Aviation Weather Services

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INTRODUCTION

The National Weather Service (NWS) has a vast operating program. NWS personnel are found at over 400 facilities in the 50 states and elsewhere. Altogether, NWS has about 5,000 people working in meteorological, hydrological and oceanographic operations. In one year, about 3.5 million forecasts and warnings are issued. In addition, countless individual briefings and services are provided on a routine but unscheduled basis.

The provision of forecasts and weather warnings to the general public and to specialized users is the heart of the NWS operations. The offices most involved in the production of forecasts are the Weather Service Forecast Offices (WSFOs), while warnings are issued by both WSFOs and the more localized Weather Service Offices (WSOs). In general, WSFOs' areas of responsibility conform to state boundaries. However, larger and more populous states (Texas, California, New York, etc.) contain more than one WSFO, while some smaller states are within the area of responsibility of WSFOs of neighboring states (Connecticut and Rhode Island are within WSFO Boston's area of responsiblity). WSOs generally serve the urban areas of the nation by providing a more localized and tailored service. Usually, several WSOs lie within the area of responsibility of a WSFO. Forecasts issued by the WSFOs go to the general public as well as to specialized users. A sizable effort of a WSFO is concerned with meteorological support to the aviation industry. The National Meteorological Center (NMC), located near Washington, DC, provides the WSFOs with guidance material used in developing forecasts.

Warnings from both WSFOs and WSOs are issued for severe weather such as hurricanes, tornadoes, severe thunderstorms, flash floods and extreme winter weather. The National Severe Storms Forecast Center (NSSFC) in Kansas City, and the National Hurricane Center (NHC) in Miami, provide the main support for the warnings program.

Another important aspect of NWS operations is the acquisition of meteorological data. Such data are collected from the land, the sea and the upper atmosphere by people from many countries. Additionally, satellite information is sent to many receiving stations on the ground.

BACKGROUND

The primary responsibilities of the NWS are to:

1. Provide warnings of severe weather and flooding for the protection of life and property;

2. Provide public forecasts for land and adjacent ocean areas for planning and operation;

3. Provide weather support for:

   a. Production of food and fiber;

   b. Management of water resources;

   c. Production, distribution and use of energy; and

   d. Efficient and safe air operations.

The principle role of the NWS is to issue severe weather warnings to save lives and to minimize property loss. The United States has a greater variety of severe weather than any other nation in the world. Hurricanes, tornadoes, floods, flash floods, thunderstorms and severe weather take an inordinate number of lives and cause thousands of injuries each year, despite advances in technology and skills in forecasting and warnings. It is estimated that the cost to the nation is well over $2 billion per year from these extreme weather events.

No other industry is more sensitive to weather than aviation. There are more than 825,000 certified pilots operating over 230,000 aircraft from an excess of 15,000 landing places in the United States. The last decade has been a period of rapid change. The aviation community expanded at a rate unprecedented in our Nation's history. A more mobile, safety conscious, and energy conscious society has become more demanding of sophisticated weather information. The NWS has been working to meet the challenge of getting timely and accurate weather information to the end user --- the pilot.

Providing weather service to aviation is a joint effort of the NWS, the Federal Aviation Administration (FAA), the military weather services and other aviation oriented groups and individuals. Because of international flights and a need for worldwide weather, foreign weather services also have a vital input into our service.

The cooperation between the FAA and NWS for the provision of aviation weather services and communications is described in a 1977 Memorandum of Agreement between the two agencies. One of the major responsibilities of the NWS is to produce the forecasts and warnings in support of the aviation community. The dissemination of this weather information to pilots is the responsibility of the FAA and of the air carriers, themselves. The NWS's responsibility in this area stems from the Federal Aviation Act of 1958 (Section 101: Title 49, Section 1301, United States Code) as amended, and the NWS's organic authority contained in Title 15 of the United States Code.

