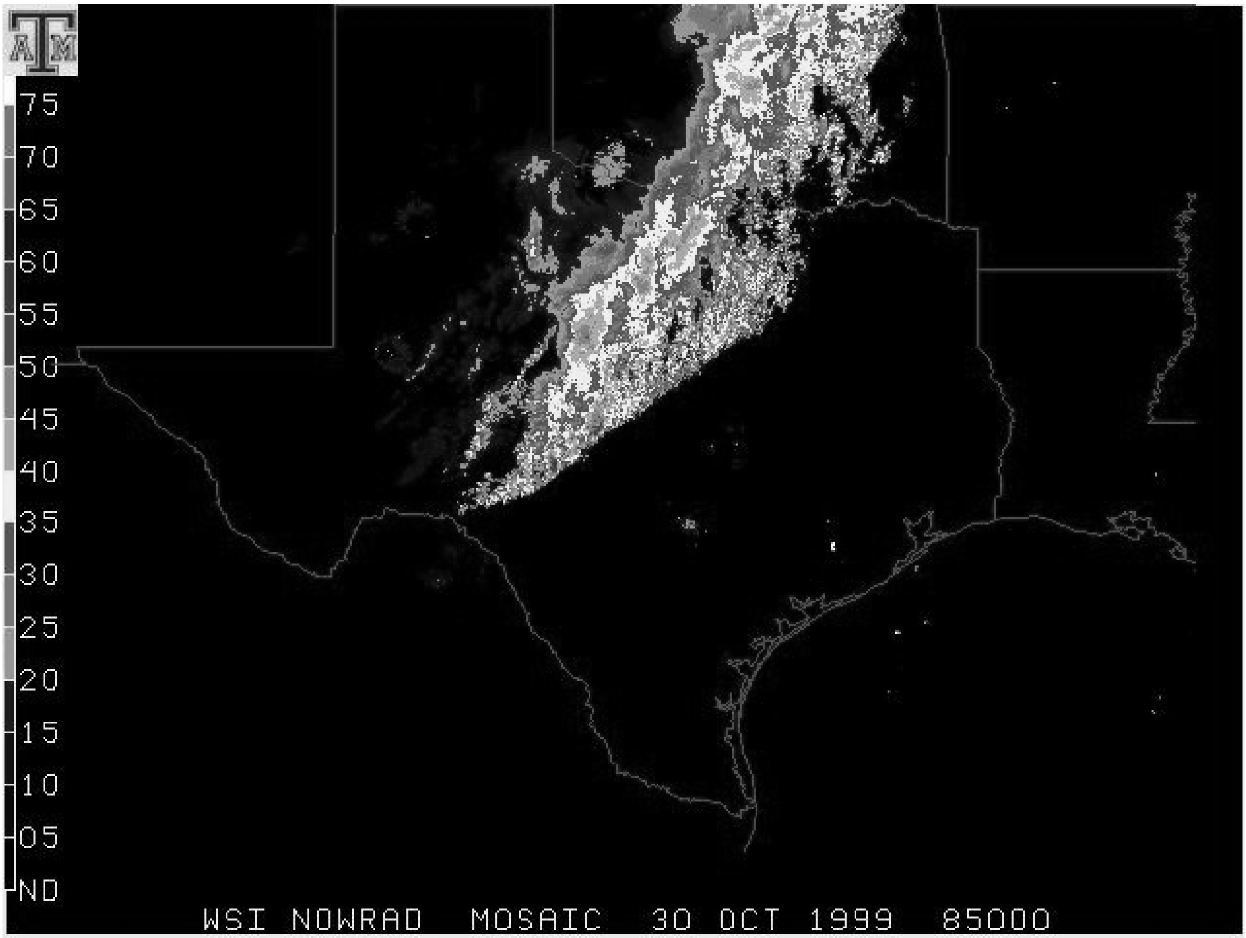


FIGURE 37. Doppler Radar Screen from the Texas A&M University Meteorology Department

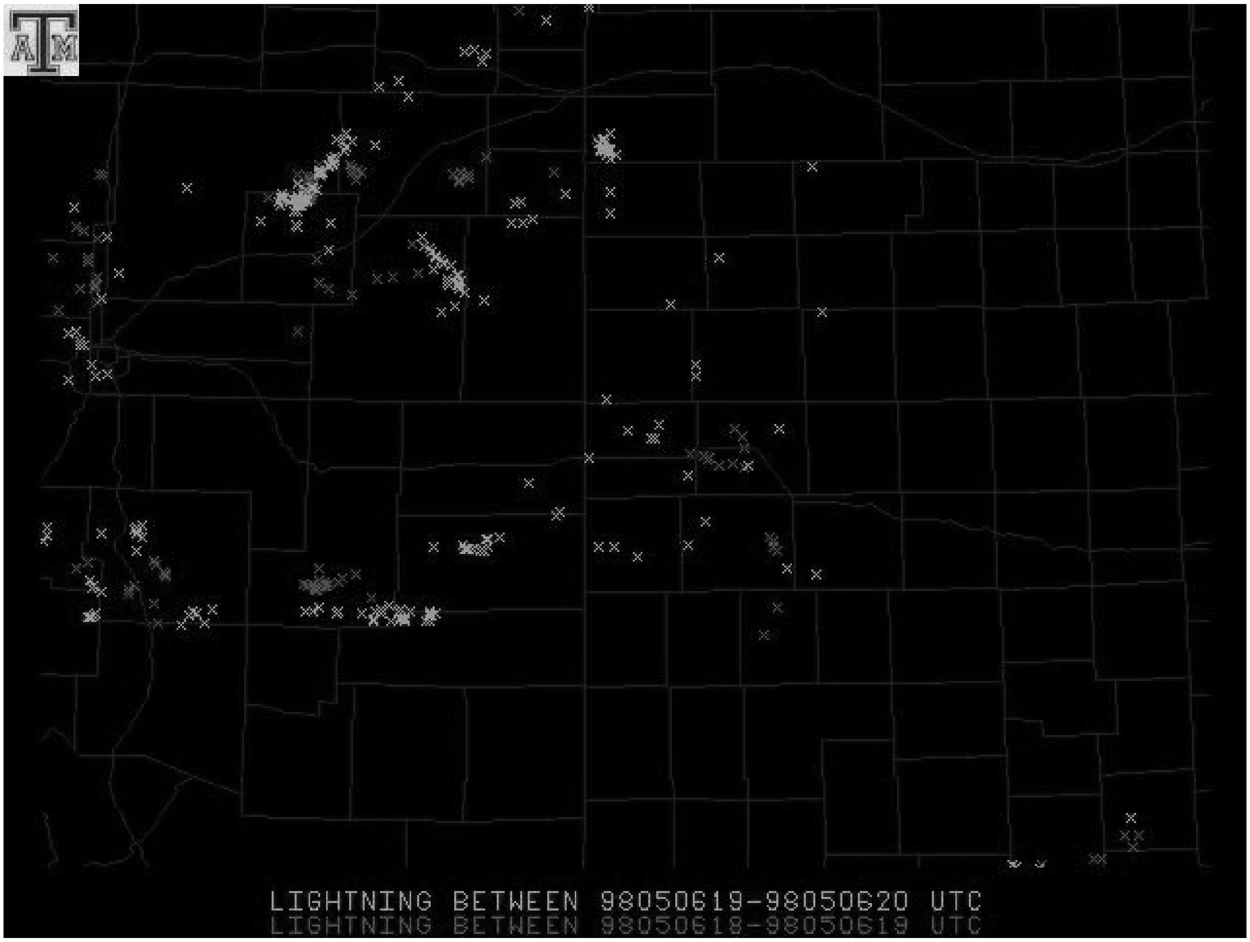


FIGURE 38. Lightning Strikes from the Texas A&M University Meteorology Department

General Aviation Sites

Several other valuable Internet sites are available to pilots that contain a variety of data, including current weather. Some of these sites are:

www.atlascomm.net/faaflyer

This site, commonly called Steve's Favorite CFI sites, is a source for many publications and interesting flying data, including weather.

www.airnav.com

This site helps pilots choose refueling airports based on the price of fuel.

www.AVweb.com

A great source for aviation news.

