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WEATHER SERVICE MODERNIZATION

Risks Remain That Full Systems Potential Will Not Be Achieved

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Mr. Chairman and Members of the Subcommittee:

We are pleased to be here today to discuss the National Weather Service's (NWS) systems modernization program. At an estimated cost of about $4.5 billion, it is one of the largest modernization programs in the federal government. The modernization is vital to the Weather Service's plans for improving operations; at the same time, it is intended to help NWS streamline and downsize its organization, and is an effort that we continue to endorse. As with most large systems-development projects, however, this program faces persistent challenges that must be overcome if the considerable anticipated benefits of full modernization are to be realized. Our concerns led us to place the Weather Service effort on our 1995 list of high-risk government programs, where it remains today.[1]

The work of the National Weather Service is critically important to all Americans, as the United States experiences considerable severe weather. In a typical year, the United States is pummeled by about 10,000 violent thunderstorms; 5,000 floods; 1,000 tornadoes; and several hurricanes. As we have seen in recent months, unpredictable weather can wreak havoc in people's lives; sometimes the difference between tragedy and recoverable loss lies in the ability of early forecasts and warnings of potentially dangerous weather to help protect life and property.

Background

NWS uses a variety of systems and manual processes to collect, process, and disseminate weather data to and among its network of field offices and regional and national centers. Prior to the modernization, these systems and processes were largely outdated. Radar equipment dated back to the 1950s, and much of the current information processing, display, and data communications system has been in use since the 1970s.

To enhance its ability to deliver weather services, NWS determined some 15 years ago to use the power of technology to "do more with less." To reach the goal of better forecasting and earlier warnings with a smaller, downsized operation, the Weather Service has been acquiring new observing systems—including radars, satellites, and ground-based sensors—as well as powerful forecaster workstations. The goals of the modernization were to (1) achieve more uniform weather services nationwide, (2) improve forecasting, (3) provide more reliable detection and prediction of severe weather and flooding, (4) permit more

[1]High-Risk Series: An Overview (GAO/HR-95-1, February 1995) and High-Risk Series: Information Management and Technology (GAO/HR-97-9, February 1997).

cost-effective operations, and (5) achieve higher productivity. The modernization includes four major systems-development programs, which I will briefly describe.

The Advanced Weather Interactive Processing System (AWIPS)

This program integrates, for the first time, satellite, radar, and other data to support weather forecaster decision-making and communications; it is the linchpin of the NWS modernization. Operating under a $550-million funding cap, the system is expected to be fully deployed in 1999. AWIPS development systems have been delivered to 16 locations nationwide; this represents the first two of six modules, or "builds." AWIPS is planned for a total of 152 locations once fully deployed.

The Next Generation Geostationary Operational Environmental Satellite (GOES-Next)

This is a program to acquire, launch, and control five satellites for identifying and tracking severe weather events, such as hurricanes. The first satellite was launched in 1994, and the second in 1995. Three more satellites are planned for launch between now and 2002. The total cost for these five satellites is estimated to be just under $2 billion.

The Next Generation Weather Radar (NEXRAD)

This is a program to acquire 163 Doppler radars.[2] Largely deployed, these radars have helped NWS increase the accuracy and timeliness of warnings for severe thunderstorms, tornadoes, and other hazardous weather events. Scheduled for completion this year, 121 of a planned 123 NWS NEXRAD radars have been delivered to operational locations. The cost of this program is just under $1.5 billion.

The Automated Surface Observing System (ASOS)

This is a program to automate and enhance methods for collecting, processing, and displaying surface weather conditions, such as temperature and precipitation, and to replace human weather observers. Scheduled for completion in fiscal year 1998, the system has been installed at 265 of 314 planned NWS operational locations. Estimated costs for ASOS are about $351 million; this includes the NWS units and 554 units for the Federal Aviation Administration and the Department of Defense.

