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WEATHER FORECASTING

New Processing System Faces Uncertainties and Risks

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Mr. Chairman and Members of the Subcommittee:

Thank you for the opportunity to testify on the National Weather Service's (NWS) Advanced Weather Interactive Processing System (AWIPS)—the "linchpin" of NWS' $4.5 billion modernization program. The weather service modernization entails building and putting into place vastly more capable weather observing systems, such as Doppler radars, that will feed a network of sophisticated AWIPS workstations. This AWIPS network, in turn, is to use the observations in combination with national weather modeling results to aid forecasters in making and communicating localized weather predictions. NWS estimates that AWIPS will cost $525 million to fully deploy by 1999.

Mr. Chairman, today we are the bearers of both good and bad news, some of which we pointed out last February during testimony before this Subcommittee. The good news is that NWS has done a stellar job of involving its forecaster community in defining what AWIPS should be. Heeding the advice of a 1994 independent review team, NWS has also reorganized the program to address fundamental management impediments to establishing an acceptable system design and moving the program forward. Additionally, NWS has acted on some of our recent recommendations to strengthen its in-house software development capability.

The bad news is that NWS runs the risk of wasting money on AWIPS capabilities that may not be needed because it has yet to link all planned capabilities to promised mission improvements, such as cheaper operations and better forecasts. Additionally, NWS' ability to meet its AWIPS commitments is being jeopardized by a risky development approach that (1) prematurely begins developing one software increment before the previous increment is stabilized, (2) complicates government versus contractor accountability for inevitable system integration and performance problems, and (3) omits a vital development process known as software quality assurance. Also, NWS expectations for staffing reductions from the modernization continue to shrink.

AWIPS: A Brief Description

AWIPS is to serve as both a weather decision support system and communication system. More specifically, AWIPS is to support forecasters in graphically integrating and analyzing the volumes of weather observations and products that form the basis for decisions on each day's forecasts and warnings. It is also to provide the national communications

infrastructure for NWS field offices and national centers, connecting them not only to each other but also linking them to NWS' diverse customer base. Through AWIPS, NWS expects to tap a reservoir of data from its new observing systems that the aging processing and communication system currently in place, known as AFOS, cannot.[1]

AWIPS' progress to date has been uneven. Despite early successes in effectively involving forecasters in AWIPS requirements analysis and definition activities and demonstrating the technical feasibility of AWIPS functions, AWIPS made little progress during 1993 and 1994 because of an impasse with the development contractor over the AWIPS design and shortcomings in NWS' program management. Acting on the recommendations of an independent review team, NWS was able to move the program forward in 1995 by restructuring the program and renegotiating the development phase of the AWIPS contract. Renegotiation of the deployment phase of the contract is ongoing.

Under the restructuring, NWS assumed responsibility for developing all AWIPS hydrology and meteorology application software. Also, development of the system was divided into a series of seven increments of increasing functional capability. Thus far, the first increment has been installed at three sites to gain experience in developing, testing, deploying, and operating a very limited version of AWIPS. Development of the second increment is underway.

NWS' current project cost estimate for AWIPS, which was first reported in December 1994 and according to NWS is still valid, is $525 million or roughly $58 million more than its previous official estimate done in October 1992. The current schedule calls for AWIPS deployment to be completed in 1999 or 1 year later than NWS projected in 1992.

How Much AWIPS Capability Is Enough?

Since its inception in the early 1980s, NWS has justified the modernization, and its component systems, on the grounds that it will produce significant "service-to-the-public" improvements—namely, better forecasts at less cost. To facilitate attaining these goals, NWS has specified that AWIPS must provide about 450 high-order capabilities, such as the ability to execute certain models or display data in certain formats and colors. All told, these high-order capabilities are composed of about 22,000 separate system requirements.

[1]AFOS stands for Automation of Field Operations and Services.

In defining AWIPS' capabilities, NWS effectively solicited and incorporated the views of the forecaster community. In this regard, it performed multiple requirements analyses and reviews and it effectively employed system prototyping to ensure that forecaster perspectives were heard and understood.

However, the true measure of AWIPS' value is not that forecasters like it, but rather that it contributes significantly to improving NWS' mission performance. In studying the practices of leading public and private sector organizations, we found that successful organizations' system investments are based on explicit and quantifiable mission improvements. By doing so, these organizations know that investing in system capabilities is justified and will make a difference in mission outcomes, such as service delivery or product quality.[2]

Unfortunately, NWS has not demonstrated that the package of capabilities it envisions for AWIPS will enable it to make better forecasts, operate fewer field offices, and reduce staffing levels, leaving the question wide open as to whether AWIPS, as envisioned, is the "right thing." In our view, unless NWS takes advantage of ongoing and planned AWIPS prototyping to validate that proposed capabilities produce measurable mission improvements, it runs the risk of wasting taxpayer money.

AWIPS Software Development Risks Remain

Our recent work on the NWS modernization has identified several AWIPS development risks, particularly with regard to the system's software. Despite the fact that NWS has moved to mitigate some of these risks, others remain that require careful management attention and action. The risks are (1) a development approach that is predicated on overlapping software builds,[3] (2) lines of accountability between the government and the contractor for the system's development that are unclear, and (3) extensive software development that is occurring without a software quality assurance program. Each is discussed below.

