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ENVIRONMENTAL SATELLITE ACQUISITIONS

Progress and Challenges

Statement of Dave A. Powner, Director
Information Technology Management Issues

GAO-07-1099T

July 11, 2007

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Progress and Challenges

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Highlights

Highlights of GAO-07-1099T, a testimony before the Senate Committee on Commerce, Science, and Transportation

Why GAO Did This Study

Environmental satellites provide data and imagery that are used by weather forecasters, climatologists, and the military to map and monitor changes in weather (including severe weather such as hurricanes), climate, the oceans, and the environment. Two current acquisitions are the $12.5 billion National Polar-orbiting Operational Environmental Satellite System (NPOESS) program—which is to replace two existing polar-orbiting environmental satellite systems—and the planned $7 billion Geostationary Operational Environmental Satellites-R (GOES-R) program, which is to replace the current series of satellites due to reach end of their useful lives in approximately 2012. GAO was asked to summarize its past work on the progress and challenges facing these key environmental satellite acquisitions.

What GAO Recommends

In April 2007, GAO made recommendations to the NPOESS program to complete important tasks and mitigate significant risks to the program. In September 2006, GAO made recommendations to the GOES-R program to improve its management capabilities. Implementation of these recommendations should reduce risks for these critical acquisitions.

www.gao.gov/cgi-bin/getrpt?GAO-07-1099T.

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

What GAO Found

Both the NPOESS and GOES-R satellite acquisitions are costly, technically complex, and critically important to weather forecasting and climate monitoring. NPOESS was originally estimated to cost about $6.5 billion over the 24-year life of the program, with its first satellite launch planned for April 2009. Over the last few years, NPOESS experienced escalating costs, schedule delays, and technical difficulties. These factors led to a June 2006 decision to restructure the program thereby decreasing the program's complexity by reducing the number of sensors and satellites, increasing its estimated cost to $12.5 billion, and delaying the launches of the first two satellites to 2013 and 2016 (see table below). Since that time, the program office has made progress in restructuring the satellite acquisition and establishing an effective management structure; however, important tasks remain to be done and significant risks remain.

The GOES-R acquisition, originally estimated to cost $6.2 billion and scheduled to have the first satellite ready for launch in 2012, is at a much earlier stage in its life cycle than NPOESS. In September 2006, GAO reported that the National Oceanic and Atmospheric Administration (NOAA) had issued contracts for the preliminary design of the overall GOES-R system to three vendors and expected to award a contract to one of these vendors in August 2007 to develop the satellites. However, analyses of GOES-R cost—which in May 2006 was estimated to reach $11.4 billion—led the agency, in September 2006, to reduce the program's scope from four to two satellites and to discontinue one of the critical sensors. Program officials now report that they are reevaluating that decision and may further revise the scope and requirements of the program in coming months. GAO also reported that NOAA had taken steps to implement lessons learned from past satellite programs, but more remained to be done to ensure sound cost estimates and adequate system engineering capabilities. GAO currently has work under way to evaluate GOES-R risks and challenges.

Summary of Changes to NPOESS Program

Key area	Program before restructuring	Program after restructuring
Life cycle range	1995-2020	1995-2026
Estimated life cycle cost	$8.4 billion	$12.5 billion
Launch schedule	First satellite by November 2009 Second satellite by June 2011	First satellite by January 2013 Second satellite by January 2016
Number of satellites	6 (in addition to NPP)	4 (in addition to NPP)
Number of orbits	3 (early morning, midmorning, and afternoon)	2 (early morning and afternoon; will rely on European satellites for midmorning orbit data)
Number and complement of instruments	13 instruments (10 sensors and 3 subsystems)	9 instruments (7 sensors and 2 subsystems); 4 of the sensors are to provide fewer capabilities
Number of data records	55	39 (6 are to be degraded products)

Source: GAO analysis of NPOESS program office data.

Mr. Chairman and Members of the Committee:

We appreciate the opportunity to participate in today's hearing to discuss our work on two major operational environmental satellite programs: the $12.5 billion National Polar-orbiting Operational Environmental Satellite System (NPOESS) program and the planned $7 billion Geostationary Operational Environmental Satellites-R (GOES-R) program.

Operational environmental satellites provide data and imagery that are used by weather forecasters, climatologists, and the military to map and monitor changes in weather, climate, the oceans, and the environment. NPOESS—a tri-agency program managed by the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA), the Department of Defense/US Air Force, and the National Aeronautics and Space Administration (NASA)—is expected to be a state-of-the-art, environment monitoring satellite system that will replace two existing polar-orbiting environmental satellite systems. The GOES-R series, managed by NOAA with assistance from NASA, 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. The NPOESS and GOES-R programs are considered critical to the United States' ability to maintain the continuity of data required for weather forecasting (including severe weather events such as hurricanes) and global climate monitoring through the years 2026 and 2028 respectively.

At your request, we are summarizing the results of our previous work on operational environmental satellite programs, including NPOESS and the GOES-R program.[1] In preparing this testimony, we

[1]GAO, *Polar-orbiting Operational Environmental Satellites: Restructuring is Under Way, but Technical Challenges and Risks Remain,* GAO-07-498 (Washington, D.C. April 27, 2007); *Polar-orbiting Operational Environmental Satellites: Restructuring is Under Way, but Challenges and Risks Remain,* GAO-07-910T (Washington, D.C. June 7, 2007); *Geostationary Operational Environmental Satellites: Steps Remain in Incorporating Lessons Learned from Other Satellite Programs*, GAO-06-993 (Washington, D.C.: Sept. 6, 2006); and *Geostationary Operational Environmental Satellites: Additional Action Needed to Incorporate Lessons Learned from Other Satellite Programs*, GAO-06-1129T (Washington, D.C.: Sept. 29, 2006).

relied on the work supporting our prior reports. Those reports contain detailed overviews of our scope and methodology. All of the work on which this testimony is based was performed in accordance with generally accepted government auditing standards.

Results in Brief

NOAA is involved in two major satellite acquisition programs, NPOESS and GOES-R, and both are costly, technically complex, and critically important to weather forecasting and climate monitoring. NPOESS was originally estimated to cost about $6.5 billion over the 24-year life of the program, with its first satellite launch planned for April 2009. Over the last few years, NPOESS experienced escalating costs, schedule delays, and technical difficulties. These factors led to a June 2006 decision to restructure the program thereby decreasing the program's complexity by reducing the number of sensors and satellites, increasing its estimated cost to $12.5 billion, and delaying the launches of the first two satellites to 2013 and 2016, respectively. Since that time, the program office has made progress in restructuring the satellite acquisition and establishing an effective management structure; however, important tasks remain to be done and significant risks remain. Specifically, key acquisition documents that were originally due in September 2006 are still not completed, the program office is not yet fully staffed, and the early July turnover of the program executive officer increases the program's risk. Additionally, technical risks remain in the development of key system sensors and the ground-based data processing system. In April 2007, we made recommendations to complete key acquisition documents, increase staffing at the program office, and delay reassignment of the program executive. Implementation of these recommendations should reduce risk on this critical acquisition.

