system. The P-3 aircraft, due to its number of flight hours flown and mission profile, is the most frequently lightning-struck aircraft in the Navy inventory. This system will allow passive navigation around lightning activity which is often important for an aircraft not desiring to emit radar signals. The joint NASA/AFGL icing test at Wallops Island is also designed to evaluate the airborne lightning hazards with respect to the measurable meteorological parameters. The Navy is now in engineering development of a Lightning Position and Tracking System (LPATS) developed by the Office of Naval Research with Naval Air Systems Command assistance. This ground-based system detects the unique broad-based magnetic field waveform of the cloud-to-ground lightning stroke and displays its location, intensity and movement on a video screen. The LPATS system is currently undergoing field tests at NAS Cecil Field, Florida, with the central station located in the Naval Oceanography Command Detachment office for operational evaluation.

Whatever the environmental aircraft flight safety hazard, the DOD is involved in evaluating and improving the observation and forecasting of the phenomena. In most cases, the DOD efforts are either joint or complementary efforts and are coordinated through the Office of the Federal Coordinator for Meteorology and Supporting Research.

You will note that I've skipped over the most basic of the meteorological inputs to aviation, that being the accurate observation and forecast of ceiling and visibility. Both the Air Force and the Army are working in improved visibility sensors with the Army using the laser approach and the Air Force using the forward-scatter/nephelometer approach; and both addressing different aspects of automation of these sensors for fixed base and remote combat deployment. As a participant in the Joint Automated Weather Observing Programs with NWS and FAA, DOD is most interested in pursuing the fully automated surface observation; however, before we all spend further research dollars on the automation of presently reported weather parameters, it may be the appropriate time for all of us to join together and re-evaluate the true requirements for aviation weather observations. The past-stated need for slant visual range (SVR) data might be an example where great sums of money could have been spent to produce unneeded data using hazardous towers or non-eye-safe lasers.

In summary, I wholeheartedly support the concept of this workshop and look forward to addressing further how DOD activities match up with the workshop recommendations. However, I offer two challenges: first, to attempt to prioritize the recommendations based on need, cost and achievability; second, to consider the re-evaluation of weather parameters really needed for safe landing operations to lead the way for the reliable and consistent automated observation capabilities.

Federal Aviation Administration Weather Program To Improve Aviation Safety

Robert W. Wedan
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The Federal Aviation Administration (FAA) issued the National Airspace System (NAS) Plan in December 1981 to provide for systematic developments that insure the safe and efficient movement of both civil and military aircraft. This plan was developed to meet the system capacity requirements resulting from the increased growth expected by 1993 of:

- 85% in domestic air carrier passenger miles
- 231% in commuter passenger miles
- 67% in the number of hours flown by general aviation
- 112% in the hours flown by rotary wing aircraft.

The implementation of the NAS Plan will improve vital safety services to aviation. These services include collision avoidance, improved landing systems and better weather data acquisition and dissemination. The Plan focuses on the current system and improvements that must be made in the immediate future to meet the projected needs and demands of aviation.

Efforts to improve aviation weather services initiated a few years ago are integrated into this plan. The program to improve the quality of weather information to pilots, controllers and flight service station specialists for safe and expeditious operation of aircraft encompasses the following major programs:

- Radar Remote Weather Display System (RRWDS)
- Flight Service Automation System (FSAS)
- Automatic Weather Observation System (AWOS)
- Center Weather Processor (CWP)/Center Weather Service Unit (CWSU)

- Next Generation Weather Radar (NEXRAD) Development

While these are the major efforts, it is significant to note that a total of 22 separate programs are affected to some degree by the FAA commitment to upgrade weather detection and dissemination. For example, the FAA plans to replace its outdated air traffic control computers and displays. As part of the new display consoles, severe weather will be presented to the controllers along with aircraft targets. Work still remains to determine the best way to present the weather data and to what degree the center meteorologist will interact with the display. In any event, all of what I present here, together with the weather element in the rest of the 22 programs, all have the purpose of serving the controller and the pilot with essential and real-time weather information that supports both efficient and safe flight operations.

