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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

National Weather Service Modernization and Weather Satellite Program

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Mr. Chairman and Members of the Subcommittee:

We appreciate the opportunity to join in today's hearing to discuss our work in two areas that are the responsibility of the National Oceanic and Atmospheric Administration (NOAA). At your request, we will discuss the status of the National Weather Service (NWS) systems modernization and the National Environmental Satellite, Data, and Information Service's Geostationary Operational Environmental Satellite (GOES) program.

In brief, although NWS is nearing completion of its systems modernization effort, it still faces important challenges. During the coming year, NWS plans to finish commissioning[1] the Advanced Weather Interactive Processing System (AWIPS), the final system of the modernization. At the same time, NWS is developing additional AWIPS system capabilities to be implemented in the future. According to NWS, these additional capabilities are needed for AWIPS to improve radar and satellite data processing and to provide weather forecasters with a full range of interactive forecasting techniques. The agency is also developing a systems architecture to provide a blueprint for future systems acquisitions.

Regarding the GOES program, NOAA continues to deploy weather satellites to ensure adequate satellite coverage. However, because of unexpected problems, satellite coverage is currently at risk and will remain so until a new satellite is successfully launched. NOAA plans to launch the new satellite in May 2000. To ensure continued satellite coverage beyond the current satellite series, NOAA is planning for the program's near- and long-term future. The approach we used to perform this work—our objectives, scope, and methodology—are provided in appendix I.

National Weather Service Modernization

In the 1980s, NWS began a nationwide modernization program to upgrade weather observing systems such as satellites and radars, to design and develop advanced computer workstations for forecasters, and to reorganize its field office structure. The goals of the modernization were to achieve more uniform weather services across the nation, improve forecasting, provide more reliable detection and prediction of severe weather and flooding, permit more cost-effective operations through staff and office reductions, and achieve higher productivity.

[1]Commissioning involves performing a series of tests on a system with the goal of certifying that the system can be used in an official capacity.

The modernization includes five major system development programs which, when combined with NWS' new facilities and restructuring activities, are expected to cost about $4.5 billion. I would like to briefly describe each of the five major systems development programs.

Next Generation Weather Radar (NEXRAD). This program acquired, deployed, and commissioned 125 Doppler radars at NWS sites by 1996. NWS reported that the cost of this program was about $800 million.[2] These radar systems have helped NWS increase the accuracy and timeliness of warnings for severe thunderstorms, tornadoes, and other hazardous weather events. More recently, NWS initiated product improvements, including moving NEXRAD from a proprietary to an open systems architecture.[3]

Automated Surface Observing System (ASOS). This program acquired systems to collect, process, display, and transmit surface weather conditions, such as temperature and precipitation. NWS began deploying this system to 314 locations in 1992, and to date has commissioned all but one of them.[4] Additionally, NWS has been working on system improvements—such as enhancing the measurement of frozen precipitation. NWS reported that the cost of its ASOS program was approximately $150 million.[5]

Advanced Weather Interactive Processing System (AWIPS). This program is to acquire systems to integrate—for the first time—satellite, radar, and other data to support weather forecaster decisionmaking and communications. Originally planned to be developed incrementally in a series of six "builds," AWIPS was deployed in June 1999 after the fourth build—with less than the full functionality AWIPS was planned to provide—at 152 locations, at a cost of $539 million. In January 2000, NWS started commissioning these systems, and expects to complete this process by the end of August 2000.[6] Thereafter, NWS plans to

[2]NWS also managed the procurement of NEXRAD radar systems for the Air Force and the Federal Aviation Administration (FAA). The total cost of the program–including 125 NWS, 29 Air Force, and 12 FAA radars–was approximately $1.4 billion.

[3]An open systems architecture emphasizes commercially supported products based on publicly available specifications and standards, instead of vendor specific ones.

[4]NWS has not yet commissioned ASOS at Johnston Island in the Pacific Ocean, due to problems with the communications system on the island. Program officials now plan to commission this system in May 2000.