NATIONAL WEATHER SERVICE BASIC SERVICES

Today, the NWS provides a broad range of products to the aviation community. Fifty-two WSFOs prepare airport terminal forecasts three times per day with amendments as needed for nearly 500 airports in the 50 states and in the Caribbean. Our offices also produce about 300 individual route-oriented forecasts three times per day for the 48 contigious states. Thirteen of these offices prepare area forecasts twice a day of general weather conditions over the entire country. These same offices issue in-flight advisories of hazardous weather conditions due to turbulence, icing, strong low-level winds and/or broad areas of low clouds or restricted visibilities. In-flight advisories of dangerous conditions associated with thunderstorms are issued each hour by a dedicated aviation unit at the NSSFC in Kansas City.

The question of how this information can best be conveyed to those with "a need to know", including FAA specialists and controllers and users of the National Airspace System, in the most timely and efficient manner possible has been of concern for some time. We have been working with the FAA to alleviate this problem. The problem is especially critical when hazardous weather is involved. To illustrate this point, one merely has to look at the statistics on aircraft accidents; they don't change much from year to year. Of the 4,000 to 5,000 general aviation accidents occurring annually, 20 to 25 percent of all fatal accidents are weather-related. In many cases, these weather-related accidents involve the loss of a large number of lives. The most recent examples are the accidents that occurred at New Orleans and in Washington earlier this year.

Many things have been done and are being done to improve the flow of the most vital real-time weather information to the users of the National Airspace System.

The Center Weather Service Unit (CWSU) program began in 1978. This cooperative effort with the FAA represents a major effort to improve the dissemination of real-time weather information by controllers to the pilot in flight. The program expanded from 13 to 21 Air Route Traffic Control Centers (ARTCCs) and was completed early this year with the addition of a fourth meteorologist position in each center. The program uses NWS meteorologists located in ARTCCs to provide meteorological consultation and advisories to air traffic personnel.

The CWSU meteorologists monitor major air traffic terminals and routes of flight in the ARTCC's area of responsibility. They inform the flow controller, the weather coordinator and meteorologists at the Central Flow Control Facility (CFCF) in Washington of any weather changes that may affect the safe and efficient flow of air traffic. They also coordinate with the NWSFOs to ensure the most accurate terminal and area forecasts and in-flight advisories possible with the existing state of the science. When such coordination is not possible, they modify and update those forecasts for the internal guidance of the ARTCC's controllers.

The CWSU meteorologists have the following specific responsibilities:

1. They monitor all weather reports, forecasts and warnings issued by responsible WSOs in and near the Center's area of responsibility and remain aware of any weather conditions which might adversely affect air traffic operations.

2. They work closely with the FAA officials having responsibilities and/or interests in aviation safety for their Center area.

3. They provide detailed briefings of current and forecast weather several times per day for the ARTCC's area.

4. They serve as consultants to the ARTCC controllers, to en route flight advisory service specialists and to central flow meteorologists in situations where hazardous weather impedes the normal flow of air traffic requiring an alternate traffic routing to be determined.

5. They use weather radar and satellite receiving equipment, along with other available data sources, to forecast and alert ARTCC controllers to weather conditions affecting or expected to affect air routes within their area of responsibility.

6. They concern themselves with the efficient collection of Pilot Reports (PIREPS) received at the ARTCC and their distribution to the weather communications network. Working with the weather coordinator, they obtain specific PIREPS from their areas of concern.

7. They participate in special programs involving localized meteorological phenomena which could affect aircraft operations at specific airports.

8. They conduct weather training sessions for air traffic controllers and specialists and are, themselves, involved in various NWS training programs aimed at up-grading their use of satellite and radar information as it affects aircraft operations.

Several improvements are currently being implemented in ARTCCs to improve the flow of vital weather information. Namely, the FAA's new high-speed communications system, the Leased Service A System, is being installed to aid in more rapid accumulation of weather intelligence from places outside the Center. Also, color radar monitors to aid in the identification of hazardous weather phenomena, especially thunderstorms, are being installed for the use of CWSU meteorologists. The program is expected to be completed in the Spring of 1983.

