United States Government Accountability Office

Report to the Committee on Science, Space, and Technology, House of Representatives

May 2016

POLAR WEATHER SATELLITES

NOAA Is Working to Ensure Continuity but Needs to Quickly Address Information Security Weaknesses and Future Program Uncertainties

GAO-16-359

Highlights of GAO-16-359, a report to the Committee on Science, Space, and Technology, House of Representatives

Why GAO Did This Study

NOAA established the JPSS program in 2010 to replace aging polar satellites and provide critical environmental data used in forecasting the weather. However, the potential exists for a gap in satellite data if the current satellite fails before the next one is operational. Because of this risk and the potential impact of a gap on the health and safety of the U.S. population and economy, GAO added this issue to its High Risk list in 2013, and it remained on the list in 2015.

GAO was asked to review the JPSS program. GAO's objectives were to (1) evaluate progress on the program, (2) assess efforts to implement appropriate information security protections for polar satellite data, (3) evaluate efforts to assess and mitigate a potential near-term gap in polar satellite data, and (4) assess agency plans for a follow-on polar satellite program. To do so, GAO analyzed program status reports, milestone reviews, and risk data; assessed security policies and procedures against agency policy and best practices; examined contingency plans and actions, as well as planning documents for future satellites; and interviewed experts as well as agency and contractor officials.

What GAO Recommends

GAO recommends that NOAA take steps to address deficiencies in its information security program and complete key program planning actions needed to justify and move forward on a follow-on polar satellite program. NOAA concurred with GAO's recommendations and identified steps it is taking to address them.

View GAO-16-359. For more information, contact David A. Powner at (202) 512-9286 or pownerd@gao.gov.

May 2016

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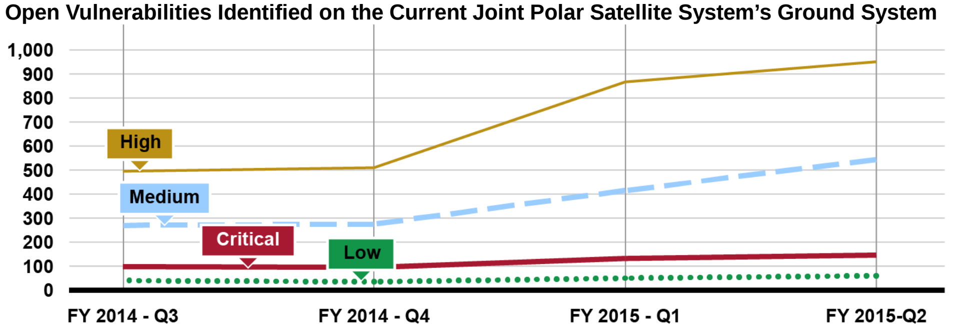
NOAA Is Working to Ensure Continuity but Needs to Quickly Address Information Security Weaknesses and Future Program Uncertainties

What GAO Found

The $11.3 billion Joint Polar Satellite System (JPSS) program has continued to make progress in developing the JPSS-1 satellite for a March 2017 launch. However, the program has experienced recent delays in meeting interim milestones, including a key instrument on the spacecraft that was delivered almost 2 years later than planned. In addition, the program has experienced cost growth ranging from 1 to 16 percent on selected components, and it is working to address selected risks that have the potential to delay the launch date.

Although the National Oceanic and Atmospheric Administration (NOAA) established information security policies in key areas recommended by the National Institute of Standards and Technology, the JPSS program has not yet fully implemented them. Specifically, the program categorized the JPSS ground system as a high-impact system, and selected and implemented multiple relevant security controls. However, the program has not yet fully implemented almost half of the recommended security controls, did not have all of the information it needed when assessing security controls, and has not addressed key vulnerabilities in a timely manner (see figure). Until NOAA addresses these weaknesses, the JPSS ground system remains at high risk of compromise.

Open Vulnerabilities Identified on the Current Joint Polar Satellite System's Ground System



Source: GAO, based on National Oceanic and Atmospheric Administration data. | GAO-16-359

Note: The National Oceanic and Atmospheric Administration identifies vulnerabilities as critical, high, medium, and low risk; critical and high risk vulnerabilities pose an increased risk of compromise.

NOAA has made progress in assessing and mitigating a near-term satellite data gap. GAO previously reported on weaknesses in NOAA's analysis of the health of its existing satellites and its gap mitigation plan. The agency improved both its assessment and its plan; however, key weaknesses remain. For example, the agency anticipates that it will be able to have selected instruments on the next satellite ready for use in operations 3 months after launch, which may be optimistic given past experience. GAO is continuing to monitor NOAA's progress in addressing prior recommendations.

Looking ahead, NOAA has begun planning for new satellites to ensure data continuity. This program would include two new JPSS satellites and a smaller interim satellite. However, uncertainties remain on the expected useful lives of the current satellites, and NOAA has not evaluated the costs and benefits of different launch scenarios based on up-to-date estimates. Until it does so, NOAA may not be making the most efficient use of the nation's sizable investment in the polar satellite program.

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Figures

Abbreviations

ATMS	Advanced Technology Microwave Sounder
ATO	authorization to operate
COSMIC	Constellation Observing System for Meteorology, Ionosphere, and Climate
CrIS	Cross-Track Infrared Sounder
DMSP	Defense Meteorological Satellite Program
DOD	Department of Defense
EON-MW	Earth Observing Nanosatellite-Microwave
FISMA	Federal Information Security Modernization Act of 2014
JPSS	Joint Polar Satellite System
Metop	Meteorological Operational (satellite)
NASA	National Aeronautics and Space Administration
NESDIS	National Environmental Satellite, Data, and Information Service
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-orbiting Operational Environmental Satellite System
OMB	Office of Management and Budget
OMPS	Ozone Mapping and Profiler Suite
PFO	Polar Follow-on
POA&M	plan of action and milestones
POES	Polar-orbiting Operational Environmental Satellites
S-NPP	Suomi National Polar-orbiting Partnership
VIIRS	Visible Infrared Imaging Radiometer Suite

U.S. GOVERNMENT ACCOUNTABILITY OFFICE
441 G St. N.W.
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May 17, 2016

The Honorable Lamar Smith
Chairman
The Honorable Eddie Bernice Johnson
Ranking Member
Committee on Science, Space, and Technology
House of Representatives

Polar-orbiting satellites provide critical environmental data that are used in weather forecasting. In 2010, the National Oceanic and Atmospheric Administration (NOAA) initiated the Joint Polar Satellite System (JPSS) program with assistance from the National Aeronautics and Space Administration (NASA). The JPSS program is to provide the next generation of polar-orbiting satellites, replacing existing satellites as they reach the end of their useful lives. The JPSS program includes three satellites, the first of which was successfully launched in October 2011. NOAA plans to use the next satellite in the program as a replacement for that first satellite.

However, the potential remains for a near-term satellite data gap. Because of the criticality of satellite data to weather forecasting, the possibility of a satellite data gap, and the potential impact of a gap on the health and safety of the U.S. population and economy, we added this issue to GAO's High Risk List in 2013 and it remained on the list in 2015.[1]

Given your continuing concerns about the potential impact of a gap in polar satellite data, you asked us to review the JPSS program and the potential for future gaps in polar satellite coverage. Our objectives were to (1) evaluate NOAA's progress on the JPSS satellite program with respect to schedule, cost, and key risks; (2) assess NOAA's efforts to plan and implement appropriate information security protections for polar satellite data; (3) evaluate NOAA's efforts to assess the probability of a near-term gap in polar satellite data, as well as its progress in implementing key

[1]GAO, *High Risk Series: An Update*, GAO-15-290 (Washington, D.C.: Feb. 11, 2015).

activities for mitigating a gap; and (4) assess NOAA's efforts to plan and implement a follow-on polar satellite program.

To evaluate NOAA's progress on the JPSS satellite program with respect to schedule, cost, and key risks, we compared project schedule and cost data to baseline targets between July 2013 and December 2015, reviewed key program risk areas and planned actions to mitigate risks, and examined the effect of any schedule delays and risks on a potential gap in satellite data. In addition, we interviewed JPSS program office staff for details on schedule, cost, and risk information. We assessed the reliability of cost, schedule, and risk data for the JPSS program by comparing information in program source reports at different points in time, by comparing risk data to source documents such as risk registers, and by following up on specific cost and schedule information in meetings with agency officials. We found that these data were sufficiently reliable for our purposes.

To assess NOAA's efforts to plan and implement appropriate information security protections for polar satellite data, we compared information security policies and practices for the current and future state of the JPSS program against the Federal Information Security Modernization Act of 2014 and supporting guidance.[2] We assessed the JPSS program's efforts to categorize the security level of the system; select, implement, and test security controls; authorize the system for operations; and monitor controls. We also analyzed information on recent security incidents and NOAA's response to them, and interviewed key managers and staff.

To evaluate NOAA's efforts to assess the probability of a near-term gap in polar satellite data, as well as its progress in implementing key activities for mitigating a gap, we analyzed NOAA's analysis of polar satellite availability and gap mitigation plan against best practices in contingency planning, examined progress and reporting on NOAA's key gap mitigation activities, and interviewed key officials. In order to assess NOAA's efforts

[2]The Federal Information Security Modernization Act of 2014, Pub. L. No. 113-283, 128 Stat. 3073 (Dec. 18, 2014), largely supersedes the very similar Federal Information Security Management Act of 2002, Pub. L. No. 107-347, 116 Stat. 2899, 2946 (Dec. 17, 2002). The 2002 act's requirements that the National Institute of Standards and Technology establish standards and guidance for implementation of the act were not superseded and continue to apply.

to plan and implement a follow-on polar satellite program, we determined the scope, expected cost, timelines, and key risks of the JPSS Polar Follow-On program, analyzed documentation for key program milestones with respect to program criteria and charts of expected satellite life, and interviewed JPSS program staff.

We conducted this performance audit from May 2015 to May 2016 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives. Additional details on our objectives, scope, and methodology are provided in appendix I.

Background

Since the 1960s, the United States has operated two separate polar-orbiting meteorological satellite systems: the Polar-orbiting Operational Environmental Satellite (POES) series, which is managed by NOAA, and the Defense Meteorological Satellite Program (DMSP), which is managed by the Air Force. These 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 days in advance—including forecasting the path and intensity of hurricanes.[3] 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 its 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.

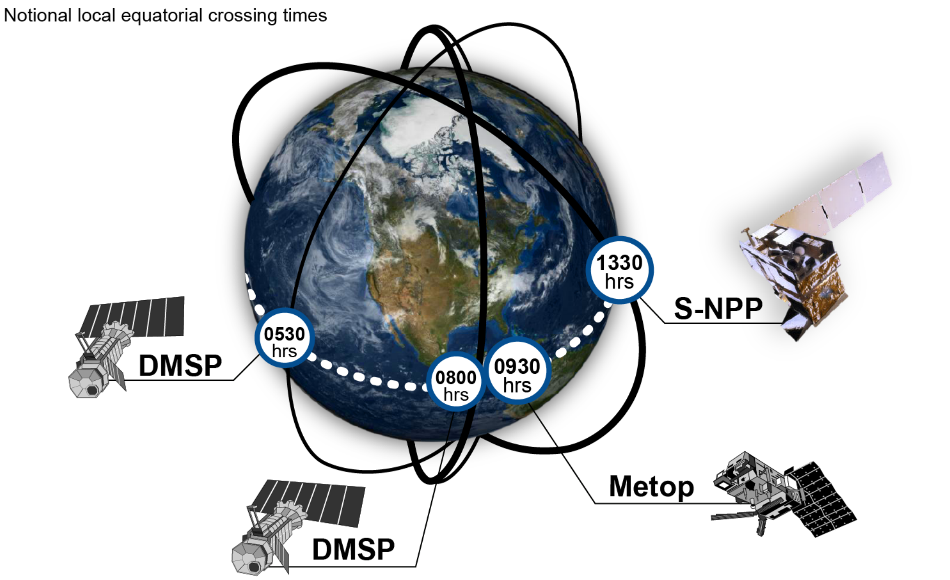
Unlike geostationary satellites, which maintain a fixed position relative to the earth, polar-orbiting satellites constantly circle the earth in an almost north-south orbit, providing global coverage of conditions that affect the weather and climate. Each satellite makes about 14 orbits a day. As the

[3]According to NOAA, 80 percent of the data assimilated into its National Weather Service numerical weather prediction models that are used to produce weather forecasts 3 days and beyond comes from polar-orbiting satellites.

earth rotates beneath it, each satellite views the entire earth's surface twice a day. Currently, a NOAA/NASA satellite (called the Suomi National Polar-orbiting Partnership, or S-NPP) and two operational DMSP satellites are positioned so that they cross the equator in the early morning, mid-morning, and early afternoon. In addition, the government relies on a series of European satellites, called the Meteorological Operational (Metop) satellites, for satellite observations in the midmorning orbit.[4] These polar-orbiting satellites are considered primary satellites for providing input to weather forecasting models. In addition to these primary satellites, NOAA, the Air Force, and a European weather satellite organization maintain older satellites that still collect some data and are available to provide limited backup to the operational satellites should they degrade or fail. Figure 1 illustrates the current operational polar satellite constellation.

[4]The European Organisation 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 flown sequentially over 14 years. The first of these satellites was launched in 2006, the second was launched in 2012, and the final satellite in the series is expected to launch in 2018.

Figure 1: Configuration of Operational Polar Satellites



Sources: GAO, based on NPOESS Integrated Program Office, National Oceanic and Atmospheric Administration, and Department of Defense data; National Aeronautics and Space Administration/Goddard Space Flight Center Scientific Visualization Studio (earth); S-NPP image provided courtesy of University of Wisconsin-Madison Space Science and Engineering Center. | GAO-16-359

Note: DMSP—Defense Meteorological Satellite Program, Metop—Meteorological Operational (satellite), and S-NPP—Suomi National Polar-orbiting Partnership.

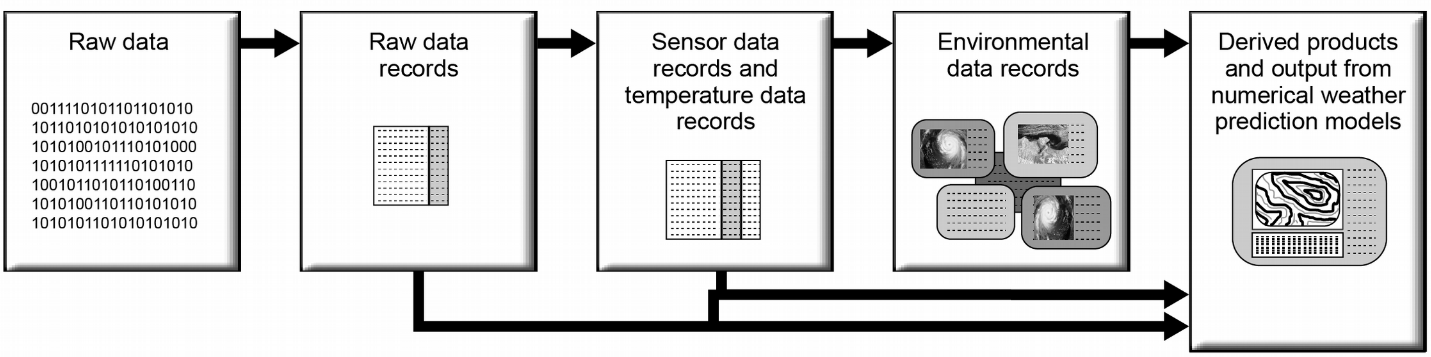
According to NOAA, 80 percent of the data assimilated into its National Weather Service numerical weather prediction models that are used to produce weather forecasts 3 days and beyond comes from polar-orbiting satellites. Specifically, a single afternoon polar satellite provides NOAA 45 percent of the global coverage it needs for its numerical weather models. NOAA obtains the rest of the polar satellite data it needs from other satellite programs, including the Department of Defense's (DOD) early morning satellites and the European mid-morning satellite.

Polar Satellite Data and Products

Polar satellites gather a broad range of data that are transformed into a variety of products. Satellite sensors observe different bands of radiation wavelengths, called channels, which are used for remotely determining information about the earth's atmosphere, land surface, oceans, and the space environment. When first received, satellite data are considered raw data. To make them usable, processing centers format the data so that they are time-sequenced and include earth-location and calibration information. After formatting, these data are called raw data records.

The centers further process these raw data records into channel-specific data sets, called sensor data records and temperature data records. These data records are then used to derive weather and climate products called environmental data records. These environmental data records include a wide range of atmospheric products detailing cloud coverage, temperature, humidity, and ozone distribution; land surface products showing snow cover, vegetation, and land use; ocean products depicting sea surface temperatures, sea ice, and wave height; and characterizations of the space environment. Combinations of these data records (raw, sensor, temperature, and environmental data records) are also used to derive more sophisticated products, including outputs from numerical weather models and assessments of climate trends. Figure 2 is a simplified depiction of the various stages of satellite data processing.