RRWDS

Radar Remote Weather Display Systems will be able to access six (6) levels of precipitation intensity (reflectivity) from 134 radars nationwide. By mid-1983, all 20 conterminous Air Route Traffic Control Centers (ARTCCs) - Center Weather Service Units (CWSUs) and 44 En route Flight Advisory Service (EFAS) positions will have dedicated and dial-up rapid access to these National Weather Service (NWS) and FAA radars. Data from these sources will provide six-level color weather contours displayed on CRTs and be used by the CWSU meteorologist and Flight Service Station (FSS) specialists. Data from the RRWDS will be used primarily to develop CWSU advisories to controllers on location, intensity and movement of hazardous convective weather and by the EFAS specialists to alert pilots to the same hazards.

We have tested and will continue to evaluate techniques for presenting weather radar contours on controllers en route plan view displays. By 1985, it is expected that RRWDS in the form of contoured reflectivity data will be available to en route traffic controllers on their Plan View Displays via the Center Weather Processor and the existing 9020 en route Air Traffic Control processor. As mentioned earlier, the manner of presenting weather will be evaluated in parallel. Contouring severe weather on the controller's PVD appears to be a practical approach for the 9020 equipment. The future sector suites provide the option of presenting weather in an area by shades of grey on color fill-in. Questions that must be addressed include scope clutter and other workload or interpretive questions and computer loading.

FSAS

The Flight Service Automation System incorporates high-speed communication and computer processing techniques dedicated to collecting, formatting, editing, distributing and displaying weather data required by the FSS specialists for pilot briefings and dissemination to pilots. A national weather data base (the Aviation Weather Processor) containing United States, Canadian, Mexican and Caribbean data will be available for rapid access by 1985. Digitized weather radar data, digitized weather graphics, a nationwide file of pilot reports and data from the surface weather reporting stations will be availalbe to the pilot on a timely basis through the use of the FSAS and the high-speed digital communication lines from the National Airspace Data Interchange Network (NADIN). Pilots will be able to obtain more accurate and up-to-date pre-flight briefings from the FSS specialist with the elimination of the manual "paper shuffling" tasks of sorting out only those data required for a particular flight. The automated filtering of these data will be based on departure times, altitude of flight and route of flight.

Initially, Flight Service Data Processors will be installed in 14 of the 23 existing ARTCCs by 1984, which, in turn, will drive remote equipment located at 41 FSS sites. Enhanced Flight Service Data Processing Systems, which include improvements on the aforementioned 14, will be installed at the other nine ARTCCs, which will drive remote equipment located at a total of 61 FSS sites by 1988. To support these improved systems, two Airport Weather Processors will be installed at Salt Lake City and Atlanta, respectively, to process data for the total system. Details of the operation of the FSAS are presented in the article "Meteorological Impact on ATC System Design" by Frank E. Van Demark.

AWOS

Automated Weather Observation Systems (AWOS) are planned for operational evaluation at 15 airports during 1983 and 1984. These evaluations are the culmination of a series of tests on observation systems and/or weather sensors obtained from manufacturers which began in 1975 and ended in July of 1982. The AWOS will have the capability of measuring a range of surface weather parameters consisting of wind speed, wind direction and wind gusts, temperature, altimeter setting, visibility and cloud height/ceiling. The system includes automated data entry, data display, data recording, remote maintenance monitoring and failure reporting and both voice and Very High Frequency (VHF) communications output. The six major subsystems and components of AWOS are:

1. Sensors and field electronics
2. Sensor processors
3. System processor
4. Voice output
5. Communication processor
6. Remote maintenance, monitoring and data recording.

This program represents one of several major decisions made during the preparation of the NAS Plan. That is, to dedicate the VOR voice channel for dissemination of real-time weather. Another possible use of the voice channel, to broadcast digitized weather radar data, is mentioned below.