The GOES-R acquisition, originally estimated to cost $6.2 billion and scheduled to have the first satellite ready for launch in 2012, is at a much earlier stage in its life cycle than NPOESS. In September 2006, we reported that NOAA had issued contracts for the preliminary design of the overall GOES-R system to three vendors and expected to award a contract to one of these vendors in August 2007 to develop the satellites. However, analyses of GOES-R cost—which in May 2006 was estimated to reach $11.4 billion—led the agency, in September 2006, to reduce the program's scope from four to two satellites and to discontinue one of the critical sensors. Program officials now report that they are reevaluating that decision and may further revise the scope and requirements of the program in coming months. We also reported that NOAA had taken steps to implement lessons learned from past satellite programs, but more remained to be done to ensure sound cost estimates and adequate system engineering capabilities. We made recommendations to the program to improve its capabilities for managing this program and agency officials agreed with these recommendations and initiated efforts to implement them. We currently have work under way to evaluate GOES-R risks and challenges.

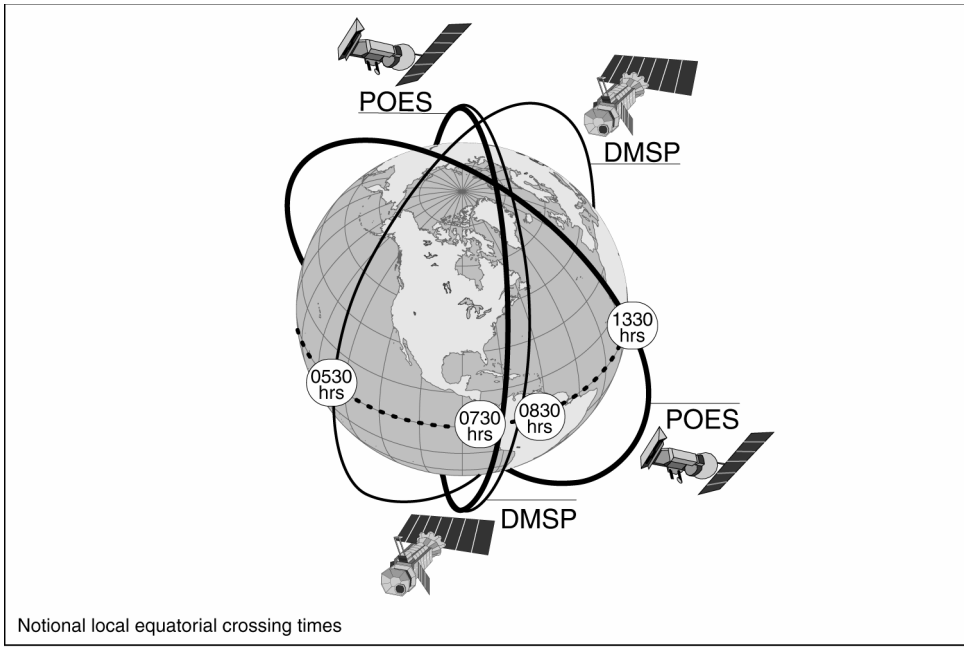
Background

Since the 1960s, geostationary and polar-orbiting operational 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 existing civilian geostationary and polar-orbiting satellite systems as two separate programs, called the Geostationary Operational Environmental Satellites and the Polar Operational Environmental Satellites (POES), respectively. The Air Force is responsible for operating a second polar-orbiting environmental satellite system—the Defense Meteorological Satellite Program (DMSP).

Polar-orbiting environmental satellites obtain environmental data that are processed to provide graphical weather images and specialized weather products. These satellite data are also the predominant input to numerical weather prediction models, which

are a primary tool for forecasting weather 3 or more days in advance—including forecasting the path and intensity of hurricanes. The weather products and models are used to predict the potential impact of severe weather so that communities and emergency managers can help prevent and mitigate their effects. Polar satellites also provide data used to monitor environmental phenomena, such as ozone depletion and drought conditions, as well as data sets that are used by researchers for a variety of studies such as climate monitoring. Figure 1 illustrates the current operational polar satellite configuration consisting of two POES and two DMSP satellites.

Figure 1: Configuration of Operational Polar Satellites

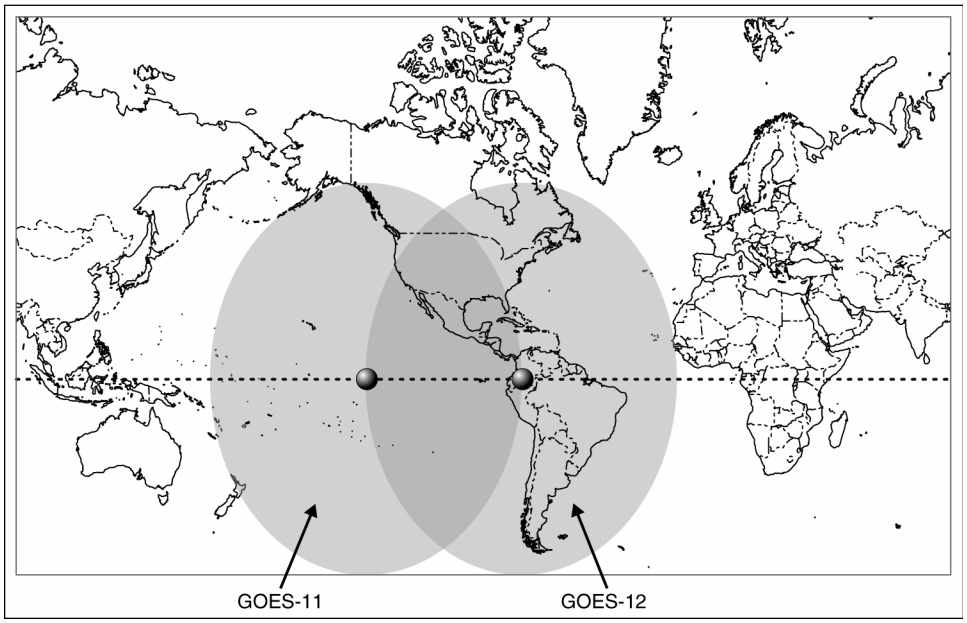


Source: GAO, based on NPOESS Integrated Program Office data.

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. 2). 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 2: Approximate GOES Geographic Coverage



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

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

Satellite acquisition 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 NPOESS, the GOES I-M series, the Air Force's Space Based Infrared System High

Program (SBIRS-High), and the Air Force's Advanced Extremely High Frequency Satellite System (AEHF).[2] Table 1 lists key problems experienced with these programs. While each of the programs faced multiple problems, all of them experienced insufficient maturity of technologies, overly aggressive schedules, insufficient subcontract management, and inadequate system engineering capabilities for overseeing contractors.

Table 1: 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

[2]GAO-07-498; GAO-06-993; 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).

Problem	NPOESS	GOES I-M	SBIRS–High	AEHF
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.

NPOESS: Overview, Issues, and Prior GAO Recommendations

With the expectation that combining the POES and DMSP programs would reduce duplication and result in sizable cost savings, a May 1994 Presidential Decision Directive required NOAA and DOD to converge the two satellite programs into a single satellite program capable of satisfying both civilian and military requirements.[3] The converged program, NPOESS, is considered critical to the United States' ability to maintain the continuity of data required for weather forecasting and global climate monitoring through the year 2026. To manage this program, DOD, NOAA, and NASA formed a tri-agency Integrated Program Office, located within NOAA.