These sites and the services they offer are free. The Aircraft Owners and Pilots Association has a similar site, but requires a name and access code, based on membership in the organization, to login to the site. Members can use the following URL:

www.aopa.org

Upon initial contact, the organization will assign a member a user name and access code. The site reports recent aviation news and many interesting features such as databanks and a computation form that assists in estimating the value of most any aircraft. This site also includes an informative aviation weather site. Non-members cannot access this site.

Bookmarks
As the pilot explores and studies these data sources, their usefulness as a pre-flight planning tool will grow and become indispensable. High-tech oriented pilots will probably soon have sets of Internet bookmarks tailored toward their individual preferences. These bookmarks will help produce a rapid and complete pre-flight briefing. A pilot can print a planned flight log, flight plan, and NOTAMs and include this with printouts of current and forecast weather.

CHAPTER 5. CONTINUING EDUCATION FOR PILOTS

Near midnight on June 1, 1999, Capt. Richard Buschmann and his First Officer, Michael Origel attempted to land a MD-82 on Runway 4R at the Little Rock AR, Airport. It was the end of a long day (13 ½ hours of duty time) involving flights from Chicago, IL, to Salt Lake City, UT, to Dallas, TX, before the ill-fated leg to Little Rock. Weather conditions in Dallas forced a nearly two-hour flight delay while the crew waited for conditions there to improve. At the time the American Airlines Flight 1420 attempted the Little Rock landing, there were severe thunderstorms with hail, rain, and gusty winds at the airport. One passenger, Barrett Baber, a student from the Ouachita Baptist University at Arkadelphia, reported the plane made a fast approach to the airport as lightning raged. Hail pelted him once he got out of the aircraft, he said.

The plane made a "firm" landing on the rain-slickened runway, deployed the thrust reversers, stowed them briefly, then deployed them again near the end of the runway. The MD-82 was unable to stop by the end of the 7,200-foot runway, plowed through the runway 22L approach lights, broke into three pieces and burst into flames. A total of 11 of the 145 people (139 passengers and six crewmembers) on board died in the accident, including the pilot. About 40 people sustained serious injuries. This serious FAR 121 accident started a long and detailed investigation that will probably determine in great detail every event that led up to the traumatic accident.

However, many facts are obvious. The pilot was a 20-year American Airlines veteran who undoubtedly received the best initial training that the system offers. More importantly, because American is a premier airline, the pilot received the best recurrent training available. His co-pilot probably received similar training.

The aircraft, a MD-82, is a mainstay of the American fleet. American has 260 of these aircraft in service. The first MD-82 flew in 1981, and these aircraft been in continuous production since that time. Therefore, it is probable that the aircraft contained an advanced, digital integrated flight guidance system (autopilot, flight directors, and autothrottles). In addition, it is possible that it also contained an EFAS, digital engine instruments, and flight management system (FMS) allowing long range navigation using IRS, GPS, etc. The aircraft contained the best flight instruments, power instruments, navigation instruments, and weather detection instruments.

The airport, Little Rock Adams, while not one of the nation's top 20 in terms of the number of operations, is a modern, relatively large, and well-equipped airport. It is located in a Class C designated airspace and provides advisory and directional (vectoring) services to inbound air traffic. It has a low-level windshear advisory sensor (LLWAS) on the airport and a NEXRAD Doppler radar is nearby at the North Little Rock Airport. There was no shortage of weather data available to the pilot, both from sources self-contained within the aircraft and on the ground.

The pilot could have avoided this accident by making a different decision. At some point, the pilots knew about the intensity, location, and movement of the Little Rock weather. However, a decision to abort, or go elsewhere, or return all would have resulted in delays, trouble to the passengers, problems for the pilots and crew, and some loss of personal prestige and reputation. These virtual, if not real, external pressures undoubtedly influenced the pilot's decision. The lesson here is as old as flying itself. Why do experienced and qualified pilots make decisions that do not reflect their experience and training? How can we teach pilot judgement? How can we improve the pilot decision-making process? How can we incorporate the principles of sound decision-making into recurrent flight training?

In this era of rapid, almost explosive change, especially with respect to high-tech equipment and procedures, it is difficult to stay abreast of the capabilities available and the procedures for making full use of them. This is true in banking, publishing and serving food. However, it is an order of magnitude more accelerated in areas based on the use of mechanical and electronic equipment. This includes vehicles for flight and the instruments used to fly them safely. GPS uses satellites for navigation, NEXRAD's remotely sense storms and precipitation, and cathode ray tubes (CRTs) present, in a chart-like format, the collected information.

Proper programming of these technologies is paramount for pilots to obtain the data they need. Because methods vary with technology and manufacturer, there is a continuing struggle for the user to stay familiar with the operations and best use of the many devices. In other words, it is a wonderful world for the proficient user, but a terror-filled world for the amateur or error-prone user.

Obviously, the answer is for the user to aggressively study and practice with the equipment and procedures they will be using. The following paragraphs discuss some of the organizations that are attempting to provide support for the information-hungry pilot.

FAA ROLE IN CONTINUING EDUCATION FOR PILOTS

The FAA has long felt the responsibility for pilot training in an attempt to promote safer and more productive general aviation flying. The Federal Aviation Act of 1958 clearly states the mission of the FAA when it says, "The Administrator shall regulate air commerce in such a manner as to best promote its development and safety" (Section 103(a)).

In this role, the FAA conducts workshops and seminars designed to broaden and refresh technical knowledge, primarily to pilots. The Aviation Safety Program (ASP), an important arm of the FAA, typically conducts the workshops and seminars. Each Flight Standards District Office (FSDO) has a Safety Program Manager (SPM) to organize the extensive ASP activities. ASP designed these activities on the premise that by encouraging members of the aviation community to improve their attitudes toward safety by refreshing their aeronautical knowledge and by improving their aeronautical skills they can reduce accident rates.

The ASP is the brainchild of James (Pete) Campbell, former Flight Standards Division Manager and the program's first national coordinator. He reasoned that if the Flight Instructor Refresher Clinic Program could reduce the accident rate for flight instructors by 40% in four years and by 87% in eight years, a similar outreach to general aviation pilots would have a similar effect. In other words, he envisioned a more positive, educational approach to safety rather than ASP being strictly a policing organization.

The program began in the late 1960s and virtually all participants welcomed the program with great enthusiasm. Although the organization and titles changed several times during the years, the mission of the ASP remains the same: to enhance aviation safety through the continuing education of pilots.