[5]NWS also managed the procurement of 678 ASOS units for FAA and the Department of Defense. The estimated cost of the total ASOS program was about $350 million.

[6]NWS plans to commission AWIPS units in 139 locations. The remaining AWIPS units are located in non-operating sites—such as test beds and training facilities—and so will not be commissioned.

decommission the system that AWIPS replaces, the Automation of Field Operations and Services system. AWIPS is discussed in more detail later in this testimony.

Central computer upgrades. NWS has historically relied on advanced computers to run numerical models of the atmosphere. Such models are used to support weather analyses, warnings, and forecasts. When NWS began planning its modernization, it determined that existing "class VI"[7] computers did not possess sufficient capacity to allow improvements in warnings and forecasts, and therefore included in the modernization a program to upgrade its processing capability to class VII computers. This program is now complete, and NWS reported that the program cost $106 million through fiscal year 1999. Looking to the future of the program, in October 1998 NWS awarded a $35.6 million contract to lease a new, high-performance supercomputer—a class VIII—to run its environmental models from 1999 through 2002. The agency does not consider this new undertaking as part of its official modernization.

Next Generation Geostationary Operational Environmental Satellite (GOES-Next). NOAA's original series of GOES satellites began identifying and tracking severe weather events, such as hurricanes, in 1975. Because this series was approaching the end of its useful life when NWS began planning its modernization, the agency included NOAA's program to develop a new series of satellites, called GOES-Next, in the modernization. GOES-Next is a program to acquire, launch, and control five geostationary satellites—designated GOES-I through GOES-M.[8] NOAA estimates that this program will cost about $2 billion. The first satellite under this series was launched in 1994, and the last two are scheduled to be launched in May 2000 and July 2001, respectively. NOAA is currently planning the next series of GOES satellites, discussed in more detail later in this testimony.

In 1995, we designated the NWS modernization a high-risk information technology investment because of its estimated cost, its complexity, its criticality to NWS' mission of helping to protect life and property through early forecasting and warnings of potentially dangerous weather, and its past problems—documented in several of our reports.[9] Our 1997 high-risk series reported that although the development and deployment of the

[7]According to NWS, a "class VI" computer represents the sixth generation of high-speed computers, with each generation representing a substantial increase in computational power over the prior generation.

[8]Weather satellites are given alphabetic designations until they are launched; they are then assigned numbers in the series. For example, after it was launched, the name GOES-J was changed to GOES-9.

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

major systems making up the modernization were nearing completion, unresolved issues remained.[10] For example, NEXRAD radars were not always up and running when severe weather threatened, and ASOS fell short of user expectations.

We recommended that NWS correct these shortfalls, and the agency has made progress in addressing them. NWS has since reported that despite specific performance problems, its new radars and satellites have enabled it to generate better data and greatly improved forecasts and warnings. For example, before the modernization, two California counties experienced 18 flash flood events between January 1992 and December 1994. No advance warnings were issued for any of these events. However, after the installation of modernization equipment, these two counties received advance warning for 17 out of 22 reported flash floods that occurred between January 1995 and February 1998. The average warning lead time for these events was over 2 hours.

Such success notwithstanding, areas of concern remain. Most recently, our 1999 high-risk series reported that although NWS was nearing completion of its modernization, we continued to view the modernization as a high-risk area for two primary reasons: (1) NWS still needed to deliver on the final piece of the modernization—AWIPS, and (2) NWS lacked an overall architecture to guide future systems development.[11] At this point, I would like to discuss these issues in more detail.

After Years of Cost Increases and Delays, a Version of AWIPS Has Been Deployed but Further Upgrades Are Planned

Over the last several years, AWIPS—the linchpin of NWS' modernization—has encountered cost overruns and schedule delays. In 1995, NWS estimated that the cost to develop AWIPS was $525 million, and that it would be fully deployed by 1999. In 1996, we pointed out the inaccuracy of this estimate due to the omission of several cost factors, including known contract increases.[12] The Department of Commerce later committed to a $550-million funding cap. However, we testified in April 1997 that costs were likely to exceed even this amount, given the size and complexity of the system's development.[13] In response to our recommendation, the

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

[11] *High-Risk Series: An Update* (GAO/HR-99-1, January 1999).