Figure 2: Stages of Satellite Data Processing



Source: GAO analysis of National Oceanic and Atmospheric Administration information. | GAO-16-359

Brief History of the NPOESS Satellite Program

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 one capable of satisfying both civilian and military requirements: the National Polar-orbiting Operational Environmental Satellite System (NPOESS).[5] NPOESS satellites were

[5]Presidential Decision Directive NSTC-2, “Convergence of U.S. Polar-orbiting Operational Environmental Satellite Systems” (May 5, 1994).

expected to replace the POES and DMSP satellites in the morning, mid-morning, and afternoon orbits when they neared the end of their expected life spans. To reduce the risk involved in developing new technologies and to maintain climate data continuity, the program planned to launch a demonstration satellite in May 2006.[6] The first NPOESS satellite was to be available for launch in March 2008.

However, in the years after the program was initiated, NPOESS encountered significant technical challenges in sensor development, program cost growth, and schedule delays. By March 2009, agency executives decided to use the planned demonstration satellite as an operational satellite because the schedule delays could have led to a gap in satellite data. Eventually, cost and schedule concerns led the White House's Office of Science and Technology Policy to announce in February 2010 that NOAA and DOD would no longer jointly procure the NPOESS satellite system; instead, each agency would plan and acquire its own satellite system. Specifically, NOAA—with support from NASA—would be responsible for the afternoon orbit and DOD would be responsible for the early morning orbit. The agencies would rely on European satellites for the mid-morning orbit.

Overview of the JPSS Program

When the decision to disband NPOESS was announced, NOAA and NASA immediately began planning for a new satellite program in the afternoon orbit called JPSS. Key plans included

- relying on NASA for system acquisition, engineering, and integration;
- completing, launching, and supporting S-NPP;
- acquiring and launching two satellites for the afternoon orbit, called JPSS-1 and JPSS-2;
- developing and integrating five instruments on the two satellites;

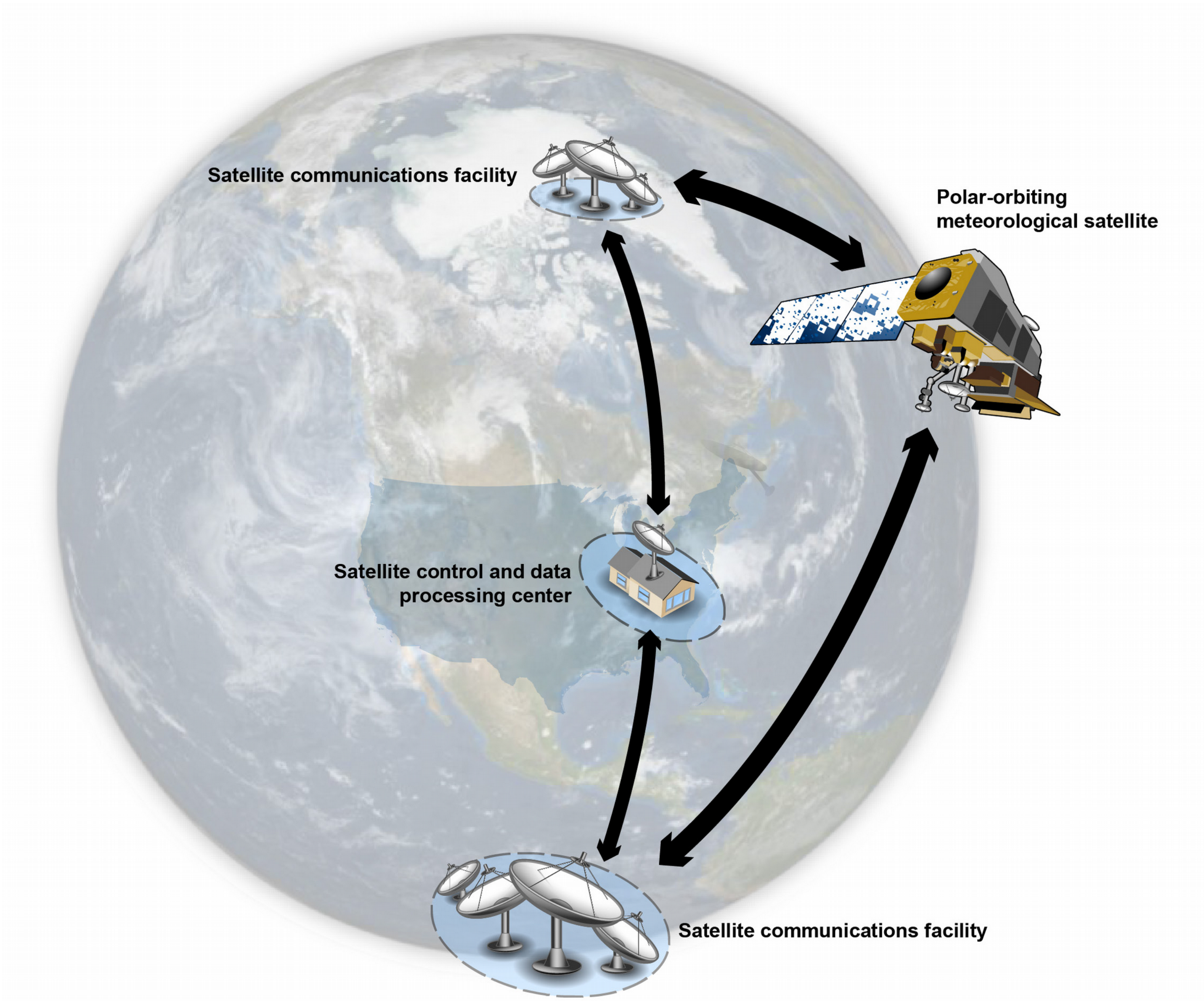
[6] Originally called the NPOESS Preparatory Project, in January 2012 the satellite's name was changed to the Suomi National Polar-orbiting Partnership (S-NPP) satellite.

- finding alternative host satellites for selected instruments[7] that would not be accommodated on the JPSS satellites; and
- providing ground system support for JPSS (including S-NPP), and data communications for other missions, including the Metop satellite.

NOAA organized the JPSS program into flight and ground projects that have separate areas of responsibility. Figure 3 depicts program components.

[7]NPOESS was to have included the Total and Spectral Solar Irradiance Sensor, an environmental instrument used to monitor and capture total and spectral solar irradiance data; the Search and Rescue Satellite-aided Tracking system, which detects and locates aviators, mariners, and land-based users in distress; and the Data Collection System which collects environmental data from platforms around the world and delivers them to users.

Figure 3: Simplified Visualization of Polar Satellite Program Components



Source: GAO, based on Joint Polar Satellite System program office data and images; NASA/Goddard Space Flight Center Scientific Visualization Studio (earth). | GAO-16-359

The flight project includes a set of five instruments, the spacecraft, and launch services. Table 1 lists and describes the instruments.

Table 1: Joint Polar Satellite System (JPSS) Instruments

Instrument	Description
Advanced Technology Microwave Sounder (ATMS)	Provides atmospheric temperature and moisture data for operational weather and climate applications; collects microwave radiation from earth's atmosphere and surface.
Clouds and the Earth's Radiant Energy System[a]	Measures reflected sunlight and thermal radiation emitted by the earth; helps provide measurements of the spatial and temporal distribution of the earth's radiation.
Cross-Track Infrared Sounder (CrIS)	Collects measurements of the infrared radiation emitted and scattered by the earth and atmosphere to determine the vertical distribution of temperature, moisture, and pressure in the atmosphere.
Ozone Mapping and Profiler Suite (OMPS)	Collects data needed to measure the amount and distribution of ozone in the earth's atmosphere, including information on how ozone concentration varies with altitude. Consists of two components (nadir and limb) that can be provided separately.
Visible Infrared Imaging Radiometer Suite (VIIRS)	Collects images and radiometric data used to provide information on the earth's clouds, atmosphere, ocean, and land surfaces. Provides imagery during the day as well as under extremely low light conditions at night. Provides cloud imagery under sunlit conditions as well as infrared coverage for night and day cloud imaging.

Source: GAO analysis of NOAA data. | GAO-16-359.

[a]The Clouds and the Earth's Radiant Energy System instrument is on S-NPP and is planned to fly on JPSS-1. NASA plans to provide a similar instrument, called the Radiation Budget Instrument, for JPSS-2.

The ground project consists of ground-based systems that handle satellite communications and data processing. The JPSS program is working to implement a critical upgrade to the JPSS ground system that will allow it to support both the S-NPP and all planned JPSS satellites. The ground system's versions are numbered; the version that is currently in use is called Block 1.2, and the new version that is under development is called Block 2.0. While Block 2.0 is planned to replace Block 1.2, a JPSS program official stated that there will be a period of overlap of about 60 days during which both versions are operational, and noted that Block 1.2 may stay online longer, if warranted, to address unanticipated problems on Block 2.0. In addition to multi-mission support, program officials stated that the new iteration of the ground system will also have a different set of security requirements that are designed specifically for the JPSS system, as opposed to the old requirements which were based on legacy needs. Officials also stated that the upgrade will include an enhanced architecture that is more scalable to future changes, and will allow NOAA to replace obsolete hardware and software.

Program Costs Have Varied over Time

Since its inception, the composition and cost of the JPSS program have varied. In 2010, NOAA estimated that the life-cycle costs of the JPSS program would be approximately $11.9 billion for a program lasting through fiscal year 2024, which included $2.9 billion in NOAA funds spent on NPOESS through fiscal year 2010.[8] Following this, the agency undertook a cost estimating exercise where it validated that the cost of the full set of JPSS functions from fiscal year 2012 through fiscal year 2028 would be $11.3 billion. After adding the agency's sunk costs, which had increased to $3.3 billion through fiscal year 2011, the program's life-cycle cost estimate totaled $14.6 billion.

Subsequently, NOAA took steps to lower this estimate, since it was $2.7 billion higher than the original estimate for JPSS at the time that NPOESS was disbanded. In fiscal year 2013, NOAA officials agreed to cap the JPSS life-cycle cost at $12.9 billion, and to merge funding for two climate sensors into the JPSS budget. By October 2012, NOAA also decided to remove selected elements from the satellite program, such as the number of ground-based receptor stations (thus affecting the time it takes for products to reach end users) and the number of interface data processing segments.

The administration then directed NOAA to begin implementing additional changes in the program's scope and objectives in order to meet the agency's highest-priority needs for weather forecasting and reduce estimated life-cycle costs from $12.9 billion to $11.3 billion. By April 2013, NOAA had decided to, among other things, cancel one of two planned free-flyer[9] missions and transfer the remaining free-flyer mission to a new program within NOAA called the Solar Irradiance, Data, and Rescue mission.[10] In addition, requirements for certain climate sensors were moved to NASA. As we reported previously, NOAA also reduced the estimated life-cycle cost of the program by eliminating the operational

[8]This figure does not include approximately $2.9 billion in sunk costs that DOD spent on NPOESS through fiscal year 2010.

[9]A free flyer is an alternative host satellite for the selected instruments that are not accommodated on the JPSS satellites.

[10]The Solar Irradiance, Data, and Rescue mission is to accommodate the Total and Spectral Solar Irradiance Sensor, the Advanced Data Collection System, and the Search and Rescue Satellite-Aided Tracking system.

costs for the 3 years at the end of the JPSS mission; the current life-cycle cost estimate includes operational costs through 2025 even though the JPSS-2 satellite is expected to be operational until 2028.[11] Table 2 compares the planned cost, schedule, and scope of the JPSS program at different points in time.

[11]See GAO, *Polar Weather Satellites: NOAA Needs to Prepare for Near-term Data Gaps*, GAO-15-47 (Washington, D.C.: Dec. 16, 2014) and *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, GAO-09-3SP (Washington, D.C.: March 2009), A life-cycle cost estimate should include operational costs through the entire estimated life of the program. We also note that a statute governing NOAA's development of major programs (33 U.S.C. § 878a(a)(6)) defines "life-cycle cost" as "the total of the direct, indirect, recurring, and nonrecurring costs, including the construction of facilities and civil servant costs, and other related expenses incurred or estimated to be incurred in the design, development, verification, production, operation, maintenance, support, and retirement of a program over its planned lifespan, without regard to funding source or management control."

Table 2: Comparison of the Joint Polar Satellite System (JPSS) Program at Different Points in Time

Key area	As of May 2010	As of June 2012	As of December 2014
Life cycle	2010-2024	2010-2028	2010-2025
Estimated life-cycle cost	$11.9 billion (which includes about $2.9 billion spent through fiscal year 2010 on the National Polar-orbiting Operational Environmental Satellite System (NPOESS))	$12.9 billion (which includes about $2.9 billion spent through fiscal year 2010 on NPOESS)	$11.3 billion (which includes about $2.9 billion spent through fiscal year 2010 on NPOESS)
Number of satellites	2 (in addition to Suomi National Polar-orbiting Partnership (S-NPP))	2 JPSS satellites (in addition to S-NPP) 2 free flyer satellites	2 (in addition to S-NPP)
Number of orbits	1 (afternoon orbit)	1 (afternoon orbit)	1 (afternoon orbit)
Launch schedule	S-NPP—no earlier than Sept. 2011 JPSS-1 available in 2015 JPSS-2 available in 2018	S-NPP—successfully launched in Oct. 2011 JPSS-1 by March 2017 JPSS-2 by Dec. 2022 Free flyer-1 and -2: not determined	S-NPP—successfully launched in Oct. 2011 JPSS-1 by March 2017 JPSS-2 by Dec. 2021
Number of instruments	S-NPP: 5 JPSS-1: 5[a] JPSS-2: 5	S-NPP: 5 JPSS-1: 5 JPSS-2: 5 Free flyer-1 and-2: 1 sensor and 2 user services systems[b]	S-NPP: 5 JPSS-1: 5 JPSS-2: 5[c] No free flyers[d]

Source: GAO analysis of NOAA, DOD, and task force data. | GAO-16-359

[a]The five instruments are the Advanced Technology Microwave Sounder, Clouds and the Earth's Radiant Energy System, Cross-Track Infrared Sounder, Ozone Mapping and Profiler Suite, and Visible Infrared Imaging Radiometer Suite. The National Oceanic and Atmospheric Administration (NOAA) committed to finding an alternative spacecraft and launch accommodation for the Total and Spectral Solar Irradiance Sensor, the Advanced Data Collection System, and the Search and Rescue Satellite-Aided Tracking system.

[b]NOAA planned to launch two stand-alone satellites, called free-flyer satellites, to accommodate instruments removed from the JPSS program: the Total and Spectral Solar Irradiance Sensor, the Advanced Data Collection System, and the Search and Rescue Satellite-Aided Tracking system.

[c]In a fiscal year 2014 budget document, responsibility for two instruments was moved from NOAA to NASA: the Radiation Budget Instrument (formerly known as the Clouds and the Earth's Radiant Energy System) and Ozone Mapping and Profiler Suite–Limb. NOAA plans to accommodate these instruments on the JPSS-2 satellite as long as they do not impact the likelihood of mission success.

[d]NOAA canceled Free flyer-1 and established Free flyer-2 as a new program outside the JPSS program. This new program, called the Solar Irradiance, Data, and Rescue mission, is to accommodate the Total and Spectral Solar Irradiance Sensor, the Advanced Data Collection System, and the Search and Rescue Satellite-Aided Tracking system.

