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Report to the Chairman, Committee on Science, Space, and Technology, House of Representatives

October 1989

AVIATION WEATHER

FAA Needs to Resolve Questions Involving the Use of New Radars

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Resources, Community, and
Economic Development Division

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The Honorable Robert A. Roe
Chairman, Committee on Science,
Space, and Technology
House of Representatives

Dear Mr. Chairman:

In response to your August 1988 request, we evaluated specific aspects of three weather-related systems: the Airport Surveillance Radar (ASR-9) weather channel, the Terminal Doppler Weather Radar (TDWR), and the Aeronautical Data Link. Developed as part of its National Airspace System (NAS) Plan, these three systems are designed to enhance the Federal Aviation Administration's (FAA) ability to disseminate hazardous weather information to pilots.[1]

Specifically, the ASR-9 radar will support air traffic control functions, but unlike previous surveillance radars, it has the capability to provide more precise information on precipitation location and intensity. The TDWR will detect low-altitude wind shear and other hazardous weather conditions in airport terminal areas so that pilots can avoid or prepare for encounters with such events. The Aeronautical Data Link will initially be used to enable pilots to directly access weather information from FAA ground-based systems, instead of receiving this information by voice communication from controllers.

The availability of weather information from these systems is vital to the safety of aviation. In 1986, the most recent year that data are available, weather was cited as a factor in almost 44 percent of all major airline accidents.

As agreed with your office, the objectives of our evaluation were to (1) describe FAA's progress in preparing operational procedures for using and disseminating weather information from the ASR-9 and the TDWR and (2) assess the status and availability of initial data link weather services.

[1]These systems are discussed in further detail in Aviation Weather: Status of FAA's New Hazardous Weather Detection and Dissemination Systems, GAO/RCED-87-208, Sept. 29, 1987.

Results in Brief

We found that

- FAA has not established formal procedures for sending ASR-9 weather data from air traffic controllers to pilots, although the first radar is now operational and additional radars will soon be deployed. FAA believes that before implementing formal procedures, controllers need to experience basic changes in the system's precipitation detection capabilities. Moreover, a policy question regarding whether to route aircraft around storms using ASR-9 weather data will not be answered until FAA learns more about precipitation effects on aircraft and the work load effects on controllers.
- FAA is currently evaluating procedures for disseminating TDWR weather information. Operational tests have shown that the TDWR can detect wind shear and microbursts. Unresolved is how this new information will be integrated within existing air traffic control procedures. Instances of pilots misinterpreting advisories from controllers occurred during operational testing. Several pilots appeared to key on the part of the controller message authorizing them to land, not on the warning of intense wind shifts. Although FAA has considered some changes to the structure and content of these advisory messages, it has not yet established how this will be eventually performed. In addition, FAA's reluctance to establish procedures for rerouting aircraft during periods of wind shear stems from uncertainties about added controller work load, as well as the policy implications this would have on pilot and controller responsibilities.
- Initial weather services, such as hazardous weather advisories, which FAA plans to provide aircraft through the Aeronautical Data Link, may be delayed for more than 2 years—from December 1990 to March 1993—because of significant slippage in the schedule for a major interrelated system. Additionally, that delay will require FAA to conduct another set of operational tests after data link processors are installed in the field. Any problems uncovered in that testing could result in additional program costs, as well as further delays in the schedule for the initial weather services.

Background

Hazardous weather is a factor in many aviation accidents, and wind shear can be particularly disastrous for aircraft, especially when encountered below 1,000 feet. Microbursts, the most hazardous form of wind shear, produce more powerful and concentrated down drafts than other wind shear events. Between 1975 and 1985, wind shear and microbursts contributed to 14 major aircraft accidents, resulting in over 400 deaths. In addition to being a safety concern, hazardous weather conditions affect the air traffic control system's operational efficiency. A recent FAA report on system delays states that 65 percent of airline delays were attributable to weather. To help detect hazardous weather and provide such vital information to pilots, FAA has designed the ASR-9 weather channel, the TDWR, and the Aeronautical Data Link.