The modernization also includes upgrades to existing systems, improved weather models, and the acquisition of several smaller systems. In addition, NWS is restructuring its field offices to be more efficient; table 1 indicates the before-and-after plan.

[2]This includes radars for NWS, the Air Force, and the Federal Aviation Administration.

Table 1: NWS Office Restructuring Plan

Pre-modernization	Future
52 Weather Service Forecast Offices 204 Weather Service Offices	119 Weather Forecast Offices[a]
3 National Centers	9 National Centers
13 River Forecast Centers	13 River Forecast Centers[a]

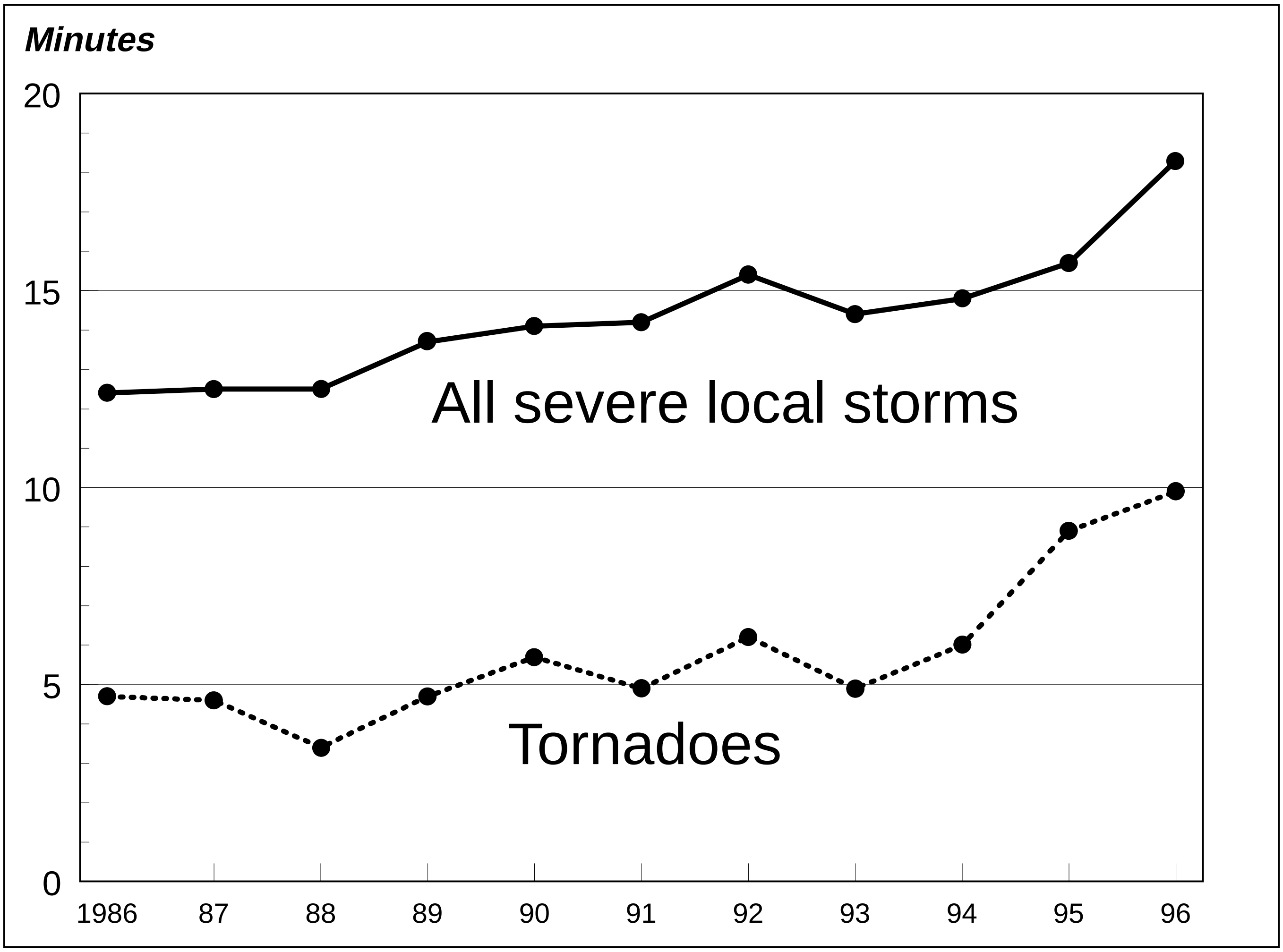
[a]These offices are to be co-located.

