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Report to the Subcommittee on Environment, Technology, and Standards, Committee on Science, House of Representatives

September 2006

GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITES

Steps Remain in Incorporating Lessons Learned from Other Satellite Programs

GAO-06-993

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Highlights

Highlights of GAO-06-993, a report to the Subcommittee on Environment, Technology, and Standards, Committee on Science, House of Representatives

Why GAO Did This Study

The National Oceanic and Atmospheric Administration (NOAA) plans to procure the next generation of geostationary operational environmental satellites, called the Geostationary Operational Environmental Satellites-R series (GOES-R). This new series is considered critical to the United States' ability to maintain the continuity of data required for weather forecasting through the year 2028. GAO was asked to (1) determine the status of and plans for the GOES-R series procurement, and (2) identify and evaluate the actions that the program management team is taking to ensure that past problems experienced in procuring other satellite programs are not repeated.

What GAO Recommends

We are making recommendations to the Secretary of Commerce to direct its NOAA Program Management Council to establish a process for reconciling the government and independent cost estimates; perform a comprehensive review of a key instrument prior to moving it into production; and to evaluate the appropriate levels of resources needed at the program office to oversee the contractor's performance in meeting cost and schedule targets. In written comments, the Department of Commerce agreed with the recommendations and identified plans for implementing them.

www.gao.gov/cgi-bin/getrpt?GAO-06-993.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Dave Powner at (202) 512-9286 or pownerd@gao.gov.

What GAO Found

NOAA is nearing the end of the preliminary design phase of its GOES-R system—which was estimated to cost $6.2 billion and scheduled to have the first satellite ready for launch in 2012. It expects to award a contract in August 2007 to develop this system. However, according to program officials, NOAA's plans for the GOES-R procurement could change in the near future. Recent analyses of the GOES-R program cost—which in May 2006 the program office estimated could reach $11.4 billion—have led the agency to consider reducing the scope of requirements for the satellite series. NOAA officials estimated that a decision on the future scope and direction of the program could be made by the end of September 2006.

NOAA has taken steps to implement lessons learned from past satellite programs, but more remains to be done. Prior satellite programs—including a prior GOES series, a polar-orbiting environmental satellite series, and various military satellite programs—often experienced technical challenges, cost overruns, and schedule delays. Key lessons from these programs include the need to (1) establish realistic cost and schedule estimates, (2) ensure sufficient technical readiness of the system's components prior to key decisions, (3) provide sufficient management at government and contractor levels, and (4) perform adequate senior executive oversight to ensure mission success. NOAA has established plans to address these lessons by conducting independent cost estimates, performing preliminary studies of key technologies, placing resident government offices at key contractor locations, and establishing a senior executive oversight committee. However, many steps remain to fully address these lessons (see table). Until it completes these activities, NOAA faces an increased risk that the GOES-R program will repeat the increased cost, schedule delays, and performance shortfalls that have plagued past procurements.

Key Lessons Learned and the Activities Taken or Remaining to Fully Address Them

Lesson learned	Actions taken or under way	Actions remaining
Establish realistic cost and schedule estimates	• Obtaining multiple independent cost estimates • Conducting risk analysis of schedule estimates	• Ensuring objectivity when reconciling alternative estimates
Ensure sufficient technical readiness of the system's components prior to critical decisions	• Conducted preliminary studies of key technologies and components	• Ensuring sufficient technical maturity before proceeding to production
Provide sufficient management of contractors and subcontractors	• Increased presence at contractor sites • Plan to increase number of system engineers • Plan to hire three specialists in earned value	• Assessing the number of earned value specialists needed commensurate with increased acquisition activities
Perform effective executive-level oversight	• NOAA's program management council meets regularly to oversee project	

Source: GAO analysis.

Contents

Abbreviations

ABI	Advanced Baseline Imager
AEHF	Advanced Extremely High Frequency Satellite System
DOD	Department of Defense
GOES-R	Geostationary Operational Environmental Satellites-R series
NASA	National Aeronautics and Space Administration
NESDIS	National Environmental Satellite Data and Information Service
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-orbiting Operational Environmental Satellite System
SBIRS-High	Space Based Infrared System High Program

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Accountability * Integrity * Reliability

United States Government Accountability Office
Washington, DC 20548

September 6, 2006

The Honorable Vernon J. Ehlers
Chairman
The Honorable David Wu
Ranking Minority Member
Subcommittee on Environment, Technology, and Standards
Committee on Science
House of Representatives

Operational geostationary environmental satellites play a critical role in our nation's weather forecasting. These satellites—which are managed by the National Oceanic and Atmospheric Administration (NOAA)—provide critical information on atmospheric, oceanic, climatic, and solar conditions that help meteorologists observe and predict global and local weather events. They also provide the best means to identify severe storm conditions, such as hurricanes and tornadoes, and to track the movement and intensity of these storms once they develop.

NOAA, with the aid of the National Aeronautics and Space Administration (NASA), is planning to procure the next generation of geostationary satellites, called the Geostationary Operational Environmental Satellites-R series (GOES-R). The GOES-R series is to replace the current series of satellites which will likely begin to reach the end of their useful lives in approximately 2012. This new series is expected to mark the first major technological advance in GOES instrumentation since 1994. It is also considered critical to the United States' ability to maintain the continuity of data required for weather forecasting through the year 2028.

This report responds to your request that we review NOAA's management of the GOES-R program. Specifically, we were asked to (1) determine the status of and plans for the GOES-R series procurement, and (2) identify and evaluate the actions that the program management team is taking to ensure that past problems experienced in procuring other satellite programs are not repeated.

To determine GOES-R status and plans, we reviewed program documents on the planned acquisition schedules, cost estimates, and system requirements, and interviewed program officials. To assess the program office's actions to address lessons learned from past satellite programs, we analyzed lessons learned from past satellite programs—including a prior

GOES satellite series (called GOES I-M), the National Polar-orbiting Operational Environmental Satellite System (NPOESS), and selected military satellite programs. We analyzed program management documents, including data on a critical instrument's development, to determine and evaluate plans for addressing past lessons. We also interviewed program officials from NOAA and NASA.

We conducted our work at NOAA and NASA offices in the Washington, D.C., metropolitan area between December 2005 and August 2006, in accordance with generally accepted government auditing standards. Appendix I contains further details on our objectives, scope, and methodology.

Results in Brief

NOAA is nearing the end of the preliminary design phase of its GOES-R system, which is officially estimated to cost $6.2 billion and scheduled to have the first satellite ready for launch in 2012. To date, NOAA has issued contracts for the preliminary design of the overall GOES-R system to three vendors and expects to award a contract to one of these vendors in August 2007 to develop the satellites. In addition, to reduce the risks associated with developing new instruments, NOAA has issued contracts for the early development of one critical instrument and for the preliminary designs of four other instruments. The agency plans to turn these instrument contracts over to the vendor that is awarded the contract for the overall GOES-R program. However, according to program officials, NOAA's plans for the GOES-R procurement could change in the near future. Recent analyses of the GOES-R program cost—which in May 2006 the program office estimated could reach $11.4 billion—have led the agency to consider reducing the scope of requirements for the satellite series. NOAA officials estimated that a decision on the future scope and direction of the program could be made by the end of September 2006.

NOAA has taken steps to implement lessons learned from past satellite programs, but more remains to be done. Prior satellite programs—including a prior GOES series, a polar-orbiting environmental satellite series, and various military satellite programs—often experience technical challenges, cost overruns, and schedule delays. Key lessons from these programs include the need to (1) establish realistic cost and schedule estimates, (2) ensure sufficient technical readiness of the system's components prior to key decisions, (3) provide sufficient management at government and contractor levels, and (4) perform adequate senior executive oversight to ensure mission success. NOAA has established plans to address these lessons by conducting independent cost estimates,

performing preliminary studies of key technologies, placing resident government offices at key contractor locations, and establishing a senior executive oversight committee. However, many steps remain to fully address these lessons. Specifically, NOAA has not yet developed a process to evaluate and reconcile the independent and government cost estimates. In addition, NOAA has not yet determined how it will ensure that a sufficient level of technical maturity will be achieved in time for an upcoming decision milestone, nor has it determined the appropriate level of resources it needs to adequately track and oversee the program using earned value management.[1] Until it completes these activities, NOAA faces an increased risk that the GOES-R program will repeat the increased cost, schedule delays, and performance shortfalls that have plagued past procurements.

We are making recommendations to the Secretary of Commerce to direct its NOAA Program Management Council to establish a process for objectively evaluating and reconciling the government and independent life cycle cost estimates once the program requirements are finalized; to establish a team of system engineering experts to perform a comprehensive review of the Advanced Baseline Imager instrument to determine the level of technical maturity achieved on the instrument before moving it into production; and to seek assistance in determining the appropriate levels of resources needed at the program office to adequately track and oversee the contractor's earned value management data.

The Department of Commerce provided written comments on a draft of this report in which it agreed with our recommendations and identified planned steps for implementing them (see app. III). The department also provided technical corrections, which we have incorporated in this report as appropriate.