Requirements for Ensuring Information Security for the Nation's Weather Forecasting Infrastructure Are Established in Law and Guidance

Safeguarding federal computer systems and the systems supporting the nation's infrastructures, including the nation's weather observation and forecasting infrastructure, is essential to protecting national and economic security, and public health and safety. For government organizations, information security is also a key element in maintaining the public trust. Inadequately protected systems may be vulnerable to insider threats as well as the risk of intrusion by individuals or groups with malicious intent who could unlawfully access the systems to obtain sensitive information, disrupt operations, or launch attacks against other computer systems and networks. Moreover, cyber-based threats to federal information systems are evolving and growing. Accordingly, we designated information security as a government-wide high risk area in 1997 and it has remained on our high-risk list since then.[12]

Federal law and guidance specify requirements for protecting federal information and information systems. The Federal Information Security Management Act of 2002 and the Federal Information Security Modernization Act of 2014 (FISMA), which largely supersedes the 2002 act, require executive branch agencies to develop, document, and implement an agency-wide information security program to provide security for the information and information system that support operations and assets of the agency.[13]

The 2002 act also assigns certain responsibilities to the National Institute of Standards and Technology (NIST), which is tasked with developing, for systems other than national security systems, standards and guidelines that must include at a minimum, (1) standards to be used by all agencies to categorize all of their information and information systems based on the objectives of providing appropriate levels of information security, according to a range of risk levels; (2) guidelines recommending the types of information and information systems to be included in each category;

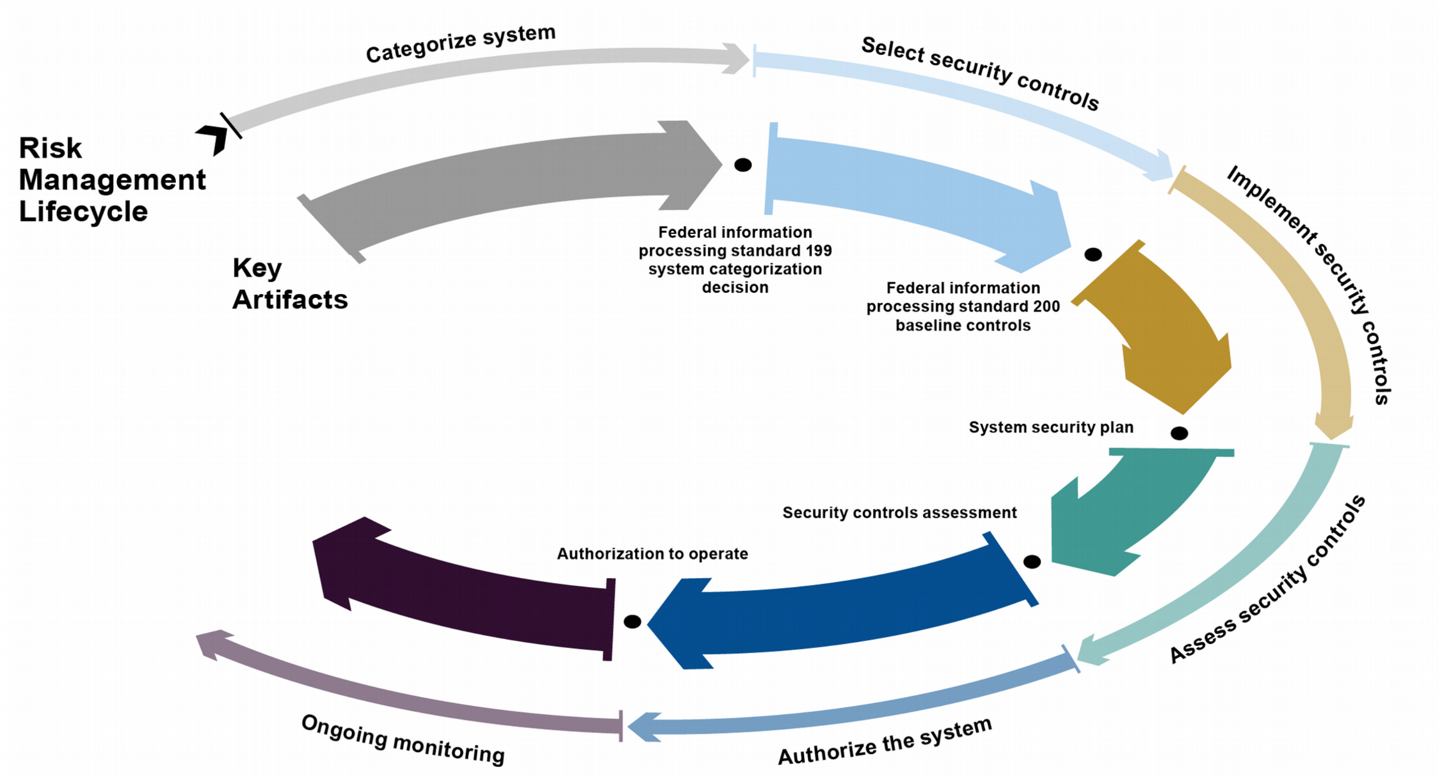
[12]GAO, *High-Risk Series: Information Management and Technology*, GAO/HR-97-9 (Washington, D.C.: Feb. 1, 1997).

[13]The Federal Information Security Modernization Act of 2014, Pub. L. No. 113-283, 128 Stat. 3073 (Dec. 18, 2014) largely superseded the Federal Information Security Management Act of 2002, enacted as Title III, E-Government Act of 2002, Pub. L. No. 107-347, 116 Stat. 2899, 2946 (Dec. 17, 2002). As used in this report, FISMA refers to the requirements in the 2014 law. Many of the requirements of the 2002 law were unchanged by or incorporated into the 2014 law and continue in full force and effect.

and (3) minimum information security requirements for information and information system in each category.

Accordingly, NIST developed a risk management framework of standards and guidelines for agencies to follow in developing information security programs. The framework addresses broad information-security and risk-management activities, including categorizing the system's impact level; selecting, implementing, and assessing security controls; authorizing the system to operate (based on progress in remediating control weaknesses and an assessment of residual risk); and monitoring the efficacy of controls on an ongoing basis. Figure 4 shows an overview of this framework and table 3 describes the framework's key activities and artifacts. In addition, appendix II describes relevant NIST publications.

Figure 4: Overview of the National Institute of Standards and Technology's Risk Management Framework for an Information Security Program



Sources: GAO and National Institute of Standards and Technology. | GAO-16-359

Table 3: Elements of the National Institute of Standards and Technology's Risk Management Framework

Element	Description	Key artifacts
Categorize the system	Categorize the information system and the information processed, stored, and transmitted by that system as low-impact, moderate-impact, or high impact for the security objectives of confidentiality, integrity, and availability, based on an impact analysis.	Risk Assessment Report–used to document risks and help make decisions on the impact level of the system. Federal Information Processing Standard 199 system categorization decision—used to document the impact level of the system.
Select security controls	Select an initial set of baseline security controls for the information system based on the security categorization; tailor and supplement the security control baseline as needed based on an organizational assessment of risk and local conditions.	Federal Information Processing Standard 200 baseline controls—identifies the baseline security controls that have been selected.
Implement security controls	Implement the security controls and describe how the controls are employed within the information system and its environment of operation.	System Security Plan—documents how the agencies plan to implement security controls.
Assess security controls	Test and evaluate the security controls using appropriate assessment procedures to determine the extent to which the controls are implemented correctly, operating as intended, and producing the desired outcome with respect to meeting the security requirements of the system.	Security Controls Assessment—tests security controls to determine if they are implemented correctly, operating as intended, and producing desired outcomes.
Authorize the system	A designated agency official provides the Authorization to Operate, which certifies the system for operation based on security controls, completion of remedial actions, and acceptance of residual risks to organizational operations.	Plans of Action and Milestones—describe actions and timelines for addressing control weaknesses. Authorization to Operate—documents approval to operate a system by the agency authorizing official.
Monitor controls	Monitor the security controls in the information system on an ongoing basis, including assessing control effectiveness, documenting changes to the system or its environment of operation, conducting impact analyses on changes, and reporting the security state of the system to designated officials.	Continuous Monitoring policies—used to document strategies for monitoring the effectiveness of controls.

Source: GAO analysis of National Institute of Standards and Technology guidance. | GAO-16-359

Federal agencies face an evolving array of information security-based threats which put federal systems and information at an increased risk of compromise. In September 2015, we reported that federal agencies showed weaknesses in several major categories of information system controls including access controls, which limit or detect access to computer resources, and configuration management controls, which are intended to prevent unauthorized changes to information system resources.[14] Further, in November 2015, we reported that over the past 6 years we had made about 2,000 recommendations to improve information security programs and associated security controls. We noted that agencies had implemented about 58 percent of these recommendations.[15]

Recent GAO Reports Recommended Actions to Improve JPSS Management and Address the Risk of a Near-Term Satellite Gap

Since 2012, we issued three reports on the JPSS program that highlighted technical issues, component cost growth, management challenges, and key risks.[16] In these reports, we made a total of 11 recommendations to NOAA to improve the management of the JPSS program. These recommendations included addressing key risks and establishing a comprehensive contingency plan consistent with best practices. The agency agreed with these 11 recommendations. As of December 2015, the agency had implemented 2 recommendations and was working to address the remaining 9.

More specifically, in September 2013 and December 2014, we reported that while NOAA had taken steps to mitigate an anticipated gap in polar satellite data, it had not yet established a comprehensive contingency plan. For example, its plan did not fully identify risks to its contingency plans such as including recovery time objectives for key products, identifying opportunities for accelerating calibration and validation of products, and providing an assessment of available alternatives based on their costs and potential impacts. In addition, we found that NOAA had not prioritized these alternatives. We recommended that NOAA revise its plan to, among other things, identify recovery time objectives for key products, provide an assessment of alternatives based on costs and potential impacts, and establish a schedule with meaningful timelines and

[14] GAO, *Federal Information Security: Agencies Need to Correct Weaknesses and Fully Implement Security Programs*, GAO-15-714 (Washington, D.C.: Sept. 29, 2015).

[15] GAO, *Information Security: Federal Agencies Need to Better Protect Sensitive Data,* GAO-16-194T (Washington, D.C.: Nov. 17, 2015).

[16] GAO, *Polar Weather Satellites: NOAA Needs To Prepare for Near-term Data Gaps*, GAO-15-47 (Washington, D.C.: Dec. 16, 2014); *Polar Weather Satellites: NOAA Identified Ways to Mitigate Data Gaps, but Contingency Plans and Schedules Require Further Attention*, GAO-13-676 (Washington, D.C.: Sept. 11, 2013); and *Polar-orbiting Environmental Satellites: Changing Requirements, Technical Issues, and Looming Data Gaps Require Focused Attention*, GAO-12-604 (Washington, D.C.: June 15, 2012).

linkages among mitigation activities. We also recommended that NOAA investigate ways to prioritize mitigation projects with the greatest potential benefit in the event of a gap. NOAA agreed with these recommendations and stated it was taking steps to implement them.

In December 2014, we also found that, while NOAA was providing oversight of its many gap mitigation projects and activities, the agency's oversight efforts were not consistent or comprehensive. Specifically, only one of three responsible entities obtained monthly progress reports, and the three responsible agencies reported only on selected activities on a quarterly basis. We recommended that NOAA ensure that relevant entities provide monthly and quarterly updates of progress on all gap mitigation projects during existing meetings. NOAA agreed with this recommendation and stated it was taking steps to implement it.

At that time, we also reported that NOAA had previously revised its estimate of how long a gap could last down to 3 months, but that this estimate was based on inconsistent and unproven assumptions and did not account for the risk that space debris poses to the S-NPP satellite's life expectancy. We recommended that NOAA update the JPSS program's assessment of potential polar satellite data gaps to include more accurate assumptions about launch dates and the length of the data calibration period, as well as key risks such as the potential effect of space debris. NOAA agreed with this recommendation and stated it was taking steps to implement it.

NOAA Continues to Develop JPSS, but Selected Components Have Experienced Milestone Delays, Cost Growth, and Risks

Over the last year, the JPSS program has continued to make progress in developing the JPSS-1 satellite. In early 2015, the program completed two key instruments for the JPSS-1 satellite: the CrIS and VIIRS instruments. The program also completed its Systems Integration Review for the JPSS-1 satellite in February 2015. More recently, the program completed the ATMS instrument and integrated the instruments on the spacecraft. As of December 2015, the JPSS program reported that it remained on track to meet its planned launch date of March 2017 for the JPSS-1 satellite, and still expected the JPSS-2 satellite to launch no later than November 2021.

However, the program has continued to experience delays in meeting interim milestones. In 2014, we reported that key components of the JPSS-1 satellite had experienced delays.[17] Since that time, the program has continued to experience delays on key components ranging from 3 to 10 months. In particular, one component experienced almost 2 years of delay since July 2013. Table 4 provides details on specific key milestones.

Table 4: Changes in Key Milestone Dates for Joint Polar Satellite System (JPSS) Components between July 2013 and December 2015

Key milestone	Planned date as of July 2013	Planned date as of July 2014	Planned/actual date as of December 2015	Previously reported delay from July 2013 to July 2014	Additional delay from July 2014 to December 2015	Total delay from July 2013 to December 2015
Component completion						
CrIS instrument completion	July 2014	October 2014	February 2015	3 months	4 months	**7 months**
VIIRS instrument completion	October 2014	November 2014	February 2015	1 month	3 months	**4 months**
ATMS instrument completion	March 2014	March 2015	January 2016	12 months	10 months	**22 months**
Spacecraft completion	April 2016	May 2016	September 2016	1 month	4 months	**5 months**
Program-wide reviews						
Spacecraft Pre-Environmental Review	August 2015	August 2015	March 2016	No delay	7 months	**7 months**

[17] GAO-15-47.

Key milestone	Planned date as of July 2013	Planned date as of July 2014	Planned/actual date as of December 2015	Previously reported delay from July 2013 to July 2014	Additional delay from July 2014 to December 2015	Total delay from July 2013 to December 2015
Ground System Block 2.0 Site Acceptance Test	August 2015	August 2015	March 2016	No delay	7 months	**7 months**
JPSS-1 Flight Operations Review	December 2015	December 2015	April 2016	No delay	4 months	**4 months**

Source: GAO analysis of NOAA data. | GAO-16-359

Note: CrIS=Cross-Track Infrared Sounder; VIIRS=Visible Infrared Imaging Radiometer Suite; ATMS=Advanced Technology Microwave Sounder.

As of January 2016, the program continued to experience technical challenges that could cause additional schedule delays and potentially affect the scheduled launch of the JPSS-1 satellite.

- A delay in completing a key component on the spacecraft, called a gimbal,[18] has in turn delayed the beginning of environmental testing. Since November 2014, program officials moved the component's planned completion date from April 2015 to February 2016.
- The JPSS ground system also has experienced recent delays. The program experienced an unexpectedly high number of program trouble reports in completing an upgrade on the ground system. A key milestone related to this upgrade was recently delayed from January to August 2016.

Program officials stated that delays such as these are normal and anticipated on complex and technical space system development efforts like JPSS, and that the program includes schedule reserves to address such challenges as they arise. As of January 2016, the program reported it had 24 days of margin remaining to its launch readiness date of December 2016, and another 3 months of margin between that date and the launch commitment date of March 2017. However, the margin of 24 days prior to the launch readiness date is less than the 1.9 months recommended by NASA's development standards. This margin is also a decrease from the 6 months of margin the program had in July 2014. Given this narrowing of available schedule reserves, resolving the

[18]A gimbal provides articulation for selected antennas responsible for transmitting stored data to communication satellites and ground systems.

remaining technical issues (discussed later in this report) will be critical to achieving the planned launch date.

Costs Have Grown for Selected Components

The JPSS program's baseline life-cycle cost estimate remains at $11.3 billion, but the cost of the flight segment has grown and the amount of reserve funds has decreased. Specifically, the cost of the flight segment grew by 8 percent from July 2013 to July 2014, and by another 2 percent in the period from July 2014 to December 2015. During those time frames, the cost of the ground system remained relatively steady; it dropped by 3 percent between 2013 and 2014 and then rose by 1.4 percent between 2014 and 2015.

Over this 2-year period, NOAA's estimate for the program's development, maintenance, and operations has grown from almost $10.4 billion to just under $10.7 billion, meaning that the corresponding amount of reserve funds has decreased. The program currently has about $648 million in reserve funding for unanticipated issues over the life of the program. This is a 12.7-percent reduction in the amount of reserves between July 2014 and December 2015. Table 5 shows changes in cost estimates for JPSS program components between July 2014 and December 2015, as well as the overall percentage of change between July 2013 and December 2015.

Table 5: Changes in Cost Estimates for Joint Polar Satellite System Components between July 2013 and December 2015

JPSS program components	Program estimate ($M) as of July 2013	Program estimate ($M) as of July 2014	Program estimate ($M) as of Dec. 2015	Percentage change (July 2013–July 2014)	Percentage change (July 2014–Dec. 2015)	Total percentage change (July 2013–Dec. 2015)
Flight segment	$2,758	$2,983	$3,037	8.2%	1.8%	**10.1%**
Ground segment	1,318	1,274	1,292	-3.3%	1.4%	**-2.0%**
Program office (includes satellite operations and sustainment)	3,460	3,501	3,504	1.2%	0.1%	**1.3%**
Legacy (enacted)	2,848	2,848	2,841	0%	-0.3%	**-0.3%**
Totals						
Life-cycle cost (estimate)	10,385	10,607	10,674	2.1%	0.6%	**2.8%**
Life-cycle cost (baseline)	11,349[a]	11,349[a]	11,322[b]	0%	-0.2%	**-0.2%**
Amount of reserves	964	742	648	-23%	-12.7%	**-32.8%**

Source: GAO analysis of NOAA data. | GAO-16-359

[a]Baseline cost as July 2013

[b]Baseline cost as of January 2015

Within the flight segment, selected components have continued to experience higher cost growth. Since July 2014, the ATMS instrument's cost increased by nearly 16 percent, while the OMPS instrument's cost has grown nearly 10.4 percent (with a 7 percent increase between July and August 2015). In contrast, during the same time period, the VIIRS instrument's cost decreased by 1.5 percent and the CrIS instrument's cost decreased by 3.8 percent. NOAA officials stated that they are using information gained from the development of JPSS-1 instruments to aid in developing instruments for JPSS-2. Leveraging this information will be important in controlling costs on future satellites.

Program officials stated that component cost increases such as these are normal and anticipated on complex and technical space system development efforts like JPSS. The program director explained that reserves were included in the life cycle cost estimate to address these cost increases and that the program is continuing to work within its approved life-cycle cost estimate.