ASR-9 Operational Procedures

Although the initial ASR-9 radar is now operational at one field location and more units will follow, FAA has not implemented new operational procedures for the interpretation and dissemination of precipitation information from the system's weather channel. Operational procedures provide specific guidance describing how the equipment and data are to be used in conjunction with air traffic control functions. FAA originally planned to test and develop operational procedures before installation of the radars. However, FAA officials now believe that a good understanding of the ASR-9's ability to detect hazardous weather is necessary before they prepare ironclad operational procedures and assess whether controllers can use the system to redirect traffic. The new radar provides air traffic controllers with a fundamentally new tool for identifying precipitation location and intensity. Previous airport radars provided some low quality data on precipitation location but little information on storm intensity. Because the ASR-9 weather channel provides such a new capability over and above that available with previous surveillance radars, FAA officials believe that controllers should experience the system before procedures are made final. As a result, FAA has not implemented new operational procedures, although the first ASR-9 is now deployed in the field, and additional radars will soon become operational.

FAA officials do not believe that the absence of operational procedures hinders controllers' use of the radar's weather capabilities. For example, controllers at the first ASR-9 operational site are now providing advisory voice messages on precipitation intensity to pilots. Controllers had previously issued this information based on printed reports received from the National Weather Service. FAA officials believe that an evaluation of this method is necessary before they decide how to change procedures. They also pointed out that the absence of operational procedures does not affect the radar's primary use—identifying aircraft for safe separation—since that is a separate function of the radar. However, the agency has not set time frames for implementing ASR-9 weather channel procedures. Without operational procedures, controllers have no guidance on how often to use the ASR-9 weather channel, or how to interpret the precipitation display.

ASR-9 weather capabilities raise a policy question of whether FAA and the airline industry should modify the advisory nature of weather information provided by the agency. Currently, FAA does not require controllers to use weather information to reroute planes, although in practice controllers may at times choose to redirect aircraft around severe weather, such as thunderstorms, or suggest alternative routes. Weather radar systems now aboard many aircraft can provide information superior to that available from previous airport radars. Further, pilots are responsible for their flight's safety and often contact controllers for permission to reroute when they encounter adverse weather. These requests can result in hectic situations for controllers, possibly slowing air traffic. An FAA official said that controllers would prefer to project the traffic flow, rather than react as it happens.

The ASR-9's improved weather detection could enhance national airspace system efficiency and safety by helping controllers anticipate rerouting requests or by giving them the information they need to reroute planes around adverse weather. However, according to FAA, it needs to learn more about the hazards of intense precipitation. For example, it needs to evaluate the effect of various levels of precipitation on different aircraft before it can instruct controllers on when to route planes around such weather. (Additional details on the ASR-9 are provided in app. I.)

TDWR Operational Procedures

FAA plans to have the first TDWR reach operational status by June 1993, with a total of 47 radars scheduled to be installed over the following 3 years. As part of its testing of the new radar, FAA is evaluating procedures for disseminating hazardous weather data from the TDWR to pilots. Operational tests in Denver during 1988 showed that the radar can reliably detect most wind shear and microburst phenomena. Despite this efficacy at locating wind shear events, FAA and aviation industry experts are concerned about the adequacy of using procedures developed for a less capable weather system to alert pilots to events identified by the more sophisticated TDWR. Instead of establishing new operational procedures for TDWR testing, FAA had controllers use the same method of relaying reports of microburst activity to pilots as they use for the current ground-based system, the Enhanced Low Level Wind Shear Alert System (ELLWAS).[2] In other words, controllers issued the microburst alert, together with wind speed and direction, as part of a

[2]The ELLWAS is an upgraded version of a ground-based system used to detect wind shear and microbursts. The ELLWAS consists of 11 wind sensors placed around an airport that detect changes in wind speed and direction for dissemination to controllers and pilots.

longer air traffic control voice message. FAA used existing procedures to avoid confusion on the part of controllers and pilots, especially since the TDWR was operational for only part of the day.

However, the use of existing procedures was not completely effective, as highlighted by an incident during the testing. Four commercial airline pilots from one airline flew into microburst activity, despite prior warning by the controllers and explicit airline policy to avoid microburst alert areas. Post-occurrence analysis by the airline concluded that the crews either did not hear clearly or did not know the meaning of the term "microburst alert." The crews for three of these flights could not recall hearing microburst alert upon initial contact with the tower. However, two of these crews did recall their clearance to land from the same transmission. The pilots' not recognizing the warnings has been attributed at least in part to the structure of the microburst alert message, which is inserted in the middle of routine communications providing clearance to land. Pilots reportedly keyed into the phrase that concludes with the words: "clear to land." This problem points to the need for FAA to refine procedures for disseminating microburst alerts during future testing.

