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ENVIRONMENTAL SATELLITES

Improvements Needed in NOAA's Mitigation Strategies as It Prepares for Potential Satellite Coverage Gaps

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GAO-15-386T

GAO Highlights

Highlights of GAO-15-386T, a testimony before the Subcommittees on Environment and Oversight, House Committee on Science, Space, and Technology

Why GAO Did This Study

NOAA is procuring the next generation of polar and geostationary weather satellites to replace aging satellites that are approaching the end of their useful lives. Both new sets of satellites will provide critical weather forecasting data over the next two decades. GAO has reported that gaps in polar satellite coverage and in backup coverage for geostationary satellites are likely in the near future. Given the criticality of satellite data to weather forecasts, concerns that problems and delays on the new satellite acquisition programs will result in gaps in the continuity of critical satellite data, and the impact of such gaps on the health and safety of the U.S. population, GAO added mitigating weather satellite gaps to its High-Risk List in 2013 and it remains on the 2015 update to the High-Risk List.

GAO was asked to testify on two recently released reports on NOAA's satellite programs, specifically on (1) the JPSS program's status, the potential for a gap and mitigation alternatives, and contingency plans, and (2) the GOES-R program's status, potential for a gap, and contingency plans.

What GAO Recommends

In its recently issued reports, GAO recommended that NOAA update its polar data gap assessment, address shortfalls in both its polar and geostationary contingency plans, and prioritize mitigation projects most likely to address a gap in polar satellite coverage. NOAA concurred with GAO's recommendations and identified steps it is taking to implement them.

View GAO-15-386T. For more information, contact Dave Powner at (202) 512-9286 or pownerd@gao.gov.

February 2015

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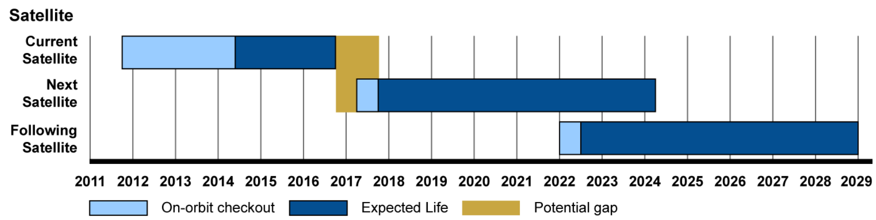
What GAO Found

The National Oceanic and Atmospheric Administration's (NOAA) $11.3 billion Joint Polar Satellite System (JPSS) program has recently completed significant development activities and remains within its cost and schedule baselines; however, recent cost growth on key components is likely unsustainable, and schedule delays could increase the potential for a near-term satellite data gap. In addition, while the program has reduced its estimate for a near-term gap in the afternoon orbit, its gap assessment was based on incomplete data. A gap in satellite data may occur earlier and last longer than NOAA anticipates. The figure below depicts a possible 11-month gap, in which the current satellite lasts its full expected 5-year life (until October 2016) and the next satellite is launched in March 2017 and undergoes on-orbit testing until September 2017.

Timeline for a Potential Gap in Polar Satellite Data in the Afternoon Orbit



Source: GAO analysis based on NOAA and NASA data. | GAO-15-386T

Multiple alternatives to prevent or reduce the impact of a gap exist. Key options for reducing the impact of a near-term gap include extending legacy satellites, obtaining additional observations such as data from aircraft, advancing data assimilation and a global forecast model, and increasing high performance computing capacity. While NOAA has improved its contingency plan by identifying mitigation strategies and specific activities, the agency's plan has shortfalls such as not assessing the cost and impact of available alternatives. In addition, NOAA has not yet prioritized mitigation projects most likely to address a gap, and key mitigation projects have been delayed. Until the agency addresses these shortfalls, the agency will have less assurance that it is prepared to deal with a near-term gap in polar satellite coverage.

NOAA's $10.8 billion Geostationary Operational Environmental Satellite-R (GOES-R) program has also made major progress on its first satellite. However, the program has continued to experience delays in major milestones and has not efficiently closed defects on selected components, both of which could increase the risk of a launch delay. As the GOES-R program approaches its expected launch date of March 2016, it faces a potential gap of more than a year during which an on-orbit backup satellite would not be available. Specifically, there could be no backup from April 2015 (when an operational satellite is expected to reach its end-of-life) through September 2016 (after GOES-R completes its post-launch test period). Any delay to the GOES-R launch date would extend the length of time without a backup satellite and, if an operational satellite were to experience a problem during that time, there could be a gap in GOES coverage. NOAA has improved its plan to mitigate gaps in satellite coverage, but it does not yet include steps for mitigating a delayed launch.