NOAA Has Identified Program Risks That Could Affect the Launch Schedule and Is Working to Address Them

The JPSS program's risk management guidance calls for identifying risks, developing action plans for addressing the risks, and reporting to management on key risks. These action plans are to include a list of steps to mitigate the risks and when those steps are to be completed. Since its inception in 2010, JPSS has identified and tracked key program risks. Moreover, the program office presents key risks during NOAA monthly program management council reviews.

Over the last 2 years, NOAA has successfully closed four key risks. These risks include components that directly impact cost, schedule, and technical aspects of the program. More specifically, NOAA resolved risks involving a delay in the use of legacy polar data; a delay in completing problem change reports related to the current ground system; and issues stemming from the sale of a supplier of high-performance computing technology.

However, as of November 2015, risks remained on both the flight and ground segment for JPSS that could potentially impact the planned completion of the spacecraft and ground system.

- **JPSS-1 spacecraft component delivery:** The program has experienced issues with development of the gimbal component, which as stated above, facilitates the transmission of data to the ground system and other satellites. The delivery date of the gimbal component continues to slip and has begun to impact remaining integration and test activities. The JPSS program office has taken steps to mitigate this risk by asking the prime spacecraft contractor to create a contingency plan on this issue, and delaying environmental testing until production is completed. However, the significant delays and rework involved have already caused critical milestone dates to slip up to five times. If this issue continues to consume program reserves, it may further delay NOAA's ability to begin environmental testing on other areas of the spacecraft, thus delaying launch readiness.

- **Ground segment issues:** The program is facing several issues in developing and testing the next version of the ground system (Block 2.0), which could delay it from being operational when needed to support the JPSS-1 satellite. Specifically, a recent site acceptance test resulted in a higher-than-expected number of problem change requests in a new version of the ground system. These have not yet been resolved. The program is also experiencing challenges in testing the ground system's requirements that may cause a delay in verifying some requirements until closer to launch. Program officials reported that they are developing a contingency plan to deal with the open change requests, and are re-planning the activities leading up to the completion of Block 2.0 in order to remove potential schedule conflicts between the ground and satellite testing schedules.

Similar to its efforts to manage the program's cost and schedule, the JPSS program office is actively monitoring these risks. Close management and monitoring of costs, schedules, and risks will be essential to ensuring a successful and timely launch.

JPSS Information Security Program Has Deficiencies

In accordance with FISMA and the NIST risk management framework, NOAA has established security policies and procedures governing its organizations and programs in each of the framework areas. The JPSS program implemented information security practices in the area of system categorization, and made progress in implementing information security practices in each of the other risk management areas. However, the program has yet to fully implement the best practices and policies established by the organization, and shortfalls exist in each of the remaining areas. For example, while the program has established plans of action to address control weaknesses, it has not addressed systemic critical issues in a timely manner. While required to remediate critical and high risk vulnerabilities within 30 days, as of August 2015, the program had over 1,400 critical and high risk vulnerabilities that were over 4 months old.

Federal Guidance and NOAA Policies Require Information Security Activities in Key Areas

As described earlier, FISMA requires federal agencies to develop, document, and implement an agency-wide information security program. It also calls for agencies to perform key activities to protect critical assets, in accordance with NIST's risk management framework. This framework provides broad information security and risk management activities which guide the life-cycle processes to be followed in developing information systems:

- **System Categorization:** Programs are to categorize systems by identifying the types of information used, selecting a provisional impact level, modifying the rating based on mission-based factors, and assigning a category based on the highest level of impact to confidentiality, integrity, and availability. Programs select the initial impact levels using an assessment of threat events and their impact to operations.

- **Selection and Implementation of Security Controls.** Programs are to determine protective measures, or security controls, to be implemented based on the system categorization results. These security controls are documented in a System Security Plan. Key controls include access controls; incident response; security assessment and authorization; identification and authentication; and configuration management. Once controls are identified, programs are to determine implementation actions for each of the designated controls. These implementation actions are also specified in the System Security Plan.

- **Assessment of Security Controls.** Programs are to develop a test plan that will determine which controls to test (called a Security Controls Assessment), prioritize and schedule assessments, select and customize techniques, and develop risk mitigation techniques to address weaknesses. In addition to testing controls, test plans may also include penetration testing, which involves simulating attacks to identify methods for circumventing the security features of an application, system, or network, and using tools or techniques commonly used by attackers.

- **Authorization to Operate (ATO):** Programs are to obtain security authorization approval in order to operate. Resolving weaknesses and vulnerabilities identified during testing is an important step leading up to achieving ATO. Programs are to establish plans of action and milestones (POA&M) to plan, implement, and document remedial actions to address any deficiencies in information security policies, procedures, and practices using POA&Ms.

- **Monitoring of Security Controls:** Agencies are to monitor their security controls on an ongoing basis after deployment, including assessing controls' effectiveness and reporting on the security state of the system. A key part of ongoing monitoring is handling incidents. NIST guidance specifies procedures for implementing FISMA incident-handling requirements, and includes guidelines on establishing an effective incident response program and detecting, analyzing, prioritizing, and handling an incident.

System Categorization: The JPSS Program Categorized the Ground System as a High-Impact System

In accordance with NOAA policy, the JPSS program implemented key elements of the NIST framework regarding system categorization and identified the ground system as a high-impact system. A high-impact system is one where the loss of confidentiality, integrity, or availability could be expected to have a severe or catastrophic adverse effect on organizational operations, organizational assets, or individuals. Steps leading to this categorization included the following:

- The JPSS program identified several information types relevant to the JPSS mission, including space operations, environmental monitoring and forecasting, contingency planning, and continuity of operations.

- For each information type, JPSS program officials identified security levels in the areas of confidentiality, availability, and integrity, based on the nature of its mission. Program officials chose these levels based on a detailed risk assessment, which allowed them to determine the extent to which threats could adversely impact the organization and the extent to which agency systems are vulnerable to these circumstances or events.

- The program assigned an overall high-impact security level for its ground system, based on the highest impact level for each of the component information types.

Selection and Implementation of Security Controls: The JPSS Program Established a System Security Plan, but Has Not Fully Implemented a Significant Number of Key Controls

In accordance with NOAA policy and NIST guidance, the JPSS program established a System Security Plan for its ground system that identifies the key security controls it plans to implement based on its system security categorization and impact analyses. Key control areas include access controls, risk assessment, incident response, identification and authentication, and configuration management.

However, the program determined that the JPSS ground system is at a high risk of compromise to its confidentiality, integrity, and availability due to the significant number of controls that were not fully implemented. According to program documentation, as of June 2015, the JPSS program had fully implemented 53 percent of the baseline system security controls, and partially implemented the remaining controls. Moreover, out of 17 control areas, the JPSS program had fully implemented all of the controls for only one area: incident response. The program has not fully implemented security controls for the remaining 16 control areas. The areas with the most partially implemented controls were physical protection, access control, audit and accountability, and configuration management.

Program officials explained that there are so many partially implemented controls because the current ground system (Block 1.2) was built under the predecessor NPOESS program to DOD moderate security standards. When NPOESS was disbanded and NOAA initiated the JPSS program in 2010, the program took over development of the S-NPP satellite and ground system. Program officials noted that NOAA's early priorities were to transition the DOD contracts to NOAA and to establish the JPSS program office, and that they were not able to begin planning to upgrade the ground system until 2012. NOAA acknowledged that they need to increase the security of the ground system and noted that they have been working to do that. Program officials stated that they implemented compensating controls to mitigate the risks inherent in the Block 1.2 system. These compensating controls include increased logging and monitoring of traffic to identify anomalies, segmentation of the environment, and increased staffing on remediating and patching weaknesses. In addition, program officials stated that they plan to implement the remaining controls when the program upgrades the ground system from Block 1.2 to Block 2.0 in August 2016.

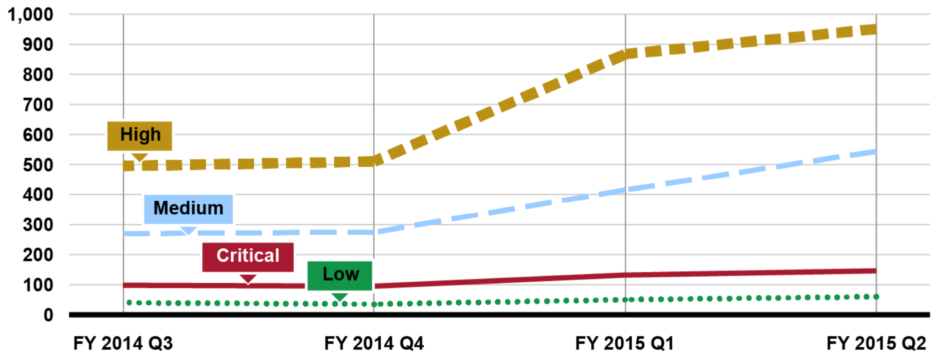
Assessment of Security Controls: The JPSS Program Assessed the Implementation of its Security Controls and Identified Security Weaknesses, but the Assessment Had Significant Limitations

In accordance with NOAA policy and the NIST framework, the JPSS program developed a plan for assessing its security controls, customized its testing approach to the ground system, and implemented the assessment. Specifically, in 2015, a contractor working for NOAA's National Environmental Satellite, Data, and Information Service (NESDIS) tested how the program implemented the controls identified in the System Security Plan and identified weaknesses in the required controls established by the program. The results of this test, called a Security Controls Assessment, were documented in a subsequent report. The Security Controls Assessment also included results of an annual penetration test that was conducted by a private sector company in May 2015 to verify the effectiveness of security controls.

The June 2015 Security Controls Assessment identified a large number of critical and high risk vulnerabilities, and these numbers have been growing over time.[19] Specifically, the assessment identified 146 critical and 951 high risk vulnerabilities on Block 1.2 of the ground system, as well as 102 critical and 295 high risk vulnerabilities on Block 2.0 of the ground system. Figure 5 shows the number of open vulnerabilities on the Block 1.2 system, by severity, from the third quarter of 2014 to the second quarter of 2015. The program is currently working to address the vulnerabilities through the creation of plans of action to remediate them, as discussed in the following section.

[19]NOAA assigns a risk level to each vulnerability. Risk levels include low, medium, high, and critical. Vulnerabilities ranked as high and critical risks pose increased risk of compromise.

Figure 5: Open Vulnerabilities Identified on the Current Joint Polar Satellite System Ground System



Source: GAO, based on National Oceanic and Atmospheric Administration data. | GAO-16-359

Note: NOAA identifies vulnerabilities as critical, high, medium, and low risk. Critical and high risk vulnerabilities pose an increased risk of compromise.

However, the program's assessment of its security controls had significant limitations. Specifically, the assessment team reported that it did not have all of the information it needed to plan or test the entire system and its artifacts. In establishing procedures for the assessment, the assessment team noted concerns regarding uncertainty about the physical locations for JPSS components, inconsistencies in system inventory management, and communication and information availability between different groups within JPSS, including contractors. Also, in implementing the assessment, the team encountered a discrepancy between the security scans and the asset inventory being assessed.

These shortcomings were noted again in a later security scan, which according to the program office, showed a struggle with understanding the rules of security scans, using the assessment tool, and maintaining a valid inventory.

According to NESDIS officials, while the assessment team had the information it needed when it initiated its review, the program continued to develop and revise the system. Thus, the inventory of system components that was assessed did not match the evolving system. Moreover, NOAA officials stated that the assessment attempted to account for the limitations by factoring a high likelihood and high impact of an unknown risk into the system's overall risk score.

These limitations increase the risk that devices in place on the current JPSS network have not been identified or tested. As a result of these testing limitations, the Security Controls Assessment may not have identified all of the system's specific control weaknesses.

Authorization to Operate (ATO): The JPSS Program Implemented an ATO Process, but Has Delayed Fixing Critical Weaknesses

Consistent with FISMA requirements and NIST guidance, NOAA has a process for authorizing its systems to operate. In order to achieve ATO, NOAA requires its programs to establish plans of actions and milestones (POA&M) to address control weaknesses, make satisfactory progress in completing POA&Ms, and resolve at least 80 percent of the POA&Ms on or before their due dates. NOAA also follows a Department of Commerce policy which requires it to remediate all vulnerabilities deemed critical or high risk within 30 days of discovery.[20] The Commerce policy notes that vulnerabilities that are not remediated within 30 days must be managed through the POA&M process or accepted with written justification by the authorizing official. NOAA's POA&M policy requires mitigation of critical and high risk vulnerabilities within 30 days, which NOAA officials explained that they interpreted as requiring mitigation within 30 days of establishment of a POA&M. In addition, the Commerce policy calls for the authorizing official to officially accept the risk if the vulnerability cannot be remediated within the required timeframe.

The JPSS program has implemented the ATO process on both its current system (Block 1.2) and planned system upgrade (Block 2.0) in July 2015, and plans to obtain another ATO for both blocks by July 2016. The authorizing officials for the JPSS ground system are the Deputy Assistant Administrator at NESDIS and the NOAA Chief Information Officer. To obtain its ATO, the JPSS program made progress in addressing many of its security weaknesses through POA&Ms. Specifically, the program assigned a level of criticality to each POA&M, and tracks and reports the status of all POA&Ms at the monthly Program Management Council meetings. The JPSS program office drafted POA&Ms for deficiencies in both the existing ground system (Block 1.2) and its planned ground system upgrade (Block 2.0). Also, the program office plans to remediate all critical and high risk vulnerabilities before going live with Block 2.0 in August 2016.

[20]High risk and critical are the two highest of the four categories for rating vulnerabilities.

However, the program has not complied with the Department of Commerce policy for remediating critical and high risk vulnerabilities within 30 days or with NOAA's policy for remediating such POA&Ms within 30 days. After a security scan conducted in March 2015 identified over 1,000 critical and high risk vulnerabilities on Block 1.2 and almost 400 critical and high risk vulnerabilities on Block 2.0, the program established POA&Ms to address these vulnerabilities. These vulnerabilities included use of outdated software, an obsolete web server, and older virus definitions. At the time the POA&Ms were established in August 2015, the 1,400 vulnerabilities were already over 4 months old. The JPSS program set completion dates for the POA&Ms of August 2016 for Block 2.0 and January 2017 for Block 1.2. These anticipated completion dates are 17 and 22 months later than required by Commerce and NOAA policies.

In addition to the POA&Ms resulting from the Security Controls Assessment, the JPSS program does not plan to address other POA&Ms in a timely manner. The program consistently establishes due dates for its POA&Ms that are 1 to 3 years in the future. This is illustrated by the following examples:

- NOAA created a POA&M for upgrading its operating systems to supportable platforms and applying all recommended patches to the system to improve security posture and reduce its risk. The issues associated with the unsupportable platforms are scheduled for completion in 2016, 3 years after the POA&M was opened.
- NOAA created a POA&M in 2013 to improve configuration settings for its antivirus software. This fix is also estimated to occur in late 2016, 3 years after the issue was identified.
- In 2013, NOAA created a POA&M to protect the integrity of data transmissions.[21] This POA&M would ensure that the system monitors for unauthorized access to the system and enforces authorization requirements. NOAA plans to fully mitigate this weakness in late 2016.

[21]Remote access is any access to an organizational information system by a user (or process acting on behalf of a user) communicating through an external network (for example, the Internet).

The extended time it takes the JPSS program to resolve vulnerabilities is a longstanding issue. In August 2014, the Department's Inspector General reported that it took the program 11 to 14 months to remediate high risk vulnerabilities identified between 2011 and 2013.[22] The Inspector General noted that this slow rate of remediation was not sufficient to keep up with the rapid growth in the number of vulnerabilities.

Program officials also noted that it is often not possible to remediate critical and high risk vulnerabilities within 30 days because patches may not be available for selected components, testing may take longer than 30 days, and certain changes need to be coordinated with mission partners. Program officials also stated that they plan to modify their internal procedures associated with the Federal Information Processing Standard 200 security control baseline analysis document to allow longer timelines when 30 days is not feasible. Further, in commenting on a draft of this report, NOAA officials stated that the program decided to delay the due date for certain POA&Ms on Block 1.2 that would require significant changes in architecture to coincide with the delivery of Block 2.0.

While the 30 days called for in Commerce and NOAA policies may be challenging, NOAA's ground system has been operating for years with known vulnerabilities due to the backlog of unresolved POA&Ms. These vulnerabilities threaten the confidentiality, integrity, and availability of the ground system that supports S-NPP operations. Until the program remediates these vulnerabilities and addressed POA&Ms in a timely manner, the JPSS program remains at increased risk of potential exploits.

[22]U.S. Department of Commerce, Office of Inspector General, *Expedited Efforts Needed to Remediate High-Risk Vulnerabilities in the Joint Polar Satellite System's Ground System—Final Memorandum* (Washington, D.C.: Aug. 21, 2014).