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. NOAA and DOD share the costs of funding NPOESS, while NASA funds specific technology projects and studies. The NPOESS program office is overseen by an Executive Committee, which is made up of the Administrators of NOAA and NASA and the Under Secretary of the Air Force.

[3] Presidential Decision Directive NSTC-2 (May 5, 1994).

NPOESS is a major system acquisition that was originally estimated to cost about $6.5 billion over the 24-year life of the program from its inception in 1995 through 2018. The program was to provide satellite development, satellite launch and operation, and ground-based satellite data processing. When the NPOESS engineering, manufacturing, and development contract was awarded in August 2002, the estimated cost was $7 billion. Acquisition plans called for the procurement and launch of six satellites over the life of the program, as well as the integration of 13 instruments—consisting of 10 environmental sensors and 3 subsystems (see table 2).

Table 2: Expected NPOESS Instruments as of August 31, 2004 (critical sensors are in bold)

Instrument	Description
Advanced technology microwave sounder (ATMS)	Measures microwave energy released and scattered by the atmosphere and is to be used with infrared sounding data from NPOESS's cross-track infrared sounder to produce daily global atmospheric temperature, humidity, and pressure profiles.
Aerosol polarimetry sensor	Retrieves specific measurements of clouds and aerosols (liquid droplets or solid particles suspended in the atmosphere, such as sea spray, smog, and smoke).
Conical-scanned microwave imager/sounder (CMIS)	Collects microwave images and data needed to measure rain rate, ocean surface wind speed and direction, amount of water in the clouds, and soil moisture, as well as temperature and humidity at different atmospheric levels.
Cross-track infrared sounder (CrIS)	Collects measurements of the earth's radiation to determine the vertical distribution of temperature, moisture, and pressure in the atmosphere.
Data collection system	Collects environmental data from platforms around the world and delivers them to users worldwide.
Earth radiation budget sensor	Measures solar short-wave radiation and long-wave radiation released by the earth back into space on a worldwide scale to enhance long-term climate studies.
Ozone mapper/profiler suite (OMPS)	Collects data needed to measure the amount and distribution of ozone in the earth's atmosphere.
Radar altimeter	Measures variances in sea surface height/topography and ocean surface roughness, which are used to determine sea surface height, significant wave height, and ocean surface wind speed and to provide critical inputs to ocean forecasting and climate prediction models.
Search and rescue satellite aided tracking system	Detects and locates aviators, mariners, and land-based users in distress.
Space environmental sensor suite	Collects data to identify, reduce, and predict the effects of space weather on technological systems, including satellites and radio links.
Survivability sensor	Monitors for attacks on the satellite and notifies other instruments in case of an attack.
Total solar irradiance sensor	Monitors and captures total and spectral solar irradiance data.
Visible/infrared imager radiometer suite (VIIRS)	Collects images and radiometric data used to provide information on the earth's clouds, atmosphere, ocean, and land surfaces.

Source: GAO, based on NPOESS program office data.

In addition, a demonstration satellite (called the NPOESS Preparatory Project or NPP) was planned to be launched several

years before the first NPOESS satellite in order to reduce the risk associated with launching new sensor technologies and to ensure continuity of climate data with NASA's Earth Observing System satellites.

NPOESS Experienced Cost Increases, Schedule Delays, and Technical Problems over Several Years

Over the last few years, NPOESS experienced continued cost increases and schedule delays, requiring difficult decisions to be made about the program's direction and capabilities. In 2003, we reported that changes in the NPOESS funding stream led the program to develop a new program cost and schedule baseline.[4] After this new baseline was completed in 2004, we reported that the program office increased the NPOESS cost estimate from about $7 billion to $8.1 billion, delaying key milestones, including the launch of the first satellite, and extending the life of the program until 2020.[5] In mid-November 2005, we reported that NPOESS continued to experience problems in the development of a key sensor, resulting in schedule delays and anticipated cost increases. This was due in part, to problems at multiple levels of management—including subcontractor, contractor, program office, and executive leadership. Recognizing that the budget for the program was no longer executable, the NPOESS Executive Committee planned to make a decision in December 2005 on the future direction of the program—what would be delivered, at what cost, and by when. This involved deciding among options involving increased costs, delayed schedules, and reduced functionality. We noted that continued oversight, strong leadership, and timely decision making were more critical than ever, and we urged the committee to make a decision quickly so that the program could proceed.

However, we subsequently reported that, in late November 2005, NPOESS cost growth exceeded a legislatively mandated threshold that requires DOD to certify the program to Congress.[6] This placed

[4] GAO; *Polar-Orbiting Environmental Satellites: Project Risks Could Affect Weather Data Needed by Civilian and Military Users*, GAO-03-987T (Washington, D.C., July 15, 2003)

[5] GAO-04-1054

[6] GAO, *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).

any decision about the future direction of the program on hold until the certification took place in June 2006. In the meantime, the program office implemented an interim program plan for fiscal year 2006 to continue work on key sensors and other program elements using fiscal year 2006 funding.

Nunn-McCurdy Process Led to a Decision to Restructure the NPOESS Program

The Nunn-McCurdy law requires DOD to take specific actions when a major defense acquisition program exceeds certain cost increase thresholds.[7] The law requires the Secretary of Defense to notify Congress when a major defense acquisition is expected to overrun its project baseline by 15 percent or more and to certify the program to Congress when it is expected to overrun its baseline by 25 percent or more.[8] In late November 2005, NPOESS exceeded the 25 percent threshold, and DOD was required to certify the program. Certifying the program entailed providing a determination that (1) the program is essential to national security, (2) there are no alternatives to the program that will provide equal or greater military capability at less cost, (3) the new estimates of the program's cost are reasonable, and (4) the management structure for the program is adequate to manage and control costs. DOD established tri-agency teams—made up of DOD, NOAA, and NASA experts—to work on each of the four elements of the certification process.

In June 2006, DOD (with the agreement of both of its partner agencies) certified a restructured NPOESS program, estimated to cost $12.5 billion through 2026.[9] This decision approved a cost increase of $4 billion over the prior approved baseline cost and delayed the launch of NPP and the first two satellites by roughly 3 to 5 years. The new program also entailed establishing a stronger

[7] 10 U.S.C § 2433 is commonly referred to as Nunn-McCurdy.

[8] 10 U.S.C. § 2433 (e)(2).

[9] DOD estimated that the acquisition portion of the certified program would cost $11.5 billion. The acquisition portion includes satellite development, production, and launch, but not operations and support costs after launch. When combined with an estimated $1 billion for operations and support after launch, this brings the program life cycle cost to $12.5 billion.

program management structure, reducing the number of satellites to be produced and launched from 6 to 4, and reducing the number of instruments on the satellites from 13 to 9—consisting of 7 environmental sensors and 2 subsystems. It also entailed using NPOESS satellites in the early morning and afternoon orbits and relying on European satellites for midmorning orbit data.[10] Table 3 summarizes the major program changes made under the Nunn-McCurdy certification decision.