Source: NWS.

Important Successes Achieved, Yet Problems Have Hindered the Modernization

The Weather Service has generated better data—particularly with the new radars and satellites—and greatly improved forecasts and warnings. These can be related directly to saving lives and reducing the effects of natural disasters. As shown in figure 1, lead times of warnings for severe storms and tornadoes improved by about 5 minutes between 1986 and 1996, which is not insignificant. With tornadoes, for example, it can mean the difference in whether people have time to reach shelter. In some instances, lead times are much earlier. Last year, for instance, NWS issued flood potential “statements” 2-3 days in advance of Hurricane Fran. Flash flood warnings were issued with 6 hours’ lead time. Similarly, in the East Coast blizzard of 1996, NWS issued forecasts 3 to 5 days in advance.

Figure 1: NWS Warning Lead Time for Severe Local Storms, 1986-1996 (in Minutes)



Source: NWS.

Notwithstanding such successes, however, each of the four programs has experienced cost increases and schedule delays.[3] Some of these increases

[3]A list of related GAO reports and testimony on the NWS modernization, including its four primary components, appears at the end of this statement.

and delays can be attributed to changes in requirements; others were caused by program management and development problems.

We reported in 1995 that six of eight sensors in the ASOS system did not meet contract specifications for accuracy or performance. For example, the precipitation accumulation sensor underreported rainfall amounts during heavy downpours, and the temperature and dew point sensor readings frequently fell short of dew point reliability requirements. Some of these shortfalls occurred because of the contractor's failure to deliver products that met specifications, and others resulted from the failure of government-furnished equipment to meet specifications. In addition, we found that ASOS users from the aviation, meteorology, and climate communities had needs that the ASOS system, as specified, did not satisfy.

We recommended that NWS define and prioritize—in conjunction with ASOS users—all system corrections, enhancements, and supplements necessary to meet valid user needs. We further recommended that NWS formulate—again in conjunction with ASOS users—explicit system performance and cost/benefit criteria governing the release of human observers. Because of these problems, NWS delayed plans for releasing human weather observers and implemented actions to correct shortfalls in meeting specifications and to address other user concerns.

In reference to NEXRAD, we testified in 1995 that many NWS and Air Force radars were not available nearly as often as required. For example, between 10 and 62 percent of Air Force NEXRAD radars were falling short of availability requirements. (NWS did not know if its radars were meeting the availability requirement because it was not monitoring availability on a site-by-site basis.) Further, we found that a radar upgrade to address one cause of unavailability—the lack of an uninterruptible power supply—was not to be completed until fiscal years 1999 and 2002 for the Air Force and NWS, respectively.

We recommended that NWS analyze and monitor system availability data on a site-specific basis for operational NEXRADs and correct any shortfalls in system availability revealed by the analysis. We also recommended that the Air Force improve the reliability of Air Force NEXRAD availability data and correct any shortfalls found. NWS and the Air Force did initiate steps in 1995 to implement our recommendations to improve NEXRAD availability.

In terms of staffing, the sizable reductions promised as a result of the modernization will not be realized. While NWS originally planned to reduce staff by 21 percent, we reported in 1995 that the goal had been scaled back to 8 percent. NWS attributes the reduced goal primarily to the need for more staff than originally envisioned to operate new systems, and to other unanticipated requirements.