Background

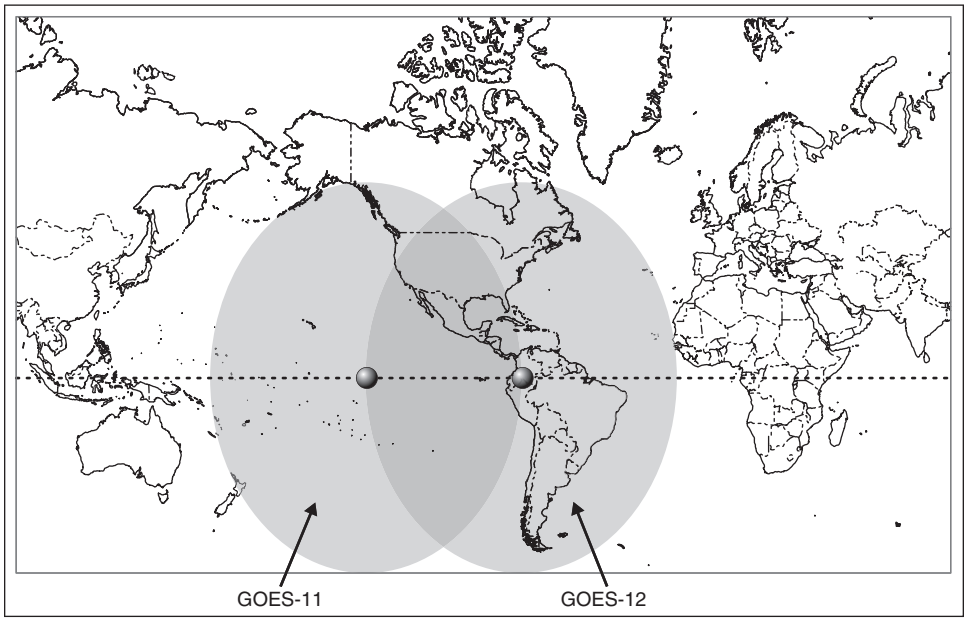
Since the 1960s, geostationary and polar-orbiting environmental satellites have been used by the United States to provide meteorological data for weather observation, research, and forecasting. NOAA's National Environmental Satellite Data and Information Service (NESDIS) is responsible for managing the civilian geostationary and polar-orbiting

[1]Earned value management is a method that compares the value of work accomplished during a given period with that of the work expected in that period.

satellite systems as two separate programs, called GOES and the Polar Operational Environmental Satellites, respectively.

Unlike polar-orbiting satellites, which constantly circle the earth in a relatively low polar orbit, geostationary satellites can maintain a constant view of the earth from a high orbit of about 22,300 miles in space. NOAA operates GOES as a two-satellite system that is primarily focused on the United States (see fig. 1). These satellites are uniquely positioned to provide timely environmental data to meteorologists and their audiences on the earth's atmosphere, its surface, cloud cover, and the space environment. They also observe the development of hazardous weather, such as hurricanes and severe thunderstorms, and track their movement and intensity to reduce or avoid major losses of property and life. Furthermore, the satellites' ability to provide broad, continuously updated coverage of atmospheric conditions over land and oceans is important to NOAA's weather forecasting operations.

Figure 1: Approximate GOES Geographic Coverage



Sources: NOAA (data), MapArt (map).

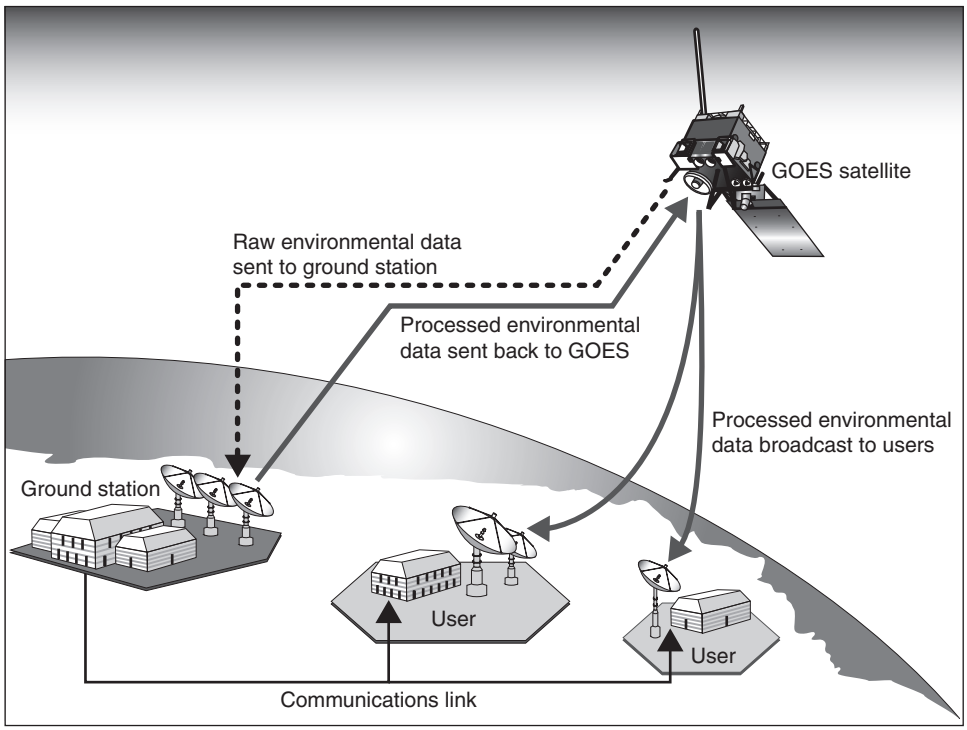
To provide continuous satellite coverage, NOAA acquires several satellites at a time as part of a series and launches new satellites every few years. Three satellites—GOES-11, GOES-12, and GOES-13—are currently in orbit.

Both GOES-11 and GOES-12 are operational satellites, while GOES-13 is in an on-orbit storage mode. It is a backup for the other two satellites should they experience any degradation in service. The others in the series, GOES-O and GOES-P, are planned for launch over the next few years.[2] NOAA is also planning a future generation of satellites, known as the GOES-R series, which are planned for launch beginning in 2012.

Each of the operational geostationary satellites continuously transmits raw environmental data to NOAA ground stations. The data are processed at these ground stations and transmitted back to the satellite for broadcast to primary weather services both in the United States and around the world, including the global research community. Raw and processed data are also distributed to users via ground stations through other communication channels, such as dedicated private communication lines and the Internet. Figure 2 depicts a generic data relay pattern from the geostationary satellites to the ground stations and commercial terminals.

[2]Satellites in a series are identified by letters of the alphabet when they are on the ground and by numbers once they are in orbit.

Figure 2: Generic GOES Data Relay Pattern



Source: GAO analysis of NOAA data.

A Brief History of Prior GOES Series

To date, NOAA has procured three series of GOES satellites and is in the planning stages to acquire a fourth one (see table 1).

Table 1: Summary of the Procurement History of GOES

Series name	Procurement duration[a]	Satellites
Original GOES[b]	1970–1987	1, 2, 3, 4, 5, 6, 7
GOES I-M	1985–2001	8, 9, 10, 11, 12
GOES-N	1998–2011	13, O, P, Q[c]
GOES-R	2007–2020	R, S, T, U

Source: GAO analysis of NOAA data.

[a]Duration includes time from contract award to final satellite launch.

[b]The procurement of these satellites consisted of four separate contracts for (1) two early prototype satellites and GOES-1, (2) GOES-2 and -3, (3) GOES-4 through -6, and (4) GOES-G (failed on launch) and GOES-7.

[c]NOAA decided not to exercise the option for this satellite.

Original GOES Satellites

In 1970, NOAA initiated its original GOES program based on experimental geostationary satellites developed by NASA. While these satellites operated effectively for many years, they had technical limitations. For example, this series of satellites was "spin-stabilized," meaning that the satellites slowly spun while in orbit to maintain a stable position with respect to the earth. As a result, the satellite viewed the earth only about 5 percent of the time and had to collect data very slowly, capturing one narrow band of data each time its field-of-view swung past the earth. A complete set of sounding data took 2 to 3 hours to collect.

GOES I-M Series

In 1985, NOAA and NASA began to procure a new generation of GOES, called the GOES I-M series, based on a set of requirements developed by NOAA's National Weather Service, NESDIS, and NASA, among others. GOES I-M consisted of five satellites, GOES-8 through GOES-12, and was a significant improvement in technology from the original GOES satellites. For example, GOES I-M was "body-stabilized," meaning that the satellite held a fixed position in orbit relative to the earth, thereby allowing for continuous meteorological observations. Instead of maintaining stability by spinning, the satellite would preserve its fixed position by continuously making small adjustments in the rotation of internal momentum wheels or by firing small thrusters to compensate for drift. These and other enhancements meant that the GOES I-M satellites would be able to collect significantly better quality data more quickly than the older series of satellites.

GOES-N Series

In 1998, NOAA began the procurement of satellites to follow GOES I-M, called the GOES-N series. This series used existing technologies for the instruments and added system upgrades, including an improved power subsystem and enhanced satellite pointing accuracy. Furthermore, the GOES-N satellites were designed to operate longer than its predecessors. This series originally consisted of four satellites, GOES-N through GOES-Q. However, the option for the GOES-Q satellite was cancelled based on NOAA's assessment that it would not need the final satellite to continue weather coverage. In particular, the agency found that the GOES satellites already in operation were lasting longer than expected and that the first satellite in the next series could be available to back up the last of the GOES-N satellites. As noted earlier, the first GOES-N series satellite—GOES-13—was launched in May 2006. The GOES-O and GOES-P satellites are currently in production and are expected to be launched in July 2008 and July 2011, respectively.