[12] *Weather Service Forecasting: Recommendations to Address New Weather Processing System Development Risks* (GAO/AIMD-96-74, May 13, 1996) and *Weather Forecasting: New Processing System Faces Uncertainties and Risks* (GAO/T-AIMD-96-47, February 29, 1996).

[13] *Weather Service Modernization: Risks Remain That Full Systems Potential Will Not Be Achieved* (GAO/T-AIMD-97-85, April 24, 1997).

department contracted for an independent cost estimate of AWIPS. The resulting February 1998 assessment reported that the likely cost to complete AWIPS through its final build—build six—was $618 million. In March 1998, we reported that although AWIPS was planned for full deployment through build six in 1999, this schedule was in doubt. When we testified early last year, NWS planned to deploy AWIPS' fourth build—actually build 4.2—by June 1999, within the $550 million cap. At that time, completion dates for builds five and six were uncertain.

AWIPS has now been deployed—with less than full functionality—to NWS field sites. In June 1999, NWS completed deployment of build 4.2 to 152 sites, and subsequently issued additional software releases to correct isolated problems—at a total reported cost of $539 million. Subsequently, the agency began commissioning these systems in January 2000, and plans to commission the final site by the end of August 2000. As of March 15, 2000, NWS reported that 25 AWIPS sites had been commissioned. Agency officials stated that AWIPS' fourth build provides immediate benefits—including improved forecasts and warnings and a reduction in staff. However, they acknowledge that build four provides less than the full functionality that AWIPS was planned to provide. For example, it does not provide weather forecasters with a full range of interactive forecast preparation techniques, such as allowing forecasters to enter human weather observations into radar-based warning tools.

To provide additional functionality, NWS is now designing and developing a fifth AWIPS build. This build is to provide radar and infrastructure enhancements that will allow more efficient, improved forecasts and a further reduction in staff. An August 1998 independent review team report noted that build five's requirements were essential to NWS' core mission because they will allow forecasters to assimilate critical radar and satellite data, and will ensure that weather forecasting offices can back each other up during catastrophic outages. The review team estimated that the cost to complete build five would range from an additional $20 to $25 million. NWS plans to deploy build five capabilities in three separate releases—builds 5.0, 5.1, and 5.2—beginning in January 2001, November 2001, and September 2002, respectively.

As for build six, in accordance with the independent review team's recommendation that the build not proceed until its requirements are better defined, NWS has deferred its plans. NWS officials report that the agency will submit requirements and funding needs for additional capabilities when they have been determined.

NWS Is Now Developing an Overall Systems Architecture

A systems architecture, or overall blueprint, is widely recognized as an essential tool for guiding effective and efficient systems development and evolution. We initially reported in 1994 that the NWS modernization needed such an architecture.[14] This lack of a systems architecture had led to incompatibilities among component systems' communications protocols and application languages, and resulted in more difficulty and expense to maintain these systems. Even now, as NWS is completing its modernization, an overall architecture is important because component systems will continue to evolve to meet additional demands and to take advantage of improved technology. Without an architecture, NWS' modernization is likely to continue to experience higher costs and reduced performance.

NWS initially agreed with our recommendation to develop a systems architecture and, in April 1997, issued a plan for developing and using one. However, the agency did not meet any of the target dates in the plan, partially due to lack of management attention.

This problem has since been remedied. As we testified last year, the assistant administrator for weather services stated that NWS planned to intensify its efforts to develop a systems architecture.[15] Subsequently, NWS assembled a systems architecture team to develop its portion of NOAA's information technology architecture. NWS officials estimate that the first version of this architecture will be issued by the end of September 2000.