FAA has considered some alternatives to deal with this cognitive problem, such as providing microburst alerts as a distinctly separate advisory, or replacing the clear to land ending of the message with the new instruction, "say intention." In the latter case, the pilot would be required to respond whether he intended to land or terminate his final approach. During TDWR testing to be conducted at Kansas City this summer, FAA plans to move wind speed and direction information away from the alert message to reduce pilot confusion.

Alternatively, FAA could substantially reduce the potential of missing an alert message by requiring that controllers redirect planes from runways with microbursts. For example, during the 1988 Denver tests, controllers adopted the practice of routing aircraft away from runways experiencing a microburst alert. Under existing policy, such decisions are left up to the pilots. While not established as a formal policy, controllers also routinely reroute planes because of thunderstorms. Using this approach for microburst alerts could offer several advantages over existing procedures, including (1) providing controllers with a more stable situation in which they can better predict traffic flow, (2) providing earlier warnings and more time for pilot response, and (3) eliminating potential problems with pilots not heeding a warning. Notwithstanding the policy implication this would have on controller and pilot responsibilities, FAA is reluctant to institute rerouting as a formal procedure without analyzing the resultant work load on its controllers. FAA has no current plans to test the feasibility of this alternative.

To help define concerns and develop potential solutions to implementation problems, FAA established a user group specifically associated with the TDWR. The group consists of pilots, controllers, engineers, and meteorologists from both government and private industry that have been instrumental in helping to develop the user and display requirements for the system. We believe that the concept of a user group could serve as a model for coordinating system design and user needs on other FAA projects, including the ASR-9. (Additional details on the TDWR are provided in app. II.)

Status of Aeronautical Data Link Weather Services

Weather services are the first planned use of the Aeronautical Data Link. These initial services may not be available at the first field site until March 1993, well beyond FAA's original schedule of December 1990. Services at all 22 sites are planned to be operational by March 1996. The Aeronautical Data Link's initial weather services rely on the development of interdependent systems. In addition to needing the data link processor—which will retrieve data from other weather systems and prepare it for transmission to controllers and pilots—the use of the system depends heavily on integration of the Mode S.[3] The Mode S system will be the primary means through which FAA actually transmits weather messages to the aircraft. Although the data link processor is on schedule, the Mode S program has suffered significant delays with its first system now scheduled to be operational by December 1992. As a result, the initial weather services that FAA intends to have available at the first operational site may be significantly delayed.

Additionally, the slippage in the Mode S program will require FAA to conduct an additional set of operational tests. FAA will initially test the data link processor with a simulated Mode S, since an actual version of that system will not be available. If those tests are successful, the processors will be installed at field locations. After the Mode S is delivered to FAA's testing facility, a separate round of operational tests will be conducted to assure that the two systems interface properly. According to FAA officials, using simulations will not provide FAA as much confidence as using

[3]The Mode S system consists of sensors and antennae on the ground for receiving and transmitting information from and to aircraft. Mode S will replace existing radar beacon systems aboard aircraft.

real systems. Therefore, some risk exists that changes will need to be made to the data link processors after they are installed in the field. If that occurred, FAA would incur additional costs and the schedule for the initial weather services would be further delayed. The Aeronautical Data Link program manager believes that FAA must proceed with installing the data link processor, because substantial additional costs would be incurred on the contract if it was delayed to wait for an actual Mode S.

FAA expects the quality of the initial weather services to improve as new data acquisition, processing, and communication systems are integrated into the system. For example, upgrades to the automated weather observing system will update surface observation information for data link every minute, as compared with the initially planned hourly updates. Additionally, FAA has identified enhanced services, such as air traffic control functions and wind shear alerts from the TDWR, that could be phased-in after the initial weather services. However, FAA has no plans to provide ASR-9 weather channel data via the Aeronautical Data Link. (Additional details on the Aeronautical Data Link are provided in app. III.)

Conclusions

In recent tests, FAA has demonstrated that the ASR-9 and TDWR systems will provide air traffic controllers with improved information on precipitation and wind shear location and intensity. These capabilities, combined with effective operational procedures describing how the equipment is to be used and how the information will be disseminated, could reduce the number of weather-related accidents and save lives. Furthermore, the Aeronautical Data Link could upgrade the quality of weather information available to pilots.