Planned GOES-R Series

NOAA is currently planning to procure the next series of GOES satellites, called the GOES-R series. This series will consist of four satellites, GOES-

R through GOES-U, and is intended to provide the first major technological advance in instrumentation since the first satellite of the GOES I-M series was launched in 1994.[3]

GOES-R Program—An Overview

NOAA is planning for the GOES-R program to improve on the technology of prior GOES series, in terms of both system and instrument improvements. The system improvements are expected to fulfill more demanding user requirements and to provide more rapid information updates. Table 2 highlights key system-related improvements GOES-R is expected to make to the geostationary satellite program.

Table 2: Summary of Key GOES-R System Improvements

Key feature	GOES-N (current)	GOES-R
Total products	41	~152
Downlink rate of raw data collected by instruments (from satellite to ground stations)	2.6 Mbps	132 Mbps
Broadcast rate of processed GOES data (from satellite to users)	2.1 Mbps	17–24 Mbps
Raw data storage (the length of time that raw data will be stored at ground stations)	0 days	30 days

Source: GAO analysis of NOAA data.

The instruments on the GOES-R series are expected to significantly increase the clarity and precision of the observed environmental data. NOAA plans to acquire five different types of instruments. The program office considers two of the instruments—the Advanced Baseline Imager and the Hyperspectral Environmental Suite—to be most critical because they will provide data for key weather products. Table 3 summarizes the planned instruments and their expected capabilities.

[3]The instruments were based on 1980s technology.

Table 3: Expected GOES-R Series Instruments, as of June 2006

Planned instrument	Description
Advanced Baseline Imager	Expected to provide variable area imagery and radiometric information of the earth's surface, atmosphere, and cloud cover. Key features include • monitoring and tracking severe weather, • providing images of clouds to support forecasts, and • providing higher resolution, faster coverage, and broader coverage simultaneously.
Hyperspectral Environmental Suite	Expected to provide information about the earth's surface to aid in the prediction of weather and climate monitoring. Key features include • providing atmospheric moisture and temperature profiles to support forecasts and climate monitoring, • monitoring coastal regions for ecosystem health, water quality, coastal erosion, and harmful algal blooms, and • providing higher resolution and faster coverage.
Space Environmental In-Situ Suite	Expected to provide information on space weather to aid in the prediction of particle precipitation, which causes disturbance and disruption of radio communications and navigation systems. Key features include • measuring magnetic fields and charged particles, • providing improved heavy ion detection, adding low energy electrons and protons, and • enabling early warnings for satellite and power grid operation, telecom services, astronauts, and airlines.
Solar Imaging Suite	Expected to provide coverage of the entire dynamic range of solar X-ray features, from coronal holes to X-class flares, as well as estimate the measure of temperature and emissions. Key features include • providing images of the sun and measuring solar output to monitor solar storms and • providing improved imager capability.
Geostationary Lightning Mapper	Expected to continuously monitor lightning activity over the United States and provide a more complete dataset than previously possible. Key features include • detecting lightning strikes as an indicator of severe storms and • providing a new capability to GOES that only previously existed on polar satellites.

Source: GAO analysis of NOAA data.

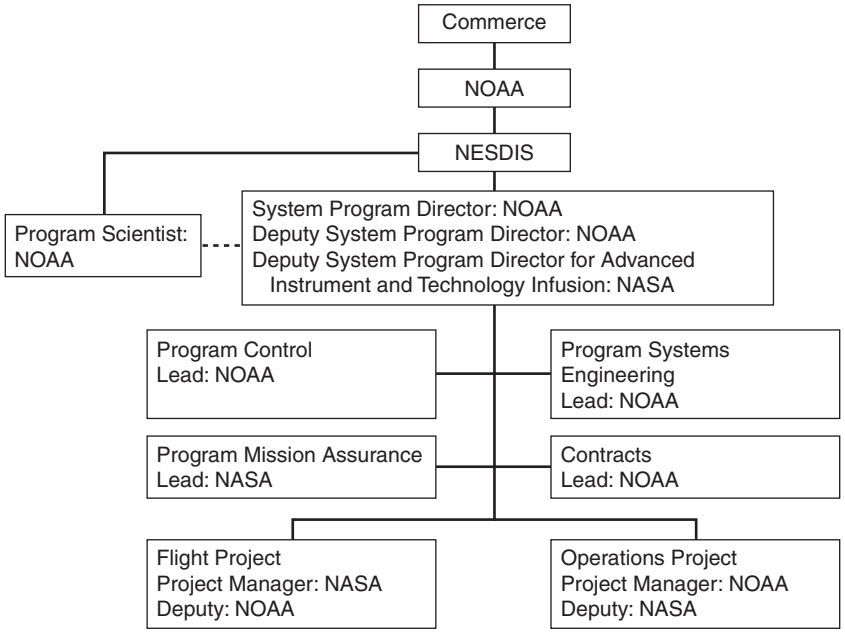
GOES-R Program Office Structure

The program management structure for the GOES-R program differs from past GOES programs. Prior to the GOES-R series, NOAA was responsible for program funding, procurement of the ground elements, and on-orbit operation of the satellites, while NASA was responsible for the procurement of the spacecraft, instruments, and launch services. NOAA officials stated that this approach limited the agency's insight and management involvement in the procurement of major elements of the system.

Alternatively, under the GOES-R management structure, NOAA has responsibility for the procurement and operation of the overall system—

including spacecraft, instruments, and launch services. NASA is responsible for the procurement of the individual instruments until they are transferred to the overall GOES-R system contractor for completion and integration onto the spacecraft. Additionally, to take advantage of NASA's acquisition experience and technical expertise, NOAA located the GOES-R program office at NASA's Goddard Space Flight Center. It also designated key program management positions to be filled with NASA personnel (see fig. 3). These positions include the deputy system program director role for advanced instrument and technology infusion, the project manager for the flight portion of the system, and the deputy project manager for the ground and operations portion of the system. NOAA officials explained that they changed the management structure for the GOES-R program in order to streamline oversight and fiduciary responsibilities, but that they still plan to rely on NASA's expertise in space system acquisitions.

Figure 3: GOES-R Program Office Structure and Staffing



Source: NOAA.

Satellite Programs Often Experience Technical Problems, Cost Overruns, and Schedule Delays

Satellite programs are often technically complex and risky undertakings, and as a result, they often experience technical problems, cost overruns, and schedule delays. We and others have reported on a historical pattern of repeated missteps in the procurement of major satellite systems, including the National Polar-orbiting Operational Environmental Satellite System (NPOESS), the GOES I-M series, the Space Based Infrared System High Program (SBIRS-High), and the Advanced Extremely High Frequency

Satellite System (AEHF).[4] Table 4 lists key problems experienced with these programs and is followed by a summary of each program.

[4]GAO, *Defense Acquisitions: Space System Acquisition Risks and Keys to Addressing Them*, GAO-06-776R (Washington, D.C.: June 1, 2006); *Polar-orbiting Operational Environmental Satellites: Cost Increases Trigger Review and Place Program's Direction on Hold*, GAO-06-573T (Washington, D.C.: Mar. 30, 2006); *Polar-orbiting Operational Environmental Satellites: Technical Problems, Cost Increases, and Schedule Delays Trigger Need for Difficult Trade-off Decisions*, GAO-06-249T (Washington, D.C.: Nov. 16, 2005); *Polar-orbiting Environmental Satellites: Information on Program Cost and Schedule Changes*, GAO-04-1054 (Washington, D.C.: Sept. 30, 2004); *Defense Acquisitions: Despite Restructuring, SBIRS High Program Remains at Risk of Cost and Schedule Overruns*, GAO-04-48 (Washington, D.C.: Oct. 31, 2003); *Military Space Operations: Common Problems and Their Effects on Satellite and Related Acquisitions*, GAO-03-825R (Washington, D.C.: June 2, 2003); *Defense Acquisitions: Assessments of Major Weapon Programs*, GAO-03-476 (Washington, D.C.: May 15, 2003); *Weather Satellites: Action Needed to Resolve Status of the U.S. Geostationary Satellite Program*, GAO/NSIAD-91-252 (Washington, D.C.: July 24, 1991). Defense Science Board/Air Force Scientific Advisory Board Joint Task Force, *Report on the Acquisition of National Security Space Programs* (May 2003).