Monitoring of Security Controls: The JPSS Program Planned and Implemented Monitoring Activities and NOAA Has Handled Multiple Incidents Affecting the JPSS Program, but NOAA and JPSS Do Not Consistently Track Security Incidents

In accordance with NOAA policy, the JPSS program established a continuous monitoring plan to ensure information security controls are working. Consistent with the plan, the program conducts regular security control and vulnerability assessments, monitors the status of remedial actions, and briefs management on a monthly basis on security status. The JPSS program also monitors potential security control weaknesses by tracking incidents and intrusions, on which it reports to a NOAA-wide incident response team.

Like other federal agencies, NOAA has experienced several recent information security incidents regarding unauthorized access to web servers and computers. Specifically, NOAA officials reported 10 medium and high severity incidents related to the JPSS ground system between August 2014 and August 2015. Of these, NOAA has closed 6 of the 10 incidents. The incidents that were closed involved hostile probes, improper usage, unauthorized access, password sharing, and other IT-related security concerns.

According to NOAA officials, the JPSS program office and the NOAA incident response team track all information security incidents. However, inconsistencies exist in the status of incidents being tracked. Specifically, there are differences between what is being tracked by the JPSS program office and what is closed by NOAA's incident response team. Two of the four incidents that were recommended for closure by the JPSS program office are currently still open according to the incident report.

JPSS program officials explained that they can only recommend the closure of an incident and the NOAA incident response team is ultimately responsible for closing an incident based on the information that was provided. Thus, the inconsistency in the status of incidents should be resolved when NOAA updates its tracking tool. Until NOAA and the JPSS program have a consistent understanding of the status of incidents, there is an increased risk that key vulnerabilities will not be identified or properly addressed.

NOAA Made Progress in Assessing the Potential for a Satellite Data Gap and Has Improved Efforts to Plan and Implement Gap Mitigation Activities

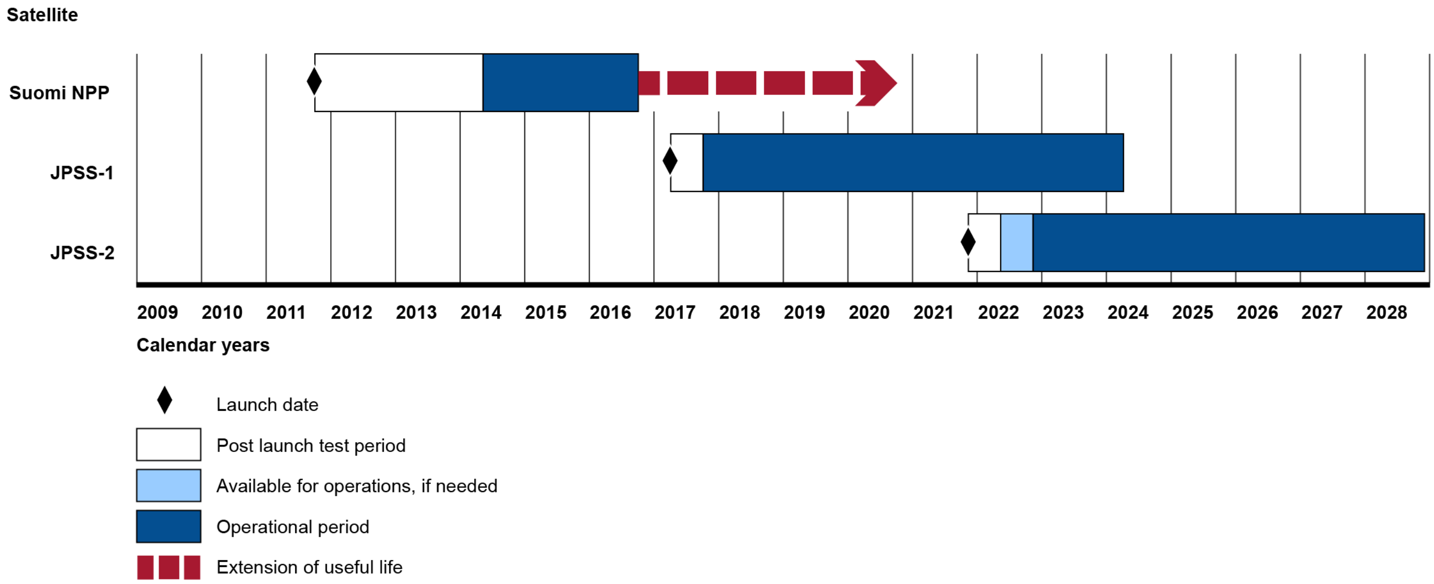
Over the last year, NOAA made progress in assessing the potential for a satellite gap, improved its satellite gap mitigation plan, and completed multiple mitigation activities; however, key shortfalls remain on these efforts. To ensure that satellites are available when needed, satellite experts consider performing annual assessments of a satellite's health and future availability to be a best practice. The JPSS satellite program completed such assessments in 2013, 2014, and 2015 and determined that a near-term gap in satellite data is unlikely, but there are weaknesses in NOAA's analysis. Further, government and industry best practices call for the development of contingency plans to maintain an organization's essential functions in the case of an adverse event such as a gap in critical satellite-based data. NOAA has developed such plans and has improved them over the last few years; however, shortcomings remain in its current plan. In addition, NOAA is in the process of implementing the activities it identified in the plan. At the conclusion of our review, program officials provided an update on the status of key mitigation activities, and noted that they plan to continue to work to improve its gap mitigation plan in 2016.

NOAA Data Show That a Near-Term Gap Is Unlikely, but Weaknesses Remain in Underlying Analysis; the Program Plans to Perform an Additional Assessment

We previously reported that NOAA was facing a potential near-term gap in polar data between the expected end of useful life of the S-NPP satellite and the beginning of operation of the JPSS-1 satellite. As of October 2013, NOAA officials stated that a 3-month gap was likely based on an analysis of the availability and robustness of the polar constellation.

In April 2015, NOAA revised its assumption of how long S-NPP will last by adding up to 4 years to its expected useful life. Under this new scenario, NOAA would not anticipate experiencing a near-term gap in satellite data because S-NPP would last longer than the expected start of operations for JPSS-1. Currently, JPSS-1 is expected to be launched in March 2017 with a 3-month on-orbit check out period (through June 2017) and JPSS-2 is expected to launch in November 2021. Figure 6 shows the latest estimate of the expected lives of NOAA's polar satellites.

Figure 6: Expected Life Span of Current Satellites in Joint Polar Satellite System (JPSS) Program, as of December 2015



Source: GAO analysis of National Oceanic and Atmospheric Administration data. | GAO-16-359

Note: S-NPP—Suomi National Polar-orbiting Partnership.

While the outlook regarding the length of a potential gap has improved, there are several reasons why a potential gap could still occur and last longer than NOAA anticipates. For instance, the S-NPP satellite could fail sooner than expected, or the JPSS-1 satellite could either encounter delays during its remaining development and testing, or fail upon launch or in early operations. Under these scenarios, a gap is still possible, and could last for up to 5 years in the event of a launch failure. If the JPSS-2 satellite were to be delayed or encounter problems as well, a gap could be even longer.

JPSS Improved Its Analysis of Polar Satellite Availability, but Weaknesses Remain; the Program Plans to Perform an Additional Assessment

Space and satellite experts consider performing annual assessments of a satellite's health and future availability to be a best practice. For example, the Department of Defense (DOD) requires annual assessments of the health of its satellite assets as part of its budget preparations.[23] The assessments show, among other things, the probability that a specific satellite or instrument will be available for use at a given time in the future.

While this assessment is not required under NOAA policy, in 2013 the JPSS program began performing an annual analysis of the expected availability of satellites in the polar constellation. The program did this to get regular updates on the health of individual satellites and to help plan future satellite programs and launch dates. According to program officials, NOAA uses these analyses to support their strategies on gap mitigation. Among other things, the analyses show the likely availability of each satellite and instrument over time, scenarios showing the effects on availability given impact from space debris and a life limiting factor on the ATMS instrument, and scenarios for overall polar constellation availability. See appendix III for more information on what the availability analysis shows for the current polar satellite constellation.

In December 2014, we reported that NOAA's 2013 assessment of satellite availability had several limitations, including inconsistent launch date plans, unproven assumptions about on-orbit checkout and validation, and exclusion of the risk of a potential failure due to space debris.[24]

Agency officials acknowledged the assessment's limitations and completed updated assessments in December 2014 and November 2015. NOAA made specific improvements in its 2014 assessment. Specifically, NOAA

- improved the underlying analysis of S-NPP quality through additional analysis of the existing life and health of the S-NPP satellite bus, using data through mid-2014;

[23] U.S. Air Force, *Air Force Space Command Instruction 10-140, Satellite Functional Availability Planning, Incorporating Change 1* (Aug. 21, 2013).

[24] GAO-15-47.

- showed both individual instrument and overall satellite availability over time for the S-NPP and JPSS satellites;
- showed overall availability over time of all key performance parameter instruments (regardless of satellite), and for the constellation's robustness criteria; and
- showed several availability scenarios depicting what would happen in the event of a loss of the JPSS-1 satellite.

In addition, the November 2015 assessment made further improvements by including key factors that could have an effect on S-NPP's useful life in its analysis. Specifically, the newer assessment includes actual instrument performance through mid-2015, assumptions about the risk of space debris, and information on the health of S-NPP's batteries. These enhancements help to better conceptualize decisions NOAA will need to make in planning and launching future satellites.

However, weaknesses remain in the latest assessment, which decrease NOAA's assurance that its satellite life estimates are reliable. Specifically:

- NOAA assumes that JPSS-1 data from key instruments will be available to satellite data users for operational use 3 months after launch, which is far less time than it took to calibrate and validate these instruments for operational use on S-NPP. While initial satellites in a series are more difficult to calibrate and validate than subsequent ones and some unvalidated data may be available earlier, this estimate (which is 2 to 3 times faster than was experienced on S-NPP) appears to be overly optimistic. This may mean that the JPSS-1 satellite takes longer to become operational than NOAA is planning.
- NOAA's analysis of the degrading health of the S-NPP satellite is not consistent with the estimated life dates from its April 2015 flyout chart (as shown in figure 6). Specifically, the flyout chart shows S-NPP with an extended useful life through late 2020, while the assessment shows that there is only a 50 percent likelihood that S-NPP will be fully functioning in 2020.

JPSS program officials stated that they plan to perform another assessment in 2016. Until it has a strong assurance of how long the JPSS satellites are likely to last using an assessment that includes assumptions that are more consistent with past experiences, NOAA risks not adequately planning for mitigating a potential loss, or not communicating to its various stakeholders when its satellites are likely to fail.

NOAA Improved Its Contingency Plan in Key Areas, but Selected Shortfalls Remain; the Program Plans to Update its Contingency Plan

Government and industry best practices call for the development of contingency plans to maintain an organization's essential functions in the case of an adverse event. A summary of guidelines for developing a sound contingency plan are identified in table 6 below.

Table 6: Guidelines for Developing Elements of a Sound Contingency Plan

Category	Description of key activities
Identifying failure scenarios and impacts	Includes defining failure scenarios; conducting impact analyses that show the impact of failure scenarios; defining minimum acceptable levels of outputs and recovery time objectives; and establishing resumption priorities.
Developing contingency plans	Includes identifying alternative solutions to address failure scenarios; selecting contingency strategies from among alternatives based on costs, benefits, and impacts; defining actions, roles and responsibilities, triggers, and timelines for implementing contingency plans; developing "zero-day" procedures; ensuring that steps reflect priorities for resumption of products and recovery objectives; and obtaining review and approval of the contingency plan from designated officials.
Validating and implementing contingency plans	Includes identifying steps for testing contingency plans and conducting training exercises; preparing for and executing tests; validating test results for consistency against minimum performance levels; executing applicable actions for implementation of contingency strategies; communicating and coordinating with stakeholders to ensure that the strategies remain optimal for reducing potential impacts; and updating and maintaining contingency plans as warranted.

Source: GAO analysis of guidance documents from the National Institute of Standards and Technology, Software Engineering Institute, and GAO. | GAO-16-359

In October 2012, NOAA developed a contingency plan (which it refers to as its gap mitigation plan), which was subsequently updated in 2014 and in April 2015. In 2013, we reviewed NOAA's original contingency plan and reported that it had shortcomings in nine areas, including that the agency had not selected strategies from its plan to be implemented or developed procedures and actions to implement the selected strategies.[25] We made

[25] GAO-13-676.

a recommendation to establish a more comprehensive contingency plan for potential satellite data gaps which included these and other elements.

NOAA agreed with our recommendation and worked to implement it. In 2014, we reviewed a revised plan and evaluated NOAA's progress against the weaknesses we had previously identified.[26] We reported that it had completed two of the nine areas, made partial progress in five areas, and made no progress in two areas. In its most recent contingency plan, NOAA fully addressed two of the remaining seven issues, conducted work in four areas, and had not addressed the remaining issue. See table 7 for details on the seven areas that were not fully addressed during our prior reviews.

Table 7: National Oceanic and Atmospheric Administration's (NOAA) Progress in Developing a Sound Contingency Plan for Its Joint Polar Satellite System (JPSS)

February 2014 contingency plan weaknesses	Status as of Feb. 2014 plan	Status as of April 2015 plan	Description of progress
Category: Identifying failure scenarios and impacts			
The plan did not address certain scenarios such as the possibility of a loss of data from the Department of Defense (DOD) and European partner satellites in morning orbits or a Japanese partner mission.	Partially addressed	Partially addressed	NOAA determined that there were no options that could address the loss of data from DOD and the European satellites in the early and mid-morning orbits, and that the other mitigation options listed in NOAA's contingency plan would have to serve as mitigation for the potential loss of the DOD or European satellites' data. However, the loss of data from DOD remains a significant risk. Specifically, the Air Force has not finalized its plans for launching the Defense Meteorological Satellite Program or beginning a new weather follow-on mission. NOAA's gap mitigation plan states that DMSP data contributes to numerical weather prediction forecast skill, and that loss of data from any of the three orbits significantly raises the need for sound mitigation options.

[26]GAO-15-47.

February 2014 contingency plan weaknesses	Status as of Feb. 2014 plan	Status as of April 2015 plan	Description of progress
The plan did not include recovery time objectives for key data products.	Not addressed	Not addressed	NOAA's April 2015 plan did not include specific objectives for the recovery of key data products on which the development and implementation of mitigation options could be based. For example, it does not include information on how quickly NOAA needs to launch a replacement satellite, such as those under development and listed in the plan, should a primary satellite fail.
Category: Developing contingency plans			
The plan did not identify the contingency strategies NOAA selected to be implemented or establish procedures and actions to implement the selected strategies.	Partially addressed	Fully addressed	NOAA's revised plan identifies approximately 35 contingency strategies in three general areas: (1) understanding the probability and the impact of a gap, (2) reducing the likelihood of a gap, and (3) reducing the impact of a gap. The plan also includes procedures and actions to implement selected strategies in each area. (See table 8 for more information on the gap mitigation activities.)
NOAA had not yet assessed its alternative strategies based on costs, benefits, and potential impacts.	Not addressed	Partially addressed	In commenting on a draft of this report, NOAA officials reported that the agency had completed several steps related to assessing the costs, benefits, and potential impacts of various mitigation options, which resulted in the options included in the plan. However, NOAA's plan does not include information on the cost, benefit, and potential impacts of its mitigation projects.
The plan did not identify opportunities for accelerating the calibration and validation phase—the time between launch and availability of operational products—for JPSS-1.	Partially addressed	Fully addressed	NOAA has added language related to the acceleration of calibration and validation. The April 2015 plan notes that certain key data records that are input to National Weather Service weather prediction models will be made available for operational use the day after the JPSS-1 satellite's commissioning (which is planned for approximately three months after launch). Visible Infrared Imaging Radiometer Suite data records will also be made available at that time. NOAA also reported that while these data products will not be fully validated and calibrated by that time, they will be capable of gap mitigation in the event of loss of those products from the Suomi National Polar-orbiting Partnership (S-NPP). Further, the National Weather Service is to begin to evaluate the Advanced Technology Microwave Sounder and Cross-Track Infrared Sounder instruments immediately after launch as a part of the JPSS calibration/validation.
The plan did not always identify specific actions with defined roles and responsibilities, timelines, and triggers.	Partially addressed	Partially addressed	While the plan identifies roles, responsibilities, and timelines for selected actions, it does not consistently provide this information. NOAA noted that it plans to provide more meaningful timelines and linkages among mitigation activities in a future plan update.

February 2014 contingency plan weaknesses	Status as of Feb. 2014 plan	Status as of April 2015 plan	Description of progress
Category: Validating and implementing contingency plans			
NOAA had not yet initiated efforts to validate or implement its gap mitigation plan.	Partially addressed	Partially addressed	NOAA implemented several gap mitigation activities. For example, it completed selected observing system experiments. However, the agency intends to further define completion dates for testing and validating actions at some point in the future. (See table 8 for more information on the status of NOAA's gap mitigation activities.)

Source: GAO analysis of NOAA documents. | GAO-16-359

In summary, NOAA made progress by listing the contingency strategies it selected to be implemented and has integrated strategies identified after the 2014 plan was developed. It also detailed plans to make JPSS-1 data available as soon as possible after launch. However, NOAA has not yet documented the JPSS program's required recovery time and has not developed an integrated master schedule for gap mitigation activities. The program updated the status of ongoing and planned mitigation activities in early 2016, and plans to issue an updated contingency plan later in 2016.