Although the first ASR-9 is now operational, FAA is deferring the establishment of firm operational procedures until controllers are more familiar with the system. However, the agency has set no time frames for developing those procedures. While deferring final guidance may be justified to gain greater experience, we believe that the impending full deployment of the ASR-9 requires FAA to promptly issue operational guidelines that provide interim direction to controllers operating its weather channel, particularly if such a deferral will be lengthy. The implementation of operational procedures would maximize use of the ASR-9's new capability and ensure that controllers use it consistently. In the longer term, to achieve the greatest benefit from the radar's weather channel, FAA needs to address how this information will be used and to evaluate the effects of the various alternatives, such as redirecting flights, on national airspace safety and efficiency. Resolving the fundamental safety and policy questions involving ASR-9 weather data use will require advice from air traffic controllers, meteorologists, airlines, pilots, and aircraft manufacturers, since those groups all play an important role in the national airspace system. FAA should expedite the process of answering these questions and implementing effective procedures by replicating its successful TDWR experience of assembling and achieving consensus from a working group made up of experts from these varied interests.

While deployment of the TDWR is not scheduled until 1993, concerns about operational procedures for the new radar also need to be resolved. TDWR operational testing to date has shown that the procedures used to warn pilots of wind shear and microbursts were not always effective. Analysis of 1988 testing showed that pilots may have misunderstood or not heard the type of warning issued using existing procedures. Because the first TDWR will not be operational until 1993 and therefore testing will continue for the next 4 years, FAA should use that time to thoroughly evaluate the impact and effectiveness of the full range of alternative procedures for TDWR, including the potential for redirecting flights around microbursts.

One of the major challenges to achieving the full promise of FAA's weather-related systems is the integration of their new capabilities into the existing air traffic control environment. While technical capabilities to detect hazardous weather information have been developed, effective dissemination of this information will likely require a policy decision concerning the controller's authority to reroute traffic during periods of inclement weather. We recognize that if controllers are to use hazardous weather warnings as more than just advisory information for pilots, this will entail a change in the way FAA controls aircraft and will also require fundamental changes by users of the national airspace system. The current problems associated with developing operational procedures for the ASR-9 and the TDWR reflect FAA's difficulty in tackling this issue. Although a long-term resolution of this policy issue is required for FAA to obtain maximum benefits from these new systems and capabilities, action should be taken now to enhance the basis from which such a decision will be made.

Recommendations

To ensure the consistent dissemination and use of new weather data available from the ASR-9, we recommend that the Secretary of Transportation direct the Administrator, FAA, to (1) establish time frames for issuing ASR-9 operational procedures, (2) convene a joint government/industry user group, similar to that used for the TDWR, to resolve uncertainties regarding the use and dissemination of ASR-9 weather data, and (3) issue interim guidelines if significant ASR-9 implementation will occur before final procedures are developed.

We also recommend that the Secretary of Transportation direct the Administrator, FAA, to evaluate, during subsequent operational tests of the TDWR, the impact and efficiency of having controllers direct aircraft around microbursts. The agency could then resolve the policy question concerning the dissemination of microburst warnings and therefore implement the most effective operational procedures.

Views of Agency Officials

FAA and Department of Transportation officials provided oral comments on a draft of this report. These officials agreed with our conclusions and recommendations. The officials did suggest some technical changes to the report which we incorporated as appropriate.

In conducting our review, we examined pertinent system planning documents, test results, interviewed FAA and Martin Marietta officials, and participated in a session of the TDWR working group. (See app. IV for details on our scope and methodology.) Our review was conducted between August 1988 and July 1989 in accordance with generally accepted government auditing standards.

As agreed with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 7 days from the date of this letter. At that time we will send copies to the Secretary of Transportation and the Administrator, FAA. This work was done under the direction of Kenneth M. Mead, Director, Transportation Issues, who may be reached at (202) 275-1000, if you or staff have any questions. Other contributors are listed in appendix V.