Table 4: Key Problems Experienced on Selected Major Space Systems

Problem	NPOESS	GOES I-M	SBIRS–High	AEHF
Insufficient technical readiness prior to critical decision points				
Inadequate preliminary studies prior to the decision to award a development contract	X	X	X	
Insufficient technical maturity prior to the decision to move to production	X	X	X	X
Unrealistic cost and schedule estimates				
Optimistic assumptions including:				
• savings from heritage systems	X	X	X	
• readiness of technology maturity	X	X	X	X
• constant and available industrial base			X	
• no weight growth	X		X	X
• no requirements growth				X
• savings from lot buys versus single-unit purchase			X	
• overly aggressive schedule	X	X	X	X
Poor program and contractor management				
Quality and subcontractor issues	X	X	X	X
Inadequate systems engineering capabilities	X	X	X	X
Inadequate earned value management capabilities	X		X	X
Insufficient management reserve	X			X
Ineffective contract award fee structure	X	X	X	
Poor senior executive level oversight				
Infrequent meetings	X			
Inability to make timely decisions	X			
Other				
Unstable funding stream	X		X	X
Unstable requirements			X	X

Source: GAO analysis of NOAA and DOD data.

National Polar-orbiting Operational Environmental Satellite System

NPOESS is being developed to combine two separate polar-orbiting environmental satellite systems currently operated by NOAA and the Department of Defense (DOD) into a single state-of-the-art environment monitoring system. A tri-agency program office—comprised of officials from DOD, NOAA, and NASA—is responsible for managing this program. Within the program office, each agency has the lead on certain activities. NOAA has overall program management responsibility for the converged system and for satellite operations; DOD has the lead on the acquisition; and NASA has primary responsibility for facilitating the development and incorporation of new technologies into the converged system.

Since its inception, the NPOESS program has encountered cost overruns and schedule delays. Specifically, within a year of the contract award, the program cost estimate increased by $1.2 billion, from $6.9 billion to $8.1 billion, and the expected availability of the first satellite was delayed by 20 months. We reported in September 2004 that these cost increases and schedule delays were caused, in part, by changes in the NPOESS funding stream.[5] Subsequently, in November 2005, we reported that problems in the development of a critical sensor would likely cause program costs to grow by at least another $3 billion and the schedule for the first launch would likely be delayed by almost 3 years.[6] The senior executive oversight committee for NPOESS was expected to make a decision in December 2005 on the direction of the program—which involved increased costs, delayed schedules, and reduced functionality. We urged this committee to make a decision quickly so that the program could proceed. However, in late November 2005, the NPOESS program's anticipated cost growth triggered a legislative requirement forcing DOD to reassess its options and to recertify the program.[7] In June 2006, DOD decided to reduce the system's capabilities and number of satellites from six to four, and announced that the newly-restructured program was estimated to cost $11.5 billion and the launch of the first satellite had been delayed by at least 4 years from the time the contract was awarded.

NPOESS' problems involved a number of factors, including unrealistic cost and schedule estimates, insufficient technical maturity of critical sensors at a key development milestone, poor performance at multiple levels of contractor and government management, insufficient executive oversight, and excessive award fee payments to the contractor. Specifically, in 2003, an Air Force cost group performed an independent cost estimate for NPOESS and found that, based on actual outcomes from historical programs similar to NPOESS, the program office underestimated contract costs by almost $1 billion. This group also concluded that the program office underestimated the required time needed to integrate the sensors onto the spacecraft by almost 80 percent. Despite the differences in planned cost and schedule, the program office moved forward with its

[5]GAO-04-1054.

[6]GAO-06-573T and GAO-06-249T.

[7]10 U.S.C. section 2433, as amended by Pub. Law No. 109-163, Div. A, section 802 (Jan. 6, 2006).

own estimates—and, in turn, established unrealistic budgets that led, in part, to the eventual restructuring of the program.

Further, an independent review team charged with assessing the NPOESS program found that the program management office did not sufficiently validate the subcontractors' design work on various sensors. As a result, the sensors were approved to move into production before they reached a sufficient level of technical maturity. This resulted in unexpected technical problems during sensor production.

We also reported that the development issues on one critical sensor were attributed, in part, to the subcontractor's inadequate project management.[8] Specifically, after a series of technical problems, internal review teams sent by the prime contractor and the program office found that the sensor's subcontractor had deviated from a number of contract, management, and policy directives set out by the main office and that both management and process engineering were inadequate. Neither the contractor nor the program office recognized the underlying problems in time to fix them. Further, an independent review team reported that the program management office did not have the technical system engineering support it needed to effectively manage the contractor. In addition, the program office and contractor set aside less than 10 percent of their budgets in management reserve—an amount which was insufficient to effectively deal with these technical problems. With just 2 years into the contract, the prime contractor had spent or allocated over 90 percent of its reserves.

The involvement of the NPOESS executive leadership committee was also inconsistent and indecisive—it wavered from frequent heavy involvement to occasional meetings with few resulting decisions. In the 32-month period from May 2003 through December 2005, the committee met formally six times. Despite mounting evidence of the seriousness of the critical sensor problems, the committee did not effectively challenge the program manager's optimistic assessments, and from May 2003 through December 2004, convened only twice to consider the program's status.[9]

[8]GAO-06-249T.

[9]Department of Commerce Office of Inspector General, *Poor Management Oversight and Ineffective Incentives Leave NPOESS Program Well Over Budget and Behind Schedule*, OIG-17794-6-0001 (May 8, 2006).

In May 2006, the Department of Commerce's (Commerce) Inspector General reported that the NPOESS award fee structure was not an effective system for promoting high-quality performance by the contractor. Despite the significant delays and cost overruns on the program, the contractor received about 84 percent of the available fee pool for the first six billing periods.

GOES I-M Series

In its development of the GOES I-M series, NOAA experienced severe technical challenges, massive cost overruns, and risky schedule delays. The overall development cost of the program was over three times greater than planned, escalating from $640 million to approximately $2 billion. Additionally, the launch of the first satellite of this series, which had been planned for July 1989, did not occur until April 1994. This nearly 5-year schedule delay left NOAA in danger of losing geostationary satellite coverage, although no gap in coverage occurred. We reported that these problems were caused by a number of factors, including insufficient technical readiness of the satellite design prior to contract award, unrealistic cost and schedule estimates, and inadequate management by NOAA and NASA.[10]

Specifically, NOAA and NASA did not require any engineering analyses to be completed prior to the award of the GOES I-M contract. As a result, both agencies were unable to anticipate the level of complexity of NOAA's requirements (related to the satellite's pointing accuracy) or the contractor's approach to meeting those requirements. This unanticipated design complexity led to additional analyses, redesigns, and remanufacture of parts, which resulted in increased costs and schedule delays. Additionally, the lack of adequate understanding of the system prior to contract award also prevented program officials from establishing realistic cost and schedule estimates for the program.

The inadequate management of the GOES I-M program—by both the government and contractor—played a significant part in its cost increases and program delays. Specifically, NASA and NOAA made the decision to forgo preliminary studies of the system because of fiscal constraints and pressure to launch the first satellite as quickly as possible. This decision was compounded by NASA's limited technical support in the areas of optics, satellite control systems, and thermal engineering. Additionally, both the prime contractor and major subcontractor had little experience in

[10] GAO/NSIAD-91-252.

directing the design of complex weather instruments. The subcontractor had also noted that it was not prepared for GOES I-M. For example, the instruments were expected to meet manufacturing and testing standards that the subcontractor had never experienced before. We recommended Congress consider directing NASA and NOAA to report on their progress in resolving these problems and the timeframe and cost for achieving proposed solutions. Further, we recommended that funds for the production and testing of the satellites be withheld until a favorable solution was identified and reported to Congress.

Space Based Infrared System High Program

SBIRS-High satellites are being developed to replace DOD's older missile warning satellites. In addition to missile warning and missile defense missions, the satellites are also expected to perform technical intelligence and battlespace characterization missions. After the program was initiated in 1994, it faced cost, scheduling, and technology problems. SBIRS-High had experienced schedule slips of at least 6 years and cost increases that have triggered legislative requirements to reassess and recertify the program several times—most recently in 2005. While DOD's total program cost estimate was initially about $3.9 billion, it is now $9.9 billion—nearly a 150 percent unit cost increase. DOD is currently reexamining this program, potential alternatives, and cost estimates.

Our reviews have attributed past problems on the SBIRS-High program to serious hardware and software design problems, insufficient oversight of contractors, and technology challenges.[11] Further, an independent review team chartered by DOD reported that a root cause of these problems was that system requirements were not well understood by DOD when the program began. Specifically, the requirements-setting process was often ad hoc, many decisions on requirements were deferred to the contractor, and the program was too immature to enter system design and development. As a result, there was too much instability on the program after the contract award—leading DOD to undertake four major replanning efforts. We made multiple recommendations to improve this program, including commissioning an independent task force to assess the development schedule, the stability of the program design, and software development practices, and to provide guidance for addressing the program's underlying problems. In addition, we recommended that DOD establish a mechanism for ensuring that the knowledge gained from the assessment was used to determine whether further programmatic changes were

[11] GAO-04-48 and GAO-03-476.

needed to strengthen oversight, adjust cost and schedule estimates, and address requirements changes.

Advanced Extremely High Frequency Satellite System

AEHF is a satellite system intended to be DOD's next generation of high-speed, protected communication satellites and to replace the existing Milstar system. In 2003, we reported that cost estimates developed by the Air Force for this program increased from $4.4 billion in January 1999 to $5.6 billion in June 2001 for five satellites.[12] Moreover, DOD would not meet its accelerated target date for launching the first satellite in December 2004. To minimize costs, DOD then decided to purchase three satellites with options to purchase the fourth and fifth—which brought the program cost to $4.7 billion. Despite this action, AEHF costs grew to about $6.1 billion—an increase of more than 15 percent over the baseline estimate, which triggered legislative requirements to assess and certify the program. Schedule slippages for launching this communication system have now stretched to over 3 years.