Remaining Risks

Mr. Chairman, the National Oceanic and Atmospheric Administration's (NOAA) ultimate success in completing the modernization depends, in part, on how well and how quickly it can complete a systems architecture[4] and address specific risks associated with the crucial AWIPS system. The modernization needs an overall architecture to guide systems development; NWS agrees that such a technical blueprint is necessary, and is currently working on one. Yet until such an architecture is developed and enforced, the modernization will likely continue to be subject to higher costs and reduced performance. This is an important point as component systems continue to evolve to meet additional demands and take advantage of improved technology. We cannot emphasize too strongly the need for an overall architecture to guide system evolution. An architecture would help ensure that changes to NEXRAD, for example, are compatible with the many systems with which NEXRAD must exchange data.

As we have reported several times over the past few years, *full* utilization of the data from the new observing systems has been prevented by delays and continuing problems with AWIPS. We have made several recommendations that we feel will strengthen the Weather Service's ability to acquire AWIPS. First, we recommended that NWS ensure that each "build" is fully tested and all material defects corrected before beginning software development associated with the next build. Second, we recommended that NWS establish a software quality assurance program to increase the probability of delivering promised AWIPS capability on time and within budget. Third, we recommended that NWS obtain an independent assessment of the cost to develop and deploy AWIPS.

[4] A systems architecture is a blueprint to guide and constrain the development and evolution (i.e., maintenance) of a collection of related systems; it can be viewed as having both logical and technical components. At the *logical* level, the architecture provides a high-level description of the organizational mission being accomplished, the business functions being performed and the relationships among functions, the information needed to perform the functions, and the flow of information among functions. At the *technical* level, the architecture provides the rules and standards needed to ensure that the interrelated systems are built to be interoperable, portable, and maintainable. These include specifications of critical aspects of the component systems' hardware, software, communications, data, security, and performance characteristics.

Progress to date in these areas has, however, been uneven, and we remain concerned about AWIPS development risks—risks that threaten the system's ability to be completed on time, within budget, and with the functional capability that AWIPS must be able to provide. Until AWIPS is deployed and functioning properly, NWS will not be able to take full advantage of the nearly $4 billion investment it has made in the other components of the modernization.

After early successes in demonstrating the technical feasibility of system functions, design problems and disagreements between NOAA and the development contractor in 1993-1994 stymied progress. Some development responsibility was brought in-house—to NWS/NOAA labs—in 1995. The AWIPS program strategy was changed again in 1996, when even more development responsibility—for AWIPS data acceptance, processing, and display capabilities—was brought in-house, primarily to NOAA's Forecast Systems Laboratory (FSL). At that time, NWS decided to use FSL's prototype system, called Weather Forecast Office (WFO)-Advanced, which was being developed in parallel with AWIPS as a risk-reduction tactic.

NWS officials chose WFO-Advanced because of its demonstrated superior data-acceptance, processing, and display capability over the contractor's version, hoping that it would enable the agency to deploy these AWIPS capabilities to field operations more quickly. The contractor did, however, retain responsibility for communications, system monitoring and control, and other capabilities. With these changes, NWS expects AWIPS to make its 1999 target date for full deployment, within the $550-million cap.

As we reported in December 1994, NOAA/NWS labs are research and development operations that primarily develop prototype systems; as such, they did not employ software development processes characteristic of a software-production environment. Specifically, the labs did not have the software quality assurance and configuration management processes, among others, sufficient to ensure production of stable, reliable software code.[5] Developing software code for use in one or two prototype installations requires a far less rigorous approach than what is needed when nationwide deployment is planned. However, some of the software the NOAA/NWS labs were developing was intended for operational use in

[5]*Software quality assurance* refers to a program that independently (1) monitors whether the software and the processes used to develop it fully satisfy established standards and procedures and (2) ensures that any deficiencies in the software product, process, or their associated standards are swiftly brought to management's attention. *Software configuration management* refers to a process by which changes to software products are controlled. It includes identification of products to be controlled, accounting for changes to these products, and reporting on the products' status.