Chairman Bridenstine, Ranking Member Bonamici, Chairman Loudermilk, Ranking Member Beyer, and Members of the Subcommittees:

Thank you for the opportunity to participate in today's hearing on two satellite program acquisitions within the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA). Both the Joint Polar Satellite System (JPSS) and the Geostationary Operational Environmental Satellite-R series (GOES-R) programs are meant to replace current operational satellite programs, and both are considered critical to the United States' ability to maintain the continuity of data required for weather forecasting.

As requested, this statement summarizes our two recent reports on (1) the JPSS program's status, key risks and risk mitigation alternatives, and contingency planning, and (2) the GOES-R program's status, testing plans and procedures, and contingency planning.[1] In preparing this testimony, we relied on the work supporting those reports. They each contain a detailed overview of our objectives, scope, and methodology, including the steps we took to assess the reliability of cost and schedule data. As noted in those reports, we found that cost and schedule data for both the JPSS and GOES-R programs were sufficiently reliable for our purposes.

All of our work for the reports was performed 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.

Background

Since the 1960s, the United States has used polar-orbiting and geostationary satellites to observe the earth and its land, ocean, atmosphere, and space environments. Polar-orbiting satellites constantly circle the earth in a nearly north-south orbit, providing global coverage of

[1]GAO, *Polar Weather Satellites: NOAA Needs to Prepare for Near-term Data Gaps*, GAO-15-47 (Washington, D.C.: Dec. 16, 2014) and *Geostationary Weather Satellites: Launch Date Nears, but Remaining Schedule Risks Need to be Addressed,* GAO-15-60 (Washington, D.C.: Dec. 16, 2014).

conditions that affect the weather and climate. As the earth rotates beneath it, each polar-orbiting satellite views the entire earth's surface twice a day. In contrast, geostationary satellites maintain a fixed position relative to the earth from a high orbit of about 22,300 miles in space.

Both types of satellites provide a valuable perspective of the environment and allow observations in areas that may be otherwise unreachable. Used in combination with ground, sea, and airborne observing systems, satellites have become an indispensable part of monitoring and forecasting weather and climate. For example, polar-orbiting satellites provide the data that go into numerical weather prediction models, which are a primary tool for forecasting weather days in advance—including forecasting the path and intensity of hurricanes. Geostationary satellites provide the graphical images used to identify current weather patterns and provide short-term warning. These 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.

Federal agencies are currently planning and executing major satellite acquisition programs to replace existing polar and geostationary satellite systems that are nearing the end of their expected life spans. However, these programs have troubled legacies of cost increases, missed milestones, technical problems, and management challenges that have resulted in reduced functionality and major delays to planned launch dates over time. We and others—including an independent review team reporting to the Department of Commerce and its Inspector General—have raised concerns that problems and delays with environmental satellite acquisition programs will result in gaps in the continuity of critical satellite data used in weather forecasts and warnings.

According to officials at NOAA, a polar satellite data gap would result in less accurate and timely weather forecasts and warnings of extreme events, such as hurricanes, storm surges, and floods. Such degradation in forecasts and warnings would place lives, property, and our nation's critical infrastructures in danger. The importance of having such data available was highlighted in 2012 by the advance warnings of the path, timing, and intensity of Superstorm Sandy. Given the criticality of satellite data to weather forecasts, concerns that problems and delays on the new satellite acquisition programs will result in gaps in the continuity of critical satellite data, and the impact of such gaps on the health and safety of the U.S. population, we concluded that the potential gap in weather satellite data is a high-risk area. We added this area to our High-Risk List in 2013 and it remains on the 2015 update to the High-Risk List that was issued yesterday.[2]