A number of factors contributed to cost and schedule overruns and performance shortfalls. First, in the early phases of the AEHF program, DOD substantially and frequently altered requirements—resulting in major design modifications that increased costs by millions of dollars. For instance, a new requirement for additional anti-jamming protection led to a cost increase of $100 million and an added set of requirements for training, support, and maintainability that cost an additional $90 million. Second, based on a satellite constellation gap caused by the failure of a Milstar satellite, DOD accepted a high-risk schedule that turned out to be overly optimistic and highly compressed—leaving little room for error and depending on a chain of events taking place at certain times. Third, AEHF allocated 4 percent of its budget to management reserve—which was an inadequate amount to cover unforeseen problems for the duration of the program. Between December 2002 and June 2005, the contractor had depleted about 86 percent of its reserves with 5 years remaining on the contract. Lastly, at the time DOD decided to accelerate the program, it did not have the funding needed to support the activities or the manpower needed to design and build the satellites more quickly. The lack of funding also contributed to schedule delays, which in turn, caused more cost increases. We made a number of recommendations to improve this program and others, including implementing processes and policies that stabilize requirements and addressing shortfalls in staff with science and

[12] GAO-03-825R and GAO-03-476.

engineering backgrounds. These recommendations were made to assure that DOD had an investment strategy in place that would better match resources to requirements.

GOES-R Procurement Activities Are Under Way, but System Requirements and Cost Estimates May Change

NOAA is nearing the end of the preliminary design phase on its GOES-R program and plans to award a contract for the system's development in August 2007; however, because of concerns with potential cost growth, NOAA's plans for the GOES-R procurement could change in the near future. To date, NOAA has issued contracts for the preliminary design of the overall GOES-R system to three vendors and expects to award a contract to one of these vendors to develop the system in August 2007. In addition, to reduce the risks associated with developing new instruments, NASA has issued contracts for the early development of one critical instrument and for the preliminary designs of four other instruments. The agency plans to award these contracts and then turn them over to the contractor responsible for the overall GOES-R program. However, this approach is under review and NOAA may wait until the instruments are fully developed before turning them over to the system contractor. Table 5 provides a summary of the status of contracts for the GOES-R program.

Table 5: Status of GOES-R Program Contracts, as of June 2006

Contract item	Date contract was awarded for design	Planned date contract will be awarded for development
Instruments		
Advanced Baseline Imager	May 2001	September 2004 (actual)
Space Environmental In-Situ Suite	December 2004	August 2006
Solar Imaging Suite	September 2004	September 2006
Hyperspectral Environmental Suite	June 2004	June 2007
Geostationary Lightning Mapper	February 2006	August 2007
GOES-R System		
Acquisition and Operations	October 2005	August 2007

Source: NOAA.

According to program documentation provided to the Office of Management and Budget in 2005, the current life cycle cost estimate for GOES-R is approximately $6.2 billion (see table 6). However, program officials reported that this estimate is over 2 years old and is under review.

Table 6: GOES-R Program Life Cycle Cost Estimate, as of June 2006

Major cost category	Dollars in millions
System level	$533
Space segment	2,494
Ground segments	729
Launch segment	686
Operations and support	1,147
Government program office	637
Total	**$6,226**

Source: NOAA.

NOAA is tentatively planning to launch the first GOES-R series satellite in September 2012. The development of the schedule for launching the satellites was driven by a requirement that the satellites be available to back up the last remaining GOES satellites (GOES-O and GOES-P) should anything go wrong during the planned launches of these satellites. Table 7 provides a summary of the planned launch schedule for the GOES-R series.

Table 7: GOES-R Program Schedule, as of June 2006

Milestone	Planned date
GOES-O launch[a]	April 2008
GOES-P launch[a]	October 2009[b]
GOES-R satellite available for launch	September 2012
GOES-S satellite available for launch	April 2014
GOES-T satellite available for launch	October 2015
GOES-U satellite available for launch	April 2017
End of operations and maintenance	2028

Source: NOAA.

[a]GOES-O and GOES-P are not part of the GOES-R series program. Their launch dates are provided because of their relevance to the GOES-R series satellite schedules.

[b]Because GOES satellites have been operating longer than expected, NOAA is considering moving the planned launch of the GOES-P satellite to July 2011.

Commerce is scheduled to make a major acquisition decision before the end of this year. Commerce will decide whether or not the GOES-R series should proceed into the development and production phase in December 2006. Program officials reported that the final request for proposal on the

GOES-R contract would be released upon completion of this decision milestone.

However, NOAA's plans for the GOES-R procurement could change in the near future because of concerns with potential cost growth. Given its experiences with cost growth on the NPOESS acquisition, NOAA recently asked program officials to recalculate the total cost of the estimated $6.2 billion GOES-R program. In May 2006, program officials estimated that the life cycle cost could reach $11.4 billion. The agency then requested that the program identify options for reducing the scope of requirements for the satellite series. Program officials reported that there are over 10 viable options under consideration, including options for removing one or more of the planned instruments. The program office is also reevaluating its planned acquisition schedule based on the potential program options. Specifically, program officials stated that if there is a decision to make a major change in system requirements, they will likely extend the preliminary design phase, delay the decision to proceed into the development and production phase, and delay the contract award date. NOAA officials estimated that a decision on the future scope and direction of the program could be made by the end of September 2006.

The GOES-R Program Office Has Taken Steps to Address Past Lessons Learned, but Significant Actions Remain

NOAA has taken steps to apply lessons learned from problems encountered on other satellite programs to the GOES-R procurement. Key lessons include (1) establishing realistic cost and schedule estimates, (2) ensuring sufficient technical readiness of the system's components prior to key decisions, (3) providing sufficient management at government and contractor levels, and (4) performing adequate senior executive oversight to ensure mission success. NOAA has established plans designed to mitigate the problems faced in past acquisitions; however, many activities remain to fully address these lessons. Until it completes these activities, NOAA faces an increased risk that the GOES-R program will repeat the increased cost, schedule delays, and performance shortfalls that have plagued past procurements.

NOAA Is Taking Steps to Improve the Reliability of Cost and Schedule Estimates, but Key Steps Remain in Reconciling Cost Estimates

We and others have reported that space system acquisitions are strongly biased to produce unrealistically low cost and schedule estimates in the acquisition process. For example, we testified last July on the continued large cost increases and schedule delays being encountered on military space acquisition programs—including NPOESS, SBIRS-High, and AEHF.[13] We noted that during program formulation, the competition to win funding is intense and has led program sponsors to minimize their program cost estimates.[14] Furthermore, a task force chartered by DOD to review the acquisition of military space programs found that independent cost estimates and government program assessments have proven ineffective in countering this tendency.[15] NOAA programs face similar unrealistic estimates. For example, the total development cost of the GOES I-M acquisition was over three times greater than planned, escalating from $640 million to $2 billion. The delivery of the first satellite was delayed by 5 years.

NOAA has several efforts under way to improve the reliability of its cost and schedule estimates for the GOES-R program. NOAA's Chief Financial Officer has contracted with a cost-estimating firm to complete an independent cost estimate, while the GOES-R program office has hired a support contractor to assist with its internal program cost estimating. The program office is re-assessing its estimates based on preliminary information from the three vendors contracted to develop preliminary designs for the overall GOES-R system. Once the program office and independent cost estimates are completed, program officials intend to compare them and to develop a revised programmatic cost estimate that will be used in its decision on whether to proceed into system development and production. In addition, NOAA has planned for an independent review team—consisting of former senior industry and government space acquisition experts—to provide an assessment of the program office and independent cost estimates for this decision milestone. To improve its schedule reliability, the program office is currently conducting a schedule risk analysis in order to estimate the amount of adequate reserve funds and schedule margin needed to deal with unexpected problems and setbacks. Finally, the NOAA Observing System

[13]GAO, *Space Acquisitions: Stronger Development Practices and Investment Planning Needed to Address Continuing Problems*, GAO-05-891T (Washington, D.C.: July 12, 2005).

[14]GAO-05-891T.

[15]Defense Science Board/Air Force Scientific Advisory Board Joint Task Force, *Report on the Acquisition of National Security Space Programs* (May 2003).

Council[16] submitted a prioritized list of GOES-R system requirements to the Commerce Undersecretary for approval. This list is expected to allow the program office to act quickly in deleting lower priority requirements in the event of severe technical challenges or shifting funding streams.

While NOAA acknowledges the need to establish realistic cost and schedule estimates, several hurdles remain. As discussed earlier, the agency is considering reducing the requirements for the GOES-R program to mitigate the increased cost estimates for the program. Therefore, the agency's efforts to date to establish realistic cost estimates cannot be fully effective in addressing this lesson until this uncertainty is resolved. NOAA suspended the work being performed by its independent cost estimator until a decision is made on the scope of the program. Further, the agency has not yet developed a process to evaluate and reconcile the independent and program office cost estimates once final program decisions are made. Without this process, the agency may lack the objectivity necessary to counter the optimism of program sponsors and is more likely to move forward with an unreliable estimate. Until it completes this activity, NOAA faces an increased risk that the GOES-R program will repeat the cost increases and schedule delays that have plagued past procurements.