NOAA Is Making Progress on Gap Mitigation Activities, but None Can Fully Mitigate a Near-Term Gap in Satellite Data

NOAA identified 35 gap mitigation activities and is making progress in implementing them. These activities fall into three general categories: (1) understanding the probability and the impact of a gap, (2) reducing the likelihood of a gap, and (3) reducing the impact of a gap.

As of January 2016, 16 activities had been completed, including transitioning the S-NPP satellite from a research satellite to a fully operational satellite. Another 18 activities are ongoing, including assimilating more observations from commercial aircraft observations and unmanned aerial systems into weather models, and leveraging data and models from the European Center for Medium-range Weather Forecasts into National Weather Service weather models. One other activity is planned for the future. See table 8 below for details on these activities. While these gap mitigation activities are important to help mitigate the impact of a satellite data gap, NOAA acknowledges that no mitigation activities can fully replace polar-orbiting satellite observations.

Table 8: Status of Gap Mitigation Options for National Oceanic and Atmospheric Administration (NOAA) Polar Satellites

	Mitigation action	Status
Understanding the probability and the impact of a gap		
1	Create capacity to conduct routine Observing System Experiments and Observing System Simulation Experiments.	Completed. NOAA procured hardware and software to conduct the experiments.
2	Upgrade Observing System Simulation Experiments capability to assess the impact of a data gap and the performance of various mitigation options.	Completed. NOAA performed a one-time upgrade of its two relevant supercomputers.
Reduce the likelihood of a gap		
3	Provide continuous monitoring of spacecraft to preserve and maximize their lifetimes.	Completed. NOAA provides continuous monitoring of the Suomi National Polar-orbiting Partnership (S-NPP) spacecraft.
4	Perform avoidance maneuvers away from space debris.	Completed. NOAA performs avoidance maneuvers as needed on an ongoing basis. Two such maneuvers were performed in calendar year 2014. In addition, during 2015, NOAA reported that it conducted one maneuver to avoid an approaching object and actively monitored three high-interest events that posed a potential risk to the spacecraft.
5	Apply lessons learned from long-life NOAA and NASA missions.	Completed. Results of a May 2013 meeting on this issue have been incorporated into JPSS program actions.
6	Work to extend the life of S-NPP as much as possible.	Completed. NOAA developed a plan to extend S-NPP's life and implemented it. The agency also reported that it implemented a procedure to extend the life of a key component on ATMS, and that to date it has been successful.
7	Keep JPSS-1 on schedule.	Ongoing. As of January 2016, the Joint Polar Satellite System (JPSS) program is taking corrective actions to ensure that ongoing technical challenges are addressed so as to not impact the launch schedule.
8	Keep JPSS-2 on schedule and continue to seek acceleration opportunities.	Ongoing. NOAA plans call for a JPSS-2 accelerated launch readiness date in the fourth quarter of calendar year 2021.
9	Make the JPSS program more robust and maintain continuity of critical weather data in the afternoon orbit beyond JPSS-2 by accelerating procurements and developing gap mitigation efforts.	Ongoing. The fiscal year 2016 budget includes funding for Polar Follow-On (PFO) activities.
10	Make the JPSS program more robust and maintain continuity of critical weather data in the afternoon orbit beyond JPSS-2, through funding options and planning.	Ongoing. NOAA is planning a PFO extension to the JPSS program including a robust architecture that is single-fault tolerant and requires two failures in the afternoon orbit to create a gap in Advanced Technology Microwave Sounder (ATMS) and Cross-Track Infrared Sounder (CrIS) instrument data. The PFO extension to the JPSS program also includes the development of near-term gap mitigation options.

11	Transition S-NPP into an operational system (S-NPP data processing and distribution).	Completed. NOAA obligated funds to enable full time (24 hours a day/7 days a week) processing of all S-NPP data products. This was completed in the second quarter of fiscal year 2014.
Reduce the impact of a gap		
12	Ensure continued data availability from Polar-orbiting Operational Environmental Satellites (POES) and Meteorological Operational (Metop) satellites, including upgrading processing system to ensure data continuity.	Completed. NOAA upgraded the processing system and continues to monitor data availability.
13	Complete environmental testing for Metop-C U.S. instruments.	Completed. As of January 2016, NOAA completed environmental testing on the instruments.
14	Maintain Aqua data processing.	Completed. NOAA is processing Aqua data.
15	Assimilate Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave Imager/Sounder data.	Completed. NOAA began assimilating data from the two newest DMSP satellites in January 2015.
16	Improve assimilation of cloud-impacted radiances into NOAA.	Ongoing. As of January 2016, NOAA is working to develop advanced techniques for assimilation of cloud-impacted microwave and infrared radiances in the operational global data assimilation system. While it was supposed to be implemented by the first quarter of fiscal year 2016, it is currently scheduled for completion in the third quarter of fiscal year 2016.
17	Improve atmospheric motion vectors.	Ongoing. As of January 2016, NOAA is working to transfer atmospheric motion vector algorithms developed by the U.S. Navy and University of Wisconsin into NOAA operations. While it was supposed to be implemented by the first quarter of fiscal year 2016, it is currently scheduled for completion in the third quarter of fiscal year 2016.
18	Assimilate more commercial aircraft observations and targeted observations from unmanned aerial systems.	Ongoing. As of January 2016, NOAA procured new aircraft data and had begun testing it. The agency was also working to quantify the significance of observations from unmanned aircraft to high-impact weather predictions.
19	Expand use of the Global Navigation Satellite System's radio occultation data through the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC-2) mission.	Ongoing. As of December 2015, NOAA was working with its partners to support the development of the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC-2) constellation, which consists of two sets of six satellites and is currently on schedule. The first set of COSMIC-2 satellites is planned to launch in 2017 and the second set in 2020.
20	Develop the capability to assimilate soundings from advanced geostationary imagers.	Ongoing. As of January 2016, NOAA had procured a ground system to process Japan's Himawari-8 data (using money from the Disaster Relief Appropriations Act, 2013). It is now developing and testing geostationary imager radiance products, which it plans to complete by the third quarter of fiscal year 2016.
21	Develop improvements in data assimilation, ensembling, physical parameterizations, and global modeling, particularly for 4D hybrid data assimilation.	Ongoing. As of January 2016, NOAA had an advanced 4D-ensemble-variational data assimilation system in pre-operational testing. Efforts to improve physical parameterizations and ensembles are progressing, but a recent NOAA briefing noted that there are risks associated with its completion. It is currently scheduled for completion in the third quarter of fiscal year 2016.

22	Leverage European Center for Medium-range Weather Forecast products for global models.	Ongoing. As of January 2016, NOAA was in the process of developing products with data from the European center's synthetic soundings to replace lost polar satellite data. The project also provides improved verification product sets for future use, improves consistency in the official National Weather Service forecasts, and minimizes edits at the local weather office level. It is currently scheduled for completion in the fourth quarter of fiscal year 2016.
23	Strengthen Direct Readout for Alaska and reduce data latency by improving/expanding X-band data downlinks.	Completed. NOAA installed X-band direct readout ground stations and processing hardware in Fairbanks, AK; Monterey, CA; Miami, FL; and Puerto Rico.
24	Leverage Joint Center for Satellite Data Assimilation and the Center for Satellite Applications and Research capabilities for assimilation studies, calibration and validation, and product development.	Ongoing. As of July 2015, the two centers were continually working to make the numerical weather prediction system increasingly resilient to partial data losses by assessing the impacts of various gap mitigation measures.
25	Acquire operational and research high performance computing.	Completed. A new research high performance computing system was delivered to the Office of Atmospheric Research in January 2015 and was fully available to users in March 2015. The National Weather Service operational system upgrade was completed in November 2015.
26	Begin procurement of the Earth Observing Nanosatellite-Microwave satellite for gap mitigation of microwave atmospheric sounding data.	Planned. NOAA planned to begin working on this procurement in fiscal year 2016, but the explanatory statement accompanying the Consolidated Appropriations Act, 2016 explicitly states that it does not include funding for the Earth Observing Nanosatellite-Microwave satellite (EON-MW). The Department of Commerce has included funding for EON-MW in its budget submission to OMB for fiscal year 2017.
27	Conduct polar system trades and analyses	Ongoing. To identify more efficient methods to provide data continuity while advancing capabilities to meet future requirements, the National Environmental Satellite, Data, and Information Service is identifying future requirements for overall polar architecture development. A recent study concluded that the most efficient way to provide continuity of key performance data is the extension of the JPSS series and the procurement of JPSS-3 and -4. NOAA has also conducted studies to recommend technology investment priorities and improvements in instrument technology.
28	Continue to process Metop imagery and prepare for data from the European Organisation for the Exploitation of Meteorological Satellites' Polar System-Second Generation.	Ongoing. NOAA currently receives Metop data through an agreement with the European Organisation for the Exploitation of Meteorological Satellites, and recently signed a subsequent agreement to receive data from that organization's second generation of satellites, once they are available.
29	Explore options to leverage data from the Japanese Global Change Observation Mission.	Ongoing. As of October 2015, NOAA was continuing discussions with the Japanese agency to explore use of data from the anticipated follow-on to its first global change observation mission on water, as well as its first mission on climate.

30	To mitigate the potential loss of data from Ozone Mapping and Profiler Suite-Nadir (OMPS-N), NOAA will be prepared to use and leverage the less capable Global Ozone Monitoring Experiment-2 data from the Metop series of satellites through 2024.	Ongoing. As of October 2015, NOAA routinely ingests ozone data from Metop-A/B. To begin using data from Metop-C, calibration and validation of replacement products will be required after the satellite is launched in 2017. In addition, NOAA scientists plan to evaluate Sentinel-5 and Sentinel-SP data for potential mitigation for Ozone Mapping and Profiler Suite-Nadir (OMPS-N). Sentinel-SP is scheduled for launch in 2016.
31	NOAA will explore future options to use data from the European Polar System-Second Generation and Sentinel-SP.	Completed. NOAA recently signed agreements with its European partners for use of data from the European Polar System-Second Generation and Sentinel-SP.
32	Transition OMPS-L and the Radiation Budget Instrument requirements to NASA.	Completed. As a result of fiscal year 2014 direction from Congress, OMPS-L and Radiation Budget Instrument requirements were transitioned to NASA. In addition, NASA and NOAA agreed that NOAA would host the Radiation Budget Instrument on the JPSS-2 satellite (provided it arrived in time to not impact JPSS-2's schedule), and NOAA is in the process of negotiating an agreement to host the OMPS-L instrument on JPSS-2. This agreement is expected to be completed by March 2016. In addition, these sensors are tentatively planned for JPSS-3 and -4; however, funding from NASA is currently uncertain.
33	Prepare to collect targeted observations of high-impact events.	Ongoing. In January 2016, NOAA officials reported that the agency had established a science team to help decide what types of data to collect. In addition, NOAA and NASA completed an interagency agreement to share data between the agencies. The agencies also completed a preliminary Hurricane Unmanned Aerial System impact study in December 2014. Prototype missions were initiated in fiscal year 2014 and continued through the first quarter of fiscal year 2016. Further, Pacific and Arctic storm and comprehensive oceanic storm impact studies were completed in the second quarter of fiscal year 2016. NOAA officials note that final project results will be provided to NOAA leadership by the second quarter of 2017.
34	Provide X-band direct broadcast for sites over U.S..	Completed. NOAA installed X-band direct readout ground stations and processing hardware in Fairbanks, AK; Monterey, CA; Miami, FL; and Puerto Rico. NOAA has also transmitted reformatted direct broadcast data to its National Centers for Environmental Prediction.

35	Accelerate global model advances.	Ongoing. NOAA is working to improve current and next-generation global numerical weather prediction models and data assimilation. The agency reported that it completed efforts to test a core model of its next generation global prediction system. NOAA is on track to complete evaluation of test results by the second quarter of 2017. In addition, an advanced 4D-ensemble-variational data assimilation system entered pre-operational testing in April 2015. This system will make more complete usage of available satellite data and is expected to become operational by the second quarter of fiscal year 2016. Additionally, work is progressing on improving physical parameterizations and multi-model ensembles.

Source: GAO analysis of NOAA data. | GAO-16-359

NOAA Is Planning to Develop More Polar Satellites, but Uncertainties Remain on Timing and Requirements

NOAA has begun planning for new satellites to ensure the future continuity of polar satellite data. This program is called the Polar Follow-On (PFO). According to NOAA officials, PFO will allow for polar satellite coverage in the afternoon orbit into the 2030s. NOAA plans to eventually manage PFO as an integrated program with the current JPSS program. The PFO budget includes operational costs for both it and the current JPSS program after fiscal year 2025.

NOAA officials have stated that part of its goal for the future satellite program is to provide “robustness” in order to minimize the chance of a data gap like the near-term one the agency is facing. According to NOAA documentation, the main objectives of the PFO program are to (1) have the earliest possible launch readiness for the JPSS-3 and JPSS-4 satellites in order to achieve robustness, and (2) to minimize costs.

As recommended by a 2013 Independent Review Team, NOAA would achieve robustness on its polar satellite program when (1) it would take two failures to create a gap in data for key instruments, and (2) the agency would be able to restore the system to a two-failure condition within 1 year of a failure. This means that NOAA would need a backup satellite in orbit to provide data in the event of one failure, and that the agency would have the ability to launch another satellite within a year to replace an on-orbit need. Achieving robustness would greatly minimize the chances of a single point of failure—that is, a problem with one satellite causing an immediate loss of data.

NOAA has identified the satellites it plans to build as a part of PFO. The PFO program is planned to include two more satellites in the JPSS series, called JPSS-3 and JPSS-4. NOAA plans for these satellites to be nearly identical to the JPSS-2 satellite. Each satellite will include the three instruments that are considered to be key performance parameters: the

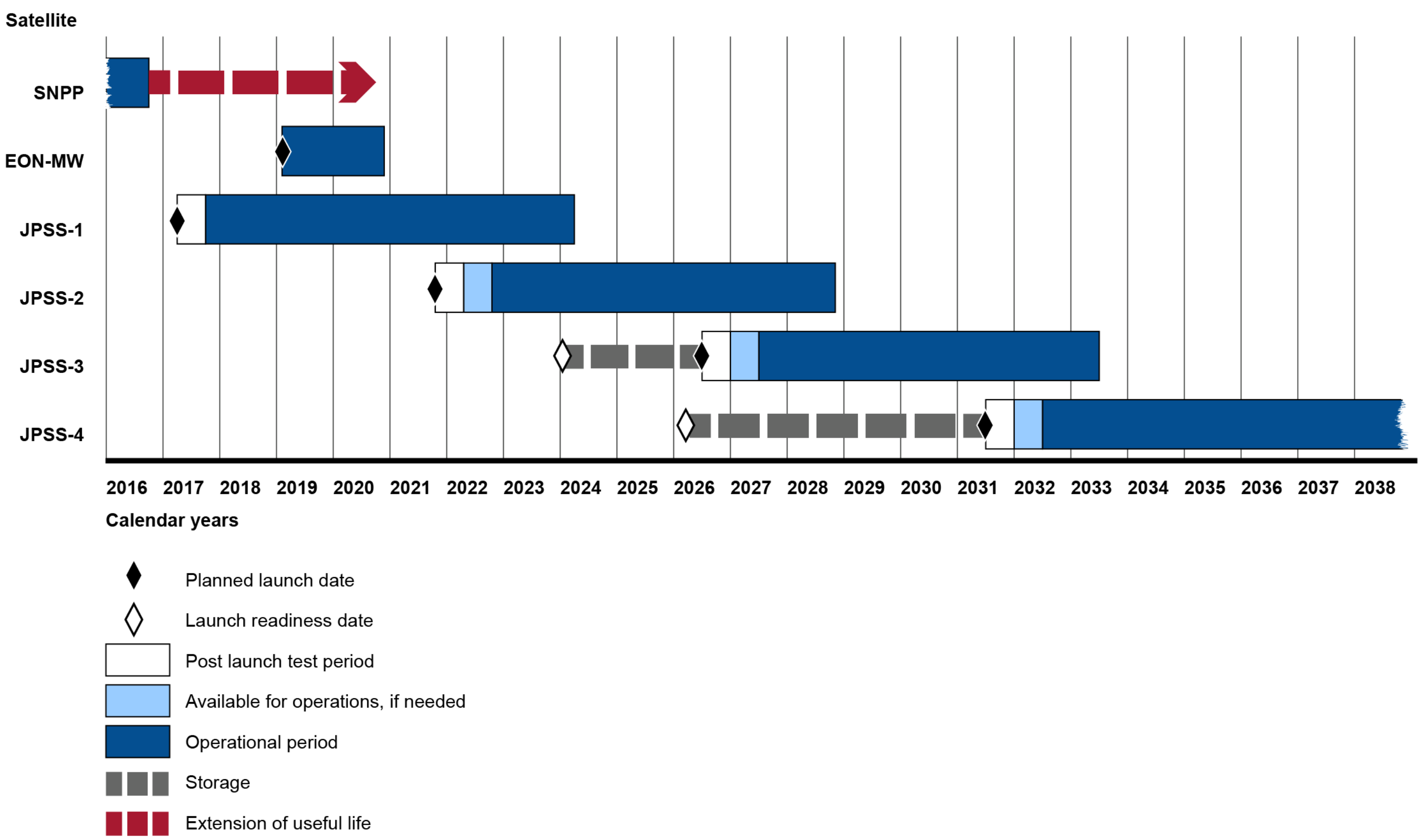
Advanced Technology Microwave Sounder (ATMS), the Cross-Track Infrared Sounder (CrIS), and the Visible Infrared Imaging Radiometer Suite (VIIRS). The satellites will also include the Ozone Mapping and Profiler Suite-Nadir (OMPS-N). These four instruments are environmental sensors that provide critical data used in numerical weather prediction and imagery.