Table 3: Summary of Changes to the NPOESS Program

Key area	Program before the Nunn-McCurdy decision	Program after the Nunn-McCurdy decision
Life cycle range	1995-2020	1995-2026
Estimated life cycle cost	$8.4 billion	$12.5 billion
Launch schedule	NPP by October 2006 First NPOESS by November 2009 Second NPOESS by June 2011	NPP by January 2010 First NPOESS by January 2013 Second NPOESS by January 2016
Management structure	System Program Director reports to a tri-agency steering committee and the tri-agency Executive Committee Independent program reviews noted insufficient system engineering and cost analysis staff	System Program Director is responsible for day-to-day program management and reports to the Program Executive Officer Program Executive Officer oversees program and reports to the tri-agency Executive Committee
Number of satellites	6 (in addition to NPP)	4 (in addition to NPP)
Number of orbits	3 (early morning, midmorning, and afternoon)	2 (early morning and afternoon; will rely on European satellites for midmorning orbit data)
Number and complement of instruments	13 instruments (10 sensors and 3 subsystems)	9 instruments (7 sensors and 2 subsystems); 4 of the sensors are to provide fewer capabilities
Number of EDRs	55	39 (6 are to be degraded products)

Source: GAO analysis of NPOESS program office data.

The Nunn-McCurdy certification decision established new milestones for the delivery of key program elements, including launching NPP by January 2010,[11] launching the first NPOESS

[10] The European Organization for the Exploitation of Meteorological Satellites' MetOp program is a series of three polar-orbiting satellites dedicated to operational meteorology. MetOp satellites are planned to be launched sequentially over 14 years.

[11] According to program officials, although the Nunn-McCurdy certification decision specifies NPP is to launch by January 2010, NASA plans to launch it by September 2009 to reduce the possibility of a climate data continuity gap.

satellite (called C1) by January 2013, and launching the second NPOESS satellite (called C2) by January 2016. These revised milestones deviated from prior plans to have the first NPOESS satellite available to back up the final POES satellite should anything go wrong during that launch.

Delaying the launch of the first NPOESS satellite means that if the final POES satellite fails on launch, satellite data users would need to rely on the existing constellation of environmental satellites until NPP data becomes available—almost 2 years later. Although NPP was not intended to be an operational asset, NASA agreed to move it to a different orbit so that its data would be available in the event of a premature failure of the final POES satellite. However, NPP will not provide all of the operational capability planned for the NPOESS spacecraft. If the health of the existing constellation of satellites diminishes—or if NPP data is not available, timely, and reliable—then there could be a gap in environmental satellite data.

In order to reduce program complexity, the Nunn-McCurdy certification decision decreased the number of NPOESS sensors from 13 to 9 and reduced the functionality of 4 sensors. Specifically, of the 13 original sensors, 5 sensors remain unchanged, 3 were replaced with less capable sensors, 1 was modified to provide less functionality, and 4 were cancelled. Table 4 shows the changes to NPOESS sensors, including the 4 identified as critical sensors.

Table 4: Changes to NPOESS Instruments (critical sensors are in bold)

Instrument	Status of instrument after the Nunn-McCurdy decision	Change description
ATMS	Unchanged	Sensor is to be included on NPP and on the first and third NPOESS satellites.
Aerosol polarimetry sensor	Cancelled	Sensor was cancelled, but could be reintegrated on future NPOESS satellites should another party choose to fund it.[a]
CMIS	Replaced	CMIS sensor was cancelled, and the program office is to procure a less complex *Microwave imager/sounder* for inclusion on the second, third, and fourth NPOESS satellites.
CrIS	Unchanged	Sensor is to be included on NPP and on the first and third NPOESS satellites.
Data collection system	Unchanged	Subsystem is to be included on all four NPOESS satellites.

Instrument	Status of instrument after the Nunn-McCurdy decision	Change description
Earth radiation budget sensor	Replaced	Sensor was cancelled, and is to be replaced on the first NPOESS satellite (and no others) by an existing sensor with fewer capabilities called the *Clouds and the Earth's Radiant Energy System.*
OMPS	Modified	One part of the sensor, called OMPS (nadir), is to be included on NPP and on the first and third NPOESS satellites; the remaining part, called OMPS (limb), was cancelled on the NPOESS satellites, but will be included on NPP [a]
Radar altimeter	Cancelled	Sensor was cancelled, but could be reintegrated on future NPOESS satellites should another party choose to fund it [a]
Search and rescue satellite aided tracking system	Unchanged	Subsystem is to be included on all four NPOESS satellites.
Space environmental sensor suite	Replaced	Sensor is to be replaced *by a less capable, less expensive, legacy sensor called the Space* Environment Monitor on the first and third NPOESS satellites.
Survivability sensor	Cancelled	Subsystem contract was cancelled, but could be reintegrated on future NPOESS satellites should another party choose to fund it [a]
Total solar irradiance sensor	Cancelled	Sensor contract was cancelled, but could be reintegrated on future NPOESS satellites should another party choose to fund it [a]
VIIRS	Unchanged	Sensor is to be included on NPP and on all four NPOESS satellites.

Source: GAO analysis of NPOESS program office data.

[a]Although direct program funding for these instruments was eliminated, the instruments could be reintegrated on NPOESS satellites should other parties choose to fund them. The Nunn-McCurdy decision requires the program office to allow sufficient space on the spacecraft for these instruments and to provide the funding needed to integrate them.

The changes in NPOESS sensors affected the number and quality of the resulting weather and environmental products, called environmental data records or EDRs. In selecting sensors for the restructured program, the agencies placed the highest priority on continuing current operational weather capabilities and a lower priority on obtaining selected environmental and climate measuring capabilities. As a result, the revised NPOESS system has significantly less capability for providing global climate measures than was originally planned. Specifically, the number of EDRs was decreased from 55 to 39, of which 6 are of a reduced quality. The 39 EDRs that remain include cloud base height, land surface temperature, precipitation type and rate, and sea surface winds. The 16 EDRs that were removed include cloud particle size and distribution, sea surface height, net solar radiation at the top of the atmosphere, and products to depict the electric fields in the space environment. The 6 EDRs that are of a reduced quality include ozone profile, soil moisture, and multiple products depicting energy in the space environment.

NPOESS Acquisition Restructuring Is Well Under Way, but Key Steps Remain To Be Completed

Since the June 2006 decision to revise the scope, cost, and schedule of the NPOESS program, the program office has made progress in restructuring the satellite acquisition; however, important tasks remain to be done. Restructuring a major acquisition program like NPOESS is a process that involves identifying time-critical and high-priority work and keeping this work moving forward, while reassessing development priorities, interdependencies, deliverables, risks, and costs. It also involves revising important acquisition documents including the memorandum of agreement on the roles and responsibilities of the three agencies, the acquisition strategy, the system engineering plan, the test and evaluation master plan, the integrated master schedule defining what needs to happen by when, and the acquisition program baseline. Specifically, the Nunn-McCurdy certification decision required the Secretaries of Defense and Commerce and the Administrator of NASA to sign a revised memorandum of agreement by August 6, 2006. It also required that the program office, Program Executive Officer, and the Executive Committee revise and approve key acquisition documents including the acquisition strategy and system engineering plan by September 1, 2006, in order to proceed with the restructuring. Once these are completed, the program office can proceed to negotiate with its prime contractor on a new program baseline defining what will be delivered, by when, and at what cost.