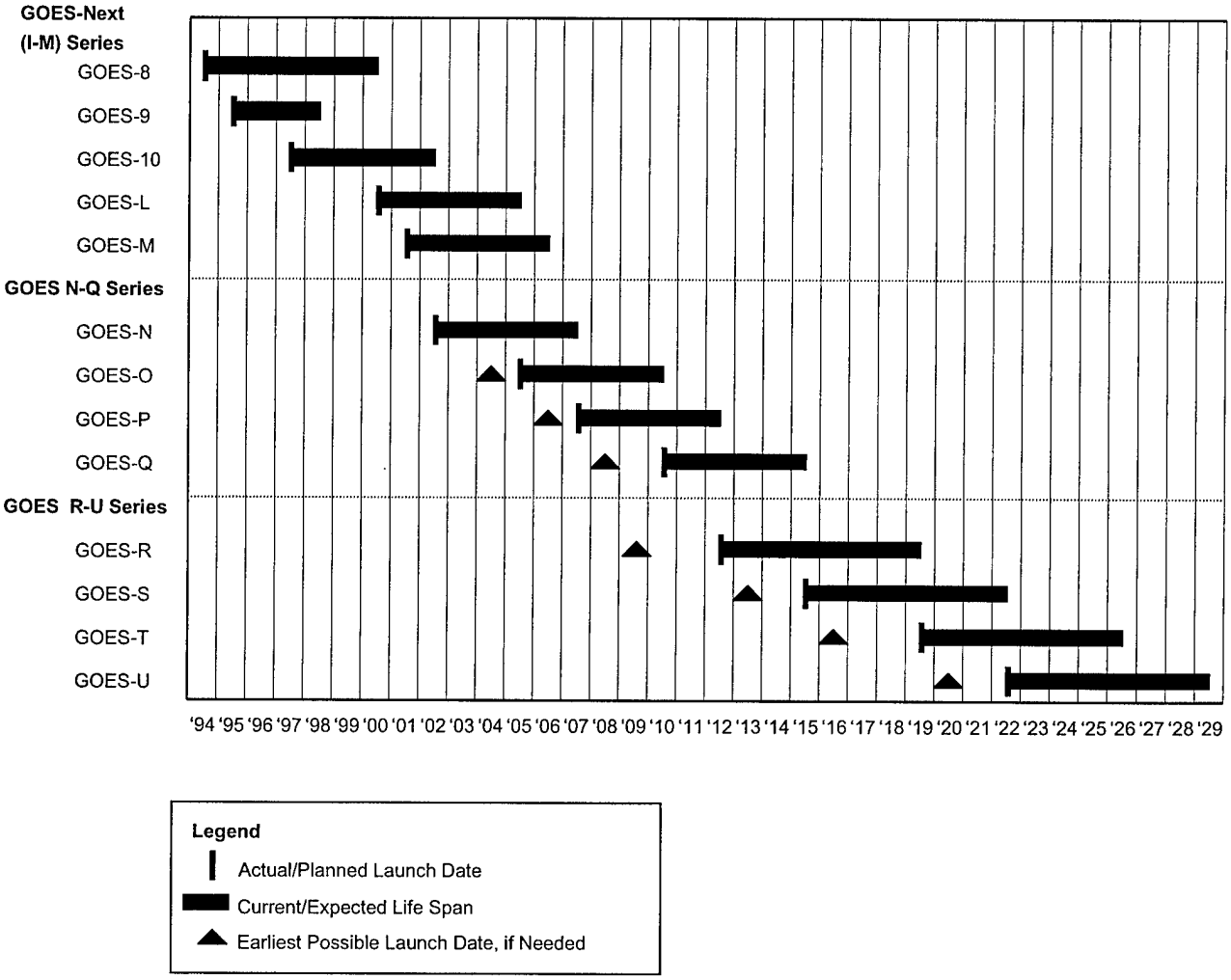
NOAA Geostationary Operational Environmental Satellite (GOES) Program

Mr. Chairman, you also asked that we discuss NOAA's acquisition strategy for its Geostationary Operational Environmental Satellite (GOES) program. GOES satellites are an integral part of weather forecasting because they are strategically positioned at specific locations above the earth to observe the development of severe weather—such as hurricanes and thunderstorms—and provide information allowing forecasters to issue timely and accurate weather warnings. To ensure adequate satellite coverage, NOAA procures several similar satellites at a time—called a series—and plans to launch individual satellites before older satellites are expected to reach the end of their useful lives. Figure 1 illustrates NOAA's current and planned series of satellites.