AWIPS and was essentially being handed off directly from the labs to the contractor. We therefore recommended that NWS and NOAA strengthen their processes for developing production-quality software code.

With the 1995 and 1996 AWIPS development changes, significantly more design and development responsibility has been transferred to the government, in particular to NOAA's FSL. In visiting FSL in Boulder, Colorado, we found that—with the exception of one subsystem that we specifically discussed in 1994—the question of capability remained: lab quality assurance and configuration management processes for production-level software were still lacking. However, NWS and NOAA officials said that they have heeded our 1994 recommendations and are improving their processes in other ways. They said that in order to preserve the labs' research and development missions, they do not wish to impose any unnecessary, rigorous software development procedures on the labs. Instead, NOAA management plans to play a more active role in preparing the government-furnished software for the contractor.

According to NWS officials, they plan to improve the software development processes for WFO-Advanced and other government-developed software using staff from NWS headquarters, NOAA's systems acquisitions division, and the contractor. Specifically, NWS plans to (1) more fully document the lab's design and software code, (2) design the integration of government-furnished software and contractor-developed software, (3) fully test all government software before it is turned over to the contractor, and (4) strengthen quality assurance and configuration management. To help accomplish this, NWS has established several specific contract task orders.

Weather Service officials acknowledge that preparing WFO-Advanced for the contractor is a large task because it comprises such a significant portion of the AWIPS software. In addition, officials understand that there is no room for schedule delays due to unforeseen problems. They feel confident, however, that they can meet this challenge because of the steps I have just described, and because they have experience in turning government software over to a contractor. For example, NWS' Office of Hydrology provided hydro-meteorological software to the contractor for the first AWIPS module ("build 1"), which was successfully tested last summer. In addition, NWS officials said that they are applying to AWIPS lessons learned from their configuration management experiences in the NEXRAD and ASOS development projects.

NOAA has put into place appropriate plans and procedures to mitigate these risks; how it implements these plans and procedures will be critical if NOAA is to avoid turning the risks into actual problems. Unfortunately, systems development risks in large projects such as AWIPS frequently do turn into problems. And, as discussed, AWIPS has suffered development setbacks in the past. Given these circumstances, we believe it will be extremely difficult for NOAA and NWS to develop and deploy the AWIPS system within the $550-million cap.

What can be done to minimize such risks? First, NOAA and NWS management need to be vigilant to identify new problems with AWIPS software development. New software and WFO-Advanced must be fully tested to ensure that they are up to production quality and will not cause complications when integrated with other AWIPS software. Second, we believe that NOAA needs to renegotiate as quickly as possible the contract for AWIPS builds 4 through 6. While NOAA officials expect no major cost or schedule changes, this is not a guarantee; NOAA must exercise close oversight of this process.

Geostationary Operational Environmental Satellite (GOES)

Another important element of the Weather Service modernization is the acquisition of geostationary operational environmental satellites (GOES). These satellites are uniquely positioned to be able to observe the development of severe weather, such as hurricanes and thunderstorms, and provide information allowing forecasters to issue timely warnings. Satellites in the current series will, however, begin to reach the end of their useful lives within 5 years; NOAA is now planning to procure replacements, which will be very similar to the current satellites. At issue, Mr. Chairman, is the type of satellite system to build for the longer term, especially in light of NOAA's budget, which is likely to remain constrained in the immediate years ahead. Our report on both short- and long-term satellite replacements was released last month.[6]

In brief, we found NOAA's approach for the near term reasonable, although we recommended that the agency clarify its policy for replacing partially failed satellites and backing up planned launches. For the longer term, we concluded that changing the GOES system design offers many potential benefits: improved performance, lower costs, and more closely meeting the needs of forecasters.