Future efforts to improve AWOS will involve refinement of algorithms for processing operational parameters and evaluation of new sensors, e.g., thunderstorm location and present weather. FAA implementation of 700 systems nationwide will begin in 1985 and be completed by the end of the decade. It is expected that private aviation interests and the Airport Improvement Program* grants will add another 900-1000 systems over the same time frame.

CWP

The Center Weather Processor is being developed into a real-time, fail-safe system for receiving, storing, processing and distributing weather information for the support of National Airspace System operations. It will be the central system for collection and dissemination of weather information and located in each Air Route Traffic Control Center. The CWP will contain alphanumeric weather observations and forecasts, weather charts, radar weather data and weather satellite images. The first system is planned to be implemented in 1985. The CWP will provide the Flight Service Data Processing System with radar weather contours derived from the RRWDSs and support an automated work station for the CWSU meteorologists. Through enhancements, the CWP will add interfaces and will eventually support en route sectors through the 9020 computer and its replacement, and advanced systems such as the en route sector suite and the Mode S data link. The air traffic control weather advisories developed by the CWSU meteorologists and automatically disseminated by the CWP will be used by pilots, controllers and FSS specialists to reduce the chances of aircraft encountering hazardous weather situations and to increase the efficiency of operations in the NAS. An additional major enhancement to the CWP will be the mosaicking of NEXRAD (see next section) and Airport Surveillance Radar weather channel data.

NEXRAD

The Next Generation Weather Radar System is being developed jointly by the Department of Transportation (FAA), Department of Commerce (NWS) and Department of Defense (Air Force Geophysics Laboratory). The FAA objective in this program is to provide Doppler weather radar information on the location, measurement and movement of potentially hazardous convective weather and its attendant hazards to aviation. NEXRAD weather data products will include automated reflectivity, radial velocity and spectral width maps, severe weather alerts, hazardous weather contour maps and echo top maps and a free text message on equipment status.

FAA requirements for NEXRAD include:

a. En route coverage from 6,000 feet to 70,000 feet.

b. Terminal area coverage within 30.0 nautical miles of the terminal from 500 to 20,000 feet.

c. Coverage within 10.8 nautical miles of selected airports from 200 - 10,000 feet.

d. Complete radar volume update cycle of 5 minutes with partial volume sampling in 1 to 2.5 minutes.

e. NEXRAD products for use by meteorologists, controllers, FSS specialists and eventually pilots via MODE S data link.

The FAA is actively participating in the development and technical studies phase of the program by funding the following:

a. Radar clutter suppression techniques

b. En route siting and update rates

c. Scanning strategies and interface techniques.

d. Algorithms and mosaicking techniques to provide hazardous weather contours to the CWP/CWSU.

e. Operational processing and display techniques.

f. Verification of data transmission rates between NEXRAD data acquisition sites, the radar product generator and the principle user processors.

The FAA airspace coverage, data update rate, data resolution, accuracy and system availability are substantially more demanding than those identified by other participating agencies. Deployment of the NEXRAD network radars begins in March 1987 with five radars. One hundred and fifty-five more will be added during the 1988-1991 period.

OTHER RE&D PROGRAM

In addition to the foregoing major weather programs, there will be research, engineering and development efforts:

- To continue studies of wind shear, downbursts and microbursts through the Joint Airport Weather Studies (JAWS) program for application in aircraft simulations and avionics certification. Details on JAWS under the direction of the National Center for Atmospheric Research are in the paper "The Joint Airport Weather Studies

*Airport and Airway Improvement Act of 1982

Project" by John McCarthy. We expect that the knowledge gained by JAWS will directly affect both the NEXRAD and CWP Programs to insure that the severe weather is adequately detected and the data properly processed.

- To develop instrumentation to detect and follow wake vortices behind aircraft for use in developing procedures to reduce separation standards between aircraft on take-offs and landings in order to increase airport capacity.