AVIATION SAFETY MEETINGS

Each FSDO has two SPMs—one for operations and one for maintenance. There are five FSDOs in Texas—Houston, Dallas, Ft. Worth, San Antonio, and Lubbock. Each FSDO has continuing education programs within their respective territories. Table 5 includes an example listing of the Aviation Safety Meetings planned for August 1999 by the Houston FSDO. The table shows classes at several sites around the Houston area covering a wide range of subjects. However, they are virtually all oriented toward improving aviation safety.

In addition to supervising the Aviation Safety Meetings the SPMs:

- promote the Pilot Proficiency Award (WINGS) Program;
- promote the Pilot and Aircraft Courtesy Evaluation (PACE) Program;
- promote the Aviation Maintenance Technician Awards Program;
- promote the Charles Taylor Awards Program;
- promote the Aviation Safety Counselor of the Year Awards Program; and
- manage the activities of the District's Aviation Safety Counselors.

These tasks are all in addition to attending to the technical and public relations obligations of the District with respect to local accidents and incidents.

The 10 SPMs coordinate the rather extensive continuing education program around the state. While all of the programs are under the auspices of the FAA, usually a local sponsor coordinates the local program.

TABLE 5
Aviation Safety Meetings in Houston

Date	Location	Topic	Sponsor
August 5, 1999	Houston Southwest Airport	High Altitude Physiology	Success Aviation
August 10, 1999	Houston Gulf Airport	Ramp Safety	Bay Area Aero Club and Houston Gulf Airport
August 10, 1999	West Houston (IWS)	Unusual Atitudes: Keeping the Right Side Up	Houston 99 and Thunderbird Composite Squadron CAP
August 12, 1999	Montgomery County Airport	Aviation Safety and the Pilot	U.S. Army Reserve and MVP Aero Academy
August 18, 1999	Tracy Gee Community Center	Attitudes for Balloon Pilots	Lone Star Balloon Association
August 18, 1999	Sugar Land Airport	Tail Wheel Instruction and Basic Aerobatics	Sugar Land Flying Club, Sugar Land Aviation, City of Sugar Land, and Sugar Land Municipal Airport
August 24, 1999	Fayette County Regional Airport	Go/No Go Weather Decisions	La Grange Aviation

Aviation Safety Counselors

Aviation Safety Counselors (ASCs) are private individuals selected by the FAA to assist in promoting aviation safety. They voluntarily serve as assistants to the FAA SPM in performing accident prevention functions in their local communities. ASCs act as advisors to the aviation population in support of aviation safety, but without designated regulatory authority. The FAA selects counselors based on their interest in aviation safety, their professional knowledge, and their personal reputation in the aviation community. Each FSDO maintains a list of the counselors active within the district.

ASCs assist the FAA (primarily the SPMs) in promoting aviation safety by:

- providing information and guidance on local flying conditions to transient pilots;
- counseling individuals who may have exhibited potentially unsafe acts;
- assisting pilots, aircraft owners, and mechanics on matters pertaining to proper maintenance of aircraft and avionics equipment;
- counseling individuals following incidents requiring flight assistance from ATC personnel;

- assisting the FAA in transmitting safety information to pilots, aircraft owners, maintenance facilities, and mechanics;

- conducting proficiency flights (when appropriately rated);

- providing FAA information and assistance in establishing local airport safety committees;

- notifying the appropriate authorities about hazardous conditions affecting safe flight or ground operation and the need for corrective action; and

- organizing and participating in safety meetings, workshops, and seminars.

On occasion, the counselors may provide remedial flight training. Only certified flight instructors (CFIs) have the authority to provide this service. Such training might be appropriate when a pilot exhibits potentially unsafe practices in the operation of an aircraft. Sometimes counseling alone is unlikely to correct these practices, but a little additional dual flight time can make a difference. Some examples of such unsafe practices might include habitual improper pattern flying including exaggerated maneuvers and extended downwind legs, excessive taxiing speed, improper leaning procedures, and low altitude maneuvering.

AIR SAFETY FOUNDATION

Chartered in 1950 by the AOPA, the Air Safety Foundation (ASF) is the nation's largest nonprofit education and safety organization dedicated to aviation. The foundation serves all pilots, not just AOPA members, by conducting research, providing safety data, and offering low-cost or free seminar programs to pilots nationwide. The mission of the foundation is to save lives and promote accident-free general aviation operations. For example, the foundation:

- maintains a national aviation safety database that contains National Transportation Safety Board (NTSB) reports on general aviation accidents since 1982;

- performs accident trend research to focus foundation resources on the principal causes of accidents;

- produces and disseminates aviation education and training videos, pamphlets, books, and newsletters to increase safety awareness;

- conducts specialized aviation training courses for students and instructors; and

- provides free public-service aviation safety seminars.

In 1997, the ASF conducted almost 400 free safety seminars for more than 43,000 pilots. The topics included airspace, air traffic control, instrument flight rules and GPS navigation. However, weather and the influence it has on the pilot, was the most popular topic.

The ASF matches state grants dollar-for-dollar thus leveraging the funds of the foundation, mostly charitable contributions from individuals and corporations that sympathize with ASF's goals.

However, several states have made significant contributions to the ASF in support of the free safety seminar program. Table 6 presents a list of the recent ASF seminars, along with dates, locations, and course topics.

TABLE 6
Example of Recent Air Safety Foundation Seminar Schedule

Date	Location	Facility	Seminar Topic
July 29, 1999	Oshkosh, WI	FAA Air Venture	GPS for VFR Pilots
July 30, 1999	Oshkosh, WI	FAA Air Venture	Weather Strategies
July 31, 1999	Oshkosh, WI	FAA Air Venture	Weather Tactics
August 1, 1999	Oshkosh, WI	FAA Air Venture	Operations at Towered Airports
August 6, 1999	Philadelphia, PA	N.E. Philadelphia Airport	Cockpit Companion
August 6, 1999	Philadelphia, PA	N.E. Philadelphia Airport	Never Again
August 9, 1999	Hartford, CT	East Windsor CT High School	Operations at Towered Airports
September 13, 1999	Little Rock, AR	Arkansas Game and Fish	Airspace Refresher
September 17, 1999	Belle Vernon, PA	Rostraver Airport	Mountain Flying
September 25, 1999	Louisville, KY	Bowman Field	Collision Avoidance

NATIONAL ASSOCIATION OF STATE AVIATION OFFICIALS

The National Association of State Aviation Officials (NASAO), based in Silver Springs, MD, organizes, promotes, and funds a variety of aviation programs. All states develop statewide aviation system plans and airport capital improvement plans. The states invest about $450 million annually in planning, infrastructure development, maintenance, navigational aids, and airport operations at 6,000 airports across the country. Many states also build, own, and operate their own airports. Each year, state aviation officials conduct safety inspections at thousands of public-use airports. The association also sponsors statewide meetings, airport symposiums, pilot safety seminars and aviation education forums.

In 1986, the non-profit NASAO Center for Aviation Research and Education opened to "enhance the public good through an increasingly safe air transportation system." Since then, the NASAO Center has been responsible for the nationwide Airport Safety Data Program. It is also a major participant in the International Aviation Art Contest for children and other aviation education efforts. In 1998, the NASAO Center began offering low interest loans to exceptional university students enrolled in aviation programs.