The NPOESS program office has made progress in restructuring the acquisition. Specifically, the program office has established interim program plans guiding the contractor's work activities in 2006 and 2007 and has made progress in implementing these plans. The program office and contractor also developed an integrated master schedule for the remainder of the program—beyond fiscal year 2007. This integrated master schedule details the steps leading up to launching NPP by September 2009, launching the first NPOESS satellite in January 2013, and launching the second NPOESS satellite in January 2016. Near-term steps include completing and testing the VIIRS, CrIS, and OMPS sensors; integrating these sensors with the NPP spacecraft and completing integration testing; completing the data processing system and integrating it with the command,

control, and communications segment; and performing advanced acceptance testing of the overall system of systems for NPP.

However, key steps remain for the acquisition restructuring to be completed. Although the program office made progress in revising key acquisition documents, including the system engineering plan, the test and evaluation master plan, and the acquisition strategy plan, it has not yet obtained the approval of the Secretaries of Commerce and Defense and the Administrator of NASA on the memorandum of agreement among the three agencies, nor has it obtained the approval of the NPOESS Executive Committee on the other key acquisition documents. As of June 2007, these approvals are over 9 months past due. Agency officials noted that the September 1, 2006, due date for the key acquisition documents was not realistic given the complexity of coordinating documents among three different agencies.

Finalizing these documents is critical to ensuring interagency agreement and will allow the program office to move forward in completing other activities related to restructuring the program. These other activities include completing an integrated baseline review with the contractor to reach agreement on the schedule and work activities, and finalizing changes to the NPOESS development and production contract. Program costs are also likely to be adjusted during upcoming negotiations on contract changes—an event that the Program Director expects to occur in July 2007. Completion of these activities will allow the program office to lock down a new acquisition baseline cost and schedule. Until key acquisition documents are finalized and approved, the program faces increased risk that it will not be able to complete important restructuring activities in time to move forward in fiscal year 2008 with a new program baseline in place. This places the NPOESS program at risk of continued delays and future cost increases.

Progress Has Been Made in Establishing an Effective NPOESS Management Structure, but Executive Turnover Increases Risks and Staffing Problems Remain

The NPOESS program has made progress in establishing an effective management structure, but—almost a year after this structure was endorsed during the Nunn-McCurdy certification process—the Integrated Program Office still faces staffing problems.

Over the past few years, we and others have raised concerns about management problems at all levels of the NPOESS program, including subcontractor and contractor management, program office management, and executive-level management.[12] Two independent review teams also noted a shortage of skilled program staff, including budget analysts and system engineers. Since that time, the NPOESS program has made progress in establishing an effective management structure—including establishing a new organizational framework with increased oversight by program executives, instituting more frequent subcontractor, contractor, and program reviews, and effectively managing risks and performance. However, DOD's plans for reassigning the Program Executive Officer in the summer of 2007 increase the program's risks. Additionally, the program lacks a staffing process that clearly identifies staffing needs, gaps, and plans for filling those gaps. As a result, the program office has experienced delays in getting core management activities under way and lacks the staff it needs to execute day-to-day management activities.

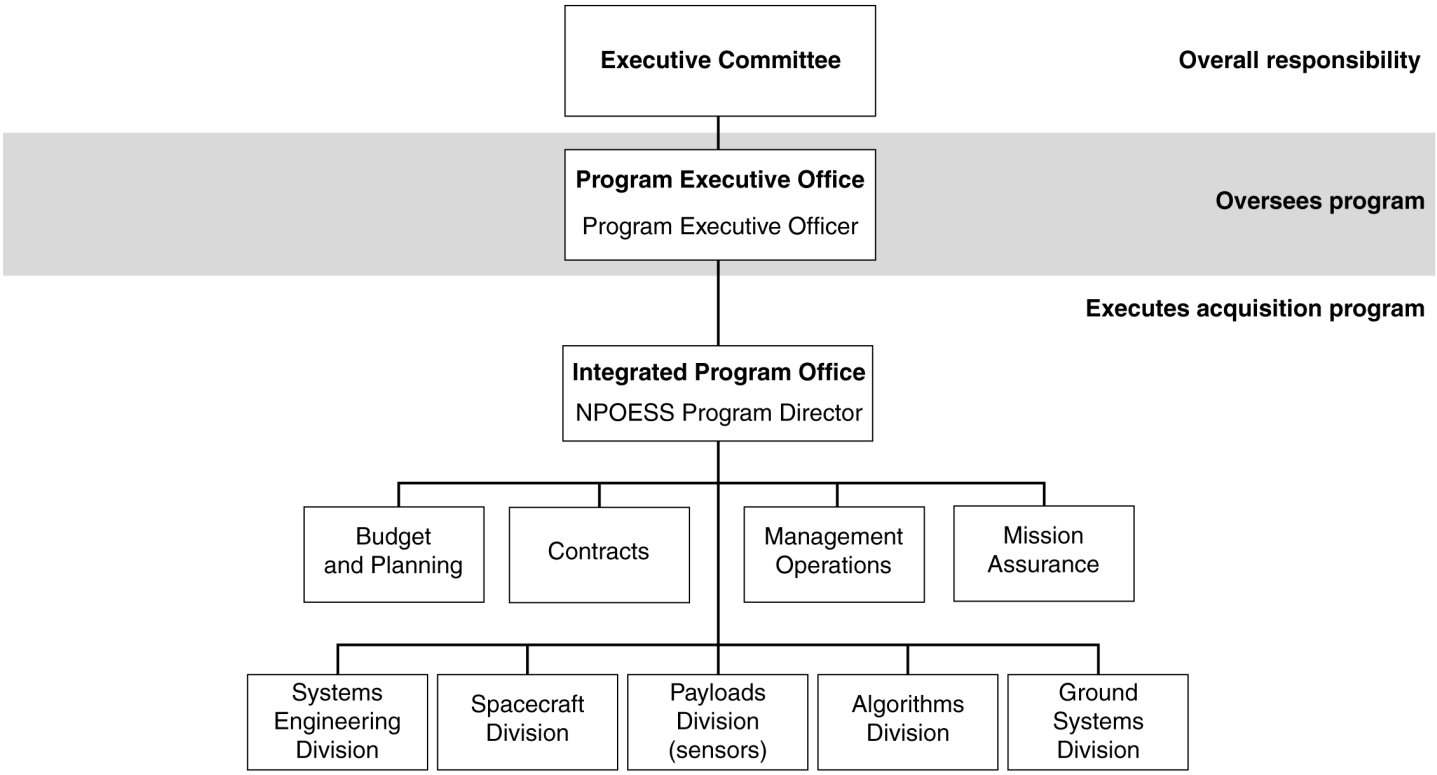
NPOESS Program Has Made Progress in Establishing an Effective Management Structure and Increasing Oversight Activities, but Executive Turnover Will Increase Program Risks

The NPOESS program has made progress in establishing an effective management structure and increasing the frequency and intensity of its oversight activities. Over the past few years, we and others have raised concerns about management problems at all levels of management on the NPOESS program, including subcontractor and contractor management, program office management, and executive-level management. In response to recommendations made by two different independent review teams, the program office began exploring options in late 2005 and early 2006 for revising its management structure.