NOAA Is Conducting Preliminary Studies in Order to Avoid Technical Problems in Later Acquisition Phases, but Steps Remain in Determining Components' Technical Maturity

Space programs often experience unforeseen technical problems in the development of critical components as a result of having insufficient knowledge of the components and their supporting technologies prior to key decision points. One key decision point is when an agency decides on whether the component is sufficiently ready to proceed from a preliminary study phase into a development phase; this decision point results in the award of the development contract. Another key decision point occurs during the development phase when an agency decides whether the component is ready to proceed from design into production (also called the critical design review). Without sufficient technical readiness at these milestones, agencies could proceed into development contracts on components that are not well understood and enter into the production phase of development with technologies that are not yet mature. For example:

[16]NOAA's Observing System Council is the principal advisory council for NOAA's earth observation and data management activities. It includes members from each NOAA line office, other relevant councils, and program offices. The Assistant Administrator for Satellite and Information Services and the Assistant Administrator for Weather Services serve as the co-chairs of the council.

- On the GOES I-M series, NOAA and NASA did not require engineering analyses prior to awarding the development contracts in order to accelerate the schedule and launch the first satellite. The lack of these studies resulted in unexpected technical issues in later acquisition phases—including the inability of the original instrument designs to withstand the temperature variations in the geostationary orbit.

- Both the NPOESS and SBIRS-High programs committed funds for system development before the design was proven and before the technologies had properly matured. For instance, at the critical design review milestone for a key NPOESS sensor, the program office decided that the sensor was ready to proceed into production even though an engineering model had not been constructed. This sensor has since faced severe technical challenges that directly led to program-wide cost and schedule overruns.

To address the lesson learned from the GOES I-M experience, in 1997, NOAA began preliminary studies on technologies that could be used on the GOES-R instruments. These studies target existing technologies and assessed how they could be expanded for GOES-R. The program office is also conducting detailed trade-off studies on the integrated system to improve its ability to make decisions that balance performance, affordability, risk, and schedule. For instance, the program office is analyzing the potential architectures for the GOES-R constellation of satellites—the quantity and configuration of satellites, including how the instruments will be distributed over these satellites. These studies are expected to allow for a more mature definition of the system specifications.

NOAA has also developed plans to have an independent review team assess project status on an annual basis once the overall system contract has been awarded. In particular, this team will review technical, programmatic, and management areas; identify any outstanding risks; and recommend corrective actions. This measure is designed to ensure that sufficient technical readiness has been reached prior to the critical design review milestone. The program office's ongoing studies and plans are expected to provide greater insight into the technical requirements for key system components and to mitigate the risk of unforeseen problems in later acquisition phases.

However, the progress currently being made on the only instrument currently under development—the Advanced Baseline Imager—has experienced technical problems and could be an indication of more problems to come in the future. These problems relate to, among other

things, the design complexity of the instrument's detectors and electronics. As a result, the contractor is experiencing negative cost and schedule performance trends. As of May 2006, the contractor incurred a total cost overrun of almost $6 million with the instrument's development only 28 percent complete. In addition, from June 2005 to May 2006, it was unable to complete approximately $3.3 million worth of work. Unless risk mitigation actions are aggressively pursued to reverse these trends, we project the cost overrun at completion to be about $23 million. (See app. II for further detail on the Advanced Baseline Imager's cost and schedule performance.)

While NOAA expects to make a decision on whether to move the instrument into production (a milestone called the critical design review) in January 2007, the contractor's current performance raises questions as to whether the instrument designs will be sufficiently mature by that time. Further, the agency does not have a process to validate the level of technical maturity achieved on this instrument or to determine whether the contractor has implemented sound management and process engineering to ensure that the appropriate level of technical readiness can be achieved prior to the decision milestone. Until it does so, NOAA risks making a poor decision based on inaccurate or insufficient information—which could lead to unforeseen technical problems in the development of this instrument.

Efforts to Strengthen Government and Contractor Management are Under Way, but Significant Work on Program Controls Remains

In the past, we have reported on poor performance in the management of satellite acquisitions.[17] The key drivers of poor management included inadequate systems engineering and earned value management[18] capabilities, unsuitable allocation of contract award fees, inadequate levels of management reserve, and inefficient decision-making and reporting structure within the program office. The NPOESS program office lacked adequate program control capabilities in systems engineering and

[17]GAO-06-573T, GAO-06-249T, GAO/NSIAD-91-252, *Defense Acquisitions: DOD Has Paid Billions in Award and Incentive Fees Regardless of Acquisition Outcomes*, GAO-06-66 (Washington, D.C.: Dec. 19, 2005), and *Weather Satellites: Cost Growth and Development Delays Jeopardize U.S. Forecasting Ability*, GAO/NSIAD-89-169 (Washington, D.C.: June 30, 1989).

[18]Earned value management is a method, used by DOD for several decades, to track a contractor's progress in meeting project deliverables. It compares the value of work accomplished during a given period with that of the work expected in that period. Differences from expectations are measured in both cost and schedule variances.

earned value management to effectively manage the contractor's cost, schedule, and technical performance. Furthermore, Commerce's Inspector General reported that NOAA awarded the NPOESS contractor excessive award fees for a program plagued with severe technical problems and a consistent failure to meet cost and schedule targets.[19] Additionally, on SBIRS-High, the program management office had fewer systems engineers than other historical space programs. As a result, the program did not have enough engineers to handle the workload of ensuring that system requirements properly flowed down into the designs of the system's components. Further, the NPOESS and AEHF programs had less than 5 percent of funds allocated to management reserve at the start of the system's development and spent or allocated over 85 percent of that reserve within 3 years of beginning development. On GOES I-M, NOAA found that it did not have the ability to make quick decisions on problems because the program office was managed by another agency.

NOAA has taken numerous steps to restructure its management approach on the GOES-R procurement in an effort to improve performance and to avoid past mistakes. These steps include:

- The program office revised its staffing profile to provide for government staff to be located on-site at prime contractor and key subcontractor locations.

- The program office plans to increase the number of resident systems engineers from 31 to 54 to provide adequate government oversight of the contractor's system engineering, including verification and validation of engineering designs at key decision points (such as the critical design review milestone).

- The program office has better defined the role and responsibilities of the program scientist, the individual who is expected to maintain an independent voice with regard to scientific matters and advise the program manager on related technical issues and risks.

- The program office also intends to add three resident specialists in earned value management to monitor contractor cost and schedule performance.

[19]Department of Commerce Office of Inspector General, *Poor Management Oversight and Ineffective Incentives Leave NPOESS Program Well Over Budget and Behind Schedule*, OIG-17794-6-0001 (May 8, 2006).

- NOAA has work under way to develop the GOES-R contract award fee structure and the award fee review board that is consistent with our recent findings, the Commerce Inspector General's findings, and other best practices, such as designating a non-program executive as the fee-determining official to ensure objectivity in the allocation of award fees.

- NOAA and NASA have implemented a more integrated management approach that is designed to draw on NASA's expertise in satellite acquisitions and increase NOAA's involvement on all major components of the acquisition.

- The program office reported that it intended to establish a management reserve of 25 percent consistent with the recommendations of the Defense Science Board Report on Acquisition of National Security Space Programs.[20]

While these steps should provide more robust government oversight and independent analysis capabilities, more work remains to be done to fully address this lesson. Specifically, the program office has not determined the appropriate level of resources it needs to adequately track and oversee the program and the planned addition of three earned value management specialists may not be enough as acquisition activities increase. By contrast, after its recent problems and in response to the independent review team findings, NPOESS program officials plan to add 10 program staff dedicated to earned value, cost, and schedule analysis. An insufficient level of established capabilities in earned value management places the GOES-R program office at risk of making poor decisions based on inaccurate and potentially misleading information. Finally, while NOAA officials believe that assuming sole responsibility for the acquisition of GOES-R will improve their ability to manage the program effectively, this change also elevates NOAA's risk for mission success. Specifically, NOAA is taking on its first major system acquisition and an increased risk due to its lack of experience. Until it fully addresses the lesson of ensuring an appropriate level of resources to oversee its contractor, NOAA faces an increased risk that the GOES-R program will repeat the management and contractor performance shortfalls that have plagued past procurements.

[20]Defense Science Board/Air Force Scientific Advisory Board Joint Task Force, *Report on the Acquisition of National Security Space Programs* (May 2003).

NOAA Has Established a Senior Executive Committee to Perform Critical Oversight of the GOES-R Program

We and others have reported on NOAA's significant deficiencies in its senior executive oversight of NPOESS.[21] The lack of timely decisions and regular involvement of senior executive management was a critical factor in the program's rapid cost and schedule growth. The senior executive committee was provided with monthly status reports that consistently described in explicit detail the growing costs and delays attributable to the development of a key instrument. Despite mounting evidence of the seriousness of the instrument's problems, this committee convened only twice between May 2003 and December 2004 to consider the program's status.