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

[15] *Department of Commerce: National Weather Service Modernization and NOAA Fleet Issues* (GAO/T-AIMD/GGD-99-97, February 24, 1999).

Figure 1: NOAA's Current and Planned GOES Satellites



At this point, I would like to discuss in more detail NOAA's current satellite series and its plans for the future.

GOES-Next (I Through M): History, Status, and Challenges

NOAA experienced severe technological problems, massive cost overruns, and dangerous schedule delays in its development of the five GOES satellites in the current series, designated GOES-I through M. In 1997 we reported that the overall development cost of the program was over three times greater than planned, escalating from $640 million to approximately $2 billion.[16] Additionally, the launch of GOES-I, which had been planned for July 1989, did not occur until April 1994. This nearly 5-year schedule delay left NOAA in danger of temporarily losing geostationary satellite coverage.[17]

To help ensure adequate satellite coverage, we recommended that NOAA (1) clarify its criteria for activating replacement spacecraft in the event of the failure of an operational GOES satellite or any of its instruments or subsystems, (2) reexamine the agency's strategy for anticipating possible launch failures, and (3) consider scheduling backups for all future launches. NOAA agreed with our recommendations and documented official criteria for activating replacement spacecraft in the event of the failure of an operational GOES satellite. The agency also implemented a new launch backup strategy to have two operational satellites, an on-orbit spare, and a spacecraft ready for launch 1 year after the previous launch.

NOAA has now successfully deployed the first three satellites in the series, but not without difficulty. It launched GOES-8, 9, and 10 in 1994, 1995, and 1997, respectively. In accordance with its strategy to ensure satellite coverage, NOAA planned that GOES-10 would be an orbital backup satellite. However, in July 1998, GOES-9 began to exhibit signs of imminent failure well before the end of its expected 5-year lifespan, and was taken out of operation and placed in orbital storage. GOES-10 was then pressed into service. During this time, NOAA was able to maintain full satellite coverage.

Today, however, continued GOES weather satellite coverage is at risk. GOES-L was scheduled for launch in March 1999, but—because of a

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

[17] NOAA was able to avoid a gap in coverage by borrowing a European satellite and by continuing to use the last satellite in the original series—GOES-7—which proved to be especially robust and was able to continue working beyond its expected lifespan.

problem with its launch vehicle engines[18]—was rescheduled for May 2000. While waiting for the GOES-L launch, NOAA has continued to rely on GOES-8 and GOES-10 for operational satellite coverage. However, GOES-8 is now operating beyond its expected 5-year lifespan—it will be 6 years old next month—and is using several backup systems in cases where primary systems have failed. NOAA officials state that if GOES-8 fails before GOES-L is launched, GOES-9 could be reactivated. Recent tests, however, suggest that GOES-9 may perform for only a few weeks before it fails. According to NOAA officials, continued operational satellite coverage will be at risk until GOES-L is launched in May 2000.

As for future plans, NOAA expects to launch GOES-M, the last in the current spacecraft series, in July 2001. Because GOES-10, L, and M are expected to reach the end of their useful lives as early as 2002, 2005, and 2006, respectively, NOAA is procuring replacements for these satellites. The next four GOES satellites have been designated GOES-N through Q.

GOES-N Through Q: Status and Challenges

NOAA has awarded contracts for up to four satellites in the GOES-N through Q series. GOES-N and GOES-O comprise the base contract, with separate options available for GOES-P and GOES-Q. The total cost of the GOES-N through Q series, including ground support and program management, is estimated to be about $2.4 billion.