NASAO's Draft Memorandum of Agreement is a document suggested by NASAO to define agreements between state agencies and the local FSDO, concerning cooperative educational and safety promoting efforts. The draft serves many purposes, but the most important is in the preparation and presentation of safety seminars for pilots.

STATE PROGRAMS

In addition to the associations listed previously, several states were contacted to detelrmine the availability of other training programs.

Arizona

Arizona has no statutes specifying that the state is responsible for training pilots. Under the direction of the Aviation Services Program Administrator, the state is involved in planning, organizing, and conducting statewide aviation safety and educational seminars, but there is no legislation requiring this effort.

Florida

The state of Florida participated in the ASF's joint training programs for four years (as of 1998). For example, more than 1,800 pilots attended ASF safety seminars in February 1998 due to a $23,000 grant from the Florida Department of Transportation Aviation Office. The ASF presented its new "Weather Strategies" seminar in 15 cities from Pensacola to Miami.

"Weather Strategies" teaches a pilot to think strategically in their approach to gathering weather data to understand "The Big Picture." While most pilots still rely on the telephone briefing for their primary weather information, the ASF seminar shows pilots how to integrate information from The Weather Channel, local TV Doppler radar, AOPA ONLINE, Internet weather services, DTN, other equipment at FBOs, and the FAA DUATS system. The seminar also teaches pilots how to evaluate information from AWOS and ASOS automated weather reporting systems.

Florida believes that the "Weather Strategies" seminar fills a real need for pilots, primarily because of the stark statistics about weather-related accidents. Nationwide, from 1983 to 1993, adverse weather was involved in more than one-quarter of all accidents. Almost one-third of weather-related accidents involves fatalities, and 94% of them result from poor pilot decision-making.

These seminars, typically in a lecture format, are free to pilots and are about two hours in length. The presenters are ASF staff members, backed up by video presentations and a take-home strategy-planning booklet.

Idaho

Under Title 21 of the Idaho Code, the Idaho Transportation Department is responsible for promoting aviation safety within the state, and to foster and encourage the use and development of aviation and aviation-related business, training, commerce, and career-oriented activities. Idaho has a healthy aviation industry due to the great distances between cities, rugged terrain, and relatively sparse population. National forests, wilderness areas, and primitive lands almost exclusively comprise the center of the state. Southern Idaho, along the Snake River, and northern Idaho, in the Palouse Country, contain most of the state's farming and manufacturing industries. Because of Idaho's geography, air transportation is a convenient mode of travel around the state and into some of the more remote areas. One can fly from Boise to Coeur d'Alene in two or three hours while driving may take as much as 10 to 12 hours. Thousands of residents and visitors fly into Idaho's backcountry each year to hike, fish, hunt, photograph, and just enjoy some of the nation's last true wilderness.

Consequently, the aviation industry has a $3.1 billion impact and generates 56,000 jobs. There are approximately 3,000 certified pilots and about 2,500 aircraft based in the state. Over 50 air-taxi companies supplement six airlines to serve residents and visitors. The Division of Aeronautics, Idaho Transportation Department is attempting to foster an active, strong aviation community that enthusiastically incorporates aviation safety into its daily activities. To accomplish this, they take a leadership position in establishing comprehensive aviation programs and operations to educate aviation users in Idaho.

The state sponsors at least one flight instructor refresher clinic, two mountain flying courses, and an aviation educational conference each year. The most recent three-day conference was a huge success. The conference featured 22 subjects in 70 sessions, the most wide-ranging and in-depth coverage of aviation continuing education ever offered. Attendance is not free, but the state subsidizes the cost of the safety-oriented conference.

Illinois

The Illinois Department of Transportation (IDOT) is responsible for training pilots. State statutes allow IDOT to take responsibility for promoting aviation safety and education. According to the statutes, the Department may establish minimum standards for protecting and insuring the general public interest and safety and the safety of people receiving instruction. The Division of Aeronautics is responsible for recurrent training and not initial pilot training. The Department conducts courses several times a year, some in conjunction with the FAA. The IDOT seminars include:

- Wings program;
- Mechanics seminar;
- Balloon seminar;
- Aerobatics seminar;
- Ultra-light seminar;
- IFR/VFR seminar; and
- Wannabe seminar.

These seminars, conducted throughout the year in the northern and southern sections of the state, include one-day and multi-day courses held on both weekends and weekdays. The state also conducts a series of Certified Flight Instructor Training (CFIT) courses. CFIs must attend courses and renew their license every two years.

Iowa

Officials at the Iowa Department of Transportation - Statewide Aviation, believe that the ASF provides more and better safety seminars in Iowa because of their monetary support to the foundation's programs. The ASF conducted a two-program sequence of seminars, Weather

Tactics and Weather Strategies, at three cities in Iowa over a two-year period.
Officials believe Iowa pilots were very happy with the seminars and gained useful information from the presentations. They anticipate that the state's support of the foundation will continue in the future.

Michigan
The Michigan Bureau of Aeronautics listed four newly developed pilot safety briefings for use in 1998/99 in addition to the other briefings previously offered. The earlier briefings included Cockpit Resource Management, Nocturnal No-No's, Fatigue Management, Thunderstorms and VFR Strategies, and Anatomy of an Instrument Approach. The new briefings include CFIT, Weight and Balance, Runway Incursions and Airport Markings. Generally, Michigan schedules these meetings for weekday evenings, but also scheduled some on Saturday mornings or afternoons. The evening meetings generally are two to two and one-half hours in length while the Saturday sessions are usually four hours in length.

Nebraska
There are no agencies within the state of Nebraska responsible for training pilots or CFI. Nebraska has three or four trained and educated pilots employed by the state, but there is no state law or regulation mandating training or education.

North Carolina
According to Chapter 63 of the North Carolina General Statutes, the Aviation Division of the North Carolina Department of Transportation has the responsibility of improving aviation safety through user education and training. Through the division's Aviation Safety Program, the state is responsible for providing "educational materials and conducting statewide safety seminars for FBOs, aircraft owners, mechanics, flight instructors, and general aviation pilots." Examples of courses provided include aircraft maintenance, aviation regulations, decision-making, and accident investigation. Typically, the Department coordinates the seminars and training courses and the FAA provides money for the mailers. They also participate in a Wings program. The Department also conducts CFI training, consisting of refresher courses and not initial pilot training.

Virginia
The general aviation safety program in Virginia is very active. It includes two-hour evening lectures, and one- and two-day weekend seminars. The state is the sole sponsor for some of these lectures and seminars, while others are joint efforts with other interested entities. It appears that Virginia, like virtually every other state, operates under a general legislative mandate to promote general aviation activity and safety. The Virginia Department of Aviation dedicates funds specifically for training.

The state sponsors several "Wings" weekends during the year at selected airports. Pilots, and flight instructors, converge on the airport and use a privately owned or rented aircraft for training. The flight instructors may or may not have aircraft for training use. Participants receive classroom-type ground instruction followed by the required three hours of flight training necessary to get FAA “Wings.” The individual pilots must pay for the cost of the flight equipment.

Typically, the evening lectures focus on current safety issues. Instructors present the two-hour (or so) program at four to eight locations throughout the state. Local experts selected and reimbursed by the state present the programs. On occasion, FAA and ASF instructors present the programs.