Overview of the JPSS Program

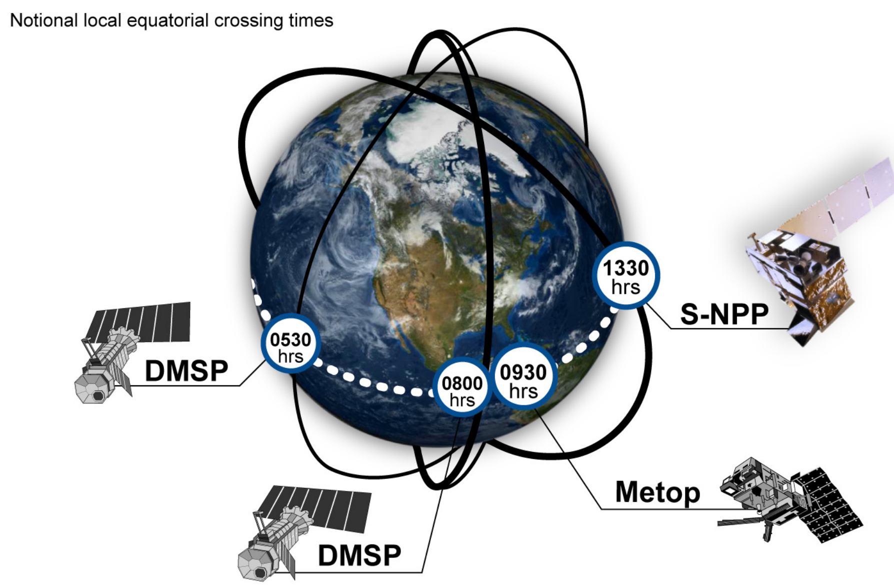
For over 40 years, the United States has operated two separate operational polar-orbiting meteorological satellite systems: the Polar-orbiting Operational Environmental Satellite series, which is managed by NOAA, and the Defense Meteorological Satellite Program (DMSP), which is managed by the Air Force.[3] Currently, there is one operational Polar-orbiting Operational Environmental Satellite (called the Suomi National Polar-orbiting Partnership, or S-NPP) and two operational DMSP satellites that are positioned so that they cross the equator in the early morning, midmorning, and early afternoon. In addition, the government relies on data from a European satellite, called the Meteorological Operational satellite, or Metop.[4] Figure 1 illustrates the current operational polar satellite constellation.

[2]Every two years at the start of a new Congress, GAO calls attention to agencies and program areas that are high risk due to their vulnerabilities to fraud, waste, abuse, and mismanagement, or are most in need of transformation. See GAO, *High Risk Series: An Update*, GAO-13-283 (Washington, D.C.: Feb. 14, 2013) and GAO, *High Risk Series: An Update*, GAO-15-290 (Washington, D.C.: Feb. 11, 2015).

[3]NOAA provides command and control for both the Polar-orbiting Operational Environmental Satellite and Defense Meteorological Satellite Program satellites after they are in orbit.

[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 2017.

Figure 1: Configuration of Operational Polar Satellites



Sources: GAO, based on NPOESS Integrated Program Office, NOAA, and DOD data; NASA/Goddard Space Flight Center Scientific Visualization Studio (earth); S-NPP image provided courtesy of University of Wisconsin-Madison Space Science and Engineering Center. | GAO-15-386T

Note: DMSP—Defense Meteorological Satellite Program; Metop—Meteorological Operational (satellite); S-NPP—Suomi National Polar-orbiting Partnership; NPOESS—National Polar-orbiting Operational Environmental Satellite System; NOAA—National Oceanic and Atmospheric Administration; DOD—Department of Defense; and NASA—National Aeronautics and Space Administration.

A May 1994 Presidential Decision Directive[5] required NOAA and the Department of Defense (DOD) to converge the two satellite programs into a single satellite program—the National Polar-orbiting Operational Environment Satellite System (NPOESS)—capable of satisfying both civilian and military requirements. However, in the years after the program was initiated, NPOESS encountered significant technical challenges in sensor development, program cost growth, and schedule delays.

Faced with costs that were expected to reach about $15 billion and launch schedules that were delayed by over 5 years, in February 2010, the Director of the Office of Science and Technology Policy in the

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

Executive Office of the President announced that NOAA and DOD would no longer jointly procure NPOESS; instead, each agency would plan and acquire its own satellite system. Specifically, NOAA would be responsible for the afternoon orbit, and DOD would be responsible for the early morning orbit.

When this decision was announced, NOAA and the National Aeronautics and Space Administration (NASA) immediately began planning for a new satellite program in the afternoon orbit—called JPSS. After the February 2010 decision to disband NPOESS, NOAA established a program office to guide the development and launch of the S-NPP satellite[6] as well as the two planned JPSS satellites, known as JPSS-1 and JPSS-2. NOAA currently estimates that the life cycle costs for the JPSS program will be $11.3 billion through fiscal year 2025. The current anticipated launch dates for JPSS-1 and JPSS-2 are March 2017 and December 2022, respectively.

Over the last several years, we have issued a series of reports on the NPOESS program—and the transition to JPSS—that highlight the technical issues, cost growth, key management challenges, and key risks of transitioning from NPOESS to JPSS.[7] In these reports, we made multiple recommendations to, among other things, improve executive-level oversight, establish mitigation plans for risks associated with pending polar satellite data gaps, and establish a comprehensive

[6]S-NPP was originally planned as a demonstration satellite, but due to schedule delays that had the potential to lead to satellite data gaps, NOAA made the decision to use it as an operational satellite. This means that the satellite's data is used for climate and weather products.