[12]GAO-06-249T; U.S. Department of Commerce, Office of the Inspector General, *Poor Management Oversight and Ineffective Incentives Leave NPOESS Program Well Over Budget and Behind Schedule*, OIG-17794-6-0001/2006 (Washington, D.C.: May 2006). In addition, two independent teams reviewed the NPOESS program in 2005: A NASA-led Independent Review Team investigated problems with the VIIRS sensor and the impact on NPP, and a DOD-led Independent Program Assessment Team assessed the broader NPOESS program. The teams briefed the NPOESS Executive Committee on their findings in August 2005 and November 2005, respectively.

In November 2005, the Executive Committee established and filled a Program Executive Officer position, senior to the NPOESS Program Director, to streamline decision making and to provide oversight to the program. This Program Executive Officer reports directly to the Executive Committee. Subsequently, the Program Executive Officer and the Program Director proposed a revised organizational framework that realigned division managers within the Integrated Program Office responsible for overseeing key elements of the acquisition and increased staffing in key areas. In June 2006, the Nunn-McCurdy certification decision approved this new management structure and the Integrated Program Office implemented it. Figure 3 provides an overview of the relationships among the Integrated Program Office, the Program Executive Office, and the Executive Committee, as well as key divisions within the program office.

Figure 3: Overview of New NPOESS Management Structure



Source: NOAA.

Operating under this new management structure, the program office implemented more rigorous and frequent subcontractor, contractor, and program reviews, improved visibility into risk management and mitigation activities, and institutionalized the use of earned value management techniques to monitor contractor performance. In addition to these program office activities, the Program Executive Officer implemented monthly program reviews and increased the frequency of contacts with the Executive Committee. The Program Executive Officer briefs the Executive Committee in monthly letters, apprising committee members of the program's status, progress, risks, and earned value, and the Executive Committee now meets on a quarterly basis—whereas in the recent past, we reported that the Executive Committee had met only five times in 2 years.[13]

Although the NPOESS program has made progress in establishing an effective management structure, this progress is currently at risk. We recently reported that DOD space acquisitions are at increased risk due in part to frequent turnover in leadership positions, and we suggested that addressing this will require DOD to consider matching officials' tenure with the development or delivery of a product.[14] In March 2007, NPOESS program officials stated that DOD is planning to reassign the recently appointed Program Executive Officer in the summer 2007 as part of this executive's natural career progression. As of June 2007, the Program Executive Officer has held this position for 19 months. Given that the program is currently still being restructured, and that there are significant challenges in being able to meet critical deadlines to ensure satellite data continuity, such a move adds unnecessary risk to an already risky program.

NPOESS Program Has Filled Key Vacancies but Lacks a Programwide Staffing Process

The NPOESS program office has filled key vacancies but lacks a staffing process that identifies programwide staffing requirements and plans for filling those needed positions. Sound human capital

[13] GAO-06-249T

[14] GAO, *Space Acquisitions: Improvements Needed in Space Acquisitions and Keys to Achieving Them*, GAO-06-626T (Washington, D.C.: Apr. 6, 2006).

management calls for establishing a process or plan for determining staffing requirements, identifying any gaps in staffing, and planning to fill critical staffing gaps. Program office staffing is especially important for NPOESS, given the acknowledgment by multiple independent review teams that staffing shortfalls contributed to past problems. Specifically, these review teams noted shortages in the number of system engineers needed to provide adequate oversight of subcontractor and contractor engineering activities and in the number of budget and cost analysts needed to assess contractor cost and earned value reports. To rectify this situation, the June 2006 certification decision directed the Program Director to take immediate actions to fill vacant positions at the program office with the approval of the Program Executive Officer.

Since the June 2006 decision to revise NPOESS management structure, the program office has filled multiple critical positions, including a budget officer, a chief system engineer, an algorithm division chief, and a contracts director. In addition, on an ad hoc basis, individual division managers have assessed their needs and initiated plans to hire staff for key positions. However, the program office lacks a programwide process for identifying and filling all needed positions. As a result, division managers often wait months for critical positions to be filled. For example, in February 2006, the NPOESS program estimated that it needed to hire up to 10 new budget analysts. As of September 2006, none of these positions had been filled. As of April 2007, program officials estimated that they still needed to fill 5 budget analyst positions, 5 systems engineering positions, and 10 technical manager positions. The majority of the vacancies—4 of the 5 budget positions, 4 of the 5 systems engineering positions, and 8 of the 10 technical manager positions—are to be provided by NOAA. NOAA officials noted that each of these positions is in some stage of being filled—that is, recruitment packages are being developed or reviewed, vacancies are being advertised, or candidates are being interviewed, selected, and approved.

The program office attributes its staffing delays to not having the right personnel in place to facilitate this process, and it did not even begin to develop a staffing process until November 2006. Program officials noted that the tri-agency nature of the program adds

unusual layers of complexity to the hiring and administrative functions because each agency has its own hiring and performance management rules. In November 2006, the program office brought in an administrative officer who took the lead in pulling together the division managers' individual assessments of needed staff and has been working with the division managers to refine this list. This new administrative officer plans to train division managers in how to assess their needs and to hire needed staff, and to develop a process by which evolving needs are identified and positions are filled. However, there is as yet no date set for establishing this basic programwide staffing process. As a result of the lack of a programwide staffing process, there has been an extended delay in determining what staff is needed and in bringing those staff on board; this has resulted in delays in performing core activities, such as establishing the program office's cost estimate and bringing in needed contracting expertise. Additionally, until a programwide staffing process is in place, the program office risks not having the staff it needs to execute day-to-day management activities.

In commenting on a draft of our report, Commerce stated that NOAA implemented an accelerated hiring model. More recently, the NPOESS program office reported that several critical positions were filled in April and May 2007. However, we have not yet evaluated NOAA's accelerated hiring model and, as of June 2007, about 10 key positions remained to be filled.

Major Program Segments Are Under Development, but Significant Risks Remain

Major segments of the NPOESS program—the space segment and ground systems segment—are under development; however, significant problems have occurred and risks remain. The program office is aware of these risks and is working to mitigate them, but continued problems could affect the program's overall cost and schedule. Given the tight time frames for completing key sensors, integrating them on the NPP spacecraft, and developing, testing, and deploying the ground-based data processing systems, it will be important for the NPOESS Integrated Program Office, the Program Executive Office, and the Executive Committee to continue to provide close oversight of milestones and risks.

Space Segment—Progress Made, but Key Sensors Continue to Face Major Risks

The space segment includes the sensors and the spacecraft. Four sensors are of critical importance—VIIRS, CrIS, OMPS, and ATMS—because they are to be launched on the NPP satellite in September 2009. Initiating work on another sensor, the Microwave imager/sounder, is also important because this new sensor—replacing the cancelled CMIS sensor—will need to be developed in time for the second NPOESS satellite launch. Over the past year, the program made progress on each of the sensors and the spacecraft. However, two sensors, VIIRS and CrIS, have experienced major problems. The status of each of the components of the space segment is described in table 5.