Sincerely yours,

J. Dexter Peach
Assistant Comptroller General

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Abbreviations

ASR-9	Airport Surveillance Radar - 9
DLP	Data Link Processor
ELLWAS	Enhanced Low Level Wind Shear Alert System
FAA	Federal Aviation Administration
GAO	General Accounting Office
NAS	National Airspace System
TDWR	Terminal Doppler Weather Radar

Information on the Airport Surveillance Radar Weather Channel

The Federal Aviation Administration's (FAA) new airport surveillance radar (ASR-9) is primarily a short-range, highly accurate radar system for monitoring aircraft movement and position within a radius of 60 nautical miles from the airport terminal. Air traffic controllers use the radar's aircraft position data to keep aircraft safely separated and to control their movements into and out of the airport.

Weather Channel Capabilities

In addition to its use for air traffic management, the ASR-9 also has weather channel capabilities. The ASR-9 represents the latest generation of radars that uses digital technology to do more sophisticated weather processing than previous radars. ASR-9 has a separate capability to provide information on precipitation location and intensity. Previous airport radars provided some low quality data on precipitation location but little information on intensity. FAA acknowledged from the onset of system design that precipitation intensity information does not always correlate with areas of potentially hazardous turbulence. FAA argues, however, that the system will improve FAA's weather detection capability. FAA has maintained that the radar's improved detection of precipitation intensity has the potential to reduce the number of aviation accidents in which severe weather is a cause or contributing factor.

FAA has been evaluating a Doppler conversion for the ASR system. Doppler capability[1] would give the ASR the ability to detect microburst activity. Doppler conversion may be part of FAA's planned ASR-10, the next-generation surveillance radar. According to FAA officials, this capability could be provided to the ASR-9 system with additional processors and software. If ASR-9, when used in conjunction with the Doppler package, provides acceptable wind shear detection, it might be able to provide wind shear detection for airports that are not among the original 47 airports receiving TDWR.

System Status and Development Plans

FAA awarded a $372 million contract to Westinghouse Electric Company in September 1983 for the production of 101 ASR-9s. The program has experienced substantial delays primarily because of technical problems during the development of the system's hardware and software. As a result, the first ASR-9 was commissioned at Huntsville, Alabama, in May 1989, about 2-1/2 years behind the 1983 contract schedule. FAA believes that all technical problems have been solved based on testing done at

[1] Doppler radars produce detailed, velocity structures of storms and have been used in wind shear efforts in the past.

Huntsville prior to commissioning. Five systems had been delivered as of June 15, 1989. Plans call for shipment at a rate of 3 per month for the remainder of the contract.

Information on the Terminal Doppler Weather Radar

In 1986, FAA added the Terminal Doppler Weather Radar (TDWR) project to the National Airspace System (NAS) Plan in response to overwhelming scientific evidence that low-altitude wind shear had caused several major air carrier accidents. The program is designed to develop a reliable automated system for detecting low-altitude wind shear in airport terminal areas. The system will be used to provide warnings to help pilots avoid or prepare for these events on approach and departure. In addition, TDWR will provide alerts of other hazardous weather conditions in the terminal area and provide advance notice of changing wind conditions in order to permit timely change of active runways.

TDWR Products

Although microburst detection is the primary concern of TDWR research and development, other weather information is also of interest. Additional TDWR products offered during operational tests were gust front detection,[1] wind shift prediction, and precipitation information. Preliminary TDWR testing indicated that aircraft operational efficiency would benefit substantially if air traffic control supervisors could receive advance warning of wind shifts—caused by gust fronts—that would result in a change in runway operations.

System Status and Development Plans

In the summer of 1988, operational testing at Denver of a TDWR prototype demonstrated to FAA that the system's overall microburst detection rate met its requirements. On the basis of that demonstration, FAA proceeded with procurement of the initial 47 systems.

FAA awarded the TDWR production contract to Raytheon in November 1988. The contract provides an option for an additional 55 TDWRs, increasing the total to 102 systems. The first production system is planned for delivery to the FAA Technical Center in late 1991 for testing. An operational system is scheduled to be delivered in late 1992. Subsequent TDWRs are planned for delivery at the rate of three per month beginning in early 1993.

TDWR testing will continue this summer at Kansas City, Missouri, although FAA believes that all testing needed to justify initial deployment has been completed. Further testing is intended to determine any environmental and climatological effects on the radar, and also to allow controllers to gain experience using the system.

[1] A gust front is the leading edge of cold air outflow from a thunderstorm. Wind shear and turbulence along the gust front are potentially hazardous to landing or departing aircraft.