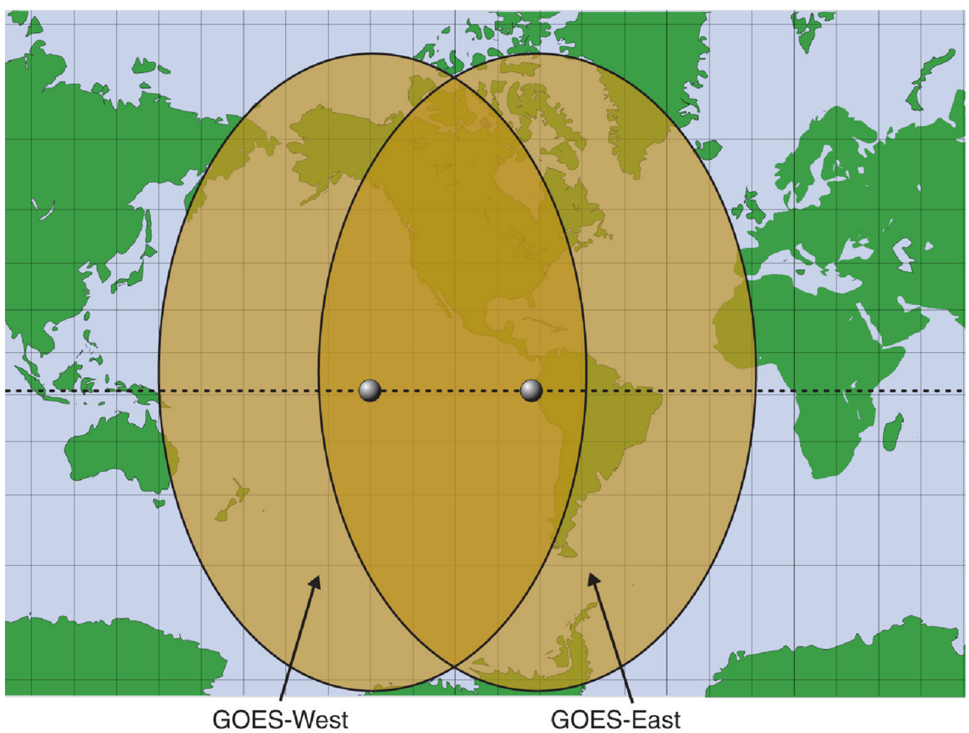
[7]See, for example, GAO, *Environmental Satellites: Focused Attention Needed to Improve Mitigation Strategies for Satellite Coverage Gaps,* GAO-13-865T, (Washington, D.C.: Sept. 19, 2013); *Polar Weather Satellites: NOAA Identified Ways to Mitigate Data Gaps, but Contingency Plans and Schedules Require Further Attention*, GAO-13-676 (Washington, D.C.: Sept. 11, 2013); *Environmental Satellites: Focused Attention Needed to Mitigate Program Risks*, GAO-12-841T (Washington, D.C.: June 27, 2012); *Polar-orbiting Environmental Satellites: Changing Requirements, Technical Issues, and Looming Data Gaps Require Focused Attention*, GAO-12-604 (Washington, D.C.: June 15, 2012); *Polar Satellites: Agencies Need to Address Potential Gaps in Weather and Climate Data Coverage*, GAO-11-945T (Washington, D.C.: Sept. 23, 2011); *Polar-orbiting Environmental Satellites: Agencies Must Act Quickly to Address Risks That Jeopardize the Continuity of Weather and Climate Data*, GAO-10-558 (Washington, D.C.: May 27, 2010); *Polar-orbiting Environmental Satellites: With Costs Increasing and Data Continuity at Risk, Improvements Needed in Tri-Agency Decision Making*, GAO-09-564 (Washington, D.C.: June 17, 2009).

contingency plan consistent with best practices. NOAA has taken steps to address our recommendations, including taking action to establish a contingency plan to mitigate potential gaps in polar satellite data.

Overview of the GOES-R Program

In addition to the polar-orbiting satellites, NOAA operates GOES as a two-satellite geostationary satellite system that is primarily focused on the United States (see figure 2). The GOES-R series is the next generation of satellites that NOAA is planning; the satellites are planned to replace existing weather satellites, the first of which is due to reach the end of its useful life in 2015. The ability of the satellites to provide broad, continuously updated coverage of atmospheric conditions over land and oceans is important to NOAA's weather forecasting operations.

Figure 2: Approximate Geographic Coverage of the Geostationary Operational Environmental Satellites



Source: NOAA (data), Mapart (map). | GAO-15-386T

NOAA is responsible for GOES-R program funding and overall mission success, and has implemented an integrated program management structure with NASA for the GOES-R program. Within the program office, there are two project offices that manage key components of the GOES-R system. NOAA has delegated responsibility to NASA to manage the Flight Project Office, including awarding and managing the spacecraft contract and delivering flight-ready instruments to the spacecraft. The Ground Project Office, managed by NOAA, oversees the Core Ground System contract and satellite data product development and distribution.