Table 5: Status of Selected Components of the Space Segment, as of April 2007

Space segment component	Risk level	Status
VIIRS	High	VIIRS development has continued in 2006 and in early 2007. In December 2006, the contractor completed environmental tests of VIIRS's engineering design unit (a prototype) and identified three problems.[a] While these problems were being studied, the program office approved the delivery of the engineering unit to the subcontractor responsible for integration and testing on NPP. In late February 2007, program officials determined that the contractor was able to mitigate all but one of the problems, and they approved the flight unit to proceed to system level integration with a goal of resolving the final problem before a technical readiness review milestone. VIIRS flight unit is scheduled to be delivered to NPP by July 2008.
CrIS	High	Development of CrIS was put on hold in October 2006 when the flight unit designated to go on NPP experienced a major structural failure during its vibration testing. As of March 2007, a failure review board established by the contractors and the NPOESS program office identified causes for failure and has planned an approach to completing flight unit development and delivery for NPP. The review board has also initiated inspections of all sensor modules and subsystems for damage. The program office expects to restart acceptance testing in July 2007, and the CrIS flight unit is expected to be delivered to NPP by February 2008.
OMPS	Moderate	As part of the Nunn-McCurdy certification in June 2006, one element of the OMPS sensor, called OMPS (limb), was removed from the program. In February 2007, program officials agreed to reintegrate OMPS (limb) on NPP if NOAA and NASA would fund it. This funding was approved in early April 2007. OMPS is currently on schedule for delivery to NPP by May 2008; however, there are concerns that the OMPS flight unit delivery will be so late in the integration testing process that there could be an insufficient schedule margin should a problem arise.
ATMS	Low	The ATMS flight unit for NPP was developed by a NASA contractor and delivered to the program in October 2005. NASA integrated the flight unit on the spacecraft and is awaiting delivery of the other sensors in order to complete integration testing.

Space segment component	Risk level	Status
Microwave imager/ sounder	Not yet rated	A new microwave imager/sounder sensor is being planned to replace the cancelled CMIS sensor. It is planned to be ready for the launch on the second NPOESS satellite. In October 2006, the program office issued a request for information seeking industry ideas for the design of the new sensor. The program office anticipates awarding a contract to develop the sensor by October 2008.
Spacecraft	Low	The development of the spacecrafts for NPP and NPOESS are on track. The NPP spacecraft was completed in June 2005. Integration testing will be conducted once the NPP sensors are delivered. Early issues with the NPOESS spacecraft (including issues with antennas and a data storage unit) have been resolved; however, risks remain that could delay the completion of the spacecraft. A key risk involves delays in the delivery of the solar array, which may arrive too late to be included in some key testing. Other risks associated with the electrical power subsystem are taking longer than anticipated to resolve.

Source: GAO analysis of NPOESS Integrated Program Office data.

[a]The three problems are (1) band-to-band co-registration, an issue in which band registration shifts with different temperatures; (2) cross-talk, which involves information from sensor cells leaking into other cells; and (3) line-spread function issues, in which the instrument's focus changes with changes in temperature.

Managing the risks associated with the development of VIIRS and CrIS is of particular importance because these components are to be demonstrated on the NPP satellite, currently scheduled for launch in September 2009. Any delay in the NPP launch date could affect the overall NPOESS program, because the success of the program depends on the lessons learned in data processing and system integration from the NPP satellite. Additionally, continued sensor problems could lead to higher final program costs.

Ground Segment—Progress Has Been Made, but Work Remains

Development of the ground segment—which includes the interface data processing system, the ground stations that are to receive satellite data, and the ground-based command, control, and communications system—is under way and on track. However, important work pertaining to developing the algorithms that translate satellite data into weather products within the integrated data processing segment remains to be completed. Table 6 describes each of the components of the ground segment and identifies the status of each.

Table 6: Status of Ground Segment Components, as of April 2007

Ground segment component/description	Risk level	Status
Interface Data Processing System (IDPS): A ground-based system that is to process the sensors' data so that they are usable by the data processing centers and the broader community of environmental data users. IDPS will be deployed at the four weather data processing centers.	Moderate	IDPS is being developed in a series of builds. Currently, IDPS build 1.4 has been delivered for testing and recently passed two key data transfer tests. Contractors are currently working to develop IDPS build 1.5, which is expected to be the build that will be used with NPP. However, work remains in three areas: system latency, algorithm performance, and calibration and validation planning. Latency—IDPS must process volumes of data within 65 minutes to meet NPP requirements. The contractor has made progress in reducing the latency of the system's data handling from 93 minutes to 73 minutes and is working to reduce it by 8 minutes more by resolving data management issues, increasing the number of processors, and increasing algorithm efficiency. Algorithm performance—IDPS algorithms are the mathematical functions coded into the system software that transform raw data into data products, including sensor data records and environmental data records. IDPS build 1.4 contains provisional algorithms, which are being refined as the sensors complete various stages of testing. Because some sensors are delayed, full characterization of those sensors in order to refine the algorithms has also been delayed and may not be completed in time for the delivery of IDPS build 1.5 in early 2009. If this occurs, agency officials plan to improve the algorithms in build 1.5 during a planned maintenance upgrade prior to NPP launch. Calibration/validation—Calibration/validation is the process for tweaking algorithms to provide more accurate observations. The contractor has documented a detailed schedule for calibration and validation during IDPS development and is developing a postlaunch task list to drive prelaunch preparation efforts. However, much work and uncertainty continue to exist in the calibration and validation area. A program official noted that, while teams can do a lot of preparation work, including building the infrastructure to allow sensor testing and having a good understanding of the satellite, sensors, and available data for calibration, many issues need to take place after launch.
Ground stations for receiving satellite data: 15 unmanned ground stations around the world (called SafetyNet™) are to receive satellite data and send these to the four data processing centers.	Low	NOAA is working with domestic and foreign authorities to gain approval to operate ground stations to receive satellite data. According to agency officials, the full complement of ground stations will not be in place in time for the C1 launch: however, the ground stations will be phased in by the launch of C2. To date, the program office has reached agreement with 4 of 15 ground station sites.

Source: GAO analysis of NPOESS program office data.

Managing the risks associated with the development of the IDPS system is of particular importance because this system will be needed to process NPP data.

Implementation of GAO Recommendations Should Reduce Risk

Because of the importance of effectively managing the NPOESS program to ensure that there are no gaps in the continuity of critical

weather and environmental observations, in our April 2007 report,[15] we made recommendations to the Secretaries of Defense and Commerce and to the Administrator of NASA to ensure that the responsible executives within their respective organizations approve key acquisition documents, including the memorandum of agreement among the three agencies, the system engineering plan, the test and evaluation master plan, and the acquisition strategy, as quickly as possible but no later than April 30, 2007. We also recommended that the Secretary of Defense direct the Air Force to delay reassigning the recently appointed Program Executive Officer until all sensors have been delivered to the NPOESS Preparatory Program; these deliveries are currently scheduled to occur by July 2008. We also made two additional recommendations to the Secretary of Commerce to (1) develop and implement a written process for identifying and addressing human capital needs and for streamlining how the program handles the three different agencies' administrative procedures and (2) establish a plan for immediately filling needed positions.