NOAA also is planning for two climate instruments that are on JPSS-2—the Ozone Mapping and Profiler Suite-Limb (OMPS-L) and the Radiation Budget Instrument—to be hosted on JPSS-3 and JPSS-4 as well. However, according to NOAA, these instruments are not essential and their funding from JPSS-2 onward is uncertain.

In addition to the JPSS-3 and JPSS-4 satellites, PFO is planned to include a Cubesat satellite.[27] Specifically, NOAA plans to fly a satellite called the Earth Observing Nanosatellite–Microwave. This satellite, due to launch in 2020, would be able to replace some, but not all, ATMS data in the event of a gap between JPSS-1 and JPSS-2. Program officials have stated that, because of its low cost and the experience the agency will gain from the mission, NOAA will launch the Earth Observing Nanosatellite–Microwave regardless of the status of the remainder of the constellation. Figure 7 shows the planned expected lives for all of the JPSS and PFO satellites.

[27]Cubesats are a class of smaller satellites made up of combined units of similar cubic shape.

Figure 7: Expected Lives of Joint Polar Satellite System (JPSS) and Polar Follow-On Satellites



Source: GAO analysis of National Oceanic and Atmospheric Administration data. | GAO-16-359

Note: S-NPP—Suomi National Polar-orbiting Partnership; EON-MW—Earth-Orbiting Nanosatellite–Microwave.

NOAA has taken several steps in planning the PFO program. Specifically, it established goal launch dates, high-level annual budget estimates, and roles and responsibilities for NOAA offices that will play a role on the new program.

However, NOAA is in the process of updating key formulation documents for PFO, such as high-level requirements, an updated concept of operations and project plan, and budget information for key components. Program officials stated that they expect to complete key documents by mid-2016.

Uncertainties Remain on Key Development Dates for PFO

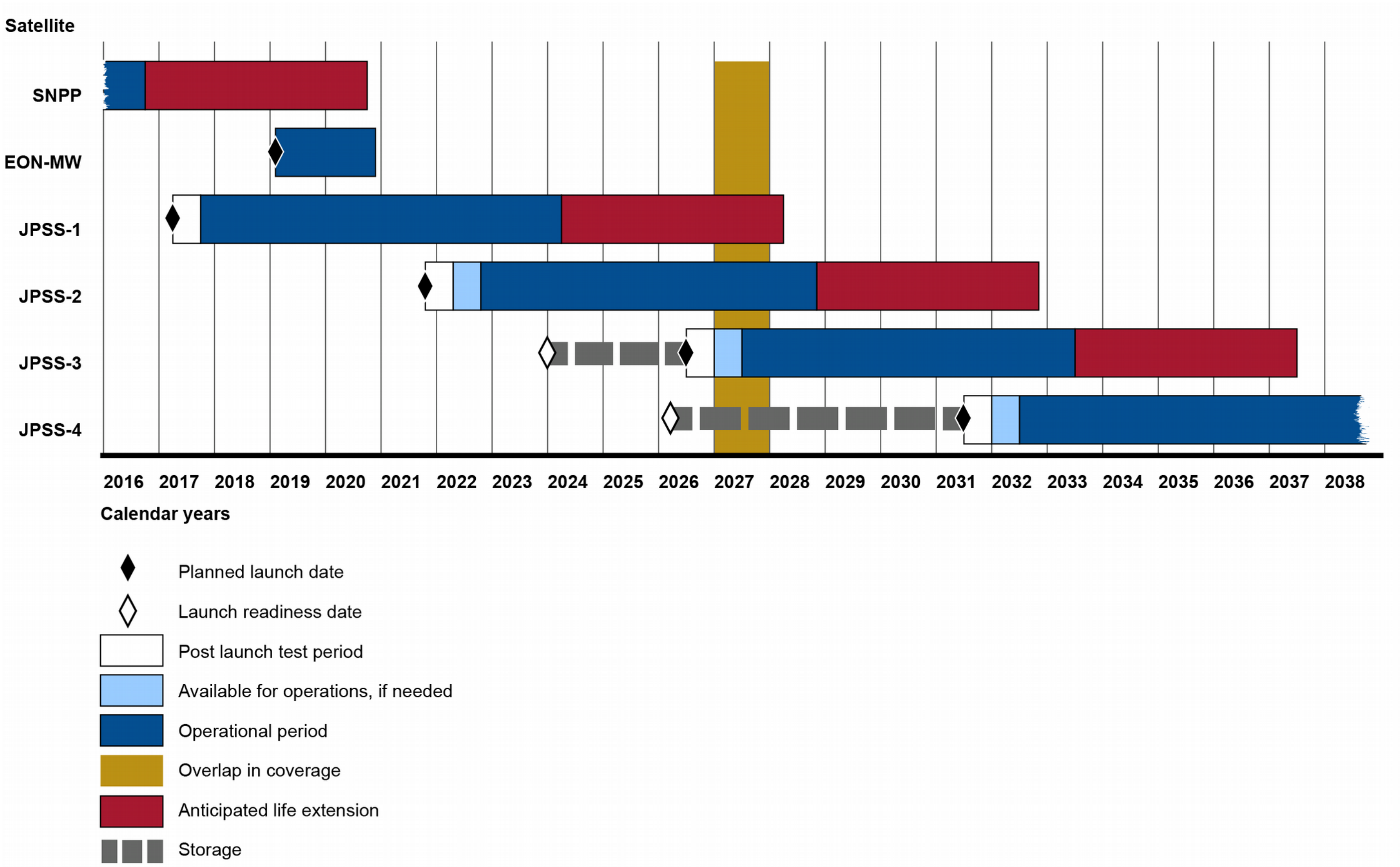
NOAA plans to develop the PFO satellites well before they are needed. In general, the agency makes a distinction between the date it wants to have a satellite available for launch (called a launch readiness date) and the actual planned launch date. NOAA set the launch readiness dates for the JPSS-3 and JPSS-4 satellites as January 2024 and April 2026, respectively. NOAA also has a contingency plan to launch the JPSS-3 satellite with only the two most important instruments (ATMS and CrIS) as early as 2023, if it is needed to mitigate a near-term satellite data gap due to unanticipated problems with JPSS-1 or JPSS-2. In contrast, NOAA's planned launch dates for JPSS-3 and JPSS-4 are 2 and 5 years later, respectively. NOAA currently plans, beginning with JPSS-2, to launch a new satellite every 5 years in order to achieve a robust constellation of satellites. Specifically, planned launch dates for the JPSS-3 and JPSS-4 satellites are July 2026 and July 2031, respectively (see figure 7).

NOAA has given several reasons for planning to achieve launch readiness several years ahead of launch.

- According to NOAA officials, this difference between planned launch readiness and actual launch dates, called the “build-ahead” strategy, is part of an effort to achieve the two robustness criteria as quickly as possible.
- NOAA officials also stated that early readiness would allow a “robust sparing strategy” for ATMS and CrIS. According to NOAA, this would allow for completed components from the JPSS-3 and JPSS-4 satellites to be substituted as needed if parts failed during integration and test of an earlier satellite.
- Additionally, according to NOAA, experienced contractor staff needed to complete development efficiently for the PFO satellites are in place now. Such staff may not be available if there is an extended break in development time.

However, uncertainties remain on whether it is necessary to develop both JPSS-3 and JPSS-4 early in order to achieve robustness. For example, while NOAA flyout charts for the polar constellation list the JPSS satellites starting with JPSS-1 as lasting only 7 years, program officials have stated that they could last as long as 10 or 11 years. In addition, NOAA recently updated the flyout chart to show that S-NPP could last as long as 9 years, based on past performance. If the satellites last longer than expected, then there could be unnecessary redundancy. For example, at the extended useful life estimate of 10 to 11 years, JPSS-1, JPSS-2, and JPSS-3 would still be available in 2027 when JPSS-4 completes development. If NOAA were to delay launching JPSS-4 until it is needed, the satellite could be in storage for 4 years. Figure 8 shows anticipated satellite lifetimes with extended useful lives.

Figure 8: Expected Lives of Joint Polar Satellite System (JPSS) Series Satellites with Extended Useful Life Estimate



Source: GAO analysis of National Oceanic and Atmospheric Administration data. | GAO-16-359

Note: S-NPP—Suomi National Polar-orbiting Partnership; EON-MW—Earth-Orbiting Nanosatellite–Microwave.

Alternatively, if the early satellites do not last longer than expected, then there is an increased potential for future gaps in polar satellite coverage, as there will be several periods in which only one satellite is on orbit. Due to this uncertainty, NOAA faces important decisions on timing the development and launch of the remaining satellites in the JPSS program.

NOAA requires cost/benefit studies for major programs to assist in making major decisions. However, the program did not evaluate the costs and benefits of launch scenarios based on the latest estimates of how long the satellites would last. Such an analysis is needed to ensure robust coverage while minimizing program costs, and could help determine the most cost-effective launch schedule. For example, if JPSS-4 development could be deferred, the annual cost of PFO might be decreased. A potential cost decrease is important because, according to NOAA documentation, the overall funding need for PFO is expected to be about $8.2 billion, compared to about $11.3 billion for the full JPSS program through 2025.

Until NOAA ensures that its plans for future polar satellite development are based on the full range of estimated lives of potential satellites, the agency may not be making the most efficient use of the nation's sizable investment in the polar satellite program.

Conclusions

Facing a potential gap in weather satellite data, NOAA has made progress in developing the JPSS-1 satellite and is on track to launch it in March 2017. However, the agency continues to experience cost growth, schedule delays, and technical risks on key components. In particular, a component on the spacecraft has fallen more than 6 months behind schedule, putting the spacecraft on the critical path leading up to the planned launch date. Continued close management of costs, schedules, and risks will be essential to ensuring a successful and timely launch.

Given the increasing information security risks across the federal government, building information security into ground systems is a critical component of the JPSS system development. Although the JPSS program has assessed key risks, established and evaluated security controls, and remediated selected control weaknesses, key deficiencies remain. Specifically, the team responsible for testing security controls did not have all the information it needed to test the entire system. Also, while the assessment found numerous vulnerabilities, the program has not addressed them in a timely manner. These security shortfalls put the program at risk of being compromised, and there have been a number of security incidents affecting the ground system in recent years. While NOAA's incident response group has effectively addressed security incidents, there are discrepancies between NOAA and the JPSS program on the status of incidents. Such discrepancies make it more difficult to ensure that all incidents are identified, addressed, and tracked to closure.

Until these deficiencies are addressed, the polar satellite infrastructure will continue to be at increased risk of compromise.

To address the risk of a near-term satellite gap and to move to a more robust constellation of polar satellites, NOAA has assessed the health of its operational satellites annually, established and improved its gap mitigation plans, and is beginning to plan a new satellite program to ensure coverage through 2038. While the JPSS program improved its satellite assessment and gap mitigation plans, shortfalls remain, including identifying recovery time objectives for key data products. In prior reports, we have made recommendations to NOAA to improve its satellite availability assessment and its gap mitigation plans. We continue to believe that these recommendations are valid and, if fully implemented, would improve NOAA's ability to assess and manage the risk of a gap in satellite data. We will continue to monitor NOAA's ongoing efforts to address our prior recommendations.

While NOAA is planning a follow-on polar satellite program to better ensure polar satellite coverage in the future, the agency has not evaluated the costs and benefits of different launch scenarios based on its updated understanding of how long its satellites might last, and uncertainties remain in determining appropriate dates for the development and launch of the satellites. Unless NOAA makes launch decisions based on the most current estimates of useful life of its satellites, the agency may not make the most effective and economical use of the nation's sizable investment in polar satellites.

Recommendations for Executive Action

Given the importance of addressing risks on the JPSS satellite program, we are making the following four recommendations to the Secretary of Commerce. Specifically, we recommend that the Secretary direct the Administrator of NOAA to take the following actions:

- Establish a plan to address the limitations in the program's efforts to test security controls, including ensuring that any changes in the system's inventory do not materially affect test results.
- When establishing plans of action and milestones to address critical and high risk vulnerabilities, schedule the completion dates within 30 days, as required by agency policy.
- Ensure that the agency and program are tracking and closing a consistent set of incident response activities.

- Evaluate the costs and benefits of different launch scenarios for the PFO program based on updated satellite life expectancies to ensure satellite continuity while minimizing program costs.

Agency Comments and Our Evaluation

We sought comments on a draft of our report from the Department of Commerce and NASA. We received written comments from the Department of Commerce transmitting NOAA's comments, which are reprinted in appendix IV. NOAA concurred with all four of our recommendations and identified steps it is taking to implement them. In its comments, NOAA wrote that it recognizes the need to close polar data gaps and to keep pace with changes in information security requirements; however, it noted that resource constraints and shifting priorities have presented challenges in meeting these objectives.

In response to our second recommendation, to schedule completion dates for plans of actions and milestones (POA&M) to address critical and high-risk vulnerabilities within 30 days as required by agency policy, NOAA concurred and noted that JPSS would continue to follow agency policy. NOAA explained that agency policy allows the authorizing official to accept and document risks when remediation of vulnerabilities cannot be performed as anticipated. It further noted that there are two situations which may result in remediation taking longer than the policy requires: (1) when applying patches to a system that must remain static while in development and testing, and (2) when applying patches to a complex operational system that requires analysis and testing prior to deployment in order to protect the availability of the system. While we acknowledge that there are valid reasons that remediating a POA&M might take longer than the 30 days required by agency policy, the JPSS program did not follow agency policy in that it did not schedule completion of key POA&Ms within 30 days and did not have documentation from the authorizing official accepting the risk of a delayed remediation schedule for critical and high-risk vulnerabilities, as we note in this report. Moving forward, NOAA noted that it plans to update its FIPS 200 compliance document to include steps to obtain and document risk acceptance from the authorizing official. We agree that updating this plan and implementing it will help ensure that the program is better aligned with agency policy and in a better position to remediate or accept vulnerabilities.

In response to our fourth recommendation, to evaluate the costs and benefits of different launch scenarios for the PFO program based on updated satellite life expectancies, NOAA concurred and noted in its letter that it had evaluated the costs and benefits of different launch scenarios using the latest estimates of satellite lives as part of its budget submission. We discussed this with program officials in April 2016. Program officials explained that the program determined it would minimize costs by building the satellites as soon as possible, and it would minimize risks by planning to launch the satellites at a cadence that would meet the program's goals for a robust polar constellation. However, the agency did not provide sufficient supporting evidence or artifacts. Without documentation showing specific comparisons of options with respect to cost totals and overall risk, the assumptions NOAA used, and the processes and time frames in which NOAA's decisions were reached, we were not able to validate the agency's results.

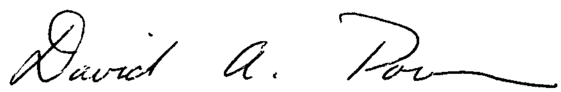
NOAA also stated in its letter that it will continue to update its analysis based on, among other things, updated satellite life expectancies and information gained from award of future spacecraft and instrument contracts. Doing so would help ensure that the agency is making the most efficient use of investments in the polar satellite program.

NOAA also provided technical comments, which we have incorporated into our report, as appropriate. In its technical comments, NOAA officials referred to our finding that the satellite availability assessment is not consistent with the estimated life dates in its flyout chart, noting that (1) its flyout charts are not intended to depict a satellite's estimated life, and (2) our focus on S-NPP's 50 percent likelihood of functioning in 2020 is inappropriate because JPSS-1 will be the primary operational satellite in 2020. However, the flyout charts show "planned mission life" according to NOAA requirements. It is misleading to show a mission life extending through late 2020 if the agency's estimate of the satellite's health puts it at only a 50 percent likelihood of full functionality. Furthermore, while JPSS-1 should be the primary satellite and S-NPP should be a secondary satellite in 2020, the status of S-NPP's health would become paramount if JPSS-1 experienced a failure on launch or on orbit.

On March 16, 2016, an audit liaison for NASA provided an e-mail stating that the agency would provide any input it might have to NOAA for inclusion in NOAA's comments.