Wisconsin

The Wisconsin Division of Transportation Infrastructure Development, Bureau of Aviation is very active in supporting continuing education for pilots. The Bureau believes that the flying public is aging (on the average) and has instituted educational programs to help pilots stay abreast of developing technology. Typically, the Bureau conducts meetings on Saturdays at easily accessed sites around the state. Most meetings are about eight hours in length. Usually, personnel from the FAA FSDO at Milwaukee or Minneapolis participate. The state funds these safety classes and instructors receive a stipend. Volunteer groups, such as the Ninety -Nines, often arrange for a lunch as a means to raise money. State DOT officials prescribe the subject content for the meeting. Generally, the Bureau schedules about four meetings per year that cover subjects pertinent to both IFR and VFR flying.

Wisconsin also supports flight instructor and mechanic refresher courses and prints state airport directories and aeronautical charts. The state also participates in providing airport-based pilot weather information services.

These activities are the result of a generally worded legislative mandate to encourage the economic development and safety of aviation in this aviation-oriented state, the home of the annual Oshkosh Air Show.

CHAPTER 6. FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Following a long, detailed study of weather sensors and distribution systems in Texas, one point becomes readily apparent. Many Texas pilots lack familiarity with, and the method to access many of the available sources. Major parts of the following recommendations concern continuing education for pilots, particularly instruction about the available high-tech resources. The following sections provide information on the varied types of available weather-related data sources.

WEATHER SATELLITE IMAGERY

One resource not well understood by most pilots is weather satellite imagery. These images show water as clouds, or vapor, in the atmosphere. The National Oceanic and Atmospheric Administration (NOAA) has two types of satellites that record these images.

- GOES satellites orbit the earth at an altitude of 22,380 miles above the equator. At this position, they orbit at the same rotational rate as the earth turns, so they remain over the exact same point on the equator. The satellites view the same geographical area all the time, hence, the name geostationary. The U.S. operates two geostationary satellites; GOES 8 covers the eastern U.S. and Atlantic, while GOES 10 covers the western U.S. and the Pacific. Figures 39 and 40 show the field of view as seen by GOES 8 and GOES 10, respectively.