The program estimates that the development for all four satellites in the GOES-R series will cost $10.9 billion through 2036. In 2013, NOAA announced that it would delay the launch of the GOES-R and S satellites from October 2015 and February 2017 to March 2016 and May 2017, respectively. These are the current anticipated launch dates of the first two GOES-R satellites; the last satellite in the series is planned for launch in 2024.

In September 2010, we recommended that NOAA develop and document continuity plans for the operation of geostationary satellites that include the implementation procedures, resources, staff roles, and time tables needed to transition to a single satellite, a foreign satellite, or other solution.[8] In September 2011, the GOES-R program provided a draft plan documenting a strategy for conducting operations if there were only a single operational satellite.

In September 2013, we reported that the GOES-R program established contingency plans for the loss of its satellites and ground systems that were generally in accordance with best practices, but that the plans were missing key elements, such as working with the user community to address potential reductions in capability under contingency scenarios and identifying alternative solutions for preventing a delay in the GOES-R launch date.[9] We recommended that the program revise its contingency plans to address these weaknesses, including providing more information

[8]GAO, *Geostationary Operational Environmental Satellites: Improvements Needed in Continuity Planning and Involvement of Key Users*, GAO-10-799 (Washington, D.C.: Sept. 1, 2010).

[9]GAO, *Geostationary Weather Satellites: Progress Made, but Weaknesses in Scheduling, Contingency Planning, and Communicating with Users Need to Be Addressed*, GAO-13-597, (Washington, D.C.: Sept. 9, 2013).

on the potential impact of a satellite failure and identifying timelines for implementing mitigation solutions. We subsequently assessed NOAA's progress in implementing this recommendation in our December 2014 report and will discuss our results at today's hearing.[10]

The JPSS Program Has Completed Significant Development Activities and Is Meeting Cost and Schedule Baselines, but Faces a Potential Near-term Data Gap That Mitigation Options are Unlikely to Fully Address

The JPSS program has recently completed significant development activities. For example, the program completed a major development milestone—the critical design review for the JPSS-1 mission—in April 2014. This is a significant accomplishment because the review affirms that the satellite design is appropriately mature to continue with development. Furthermore, NOAA is currently developing JPSS within its cost and schedule baselines.

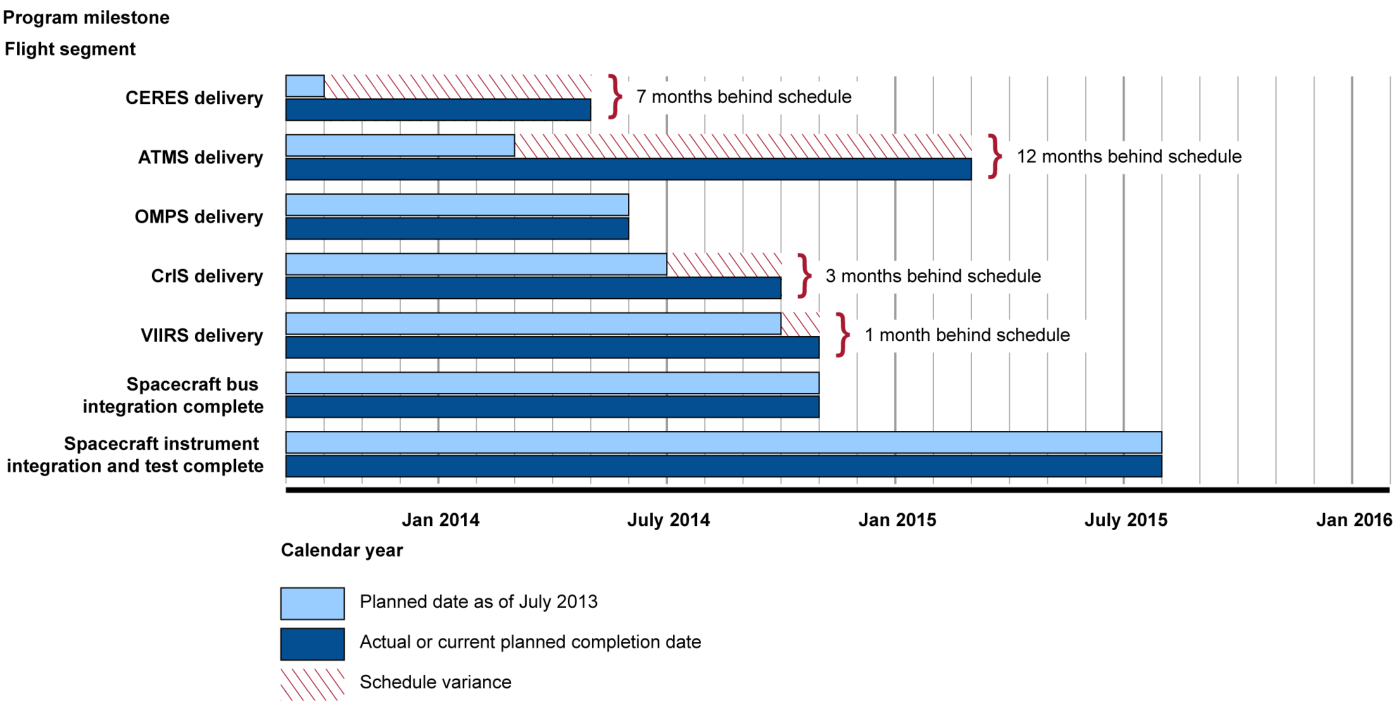
However, while JPSS development is still within its overall life cycle cost baseline, key components have experienced cost growth. Between July 2013 and July 2014, the total program cost estimate increased by $222 million (or 2 percent). More than half of this increase was for three instruments. Program officials cited multiple reasons for these cost increases, including technical issues, additional testing, and the purchase of new parts. If JPSS costs were to continue to grow at this rate, the program could end up costing $2 billion more than expected by 2025. Therefore, moving forward, it will be important for NOAA and NASA managers to aggressively monitor and control components that are threatening to exceed their expected costs.