The main area of concern is the communications capabilities from the CWSU meteorologists within the Center and to appropriate control facilities within the Center's area of responsibility including, but not limited to, Terminal Radar Approach Control (TRAC) facilities, towers, En route Flight Advisory Service (EFAS) and Flight Service Station (FSS) facilities. At the present time, in most centers, this is done manually, by telephone. It is hoped that at some time in the future, the CWSU meteorologists will be able to automatically communicate weather intelligence (by utilizing the Leased-Service A System, to appropriate locations both inside and outside the ARTCC.

NEXT GENERATION WEATHER RADAR PROGRAM

The Next Generation Weather Radar (NEXRAD) is the new weather radar system being developed by the Department of Defense, the FAA and the NWS to replace the current aging weather radars; and at the same time, improve the detection of hazardous weather. NEXRAD will have Doppler capability. The Joint Doppler Operational Project (JDOP) demonstrated the feasibility of Doppler technology in field tests at NOAA's National Severe Storms Laboratory (NSSL) in Norman, Oklahoma, during the period 1976-1979.

Since radial velocities of raindrops in a storm can be measured, Doppler radar offers marked improvements over conventional radar for early and accurate identification of thunderstorm hazards, especially tornadoes and squall lines. The NEXRAD System will also allow for a more complete geographical coverage than the present radar network. Initial field installation is expected to begin in 1987 and be completed by 1990.

JOINT AIRPORT WEATHER STUDIES

The Joint Airport Weather Studies (JAWS) Project field experiment was conducted from May 15 this year in and near Denver, Colorado. This project, under the auspices of the National Center for Atmospheric Research (NCAR) in Boulder, Colorado, and the University of Chicago, is sponsored by the National Science Foundation (NSF), the FAA, NOAA and NASA. Three ground-based Doppler radars and several research aircraft participated in the JAWS program. An examination of the data collected is currently ongoing and is expected to give new insight into the nature and behavior of thunderstorms and their inherent threat to aviation.

AUTOMATED AVIATION ROUTE FORECAST

An objective of the FAA's Flight Service Automation Program (FSA) is the capability for a pilot to obtain a self-briefing through direct access terminals or voice-response systems. The area-type aviation weather forecasts, however, are currently not in a format readily adaptable to this new technology. This indicates a need for new methods of describing area-type aviation weather phenomena. NWS proposed a new grid data base concept, the Aviation Route Forecast (ARF). Development of a working ARF prototype has been undertaken by the MITRE Corporation in McLean, Virginia, for the FAA and NWS. A graphical forecasting system has been developed in which the NWS forecaster inputs geographic contours to a computer to describe the effective areas of meteorological parameters. Overlayed on the forecaster's multi-state forecast area is a 22 x 22 mm grid. As each weather contour is completed, the computer determines the affected grid squares and sets them accordingly in the data base. Subsequently, the grids surrounding a pilot's requested route are retrieved and a briefing is assembled.

The ARF input workstation and output briefing information package underwent an operational evaluation this summer. Recommended software and/or hardware changes from this operational test will be considered this fall, and refinements to the equipment and procedures made.

WHERE DO WE GO FROM HERE?

A number of technological possibilities for detecting severe weather, for communicating, integrating and displaying the data, and for disseminating weather forecasts and warnings can be foreseen. The geostationary satellite, the Doppler radar, automated weather observing systems and a whole range of ground-based remote sensing systems will permit far better detection of severe weather than currently possible. This new capacity to observe the small-scale atmospheric circulation will improve severe weather detection and subsequent warnings. Low-cost mini- and micro-computers now make it possible for our forecasters to assimilate the information and make decisions quickly.

The automation of surface observations and of area, route and terminal forecasts will play an important role in the NWS's aviation weather services program in the eighties. The primary emphasis of the aviation program will shift towards preparing detailed terminal forecasts for a six or eight-hour period and for providing severe weather information in a timely way to the air traffic control system.

CONCLUSION

It is recognized that more than any other transportation system, aviation is affected by weather. The transitory and often short-lived nature of hazardous weather phenomena mandates the need for the latest weather information to be in the hands of aircrews, air traffic controllers, dispatchers and others concerned with the safe and efficient use of the NAS. Achieving a firm and comprehensive physical understanding of the processes that determine the character of thunderstorms is without question one of the most important challenges facing the atmospheric sciences community today.