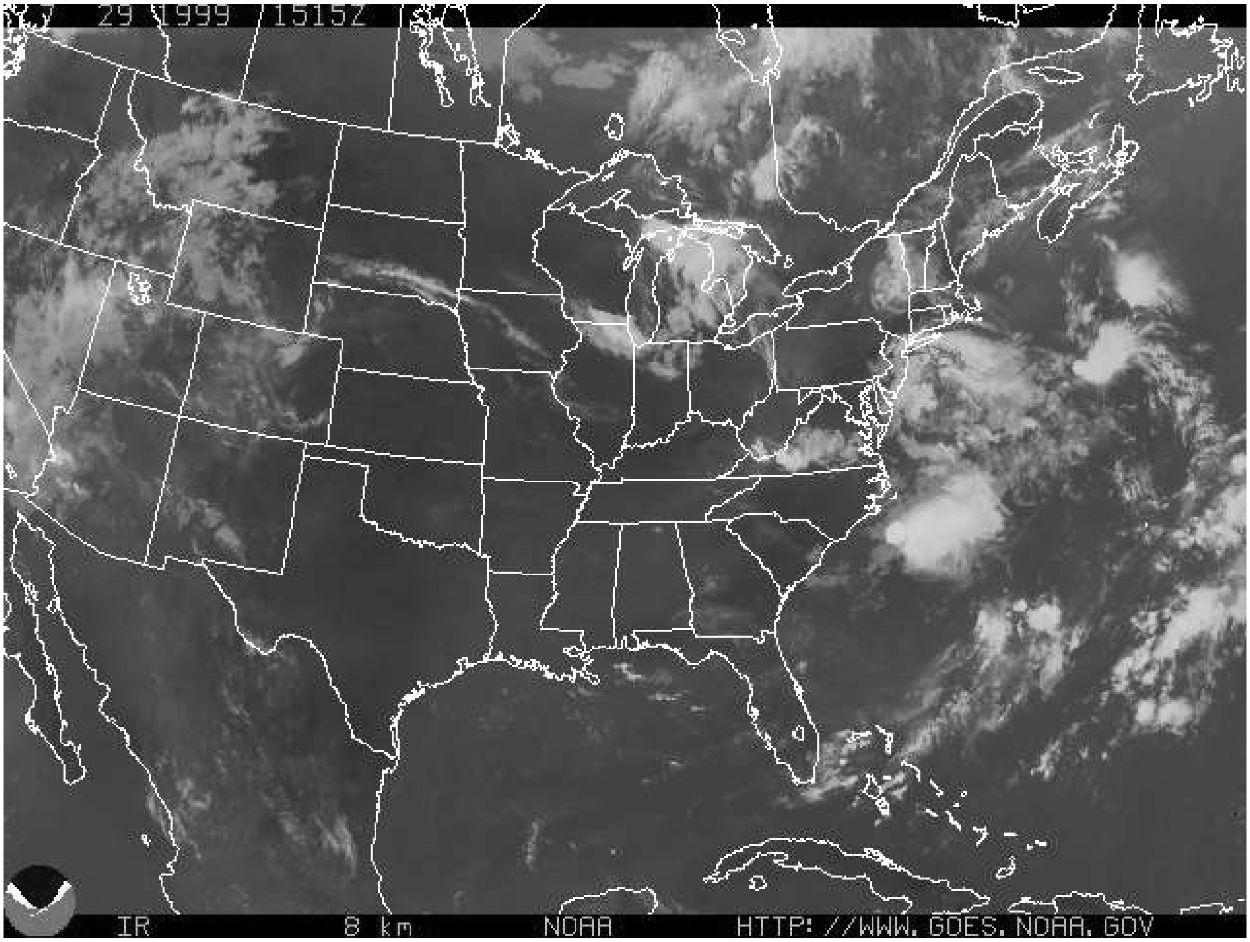


FIGURE 39. GOES 8 Satellite Image

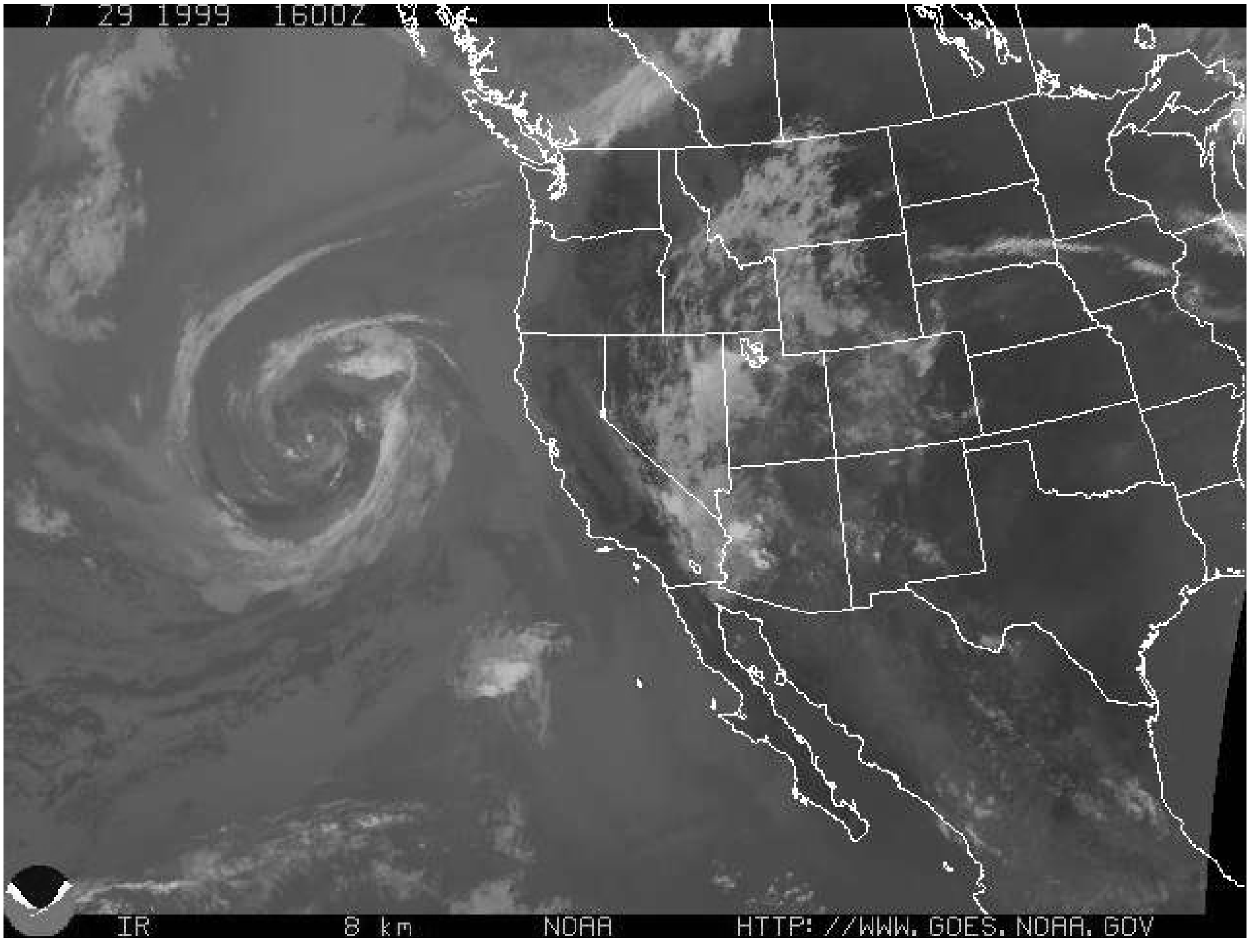


FIGURE 40. GOES 10 Satellite Image

- POES circumnavigate the earth near the north and south poles. Orbiting at lower altitudes, approximately 300 to 500 miles, they reveal more details than GOES. This is especially true at higher latitudes, where the earth's curvature may distort GOES images.

Scientists and forecasters develop mini movies using consecutive GOES images to study the movement of certain weather phenomenon during the preceding hours or days. The closer imaging by the POES has not proven as valuable to pilots as the views from GOES 8 and 10.

Visible Images

The image in Figure 41 is a visible GOES image. It is a photograph of the clouds from space. Thick clouds and fresh snow reflect more light than thin clouds and appear brighter in the images. Thin clouds appear gray and areas with no shading are generally clear.

The pilot must not solely rely on the visible images. A thin veil of clouds or fog can obstruct the view of an airport, making a VFR landing impossible, and may cover areas that appear clear on a visible image. To obtain a truer reading of the clouds, pilots must view the infrared (IR) image.

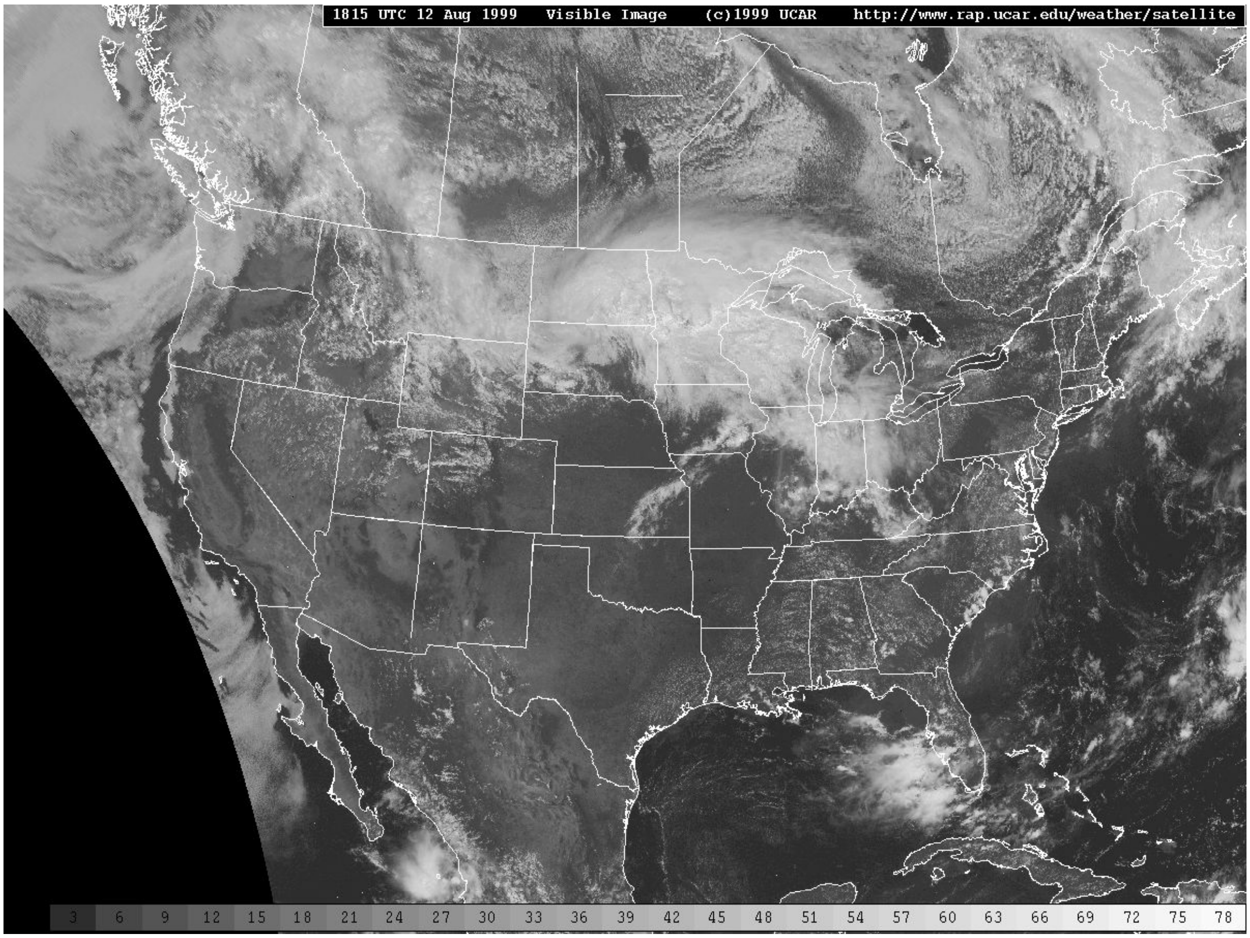


FIGURE 41. Visible GOES Image

Infrared Scan

Satellites that scan the infrared (IR) wavelength actually measure cloud top temperatures rather than reflected light, as in visible satellite images. Because temperatures in the lower portion of the atmosphere are almost inevitably warmer than temperatures in the higher portions, high level clouds will appear whiter than lower level clouds. Low clouds and fog will appear as a light gray tint only. One advantage of the IR image is that the satellite can produce an IR image at night while visible images are not available at night.