- To improve the wind shear warning capability for pilots through certification of airborne wind shear warning systems. The FAA has issued an advisory circular that describes acceptable simulation test criteria, wind field modeling data and minimum performance parameters for evaluating candidate systems. The airborne systems will complement the low-level wind shear alert systems (LLWSAS) that are currently operational at 58 airports and are scheduled for installation at 51 more.

- To evaluate products required by the CWSU meteorologist and develop the specification of the automated CWSU workstation by supporting the NWS Prototype Regional Observing and Forecast System (PROFS) at Boulder, Colorado. The intent of PROFS is to automate the analysis of inputs from automated surface weather observations, Doppler and conventional radars, special microwave upper air wind measuring equipment, and visible and infrared satellite data to produce a variety of new weather products. See the paper "Prototype Regional Observation and Forecast System" by John Hinkelman, Jr., for a detailed description. Again, we expect to see the results of this program support other FAA programs, in particular, the CWP and CWSU workstation.

- To improve the dissemination of weather information to general aviation aircraft by demonstrating a low-cost technique for getting weather radar data into the cockpit. In a recent demonstration at Columbus, Ohio, using the SWR 74C weather radar, a small ground-based microprocessor, the Zanesville VHF Omni Directional Range (VOR) station and the Appleton and Rosewood VORs, an on-board microcomputer which is interfaced with the VOR receiver and an inexpensive printer, weather radar precipitation intensity data were transmitted directly to pilots within 50 - 75 miles of the VOR. In addition, the data include the relative location of nearby VORs mapped on the printout. This provides an orientation to the pilot's present position to permit him to plan changes, if necessary, to this route.

With the installation of Mode S facilities and airborne transponders, another method of acquiring weather data will be available. On a request/reply basis, rather than by broadcasting over the VOR, the pilot will be able to access the weather data base, which resides in the CWP. This includes thunderstorm data.

To some extent, the VOR broadcast of AWOS and weather radar data may be redundant. However, four factors mitigate the question. First, not all aircraft will have Mode S transponders and terminals for acquiring weather. Second, installation plans for Mode S will call for high altitude coverage and, at some future time, coverage to 6,000 feet. This compares to current coverage of VORs to the minimum en route altitude. Third, broadcasting data by VOR does not appear to cause a saturation problem in areas of severe weather although a voice priority interrupt will still be required. On the other hand, the Mode S data link may prove to become quite saturated as the full use of the link for air traffic control becomes clearer. Finally, the airborne equipment required for receiving ground weather radar data, if designed to anticipate the Mode S data link terminal, will contain common use equipment elements. Thes include the display, keyboard and microprocessor. In summary, we currently expect that these two methods of transmitting weather data to the pilot can be very compatible.

- To provide in conjunction with the NWS an improved Aviation Route Forecast (ARF) technique for presenting forecast and observed data for routes and areas. The ARF data base will consist of forecast weather information at grid points covering the entire U. S. Information at each grid point on cloud cover, visibility, weather, convective activity, freezing level and icing and turbulence will be stored. When a route or area is entered, the computer will retrieve data from those grid points applicable to that particular route or area. The ARF system will have an input workstation for NWS meteorologists and a software routine for output which is planned for integration in the FSAS.

In summary, Figure 1 illustrates the future FAA aviation weather systems data sources.

The foregoing are active programs. When completed, the FAA will have a superior weather system in operation to assist all aircraft to operate safely and expeditiously in any weather environment.

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*NESS: National Environmental Satellite Service
*NMC: National Meteorological Center