In written comments, all three agencies agreed that it was important to finalize key acquisition documents in a timely manner, and DOD proposed extending the due dates for the documents to July 2, 2007. DOD subsequently extended the due dates to September and October 2007 and March 2008 in the case of the test and evaluation master plan. Because the NPOESS program office intends to complete contract negotiations in July 2007, we remain concerned that any further delays in approving the documents could delay contract negotiations and thus increase the risk to the program.

In addition, the Department of Commerce agreed with our recommendation to develop and implement a written process for identifying and addressing human capital needs and to streamline how the program handles the three different agencies' administrative procedures. The department also agreed with our recommendation to plan to immediately fill open positions at the NPOESS program office. Commerce noted that NOAA identified the

[15] GAO-07-498

skill sets needed for the program and has implemented an accelerated hiring model and schedule to fill all NOAA positions in the NPOESS program. Commerce also noted that NOAA has made NPOESS hiring a high priority and has documented a strategy—including milestones—to ensure that all NOAA positions are filled by June 2007.

DOD did not concur with our recommendation to delay reassigning the Program Executive Officer, noting that the NPOESS System Program Director responsible for executing the acquisition program would remain in place for 4 years. The Department of Commerce also noted that the Program Executive Officer position is planned to rotate between the Air Force and NOAA. Commerce also stated that a selection would be made before the departure of the current Program Executive Officer to provide an overlap period to allow for knowledge transfer and ensure continuity. However, over the last few years, we and others (including an independent review team and the Commerce Inspector General) have reported that ineffective executive-level oversight helped foster the NPOESS program's cost and schedule overruns. We remain concerned that reassigning the Program Executive at a time when NPOESS is still facing critical cost, schedule, and technical challenges will place the program at further risk.

In addition, while it is important that the System Program Director remain in place to ensure continuity in executing the acquisition, this position does not ensure continuity in the functions of the Program Executive Officer. The current Program Executive Officer is experienced in providing oversight of the progress, issues, and challenges facing NPOESS and coordinating with Executive Committee members as well as the Defense acquisition authorities. Additionally, while the Program Executive Officer position is planned to rotate between agencies, the memorandum of agreement documenting this arrangement is still in draft and should be flexible enough to allow the current Program Executive Officer to remain until critical risks have been addressed.

Further, while Commerce plans to allow a period of overlap between the selection of a new Program Executive Officer and the departure of the current one, time is running out. The current

Program Executive Officer is expected to depart in early July 2007, and as of early July 2007, a successor has not yet been named. NPOESS is an extremely complex acquisition, involving three agencies, multiple contractors, and advanced technologies. There is not sufficient time to transfer knowledge and develop the sound professional working relationships that the new Program Executive Officer will need to succeed in that role. Thus, we remain convinced that given NPOESS current challenges, reassigning the current Program Executive Officer at this time is not appropriate.

GOES-R: Overview, Issues, and Prior GAO Recommendations

To provide continuous satellite coverage, NOAA acquires several satellites at a time as part of a series and launches new satellites every few years (see table 7). To date, NOAA has procured three series of GOES satellites and is planning to acquire a fourth series, called GOES-R.

Table 7: 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[d]

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.

[d]NOAA recently decided to drop satellites T and U from this series, but is now reconsidering that decision.

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. NOAA is planning for the GOES-R program to improve on the technology of prior GOES series, both in terms of system and instrument improvements. The system improvements are expected to fulfill more demanding user requirements and to provide more rapid information updates. Table 8 highlights key system-related improvements that GOES-R is expected to make to the geostationary satellite program.

Table 8: 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 increase the clarity and precision of the observed environmental data. Originally, NOAA planned to acquire 5 different instruments. The program office considered two of the instruments—the Advanced Baseline Imager and the Hyperspectral Environmental Suite—to be the most critical because they would provide data for key weather products. Table 9 summarizes the originally planned instruments and their expected capabilities.

Table 9: 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.

Planned instrument	Description
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.

After our report was issued, NOAA officials told us that the agency decided to cancel its plans for the development of the Hyperspectral Environmental Suite, but expected to explore options to ensure the continuity of data provided by the current GOES series. Additionally, NOAA reduced the number of satellites in the GOES-R series from four to two satellites.

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

NOAA is nearing the end of the preliminary design phase of its GOES-R system, which was initially estimated to cost $6.2 billion and scheduled to have the first satellite ready for launch in 2012. At the time of our most recent review in September 2006,[16] NOAA had

[16] GAO-06-993.

issued contracts for the preliminary design of the overall GOES-R system to three vendors and expected 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 issued contracts for the early development of two instruments and for the preliminary designs of three other instruments.

However, analyses of the GOES-R program cost—which in May 2006 the program office estimated could reach $11.4 billion—led the agency to consider reducing the scope of requirements for the satellite series. In September 2006, NOAA officials reported that the agency had made a decision to reduce the scope and complexity of the GOES-R program by reducing the number of satellites from 4 to 2 and canceling a technically complex instrument—called the Hyperspectral Environmental Suite. As of July 2007, agency officials reported that they are considering further changes to the scope of the program, which are likely to affect the overall program cost. We have work under way to evaluate these changes.

Steps Taken to Reduce GOES-R Risk, More Work Remains

NOAA has taken steps to implement lessons learned from past satellite programs, but more remains to be done. As outlined previously, 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 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, at the time of our review, NOAA had not yet developed a process to evaluate and reconcile the independent and government cost estimates. In addition, NOAA had 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 had it determined the appropriate level of resources it needs to adequately track and oversee the program using earned

value management.[17] 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.

Implementation of GAO Recommendations Should Reduce GOES-R Acquisition Risk

To improve NOAA's ability to effectively manage the GOES-R procurement, in our September 2006 report,[18] we made 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 the instrument 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. In written comments at that time, the Department of Commerce agreed with our recommendations and provided information on its plans to implement our recommendations.

In summary, both the NPOESS and GOES-R programs are critical to developing weather forecasts, issuing severe weather warnings for events such as hurricanes, and maintaining continuity in environmental and climate monitoring. Over the last several years, the NPOESS program experienced cost, schedule, and technical problems, but has now been restructured and is making progress. Still, technical and programmatic risks remain. The GOES-R program has incorporated lessons from other satellite acquisitions,

[17]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.

[18]GAO-06-993.

but still faces challenges in establishing the management capabilities it needs and in determining the scope of the program. We have work under way to evaluate the progress and risks of both NPOESS and GOES-R in order to assist with congressional oversight of these critical programs.

Mr. Chairman, this concludes my statement. I would be happy to answer any questions that you or members of the committee may have at this time.

If you have any questions on matters discussed in this testimony, please contact me at (202) 512-9286 or by e-mail at pownerd@gao.gov. Other key contributors to this testimony include Carol Cha, Kathleen S. Lovett, and Colleen Phillips (Assistant Director).

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