Future TDWR development is planned to include technical improvements such as predicting microburst strength and detecting weaker gust fronts. FAA also plans to improve flight crew training in response to microburst alerts and the effectiveness of information transfer to controllers and pilots from the system.

Information on the Aeronautical Data Link System and Services

The Aeronautical Data Link is planned to provide pilots with direct access to weather services and other flight services, thereby reducing the burden on air traffic controllers and flight service specialists. Twenty-four data link systems will be installed, including systems at 22 Air Route Traffic Control Centers, 1 at the FAA Aeronautical Center for training, and 1 at the FAA Technical Center for development and testing.

Data Link Component Systems

To provide initial weather services, data link depends on the integration of interdependent subsystems (see fig. III.1). The data link processor is the central component of the data link system. It will interface with Mode S sensors to receive requests for weather services from pilots and route responses for transmission. In order to respond promptly to pilot requests, the data link processor will maintain its own database made up of weather products received from the Weather Message Switching Center, an existing system that disseminates information to flight centers and towers across the country.

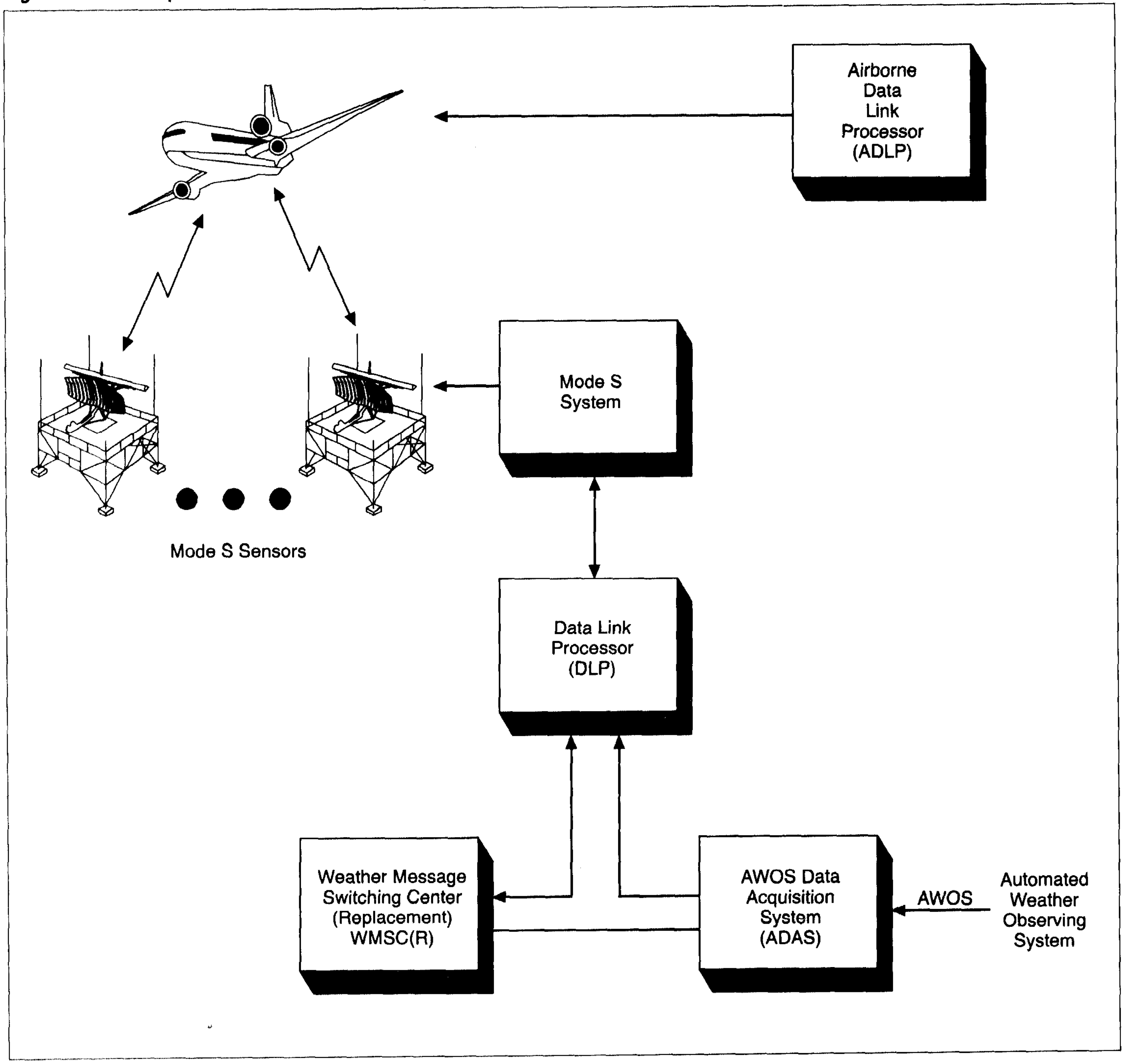
Mode S is planned to provide a communications channel between aircraft and ground systems. It will replace the current Air Traffic Control Radar Beacon System at most terminal and en-route surveillance sites and also perform aircraft surveillance functions. On board the aircraft, the airborne data link processor will enable the pilot to communicate with the ground via Mode S.