Because of NOAA's need to get the N-Q series underway quickly to ensure continued satellite coverage, the environmental sensing instruments on GOES-N, O, and P will be near-clones of the ones in GOES-I through M.[19] NOAA is considering using advanced instruments on the last of the series, GOES-Q, if funding is available. NOAA also plans to deploy one additional instrument, a solar x-ray imager, on two of the four GOES-N through Q satellites.[20]

Planned launch dates for GOES-N through Q are October 2002, April 2005, April 2007, and April 2010, respectively. Given that any satellite may

[18]According to the GOES program manager, the GOES-L spacecraft was one of several launches delayed by the failure of a similar rocket engine on May 4, 1999. The program manager reported that corrective action was taken and five launches since then have been successful.

[19]GOES I through M use imaging and sounding instruments to monitor and measure the weather.

[20]The solar x-ray imager is used to determine when to issue forecasts and alerts of "space weather" conditions that may interfere with astronauts, space systems, and ground-based commercial electric power distribution systems.

experience problems in orbit or upon launch, and the agency's historical problems in transitioning to the GOES-I through M series of satellites, adequate coverage will likely continue to be at risk until the first of the GOES-N through Q satellites are successfully launched.

GOES-R Through GOES-U: Status and Plans

In order to ensure satellite coverage after the GOES-N through Q series reaches the end of its useful life, NOAA is now considering how best to plan the procurement of a follow-up series of satellites—called GOES-R through U. In 1997, we reported that NOAA did not have a program underway to develop a new spacecraft series to follow GOES-N through Q and stated that the agency needed to begin planning if it were to take advantage of new spacecraft and instrument technologies.

NOAA has since reported that the agency expanded studies of alternative architectures and advanced technologies for GOES-R through U, and now envisions that the GOES-R through U satellites will have several improvements over previous GOES satellites. These improvements include a 7-year expected operational life for each satellite, advanced environmental sensing equipment, and increased data-processing capacity in the spacecraft and ground systems. The agency plans to begin funding a program to support the GOES-R through U procurement in fiscal year 2003. NOAA officials estimate that they would award initial instrument contracts in 2000 and a spacecraft contract in about 2006, with planned launch dates for GOES-R, S, T, and U in 2012, 2015, 2019, and 2022, respectively.

In summary, NWS faces significant tasks in the coming year—both in commissioning and developing additional capabilities for AWIPS, and in developing a systems architecture. Further, NOAA must continue to deploy additional weather satellites and plan for future satellites if it is to ensure the continuity of the GOES program.

This concludes my statement. I would be pleased to respond to any questions that you or other members of the Subcommittee may have at this time.

Contact and Acknowledgments

If you have any questions regarding this testimony, please contact Joel Willemssen at (202) 512-6408 or by e-mail at *willemssenj.aimd@gao.gov*. Individuals making key contributions to this testimony include Timothy Case, Barbarol James, and Colleen Phillips.

Objectives, Scope, and Methodology

The objectives of our review were to identify the status of (1) NWS' modernization program, with special focus on AWIPS and NWS' systems architecture, and (2) the National Environmental Satellite, Data, and Information Service's (NESDIS) GOES program.

To address the first objective, we obtained and reviewed documentation on the history, status, and plans for the key modernization systems, and interviewed NWS officials. We also observed a demonstration of AWIPS build 4.2 functions. To address the second objective, we obtained and reviewed documentation on the GOES program history, future plans, and budget estimates, and interviewed NOAA and NESDIS officials. In addition, we obtained comments from NOAA, NWS, and NESDIS officials—including the AWIPS program manager, the GOES program manager, and the GOES systems acquisition officer—on a draft of this statement. These officials generally agreed with the facts as presented and provided some technical corrections, which we have incorporated.

We performed our work in the Washington, D.C. metropolitan area between January and March 2000, in accordance with generally accepted government auditing standards.

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