NOAA formed its program management council in response to the lack of adequate senior executive oversight on NPOESS. In particular, this council is expected to provide regular reviews and assessments of selected NOAA programs and projects—the first of which is the GOES-R program. The council is headed by the NOAA Deputy Undersecretary and includes senior officials from Commerce and NASA. The council is expected to hold meetings to discuss GOES-R program status on a monthly basis and to approve the program's entry into subsequent acquisition phases at key decision milestones—including contract award and critical design reviews, among others. Since its establishment in January 2006, the council has met regularly and has established a mechanism for tracking action items to closure.

The establishment of the NOAA Program Management Council is a positive action that should support the agency's senior-level governance of the GOES-R program. In moving forward, it is important that this council continue to meet on a regular basis and exercise diligence in questioning the data presented to it and making difficult decisions. In particular, it will be essential that the results of all preliminary studies and independent assessments on technical maturity of the system and its components be reviewed by this council so that an informed decision can be made about the level of technical complexity it is taking on when proceeding past these key decision milestones. In light of the recent uncertainty regarding the future scope and cost of the GOES-R program, the council's

[21]GAO, *Polar-orbiting Environmental Satellites: Cost Increases Trigger Review and Place Program's Direction on Hold*, GAO-06-573T (Washington, D.C.: March 30, 2006); Department of Commerce Office of Inspector General, *Poor Management Oversight and Ineffective Incentives Leave NPOESS Program Well Over Budget and Behind Schedule*, OIG-17794-6-0001 (May 8, 2006).

governance will be critical in making those difficult decisions in a timely manner.

Conclusions

Procurement activities are under way for the next series of geostationary environmental satellites, called the GOES-R series—which is scheduled to launch its first satellite in September 2012. With the GOES-R system development contract planned for award in August 2007, NOAA is positioning itself to improve the acquisition of this system by incorporating the lessons learned from other satellite procurements, including the need to establish realistic cost estimates, ensure sufficient government and contractor management, and obtain effective executive oversight. However, further steps remain to fully address selected lessons. Specifically, NOAA has not yet developed a process to evaluate and reconcile the independent and government cost estimates. In addition, NOAA has not yet determined how it will ensure that a sufficient level of technical maturity will be achieved in time for an upcoming decision milestone, or determined the appropriate level of resources it needs to adequately track and oversee the program using earned value management. Until it completes these activities, NOAA faces an increased risk that the GOES-R program will repeat the increased cost, schedule delays, and performance shortfalls that have plagued past procurements.

Recent concerns about the potential for cost growth on the GOES-R procurement have led the agency to consider reducing the scope of requirements for the satellite series. A decision on the future scope and direction of the program could by made by the end of September 2006. Once the decision is made, it will be important to move quickly to implement the decision in the agency budgets and contracts.

Recommendations for Executive Action

To improve NOAA's ability to effectively manage the procurement of the GOES-R system, we recommend that the Secretary of Commerce direct its NOAA Program Management Council to take the following three actions:

- Once the scope of the program has been finalized, establish a process for objectively evaluating and reconciling the government and independent life cycle cost estimates.
- Perform a comprehensive review of the Advanced Baseline Imager, using system engineering experts, to determine the level of technical maturity achieved on the instrument, to assess whether the contractor has implemented sound management and process engineering, and to assert

that the technology is sufficiently mature before moving the instrument into production.

- Seek assistance from an independent review team to determine the appropriate level of resources needed at the program office to adequately track and oversee the contractor's earned value management. Among other things, the program office should be able to perform a comprehensive integrated baseline review after system development contract award, provide surveillance of contractor earned value management systems, and perform project scheduling analyses and cost estimates.

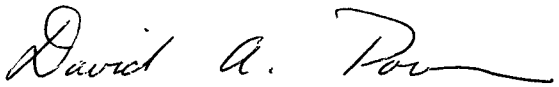
Agency Comments and Our Evaluation

We received written comments on a draft of this report from the Department of Commerce (see app. III). In the department's response, the Deputy Secretary of Commerce agreed with our recommendations and identified plans for implementing them. Specifically, the department noted that it plans to establish a process for reconciling government and independent cost estimates and to evaluate the process and results with an independent team of recognized senior experts in the satellite acquisition field. The department also noted that an independent review team is planning to perform assessments of the technical maturity of the Advanced Baseline Imager and the extent to which the program management structure and reporting process will provide adequate oversight of the GOES-R system acquisition. Additionally, the department expressed concern regarding our use of a cost estimate that they considered to be premature and misleading. During the course of our review, NOAA provided us with a cost estimate that was later determined by agency officials to be inaccurate and was subsequently corrected. We have incorporated the revised cost estimate of $11.4 billion for the overall GOES-R program to ensure that all cost estimates reported at this time are accurate.

The department provided additional technical corrections, which we have incorporated as appropriate.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies of this report to interested congressional committees, the Secretary of Commerce, the Administrator of NASA, the Director of the Office of Management and Budget, and other interested parties. In addition, this report will be available at no charge on our Web site at http://www.gao.gov.

If you have any questions on matters discussed in this report, please contact me at (202) 512-9286 or by e-mail at pownerd@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made major contributions to this report are listed in appendix IV.



David A. Powner
Director, Information Technology
Management Issues

Appendix I: Objectives, Scope, and Methodology

Our objectives were to (1) determine the status of and plans for the Geostationary Operational Environmental Satellites-R series (GOES-R) procurement and (2) identify and evaluate the actions that the project management team is taking to ensure that past problems experienced in procuring other satellite programs are not repeated. To accomplish these objectives, we focused our review on the National Oceanic and Atmospheric Administration's (NOAA) GOES-R program office, the organization responsible for the overall GOES-R program.

To determine the status of and plans for the GOES-R series procurement, we reviewed various program office plans and management reports such as acquisition schedules, cost estimates, and planned system requirements. Furthermore, we conducted interviews with NOAA and National Aeronautics and Space Administration (NASA) officials to determine key dates for future GOES-R acquisitions efforts and milestones, and potential changes in program scope, cost, and schedule.

To identify the steps the GOES-R project management team is taking to ensure that past problems experienced in procuring other satellite series are not repeated, we analyzed our past body of work on major space system acquisitions, including the Advanced Extremely High Frequency satellites, the GOES I-M satellites, the National Polar-orbiting Operational Environmental Satellite System, and the Space Based Infrared System High program in order to identify key lessons. We also analyzed findings from other government reports on satellite procurements, such as by the Defense Science Board–Air Force Scientific Advisory Board Joint Task Force and the Department of Commerce's Office of Inspector General. We assessed relevant management documents, such as cost reports and program risk plans. Our evaluation included the application of earned value analysis techniques[1] to data from contractor cost performance reports over an 11-month period (from June 2005 to May 2006). We also conducted interviews with agency officials to identify and to evaluate the adequacy of the actions taken to address these lessons.

We obtained comments on a draft of this report from officials at the Department of Commerce and incorporated these comments as appropriate. We performed our work at NOAA and NASA offices in the

[1]The earned value concept is applied as a means of placing a dollar value on project status. It is a technique that compares budget versus actual costs versus project status in dollar amounts. For our analysis, we used standard earned value formulas to calculate cost and schedule variance and forecast the range of cost overrun at contract completion.

Washington, D.C., metropolitan area between December 2005 and August 2006 in accordance with generally accepted government auditing standards.

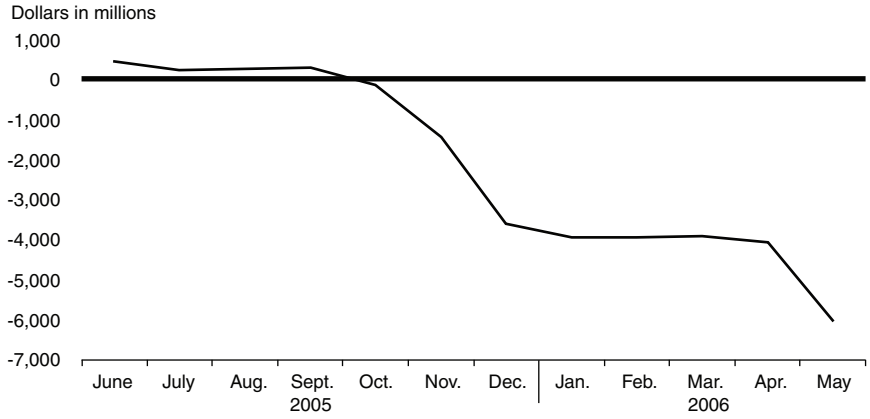
Appendix II: Current Shortfalls in Contractor Performance on Key Instrument Development

The development of one of the critical GOES-R instruments, the Advanced Baseline Imager (ABI), is experiencing technical challenges and, as a result, the contractor is missing cost and schedule targets. Despite the uncertainty regarding the future scope of the GOES-R program, it is expected that the requirements for this instrument will not change.

Contractor-provided data from June 2005 to May 2006 indicates that ABI's cost performance is experiencing a trend of negative variances. Figure 4 shows the 11-month cumulative cost variance for the ABI contract. As of May 2006, the contractor has incurred a total cost overrun of almost $6 million with ABI development only 28 percent complete. This information is useful because trends tend to continue and can be difficult to reverse unless management attention is focused on key risk areas and risk mitigation actions are aggressively pursued. Studies have shown that, once work is 15 percent complete, the performance indicators are indicative of the final outcome.