Water Vapor Channel

A third type of image developed using the weather satellites is the Water Vapor Channel image. A part of the IR scanning range, called the “vapor channel,” produces the image. These images are also available at night. Vapor channel images are sensitive to water vapor, showing water vapor as shades of gray to white—the whiter the shade the more humid the air. Black indicates air containing virtually no water.

Sources for Further Training Information

Additional training information is available at two Internet sites including:

Naval Research Laboratory, http://www.nrlmry.navy.mil/sat_products.html; and

Colorado State University, http://www.cira.colostate.edu/ramm/advimgry/toc.htm.

SPECIAL FEATURES FOR TEXAS DUATS USERS

The Aviation Division is encouraged work with the DUATS providers to obtain special features for Texas users. There are several ideas to consider, but one that seems most appropriate is to print out the airport layout, and other pertinent data, about the destination airport when a flight ends in Texas. This data is currently available in the Texas Airport Directory. DUATS providers might consider this as a desirable value added feature.

Other, and similar enhancements, could include a blank clearance form near any cross-country log or a format for recording Hobbs times, tach times, or clock times.

Inevitably other states and the FAA would note the desirability of these features and promptly begin to emulate them. By taking the initiative to suggest these enhancements, TxDOT and the state will strengthen its reputation as leaders in assisting pilots and general aviation in striving for safety.

GENERAL USE OF PERSONAL COMPUTERS FOR TRAINING

The use of personal computers (PCs) has become an integral part of virtually everyone’s life. People use PCs for writing, accounting, filing, and calculating. Indeed users have not fully explored the full extent of the PC’s potential.

That statement is as true for aviation training as for any other field. It is becoming clear that the PC will become an increasingly valuable tool to the pilot and flight instructor, for both initial and recurrency training. Currently, one of the primary uses is the interactive CD-ROM and instructional discs, used as a ground school. Instructors are using the PC to administer virtually all knowledge tests. Obviously, practice tests using PCs are excellent methods to prepare for the knowledge tests and provide the flight instructor with an evaluation of the student’s progress. Another use is to obtain pre-flight weather briefings via the DUATS. Other possible uses include adapting the PC to simulate flight, and flight problems, especially flight under IMC.

COMPUTER-BASED KNOWLEDGE TRAINING

As suggested in the previous paragraph, there is a variety of computer-based knowledge training approaches available for the student who does not favor self-study using a book or a classroom-type of ground school. Students can download the required software from the Internet and retain the information on floppy disks. The most common media is the CD-ROM. These disks provide realistic test simulation, detailed performance graphs, comprehensive chapter text, and built in-timers. The flight or ground instructor can tailor preparatory knowledge tests either foreshortening or exactly replicating actual tests to provide the student real-world experience. Instructors can select and tailor subject matter to the area covered. The instructors would receive master correction keys to simplify grading.

Personal Computer-Based Aviation Training Device

Today's pilots train in simulators, often so realistic and representative of actual aircraft that it is feasible to obtain a pilot rating from simulator time only. Less sophisticated than simulators, but still very impressive, are Flight Training Devices (FTDs). These devices have approval for initial and recurrent instrument training. Flying "games" for the digital computer have been available since the mid-1970s and have become progressively more realistic.

As one might imagine in this fast-paced age, these games have become a meaningful training aid, called the Personal Computer-Based Aviation Training Device (PCATD). They simulate the flight environment so well that they received FAA approval for up to 10-hours of the required instruction for an instrument rating. The presence and participation of a properly certified instrument instructor is necessary for students to receive credit for the 10 hours. To qualify as "approved," it is necessary for the PCATD to have the following physical controls:

- a physical, self-centering displacement yoke (or control stick) that allows continuous adjustment of pitch and bank;
- physical self-centering rudder pedals that allow continuous adjustment of yaw;
- a physical throttle lever or power lever that allows continuous movement from idle to full power settings; and
- physical controls for the following items, as applicable to the aircraft being replicated:
    - flaps;
    - propeller;
    - mixtures;
    - pitch trim;
    - communication and navigation radios;
    - clock or timer;
    - gear handle;
    - transponder;
    - altimeter;
    - microphone with a push-to-talk switch;
    - carburetor heat; and
    - cowl flaps.

These hardware items add considerably to the cost of the PCADT, but are required for students to receive credit for the training.

Instrument flying consists of several complex elements—instrument scan, aircraft control, orientation, navigation and communication. It is not easy to become proficient in all of these skills. Students must learn and practice these skills one-at-a-time although flying in simulated instrument conditions often requires proficiency in more than just the element studied. This makes for inefficient training.

In the lead editorial, "Viewpoint," in the September 27, 1999 issue of *Aviation Week and Space Technology,* Frank J. Tullo, a DC-10 captain and check airman for Continental Airlines, offered some pertinent suggestions for improving the efficiency of flight simulator training. While he directed his remarks primarily toward training airline pilots, they are equally, if not more so, pertinent to training general aviation pilots.

The primary point of his suggestions are that pilots should spend more simulator time training to recover from dire in-flight emergencies such as those resulting from unusual attitudes, loss-of-control situations, and extreme weather changes. These suggestions are certainly applicable for students using the PCATD. This requires that CFIs become familiar with the personal computer, the software, and its uses. To make the optimum use of the training time, instructors should carefully plan and program each PCADT session prior to the students arrival. Instructors can select different approaches involving mountainous terrain, turbulent weather, and low ceilings and visibilities to broaden the students experience and keep the lessons interesting.

The instructor can stop the program instantly to allow for critique and discussion. The program can simulate virtually any instrument failure, including those related to weather such as iced over pilot ports. Both overhead and profile views of the flight track are available after each flight for reflection and study.

Since TxDOT is such an integral part in updating Texas CFIs, the Department should take the lead in ensuring that Texas CFIs know how to efficiently use personal computers in the training process, particularly in the PCADT mode. The PCATDs are ideal for teaching pilots how to navigate in hazardous weather. Accomplishing this remains a bit nebulous, but it is a worthy goal and deserves special attention from the Aviation Division.

TEACHING WITH DUATS

The DUATS is a service to pilots furnished by the FAA. There are two competing private contractors who provide data via either modem or the Internet. DUATS began primarily to provide current and forecast weather information in a textural format for flight planning. However, its scope broadened considerably and many expect continued expansion of this service. Now, pilots can encode and decode airport identifiers, prepare cross-country logs, file cross-country flight plans, and obtain graphic presentations of weather conditions, all via the DUATS.

The "old-fashioned" way is still the best method to begin teaching students about cross-country flights. This means a student draws lines on the sectional and uses them to fill out a flight log form. Elemental calculations of ground speeds, magnetic headings, estimated times en-route, and fuel consumption are the first steps in the process and students must master and understand each step before proceeding to the next. Once the student masters these steps, the instructor can begin discussions on obtaining pre-flight and en-route weather data. As every student, past or present, knows, copying down the weather during a telephone briefing is a formidable task.