Data Link Integration and Interdependence

Initial weather services availability depends on the development and deployment of data link component systems. Each site must have all component systems on-line and properly integrated to have a functioning data link system. Similarly, improvements to the initial weather services depend on the availability of future systems, such as the Weather Message Switching Center Replacement and the Automated Weather Observing System's Data Acquisition System.[1] The future enhanced services will only be available when Terminal Doppler Weather Radar and other systems are operational and properly integrated with the data link processor.

[1] The Automated Weather Observing System obtains weather data via sensors and processes the data for dissemination. Its Data Acquisition System will function as a message concentrator for the sensors.

Figure III.1: Interdependencies of Data Link Component Systems



A smooth integration of complex data link component systems poses a significant challenge to FAA, directly impacting the availability of initial weather services. FAA's data link test plans state the need for adequate integration between Mode S and the data link processor, noting that these systems are intimately related and neither system can be adequately tested and evaluated without reference to the other. Because of delays in Mode S, testing of the data link processor will continue with simulators for the Mode S. After data link processors are installed at field locations, FAA will conduct a separate integration test with the processor and an actual Mode S system at its Technical Center in Pomona, New Jersey.

The development of data link component systems is interdependent (see table III.1 for the implementation schedule for data link component systems). For example, the data link processor requires at least one Mode S sensor to provide data link services, and this creates schedule interdependencies and relationships between the two projects. If the Mode S schedule changes, the data link processor schedule is re-evaluated for impacts on implementation. The data link processor and Mode S programs have been beset by delays primarily due to delays by the Mode S contractor in completing the detailed system design and in ensuring adequate system capacity.

Table III.1: Data Link Component Systems Schedule

	First on-site implementation date	
System[a]	**1988 NAS Plan**	**1989 NAS Plan**
Data Link Processor	12/90	3/93
Mode S	9/90	12/92
Weather Message Switching Center Replacement	5/92	12/92
Automated Weather Observing System Data Acquisition System	10/91	10/91
National Airspace Data Interchange Network	1/93	1/93
Terminal Doppler Weather Radar	6/93	6/93

[a]The data link processor and Mode S are needed to provide the initial weather services. The other component systems will support improvements and enhancements to the initial messages.

Descriptions of Initial Weather Services

Table III.2 lists descriptions of the six initial weather services FAA chose from a list of 38 candidate services. These services are meant to enhance safety, benefit users, or improve productivity. FAA chose these services for both apparent utility and compatibility with present-day operations. In addition, FAA believes these services will establish the credibility of data link and encourage airlines and general aviation pilots to voluntarily install data link equipment.

Table III.2: Initial Data Link Weather Services

Services	Descriptions
Surface Observations	Evaluations of one or more meteorological elements that describe the state of the atmosphere at the location where the observation is taken.
Pilot Weather Reports	Reports of weather conditions observed by pilots in-flight.
Terminal Forecasts	Twenty-four hour forecasts of surface weather conditions within the immediate vicinity of airports.
Winds and Temperatures Aloft Forecasts	Forecasts for over 130 specific locations in the contiguous United States.
Radar Summaries	Low-resolution graphic representations of precipitation intensities using characters.
Hazardous Weather Advisories	In-flight advisories, issued by the National Aviation Weather Advisory Unit to warn en-route aircraft of the development of potentially hazardous weather conditions.