Also, while the launch date of the JPSS-1 satellite has not yet been affected, key components, such as the satellite's major instruments, have encountered delays in development and testing. Figure 3 compares key planned completion dates for the JPSS-1 spacecraft and its instruments from July 2013 to their actual or planned completion dates as of July 2014.[11]

[10] GAO-15-60

[11] Since the time of our analysis, some of the milestones in figure 3 were delayed further. Specifically, ATMS delivery moved from March 2015 to June 2015, CrIS delivery moved from October 2014 to February 2015, VIIRS delivery moved from November 2014 to February 2015, and the completion of spacecraft instrument integration and test moved from August 2015 to October 2015.

Figure 3: Changes in Joint Polar Satellite System (JPSS) Spacecraft and Instrument Milestones since July 2013, as of July 2014



Source: GAO analysis of NOAA data. | GAO-15-386T

Notes: (1) In January 2015, NOAA acknowledged that delivery of the ATMS instrument would likely slip an additional 3 months to June 2015, delivery of the CrIS instrument would slip 4 months to February 2015, delivery of the VIIRS instrument would slip 3 months to February 2015, and the completion of the spacecraft instrument integration and test would slip 2 months to October 2015.

(2) CERES—Cloud and Earth's Radiant Energy System; ATMS—Advanced Technology Microwave Sounder; OMPS—Ozone Mapping and Profiler Suite; CrIS—Cross-Track Infrared Sounder; VIIRS—Visible Infrared Imaging Radiometer Suite.

JPSS program officials provided multiple reasons for the schedule changes, including technical issues the Advanced Technology Microwave Sounder (ATMS) instrument experienced during testing, a schedule adjustment to align with NOAA's geostationary satellite acquisition, and the October 2013 government shutdown. These delays have caused a reduction in schedule margin prior to the JPSS-1 satellite integration and testing phase.

Further, because of the technical issues experienced on ATMS, the instrument has now become the critical path[12] for the entire JPSS-1 mission and only 1 month of schedule reserve remains until its expected delivery in March 2015.[13] It will be important for NOAA and NASA managers to quickly resolve the instrument's technical issues before it becomes a more serious threat to the mission schedule and launch date.

NOAA Anticipates a Polar Satellite Data Gap, but Its Estimate May Prove Too Optimistic

In October 2013, the JPSS program office reported that a gap between the S-NPP satellite and the JPSS-1 satellite in the afternoon orbit could be as short as 3 months, which is 15 months less than NOAA estimated in 2012. However, we believe that this estimate is likely too optimistic. There are several reasons why this potential gap could occur sooner and last longer than NOAA currently anticipates.

- **Inconsistent launch date plans:** The program's analysis that JPSS-1 will be operational by June 2017 is inconsistent with NOAA's launch date commitment of March 2017, given that the program office estimates 6 months for on-orbit checkout and calibration/validation before the satellite data are operational.

- **Unproven predictions about the on-orbit checkout and validation phase:** The on-orbit checkout and calibration/validation phase could take longer than the program's estimated 6 months if there are issues with the instruments or ground systems. Also, additional algorithm work may be needed after the satellite launches, which could extend the validation time frame.