[6] Weather Satellites: Planning for the Geostationary Satellite Program Needs More Attention (GAO/AIMD-97-37, March 13, 1997).

Several new approaches have been suggested in recent years, by government, academic, and industry experts; many include technologies unavailable when the present series of satellites was designed. These approaches have pros and cons; all options would require careful engineering analysis before an informed decision about the future of the GOES program can be made.

Our concern centers on NOAA's delay in conducting such analyses and developing specific proposals. At present, NOAA anticipates beginning its follow-up program in 2003 at the earliest. Given that developing a new satellite takes up to 10 years, deferring a start until 2003 likely means that NOAA will have to rely on its current, early-1980s-design satellites until about 2013.

Mr. Chairman, given the range of options that exist for a significantly improved GOES system, the Congress may wish to evaluate the costs and benefits of different approaches to the timing, funding, and scope of the follow-up program. This could include a potential role for the National Aeronautics and Space Administration's advanced spacecraft technology programs.

In summary, we see clear benefits in the National Weather Service modernization—improved forecasts and warnings. We also see risks—risks that can only be reduced through development and enforcement of a systems modernization architecture, careful implementation of planned mitigation techniques in the case of AWIPS, and commitment to earlier planning in the case of the GOES satellites.

This concludes my statement, Mr. Chairman. I would be happy to respond to any questions you or other Members of the Subcommittee may have at this time.

Related GAO Products

National Oceanic and Atmospheric Administration: Weather Service Modernization and NOAA Corps Issues (GAO/T-AIMD/GGD-97-63, March 13, 1997).

Weather Satellites: Planning for the Geostationary Operational Environmental Satellite Program Needs More Attention (GAO/AIMD-97-37, March 13, 1997).

High-Risk Series: Information Management and Technology (GAO/HR-97-9, February 1997).

NOAA Satellites (GAO/AIMD-96-141R, September 13, 1996).

Weather Forecasting: Recommendations to Address New Weather Processing System Development Risks (GAO/AIMD-96-74, May 13, 1996).

Weather Forecasting: NWS Has Not Demonstrated that New Processing System Will Improve Mission Effectiveness (GAO/AIMD-96-29, February 29, 1996).

Weather Forecasting: New Processing System Faces Uncertainties and Risks (GAO/T-AIMD-96-47, February 29, 1996).

Weather Forecasting: Radars Far Superior to Predecessors, but Location and Availability Questions Remain (GAO/T-AIMD-96-2, October 17, 1995).

Weather Service Modernization Staffing (GAO/AIMD-95-239R, September 26, 1995).

Weather Forecasting: Radar Availability Requirements Not Being Met (GAO/AIMD-95-132, May 31, 1995).

Weather Forecasting: Unmet Needs and Unknown Costs Warrant Reassessment of Observing System Plans (GAO/AIMD-95-81, April 21, 1995).

Weather Service Modernization Questions (GAO/AIMD-95-106R, March 10, 1995).

Weather Service Modernization: Despite Progress, Significant Problems and Risks Remain (GAO/T-AIMD-95-87, February 21, 1995).

Meteorological Satellites (GAO/NSIAD-95-87R, February 6, 1995).

High-Risk Series: An Overview (GAO/HR-95-1, February 1995).

Weather Forecasting: Improvements Needed in Laboratory Software Development Processes (GAO/AIMD-95-24, December 14, 1994).

Weather Forecasting: Systems Architecture Needed for National Weather Service Modernization (GAO/AIMD-94-28, March 11, 1994).

Weather Forecasting: Important Issues on Automated Weather Processing System Need Resolution (GAO/IMTEC-93-12BR, January 6, 1993).

Weather Satellites: Action Needed To Resolve Status of the U.S. Geostationary Satellite Program (GAO/NSIAD-91-252, July 24, 1991).

Weather Satellites: Cost Growth and Development Delays Jeopardize U.S. Forecasting Ability (GAO/NSIAD-89-169, June 30, 1989).

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