- In its recent restructuring of the AWIPS program, NWS responded to the recommendation of a 1994 independent review team and broke the system's development into increments, thus employing a widely accepted risk reduction strategy of "build-a-little, test-a-little." Generally speaking,

[2]Executive Guide: Improving Mission Performance Through Strategic Information Management and Technology (GAO/AIMD-94-115, May 1994).

[3]Software builds are a series of software increments, each with increasing capabilities, that add to or build upon the capabilities of the preceding increment.

incremental development breaks a large, monolithic system development effort into several smaller, more manageable development pieces, thereby permitting earlier warning of significant system development problems, and avoiding expending the huge sums of money associated with developing a complete system before more basic capabilities are successfully developed.

The key to effective incremental development, however, is to ensure that each software increment or build is stabilized (i.e., free of material defects) before adding new capabilities (i.e., software components) to it during succeeding builds. Without build stabilization, new software problems are introduced on top of already existing, unresolved problems, greatly increasing the time and money needed to produce mature software. In February 1995, we testified that NWS was not providing itself the opportunity for AWIPS build stabilization because it had chosen to overlap its software builds as a means of schedule compression to meet arbitrary deployment dates.[4] Specifically, NWS plans to enhance and extend AWIPS software components (i.e., capabilities) before these more basic capabilities, upon which the enhancements and extensions will rely, are fully developed and tested. Without a mature baseline to begin each build, existing software defects are likely to be compounded, causing the time and money needed to complete AWIPS to grow.

NWS officials agree that overlapping AWIPS' software builds is a risk. However, they stated that this risk will be mitigated by completely testing one build before moving on to the next. Our analysis of the AWIPS build schedule does not support these statements, revealing that software builds are scheduled to begin before the previous build has been stabilized (i.e., fully tested and debugged).

While we appreciate and share NWS' desire to field AWIPS capabilities as soon as possible, thereby allowing it to take full advantage of its new observing systems' data sets, we believe that overlapping AWIPS' software builds introduces an element of risk that could ultimately slow the system's completion rather than accelerate it, not to mention raise its price tag.

- In January 1993, we reported on several AWIPS risks confronting NWS, including unclear roles and responsibilities between the government and

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

the contractor.[5] Again last year, prior to AWIPS' restructuring, we testified that this risk remained.[6] Under AWIPS' recent restructuring and the associated renegotiated development contract, the government has maintained a large software development responsibility, writing all the hydrology and meteorology applications, while the contractor delivers the AWIPS' hardware, systems software, and communications networks and integrates these with the applications. The government's exposure to risk, however, still remains because it is uncertain whether the government or the contractor will bear responsibility for resolving any software defects discovered during system integration that are not readily attributable to either party.

- In December 1994, we reported that NWS' in-house software development processes were not adequate for anything more than the AWIPS prototyping activities that NWS planned for itself at that time.[7] As just mentioned, however, NWS has since assumed responsibility for developing over one-half of AWIPS' 1.5 million lines of code, thus making its need for mature internal software development process capabilities absolutely vital.

While NWS has reported taking a number of steps to strengthen its software development processes, such as establishing a software development plan, we are aware of at least one serious process weakness that remains. Namely, NWS has not established a software quality assurance program for AWIPS. In a nutshell, software quality assurance exists to address the management axiom of "what is not tracked is not done." Such a program 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. In our view, the absence of a software quality assurance program for AWIPS exposes the project to unacceptable cost, schedule, and performance risk.

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

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

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

Originally Promised Staffing Reductions Will Not Materialize

Among the mission benefits to be derived from the NWS modernization was a 21-percent reduction in its then current staffing levels—a drop from 5,100 to 4,028. However, in September 1995, we reported that the 4,028 target staffing level had grown to 4,678—a decrease in projected staff savings of 650 or 61 percent.[8] NWS attributed the reduction in expected staff savings to underestimating the number of staff needed to operate and maintain the new systems as well as unexpected, external direction to add field offices and perform specialized forecasting activities. As a result of the Secretary of Commerce's October 1995 decision for NWS to add one more field office and three NEXRAD sites, expected staffing savings will decrease even more, perhaps by as much as 60, according to NWS officials. Such a staffing change would increase NWS' target staffing level to 4,738, which is 710 more than the original target levels.

In conclusion, the inadequacies of AFOS and the potential utility of incorporating new observing systems' data sets into forecast models and analyses argue strongly for an AWIPS-like system to support NWS decision-making and communications needs. However, because NWS has not linked AWIPS capabilities to explicit, measurable improvements in mission performance, we do not know whether AWIPS as currently defined with all its capabilities is a wise investment. Furthermore, because of continuing software development risks, it is uncertain that NWS will deliver AWIPS as promised.

Mr. Chairman, this concludes my statement. We will be happy to respond to any questions you or Members of the Subcommittee might have at this time.

[8]Weather Service Modernization Staffing (GAO/AIMD-95-239R, Sept. 26, 1995).

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