Using the printed page from the DUATS leads the instructor and students into a discussion of the METAR and TAF formats. The "plain language" translation feature of DUATS helps the student learn and practice the NWS language. Once the student obtains an Aero Medical, the CFI can introduce the student to the DUAT system. Depending upon the student's aptitude and progress, this is where the CFI will start expecting the student to progress privately and alone.

OTHER INTERNET RESOURCES FOR INSTRUCTORS

There are many other resources available to the instructor who is attempting to acquaint the student with current tools and techniques. Some of these are Internet sites easily available for research and study. Examples include:

www.nws.noaa.gov, homepage of the NWS;

www.awc-kc.noaa.gov, homepage of the Aviation Weather Center of the FAA; and

www.met.tamu.edu, homepage of the Meteorology Department at Texas A&M University. One interesting feature of this site is that lightning strike data is available.

REAL TIME LIGHTNING DATA

Currently, lightning information is not readily available to pilots. There are indications that the information is collected and available to some, but not to most pilots. Many believe that the intensity and frequency of lightning strikes is the best indicator of severe turbulence and hail. It provides a current and valid indicator of where the pilot should not to fly.

More importantly, images of lightning strike data can indicate changes in a thunderstorm cell. Displaying the geographical movement of the cell, including direction and speed, will help pilots determine if the storm is growing or diminishing. These data are important as the pilot plans the flight route, whether on the ground prior to takeoff or en-route. Any incentive that TxDOT could provide to assure these lightning data are conveniently available to the pilot would add to the safety of Texas flights.

SUMMARY

Recent advancements in technology are serving general aviation well by making it easier for pilots to obtain current weather information and weather forecasts that are more reliable. TxDOT has, and is, doing a good job in assuring that these advancements are widely and inexpensively available to Texas pilots. One area where the Department can improve its efforts is in educating Texas pilots, typically through the CFIs, about efficiently and safely using new weather sources to make better decisions and improve safety.

In the November 3, 1999 issue of the *Wall Street Journal*, Jerry Gray, director of Aerospace and Science Policy at the American Institute of Aeronautics and Astronautics, discussed methods to make modern flying safer. In the article he stated:

> “More attention should be given to training aircraft crew and maintenance personnel and to proficiency incentives. Perhaps even more critical is training of aircraft crews in the complex person-machine relationships demanded by today’s highly automated aircraft control systems. The new cockpit-control systems and instruments unquestionably improve the aircraft’s safety and reliability, but cockpit crews must use them wisely and effectively.”
>
> “Automation is ideal for routine, boring tasks, but not for ‘abnormal abnormalities.’ It’s crucial to maintain the crew’s vigilance and piloting skills, lest long and successful experience with automated systems causes pilots to depend too much on them.”

Gray’s words summarize the results of this research about weather data for Texas’ pilots.

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APPENDIX

ACRONYMS

The number of acronyms and technical slang is daunting for pilots and students beginning to study the sensing, processing, forecasting and dissemination of weather information. The following is a list of weather abbreviations and acronyms.

AAS	airport advisory service
ACARS	aircraft communications addressing and reporting system
ACAS	airborne collision avoidance system
ADAS	AWOS data acquisition system
ADF	automatic direction finding
ADIZ	air defense identification zone
ADLP	aircraft data link processor (the Mode S subnetwork function onboard the aircraft that implements the OSI network layer protocols)
AFSS	automated flight service station
AGL	above ground level
AI	artificial intelligence
AIRMET	inflight weather advisories hazardous to general aviation type aircraft
AIV	aviation impact variable
ARINC	Aeronautical Radio, Inc.
ARSR	air route surveillance radar
ARTCC	air route traffic control center
ARTS	automated radar terminal system
ASDF	airport surface detection equipment
ASOS	automated surface observation system
ASR	airport surveillance radar
ASRS	aviation safety reporting system
ATC	air traffic control
ATCT	air traffic control tower
ATIS	automated terminal information service
AWC	Aviation Weather Center
AWOS	automated weather observation system
AWIPS	advanced weather interactive processing system
AWPG	aviation weather products generator
BC	back course
CAAS	class A airspace
CAT	clear air turbulence
CBAS	class B airspace
CCAS	class C airspace
CDAS	class D airspace
CDT	central daylight time
CEAS	class E airspace
CEIL	ceiling

CFIT	controlled flight into terrain
CGAS	class G airspace
Cpt	clearance prior to taxi
CRM	cockpit resource (crew research) management
CST	central standard time
CTAF	common traffic advisory frequency
CTR	cathode ray tube
DME	distance measuring equipment
DATALINK	digitized information transfer (air/ground or ground/air)
DME	distance measuring equipment
DP	dew point temperature
EAT	expect approach time
EDT	eastern daylight savings time
EFAS	en route flight advisory service
EST	eastern standard time
FAA	federal aviation administration
FAR	federal aviation regulation
FMS	flight management system
FSS	flight service station
GIS	geographical information system
GLONASS	global orbiting navigation satellite system
GOES	geostationary operational environmental satellite
GMT	Greenwich Mean Time
GPS	global positioning system
HSI	horizontal situation indicator
HIWAS	hazardous inflight weather advisory service
HUD	heads-up display
ICAO	International Civil Aviation Organization
IFR	instrument flight rules
ILS	instrument landing system
IMC	instrument meteorological conditions
INS	inertial navigation system
ITWS	integrated terminal weather system
LLWAS	low level wind shear alert system
LLWAS-NE	low level wind shear alert system with network expansion
LORAN	long range navigation system
MDT	mountain daylight savings time
MLS	microwave landing system
Mode S	type of secondary surveillance radar (SSR) equipment that provides Mode A and Mode C interrogations, discrete address (Mode S) interrogations from the ground or air, and a datalink capability
MST	mountain standard time
NASA	National Aeronautics and Space Administration

NCAR	National Center for Atmospheric Research
NDB	non-directional beacon
NESDIS	National Environmental, Satellite, Data and Information Service
NEXRAD	next generation radar (predecessor of WSD-88D)
NOAA	National Oceanic and Atmospheric Administration
NOTAM	notice for airman
NTSB	National Transportation Safety Board
NWS	National Weather Service
OAT	outside air temperature
OTS	out of service
PAR	precision approach radar
PIREP	pilot report
RNAV	area navigation
RVR	runway visual range
SAV	state-of-the-atmosphere variable
SIGMET	significant meteorological information
STAR	standard terminal arrival
SWAP	severe weather avoidance program
TACAN	tactical air navigation (bearing and distance station)
TCA	terminal control area
TCAS	traffic alert collision avoidance system
TDWR	terminal doppler weather radar
TRACON	terminal radar control
TWEB	transcribed weather broadcast
UNICOM	aeronautical advisory service
UTC	coordinated universal time
VFR	visual flight rules
VMC	visual meteorological conditions
VOR	very-high-frequency, omni-directional, navigation system
VOT	VOR test signal
VV	vertical visibility
V/V	vertical velocity
WAAS	wide area augmentation system
W/P	way point
WD	wind
WSR-88D	weather surveillance radar-1988 doppler
WX	weather
Z	zulu (Greenwich mean) time