Improvements to the Initial Weather Services

FAA plans to add new systems and upgrade data link component systems in order to improve initial weather services. The Weather Message Switching Center Replacement will provide all the weather services provided by the Weather Message Switching Center but with added graphics capabilities through state-of-the-art technology. The Automated Weather Observing System's Data Acquisition System will provide minute-by-minute surface observation data rather than the initial hourly updates. The addition of the National Airspace Data Interchange Network communication system[2] will increase capacity, flexibility, and service availability for data link.

Enhanced Data Link Services

After the initial weather services are in place, FAA plans to add enhancements. For example, wind shear alerts will be part of the enhanced weather services. Additionally, FAA plans to add air traffic control functions. Table III.3 describes the enhanced data link services currently planned by FAA.

[2]The National Airspace Data Interchange Network is an FAA communications system planned to provide greater capability to transfer messages and at a faster speed.

Table III.3: Enhanced Data Link Services

Services	Descriptions
Transfer of Communications	Delivers a computer-generated message which informs the pilot which radio frequency is needed to contact the receiving controller. The service may be initiated either automatically or manually by the controller making a specific keyboard input.
Altitude Assignment Confirmation	Delivers a computer-generated altitude assignment message to the pilot, which confirms the controller voice assignment. The data link message would automatically be generated when the altitude information is entered into the air traffic control computer.
Menu Text/Free Text	Permits a controller to pre-store air traffic control instructions he desires to send to multiple aircraft. The free text service would allow the controller to enter any desired text that would then be sent to the specific aircraft desired.
Automatic Terminal Information Service	Transmits weather and airport conditions to pilots. The DLP will receive these new reports every hour. A pilot would enter a request, via data link, for the service and the DLP will return the current report for the requested location.
Wind Shear Alerts	Generates alphanumeric wind shear alert messages from the Terminal Doppler Weather Radar and sends them to the DLP which will maintain a database of all current wind shear alerts. When a wind shear alert is received, the DLP will automatically generate a data link message to all aircraft that had previously requested weather advisory information for that airport.
Notices to Airmen	Maintains a national database of recently issued Notices to Airmen, received from the Weather Message Switching Center Replacement. Notices to Airmen include such information as airport and runway closures and changes in the status of navigational aids. A pilot would request these messages via data link and the DLP would generate the response message.
Center Weather Advisories	Stores the current Center Weather Advisories as received from the Weather Message Switching Center Replacement. These messages would be provided in response to a request for hazardous weather advisories.

Objectives, Scope, and Methodology

On August 10, 1988, Chairman Robert Roe of the House Committee on Science, Space, and Technology asked us to provide information on FAA's progress in disseminating hazardous weather data from three new weather-related systems: (1) the ASR-9, (2) the TDWR, and (3) the Aeronautical Data Link. In subsequent discussions with the Chairman's office, we agreed to

- describe FAA's progress in preparing the operational procedures needed to transmit hazardous weather information from controllers to pilots for the ASR-9 and the TDWR and
- assess the status and availability of weather services FAA intends to provide through the Aeronautical Data Link.

To determine the status and issues concerning the development of operational procedures for the ASR-9, we interviewed officials in FAA's air traffic organization, as well as the program manager. We also met with officials from the Lincoln Laboratories, which was tasked by FAA with evaluating the performance of the ASR-9 weather channel and providing input to the agency on developing operational procedures.

We addressed the same objective for the TDWR through discussions with FAA's program office and reviewed test plans and other program documents. We also attended a meeting of the TDWR user group in Boulder, Colorado. We discussed the results of the initial operational tests and alternative operational procedures with the members of that group, including representatives from FAA, the National Center for Atmospheric Research, and aviation user groups. We also reviewed United Airlines' evaluation of the initial operational tests performed at Denver in 1988.

To review the status of the data link program, we met with the program manager as well as representatives from FAA's Systems Engineering and Integration Contractor for the NAS Plan. We also reviewed test plans and other relevant program documents. Additionally, we discussed the use of simulations in testing, as well as proposed improvements and enhancements to initial data link services, with officials at FAA's Technical Center in Pomona, New Jersey. We also discussed the status of the Mode S with the program manager for that system.

Our review was conducted between August 1988 and July 1989 in accordance with generally accepted government auditing standards.

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