- **Exclusion of a key risk:** The JPSS program's gap assessment does not factor in the potential for satellite failures from space debris that are too small to be tracked and avoided. Thus, the S-NPP mission

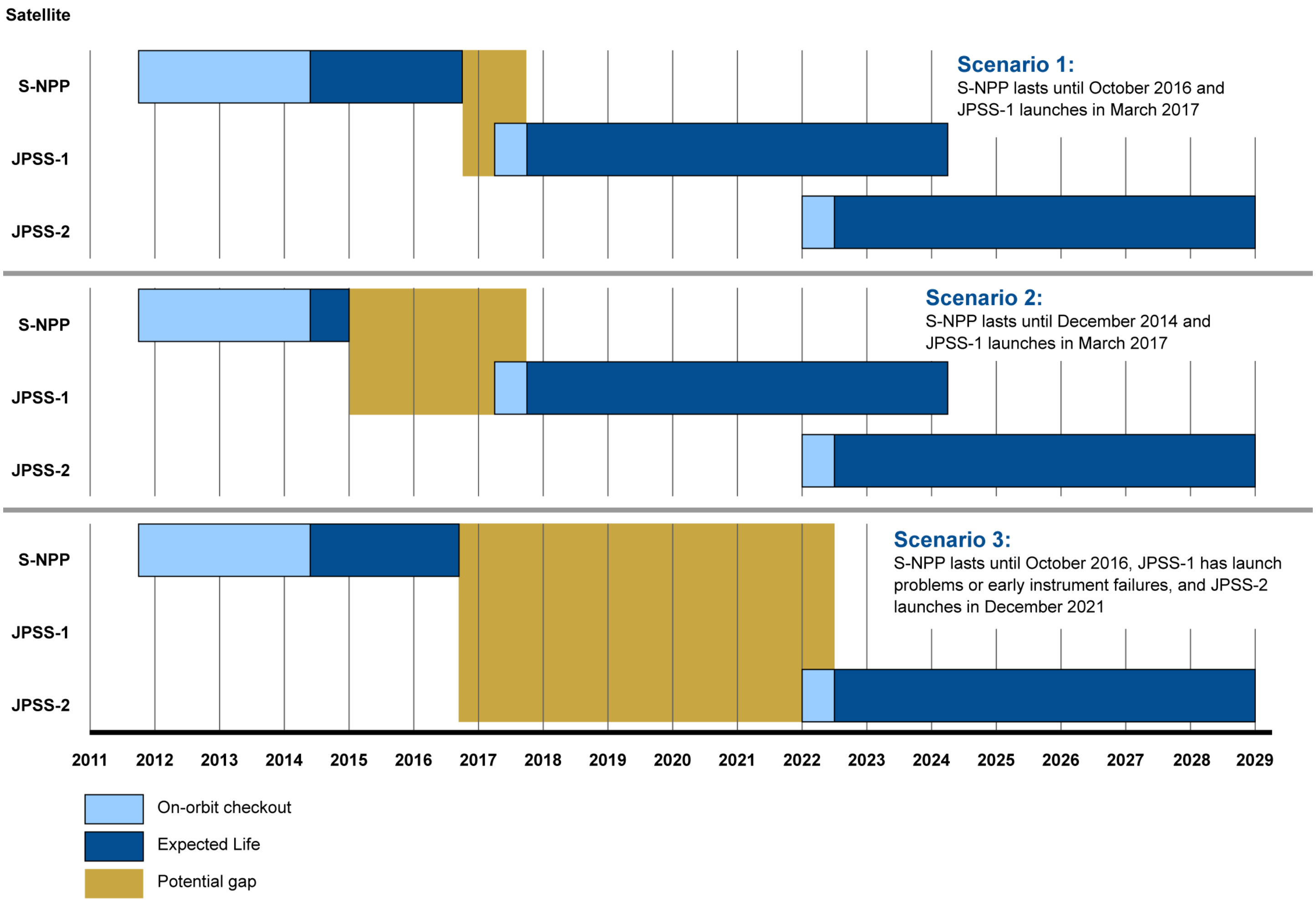
[12]The critical path is generally defined as the longest continuous sequence of activities in a schedule. As such, it defines the program's earliest completion date or minimum duration. If an activity on the critical path is delayed by a week, the program finish date will be delayed by a week unless the slip is successfully mitigated. Therefore, the critical path is most useful as a tool to help determine which activities deserve focus and, potentially, management assistance.

[13]In January 2015, after our report was issued, NOAA reported that the delivery of ATMS was moved to June 2015 and that there is no longer schedule reserve prior to that delivery.

could end earlier than its 5-year design life, resulting in a gap period that occurs sooner and lasts longer than expected.