We are sending copies of this report to the appropriate 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, the report will be available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions on the matters discussed in this report, please contact me at (202) 512-9286 or 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 V.



David A. Powner
Director, Information Technology Management Issues

Appendix I: Objectives, Scope, and Methodology

Our objectives were to (1) evaluate the National Oceanic and Atmospheric Administration's (NOAA) progress on the Joint Polar Satellite System (JPSS) program with respect to schedule, cost, and key risks; (2) assess NOAA's efforts to plan and implement appropriate information security protections for polar satellite data; (3) evaluate NOAA's efforts to assess the probability of a near-term gap in polar satellite data, as well as its progress in implementing key activities for mitigating a gap; and (4) assess NOAA's efforts to plan and implement a follow-on polar satellite program.

To evaluate NOAA's progress on the JPSS satellite program with respect to schedule, cost, and key risks, we compared actual or anticipated completion dates for important flight and ground project milestones against previously anticipated completion dates between July 2013 and December 2015, and explored the root causes of recent delays. We also compared cost data for program instruments and other components to previous data for those same components, to determine differences over time. We compared monthly management reports on key program risks to determine the status of major remaining program risks, and to determine which risks had been closed. We also compared risk data to source documents such as risk registers. In addition, we interviewed JPSS program office staff for details on schedule, cost, and risk information. We assessed the reliability of monthly reports on the JPSS program's schedule, cost, and risk information by comparing these data to other program artifacts and through interviews with knowledgeable officials. We found these data to be sufficiently reliable for our purposes.

In order to assess NOAA's efforts to plan and implement appropriate information security protections for polar satellite data, we compared Commerce and NOAA information security policies and JPSS program information security practices to selected Federal Information Security Modernization Act of 2014 (FISMA) requirements as well as implementing guidance from the Office of Management and Budget and the National

Institute of Standards and Technology (NIST).[1] Specifically, we assessed policies and practices in the areas outlined in NIST's Risk Management Framework: system categorization; selection, implementation, and assessment of security controls; authorization to operate; and ongoing monitoring. We obtained and analyzed key artifacts supporting the JPSS program's efforts to address these risk management areas, including the program's system categorization results, the System Security Plan, the System Controls Assessment report, Authorization to Operate documentation, incident reports, and the program's continuous monitoring plan. We interviewed key managers and staff from the JPSS program office and the NOAA Office of the Chief Information Officer to better understand their information security policies and practices. We assessed the reliability of the agency's information on controls and vulnerabilities by comparing it to supporting documentation and artifacts, and found that the data were sufficiently reliable for our purpose of reporting on shortfalls in agency practices.

To evaluate NOAA's efforts to assess the probability of a near-term gap in polar satellite data, as well as its progress in implementing key activities for mitigating a gap, we analyzed NOAA's methodology for determining the expected length of a potential gap and compared it against other gap estimates and availability requirements. We reviewed NOAA's April 2015 polar satellite gap mitigation/contingency plan, and compared it to best practices in contingency planning developed by leading government and industry sources[2] as well as shortfalls we previously identified in NOAA's

[1]The Federal Information Security Modernization Act of 2014, Pub. L. No. 113-283, 128 Stat. 3073 (Dec. 18, 2014) largely superseded the Federal Information Security Management Act of 2002, enacted as Title III, E-Government Act of 2002, Pub. L. No. 107-347, 116 Stat. 2899, 2946 (Dec. 17, 2002). As used in this report, FISMA refers to the requirements in the 2014 law. Many of the requirements of the 2002 law were unchanged by or incorporated into the 2014 law and continue in full force and effect. See also NIST, *Standards for Security Categorization of Federal Information and Information Systems*, FIPS Publication 199 (Gaithersburg, Md.: February 2004); *Minimum Security Requirements for Federal Information and Information Systems*, FIPS Publication 200 (Gaithersburg, Md.: March 2006); *Guide for Applying the Risk Management Framework to Federal Information Systems: A Security Life Cycle Approach*, SP 800-37, Revision 1 (Gaithersburg, Md.: February 2010); and *Security and Privacy Controls for Federal Information Systems and Organizations*, SP 800-53, Revision 4 (Gaithersburg, Md.: April 2013).

[2]Sources include the National Institute of Standards and Technology and the Software Engineering Institute's Capability Maturity Model Integration.

October 2012 and February 2014 contingency plans. We evaluated the status of NOAA's gap mitigation activities. We interviewed officials from the JPSS program, as well as NOAA's Office of Atmospheric Research, National Weather Service, and NOAA Satellite, Data, and Information Service staff for further information on satellite availability details and gap mitigation activities. We assessed the reliability of NOAA's assessment of satellite availability by comparing it to underlying analyses, prior assessments, and shortfalls we identified on prior assessments. We found the data to be sufficiently reliable for our purpose of reporting on strengths and weaknesses of the agency's assessment.

In order to assess NOAA's efforts to plan and implement the JPSS Polar Follow-On (PFO) program, we analyzed program documentation to determine the scope, expected cost, timelines, and key risks affecting the program. We compared this information against other NOAA and JPSS program documentation and identified key information that has yet to be completed for the PFO program. We also met with JPSS program staff for further insights on their plans for the PFO program.

We conducted our work at NOAA and its component offices—including the offices of the JPSS program—and the facilities of a program contractor. We conducted this performance audit from May 2015 to May 2016 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Key Publications Supporting the National Institute of Standards and Technology's Information Security Risk Management Framework

The National Institute of Standards and Technology (NIST) developed a risk management framework of standards and guidelines for agencies to follow in developing information security programs. Relevant publications include the following:

- Federal Information Processing Standard 199, *Standards for Security Categorization of Federal Information and Information Systems*, requires agencies to categorize their information systems as low-impact, moderate-impact, or high-impact for the security objectives of confidentiality, integrity, and availability. [1] The potential impact values assigned to the respective security objectives are the highest values from among the security categories that the agency identifies for each type of information resident on those information systems.
- Federal Information Processing Standard 200, *Minimum Security Requirements for Federal Information and Information Systems*, specifies minimum security requirements for federal agency information and information systems and a risk-based process for selecting the security controls necessary to satisfy these minimum security requirements.[2]
- NIST Special Publication 800-37, Revision 1, *Guide for Applying the Risk Management Framework to Federal Information Systems: A Security Life Cycle Approach*, explains how to apply a risk management framework to federal information systems, including security categorization, security control selection and implementation, security control assessment, information system authorization, and security control monitoring.[3]
- NIST Special Publication 800-53, Revision 4, *Security and Privacy Controls for Federal Information Systems and Organizations*, provides a catalog of security and privacy controls for federal information systems and organizations and a process for selecting controls to

[1]NIST, *Standards for Security Categorization of Federal Information and Information Systems*, FIPS Publication 199 (Gaithersburg, Md.: February 2004).

[2]NIST, *Minimum Security Requirements for Federal Information and Information Systems*, FIPS Publication 200 (Gaithersburg, Md.: March 2006).

[3]NIST, *Guide for Applying the Risk Management Framework to Federal Information Systems: A Security Life Cycle Approach*, SP 800-37, Revision 1 (Gaithersburg, Md.: February 2010).

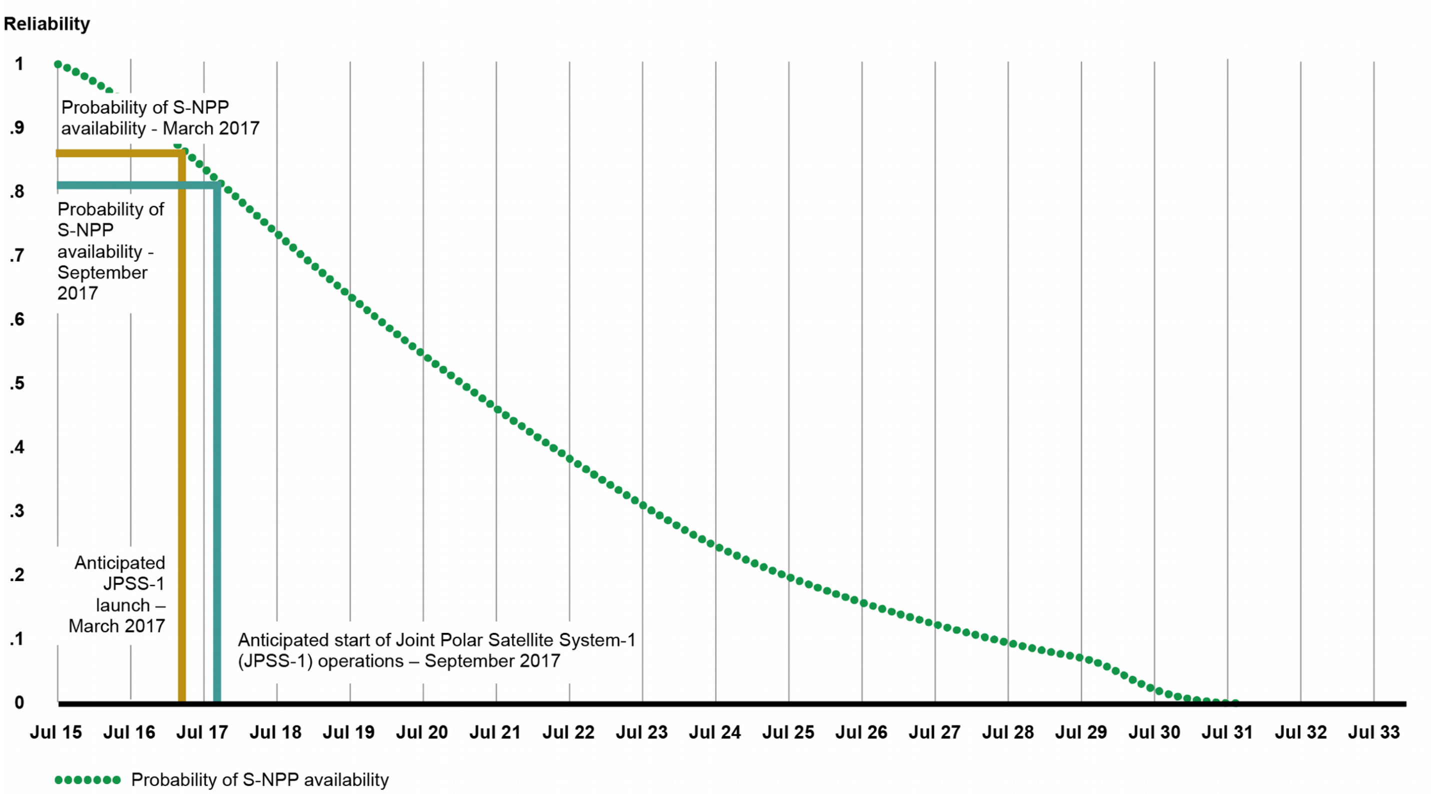
protect organizational operations, assets, individuals, other organizations, and the nation from a diverse set of threats including hostile cyber-attacks, natural disasters, structural failures, and human errors. The guidance includes privacy controls to be used in conjunction with the specified security controls to achieve comprehensive security and privacy protection.[4]

[4]NIST, *Security and Privacy Controls for Federal Information Systems and Organizations*, SP 800-53, Revision 4 (Gaithersburg, Md.: April 2013).

Appendix III: NOAA's Assessment of the Near-Term Health of the Polar Satellite Constellation

In November 2015, the National Oceanic and Atmospheric Administration (NOAA) updated its assessment of the availability the existing Suomi National Polar-orbiting Partnership (S-NPP) satellite over time. The agency determined that there is an 80 percent likelihood that S-NPP will be able to provide key measurements until data from the next Joint Polar Satellite System satellite (called JPSS-1) are available, if JPSS-1 is launched in March 2017 and available to begin operation in September 2017 (see figure 9).

Figure 9: Suomi National Polar-orbiting Partnership (S-NPP) Availability over Time



Source: GAO, based on JPSS program office data. | GAO-16-359

Appendix IV: Comments from the Department of Commerce

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

March 18, 2016

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

Dear Mr. Powner:

Thank you for the opportunity to review and comment on the Government Accountability Office's (GAO) draft report titled *Polar Weather Satellites: NOAA Is Working to Ensure Continuity, but Needs to Quickly Address Information Security Weaknesses and Future Program Uncertainties* (GAO-16-359). Enclosed are the National Oceanic and Atmospheric Administration's programmatic comments to the draft report.

If you have any questions, please contact me or Steve Haro, Assistant Secretary for Legislative and Intergovernmental Affairs, at (202) 482-3663.

Sincerely,

Bruce H. Andrews

Enclosure

National Oceanic and Atmospheric Administration
Comments on the Draft Government Accountability Office Report Entitled
Polar Weather Satellites: NOAA Is Working to Ensure Continuity, but Needs to Quickly Address Information Security Weaknesses and Future Program Uncertainties
(GAO-16-359)

General Comments

The Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) appreciates the opportunity to review and comment on the Government Accountability Office (GAO) draft report on Polar Weather Satellites. NOAA has reviewed the report and agrees with all four GAO recommendations. The response to each recommendation is provided below. We recognize the need to close polar data gaps and to keep pace with changes in information security requirements. However, resource constraints and shifting priorities have presented challenges in meeting these objectives. We are responding to these challenges by working to establish repeatable processes and resilient information architecture that together enable mission achievement.

NOAA recommends factual and technical changes to the report which are provided below our response to the recommendations, to ensure that the information presented is complete, accurate, and up-to-date.

NOAA Response to GAO Recommendations

The draft GAO report states: "Given the importance of addressing risks on the JPSS satellite program, we are making the following four recommendations to the Secretary of Commerce. Specifically, we recommend that the Secretary direct the Administrator of NOAA to take the following actions:"

Recommendation 1: "Establish a plan to address the limitations in the program's efforts to test security controls, including ensuring that any changes in the system's inventory do not materially affect test results."

NOAA Response: Concur. JPSS is already working to improve the 2016 testing of security controls including reviewing physical location of components, inventory management, communication, and information availability. The JPSS program, along with its prime contractor has already met with the Assistant CIO for Satellites to develop a common understanding of how results are captured and documented. NOAA will document its approach in the Action Plan. The system will endeavor to provide complete and accurate documentation to the independent test team to be used as the basis for independent testing to avoid any test scope limitations.

Recommendation 2: "When establishing plans of action and milestones (POA&M) to address critical and high-risk vulnerabilities, schedule the completion dates within 30 days, as required by agency policy."

NOAA Response: Concur. JPSS will continue to follow agency policy to address critical and high-risk vulnerabilities and establish POA&M, or document risk acceptance where it is not able to meet the Agency guidelines.

The guidance and policy for vulnerability scanning and patch management is captured primarily in two documents: i) the NIST Special Publication (SP) 800-53 - Security and Privacy Controls for Federal Information Systems; and ii) the Commerce Information Technology Requirement (CITR-16). The overall goal for JPSS is to maintain the availability of the information system and, secondly, the integrity confidentiality of the information. The NIST SP 800-53, within RA-5, requires JPSS to scan for vulnerabilities and remediate legitimate vulnerabilities in accordance with CITR-16. CITR-16 also recognizes that Authorizing Officials (AOs) shall manage, accept, and document risks introduced when remediation of vulnerabilities identified cannot be performed as anticipated.

JPSS considers two situations in its plans: 1) the application of patches to a system in the middle of development and verification and 2) the application of patches to a complex operational system with the requisite analysis and testing prior to deployment in order to protect the overall availability of the system. The first challenge is limited to the time period when a portion of the system is in development and must remain static to allow proper deployment and verification testing. Under that scenario, patches may not be applied within the established guidelines and POA&Ms or risk acceptance will be documented.

NOAA documents its approach to addressing the second situation in an Action Plan which will include drafting JPSS' vulnerability and patching approach in the FIPS 200 for AO approval. Deviations to the FIPS 200 will be captured in a POA&M. In both cases compensating controls will be in place to protect the information system.

Recommendation 3: "Ensure that the agency and program are tracking and closing a consistent set of incident response activities."

NOAA Response: Concur. The recommendation has been implemented under NOAA policy. NOAA maintains the central tracking system for incident reports and NOAA manages the Computer Incident Response Team that handles incidents as reported by the systems. In addition, NOAA is working to implement a new incident tracking system to improve the consistency and timeliness of incident tracking within NOAA.

Recommendation 4: "Evaluate the costs and benefits of different launch scenarios for the PFO program based on updated satellite life expectancies to ensure satellite continuity while minimizing program costs."

NOAA Response: Concur. JPSS has already analyzed the costs/benefits of different launch scenarios for the PFO program in preparation for the FY 2016 President's Budget Request. JPSS will continue to update this analysis based on updated satellite life expectancies, obsolescence risk, development costs, and information gained from award of the spacecraft and instrument contracts. The approach will be outlined in an Action Plan.

Appendix V: 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, Colleen Phillips (Assistant Director), Shaun Byrnes (Analyst-in-Charge), Chris Businsky, Kara Lovett Epperson, Torrey Hardee, Franklin Jackson, and Lee McCracken made key contributions to this report.

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