Based on contractor performance from June 2005 to May 2006, we estimated that the current ABI instrument contract—which is worth approximately $360 million—will overrun its budget by between $17 million and $47 million. Our projection of the most likely cost overrun will be about $23 million. The contractor, in contrast, estimates about a $7 million overrun at completion of the ABI contract. Given that the contractor has 72 percent of work remaining and has already accumulated a cost overrun of $5.9 million, the likelihood that the contractor will meet its estimated projection is small.

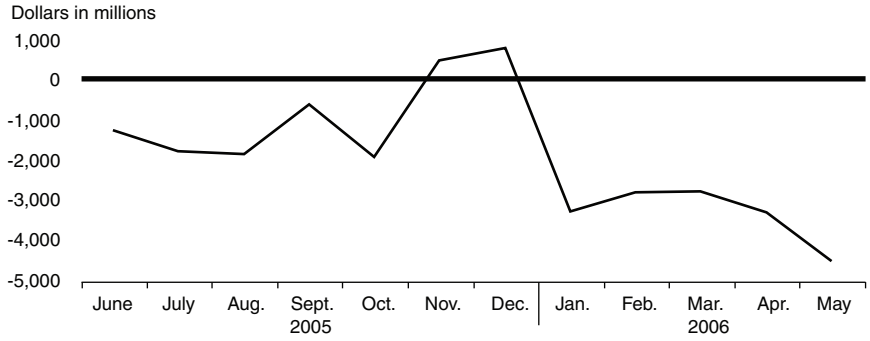
Figure 4: Cumulative Cost Variance of the ABI Instrument Contract over an 11-month Period



Source: GAO analysis based on NOAA data.

Our analysis also indicates that the contractor has been unable to meet its planned schedule targets. Figure 5 shows the 11-month cumulative schedule variance for the ABI contract. From June 2005 to May 2006, the contractor was unable to complete approximately $3.3 million worth of scheduled work. The contractor reported that its incorporation of revised subcontractor budgets resulted in the fluctuations in schedule performance data prior to March 2006. The current inability to meet contract schedule performance could be a predictor of future rising costs, as more spending is often necessary to resolve schedule overruns.

Figure 5: Cumulative Schedule Variance of the ABI Instrument Contract over an 11-month Period



Source: GAO analysis based on NOAA data.

According to contractor-provided documents, the cost and schedule overruns were primarily caused by design complexity issues experienced in the development of the instrument's detectors and the electronics design for the cryocooler[1] and the unplanned time and manpower expended to resolve these issues. Other significant cost and schedule drivers include software issues on the scanner and supplier quality issues on some parts.

[1]The cryocooler is a key component of the ABI instrument. It is intended to cool down components of the instrument.

Appendix III: Comments from the Department of Commerce

THE DEPUTY SECRETARY OF COMMERCE
Washington, D.C. 20230

August 24, 2006

Mr. David A. Powner
Director
Information Technology
Management Issues
U.S. Government Accountability Office
441 G Street, NW
Washington, D.C. 20548

Dear Mr. Powner:

Thank you for the opportunity to review and comment on the Government Accountability Office's draft report entitled *Geostationary Operational Environmental Satellites: Steps Remain in Incorporating Lessons Learned from Other Satellite Programs* (GAO-06-993). I enclose the Department of Commerce's comments to the draft report.

Sincerely,

David A. Sampson

Enclosure

Department of Commerce's Comments on the Draft GAO Report Entitled "Geostationary Operational Environmental Satellites: Steps Remain in Incorporating Lessons Learned from Other Satellite Programs" (GAO-06-993/September 2006)

General Comments

The Department of Commerce appreciates the opportunity to review this report on Geostationary Operational Environmental Satellites, specifically the R-Series (GOES-R). The report does a fair and thorough job identifying past satellite program shortfalls and assessing GOES-R efforts to leverage lessons learned from previous programs. Although not specifically identified in the GAO recommendations, the report notes the National Oceanic and Atmospheric Administration (NOAA) is taking on its first major system acquisition with GOES-R, which entails increased risk due to NOAA's limited experience. As observed by the GAO at several points in the report, NOAA has taken numerous steps to strengthen its management approach and to incorporate lessons learned to ensure effective program performance. Among these actions are increasing systems engineering staff, co-locating government staff at prime and subcontractor locations, incorporating recent GAO and Department of Commerce's Office of Inspector General recommendations concerning contract award fee structure, establishing a Program Management Council to provide regular review and assessment of the GOES-R program, and implementing comprehensive independent review of the program. In addition, NOAA is evaluating DOC/NOAA and the National Aeronautics and Space Administration roles to ensure NASA's spacecraft acquisition expertise is effectively leveraged. NOAA is scheduled to provide DOC with an assessment on this issue this fall. NOAA believes these steps will enable NOAA to effectively manage the GOES-R acquisition; we will continue to assess the need for additional actions, particularly in response to findings from the independent review teams, and will take the necessary actions to ensure effective performance on this critical acquisition.

NOAA concurs with the recommendations identified by the GAO in the report, as discussed below. The report's discussion of the Advanced Baseline Imager (ABI) earned value management (EVM) shortfalls is being addressed. NOAA remains concerned with the report's use of a premature and misleading cost estimate in a number of places. Specific instances are addressed in the technical comments section of this response.

NOAA Response to GAO Recommendations

The draft GAO report states, "To improve NOAA's ability to effectively manage the procurement of the GOES-R system, we recommend that the Secretary of Commerce direct its NOAA Program Management Council to take the following three actions:"

Recommendation 1: "once the scope of the program has been finalized, establish a process for objectively evaluating and reconciling the government and independent life cycle cost estimates."

1

NOAA Response: NOAA agrees with this recommendation. As the program scope is being finalized, NOAA will establish a process for evaluating and reconciling government and independent life cycle cost estimates, and will vet the process and results with an independent review team comprised of recognized senior experts in the satellite acquisition field.

Recommendation 2: "perform a comprehensive review of the Advanced Baseline Imager, using system engineering experts, to determine the level of technical maturity achieved on the instrument, to assess whether the contractor has implemented sound management and process engineering, and to assert that the technology is sufficiently mature before moving the instrument into production."

NOAA Response: NOAA agrees with this recommendation. Comprehensive reviews, including independent systems and technical reviews, are being performed. In addition to the extensive NASA processes described below, the GOES-R Independent Review Team is also looking at the ABI and other instruments and providing its assessment of their technical maturity and their level of risk to the program.

NASA Goddard Space Flight Center (GSFC) has implemented the requested processes in its "Integrated Independent Reviews" (IIRs). Each NASA GSFC space flight hardware development contract is subject to IIRs throughout the development cycle up to launch. The processes that are followed are documented in: GPR 8700.4F – Integrated Independent Reviews, GSFC STD 1001 – Criteria for Flight Project Critical Milestone Reviews, and GSFC STD 1000 – Rules for the Design, Development, Verification, and Operation of Flight Systems. The Integrated Independent Review Teams (IIRTs) for GOES-R are co-chaired by NASA and The Aerospace Corporation. The IIRT membership is comprised of NASA Engineering and Systems Safety and Mission Assurance, Aerospace Corporation, and NOAA personnel from outside of the GOES-R Program/Projects. The IIRTs ensure that each development effort has achieved the level of technical/design maturity required for the given phase of the effort and that the appropriate processes are in place and are followed. The ABI instrument and the ITT Industries Management Team have been subjected to two IIRs to date: the System Concept Review (SCR) in February 2005 and the Preliminary Design Review (PDR) in December 2005. The next IIR is the Critical Design Review (CDR), which is tentatively scheduled for February 2007.

Recommendation 3: "seek assistance from an independent review team to determine the appropriate level of resources needed at the program office to adequately track and oversee the contractor's earned value management. Among other things, the program office should be able to perform a comprehensive integrated baseline review after system development contract award, provide surveillance of contractor earned value management systems, and perform project scheduling analyses and cost estimates."

NOAA Response: NOAA agrees with this recommendation, and has included within the scope of the Independent Review Team an assessment of the extent to which the program management structure and reporting process will provide adequate oversight, and assessment of whether or not the program is adequately staffed in terms of personnel numbers and skills. The Independent Review Team is examining these elements and will provide recommendations concerning this, to which the program will respond.

2

The GOES-R Program Office currently plans to bring at least three EVM specialists on board, and has subjected these plans to independent review. In addition, the program is prepared to leverage additional lessons learned from other programs.

EVM will remain a factor in award fee determinations for the ABI developer. NOAA recognizes the importance of EVM and realizes that EVM is an effective management tool, not a substitute for good program management. Mission success is the key, and decisions will continue to be made to ensure GOES-R is developed to meet performance requirements. The GOES-R Program Office has made and implemented important management actions to ensure mission success–including the use of on-site resident managers who are able to oversee the procurement at the contractor's facility.

3

Appendix IV: GAO Contact and Staff Acknowledgments

GAO Contact

David A. Powner, (202) 512-9286 or pownerd@gao.gov.

Staff Acknowledgments

In addition to the contact named above, Carol Cha, Neil Doherty, Nancy Glover, Kush Malhotra, Colleen Phillips, and Karen Richey made key contributions to this report.

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