There will be scientific and technological opportunities that will enable us to make significant improvements to the services we provide the aviation community. The NWS, the FAA and other Federal agencies as well as the academic community have joined in a comprehensive, cooperative effort to meet the challenge before us today.

NASA's Aviation Safety - Meteorology Research Programs

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One of the research areas included in NASA's subsonic aircraft programs is that of aviation safety. A major element in that aviation safety research program addresses meteorological hazards to flight. The various research programs in meteorological hazards have been underway for a number of years; some are phasing out; some are just starting. I'd like to go through what we now have currently underway, what we've done recently, and some of the ideas on where we think we're going.

In general, the areas that we have in the meteorological hazards program are: severe storms and the hazards to flight generated by severe storms; clear air turbulence, an area that's been with us a long time; icing; warm fog dissipation; and landing systems. Landing systems are included since once you make your way through what may be a hazardous atmosphere and end up on the ground, you are landing in what is a very large, heavy, fast tricycle; and the interface at that point becomes a rather critical area. We have also recently completed some experiments (one of the few areas in which satellites have been used as a source of data for us) relative to remote sensing of ozone. Also using satellites in a slightly different mode, as a data relay system, we have looked at the possible benefits to be derived from using essentially real-time wind data for flight planning.

In the severe storms research, started in 1977, we are attempting to identify what, in fact, is the makeup and the structure of severe storms, principally thunderstorms. Ideally, one would like to do this kind of work with remote sensing; but in many areas, it is impossible to remotely sense the kind of information that is needed. One such program that has become very successful, and is hardly a remote sensing program, is the F-106 that is used to fly into thunderstorms in an attempt to obtain direct lightning strikes. One hundred seventy-six (176) strikes have been obtained in three (3) years. It is a highly instrumented airplane. This instrumentation is now allowing us to identify or characterize lightning strikes in flight and identify and hopefully predict the effects of lightning on aircraft systems and structures.

A second area where remote sensing may be used in the future will be to sense gust environments. Currently, it is a matter of obtaining the data by experiencing the event. That is, we are attempting to find the microstructure of the gust environment.

Through the use of a specially instrumented B-57 aircraft, we are flying into turbulence and measuring the lateral gust gradients over the span of the airplane. This program is thus attempting to identify the effect on the airplane of gust gradients of the size of the aircraft. This program will be discussed later in detail by Warren Campbell of NASA/Marshall Space Flight Center.

NASA is also a participant in the Joint Airport Weather Studies (JAWS) program which is delving into the physical properties and generation of low-level wind shears. In addition to providing flight support via our B-57 aircraft, we are also involved in certain areas of data analysis. Dr. John McCarthy of NCAR will speak on this program in detail later in the Workshop.

Clear air turbulence (CAT) has been a hazard and an annoyance throughout the years as airplanes have changed in character from propellers to jets. The drag to mass ratio has changed. The upsets experienced by the large transports represent a severe hazard in air travel. Initially, as we learned to cope with the upsets, flying procedures were implemented to alleviate the effects during the turbulence encounters; the hazard was lessened significantly. Yet, we are continually reminded that the problem has not been solved. The last encounter I can recall directly was a DC-10 encountering severe CAT over Denver, and there were a number of people hurt in the airplane. No severe damage was sustained by the aircraft; but it was an unanticipated encounter with turbulence. NASA has undertaken a long-term study of devices that may have potential for remote detection and early warning of CAT. The Laser-Doppler Velocimeter (LDV), the infra-red radiometer and the microwave radiometer all have potential, but they all have shortcomings. We are, however, continuing to explore methods of overcoming these shortcomings.

Dr. Joe Shaw of Lewis Research Center will be giving a detailed discussion on our aircraft icing research program. This area has re-emerged as an area of concentration for NASA, centered directly about the icing research tunnel facilities at the Lewis Research Center. In addition, we have found that we need data on atmospheric