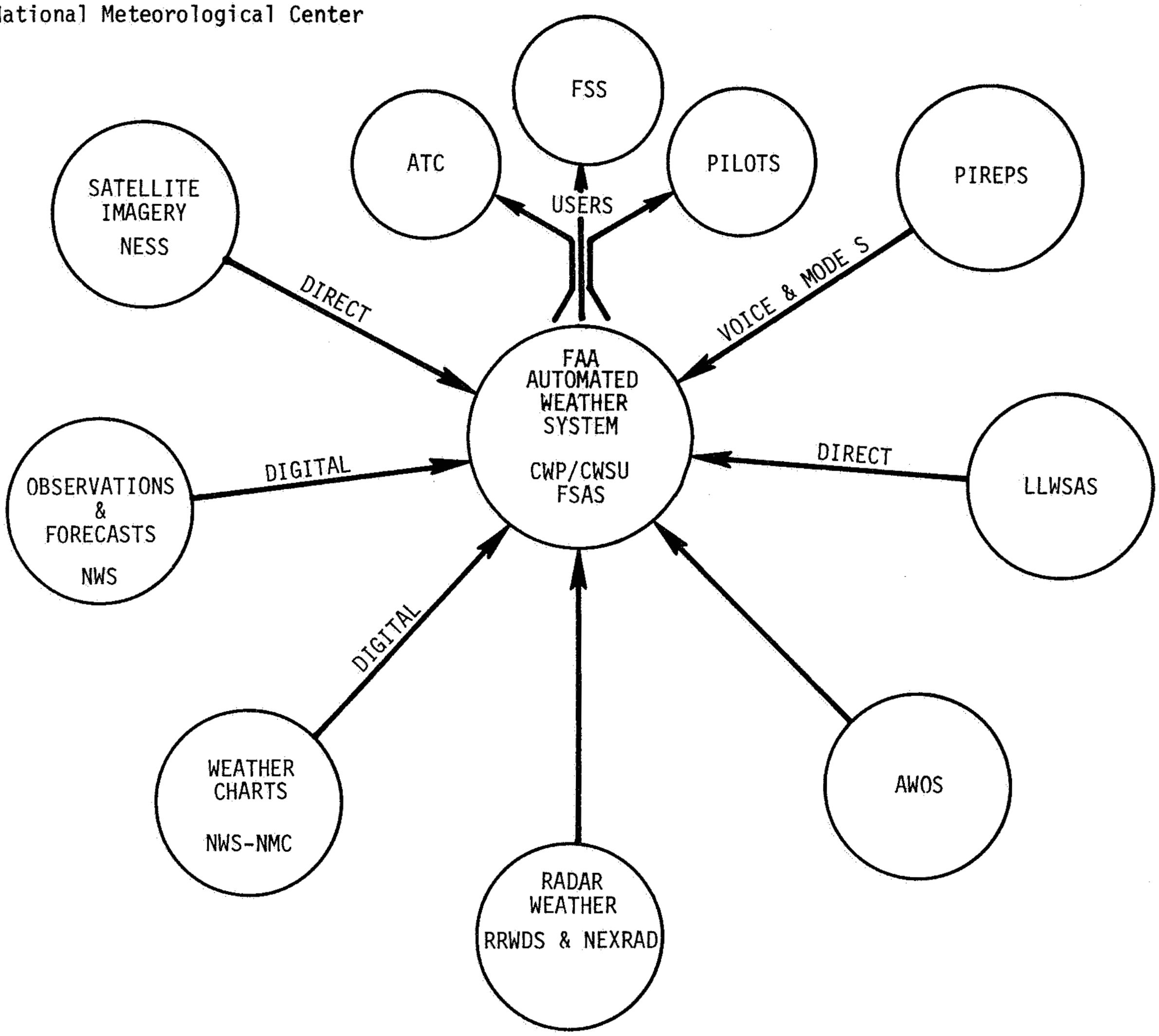

Figure 1. Future FAA Aviation Weather Systems Data Sources

Discussion From the Floor

Moderator: John H. Enders
President
Flight Safety Foundation, Inc.

QUESTION: Jack Hinkelman, PROFS Program

I would like to ask Charlie Sprinkle if he feels that centralizing the area of forecast program in Kansas City has stepped forward or backward?

RESPONSE: Charlie Sprinkle

As I indicated before, the Site Specific Terminal Forecast will remain at WSFO's. The area forecast and in-flight advisories will be centralized. I, personally, think it's a