As a result, a gap in polar satellite data may occur earlier and last longer than NOAA anticipates. In one scenario, S-NPP would last its full expected 5-year life (to October 2016), and JPSS-1 would launch as soon as possible (in March 2017) and undergo on-orbit testing for 6 months as predicted by the JPSS program office (until September 2017). In that case, the data gap would extend 11 months. Any problems encountered with JPSS-1 development resulting in launch delays, launch problems, or delays in the planned 6-month on-orbit test period could extend the gap period to as much as 5 years and 8 months. Figure 4 depicts possible gap scenarios.

Figure 4: Potential Scenarios for a Gap in Polar Satellite Data in the Afternoon Orbit



Source: GAO analysis based on NOAA and NASA data. | GAO-15-386T

Note: S-NPP—Suomi National Polar-orbiting Partnership, JPSS-1—Joint Polar Satellite System-1, and JPSS-2—Joint Polar Satellite System-2.

NOAA officials acknowledge that the gap assessment has several limitations and stated that they plan to update it. Until NOAA updates its gap assessment to include more accurate assumptions and key risks, the agency risks making decisions based on a limited understanding of the potential timing and length of a gap.

Multiple Alternatives Exist for Mitigating a Satellite Data Gap

Experts within and outside of NOAA identified almost 40 alternatives for mitigating potential gaps in polar satellite data, which offer a variety of benefits and challenges. The alternatives can be separated into two general categories. The first category includes actions to prevent or limit a potential gap by providing JPSS-like capabilities. The second category includes actions that could reduce the impact of a potential gap by (a) extending and expanding the use of current data sources with capabilities similar to the JPSS program; (b) enhancing modeling and data assimilation; (c) developing new data sources; or (d) exploring opportunities with foreign and domestic partners.

While all of the alternatives have trade-offs, several alternatives may represent the best known options for reducing the impact of a gap:

- Extending legacy satellites, continuing to obtain data from European midmorning satellites, and ensuring legacy and European satellites' data quality remains acceptable;
- Obtaining additional observations of radio occultation[14] and commercial aircraft data;
- Advancing 4-dimensional data assimilation and the next generation global forecast model to make more efficient use of data still available and produce improved techniques for evaluating data;
- Increasing high-performance computing capacity, a key factor for enabling greater resolution in existing and future models, which drives the pace of development for assimilation of data that could further improve NOAA's models.

[14]Radio occultation refers to a sounding technique in which a radio wave from an emitting spacecraft passes through an intervening planetary atmosphere before arriving at the receiver. Radio occultation techniques are used in observing atmospheric temperature profiles.

NOAA Improved its Polar Satellite Contingency Plan, but Delays Limit the Effectiveness of Key Mitigation Activities, and Mitigation Activities Have Not Been Prioritized

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.[15] NOAA developed its original polar satellite gap contingency plan in October 2012. We reported in September 2013 that NOAA had not yet selected the strategies from its plan to be implemented, or developed procedures and actions to implement the selected strategies and made a recommendation to address these shortfalls.[16]

In February 2014, NOAA updated its polar satellite gap contingency plan. NOAA made several improvements in this update, such as including additional alternatives that experts identified, and accounting for additional gap scenarios. However, additional work remains for NOAA's contingency plan to fully address government and industry best practices for contingency planning. Until NOAA fully addresses key elements to improve its contingency plan, it may not be sufficiently prepared to mitigate potential gaps in polar satellite coverage.

NOAA has also experienced challenges in implementing key activities outlined in the plan. Among a list of available alternatives, NOAA identified 21 mitigation projects that are to be implemented in order to address the potential for satellite data gaps in the afternoon polar orbit. NOAA has demonstrated progress by implementing initial activities on these gap mitigation projects.

However, NOAA has experienced delays in executing other key activities. For example:

- A planned upgrade to the National Weather Service's operational high-performance computing capacity was to occur by December 2014. According to NOAA officials, an interim upgrade is planned to occur in February 2015, with the full upgrade expected to be completed by July 2016.

[15]See GAO, *Year 2000 Computing Crisis: Business Continuity and Contingency Planning*, GAO/AIMD-10.1.19 (Washington, D.C.: August 1998); National Institute of Standards and Technology, *Contingency Planning Guide for Federal Information Systems*, NIST 800-34 (May 2010); Software Engineering Institute, *CMMI® for Acquisition, Version 1.3* (Pittsburgh, Pa.: November 2010).

[16]GAO-13-676.

- NOAA does not plan to complete observing system experiments that are to supplement its numerical weather prediction models in the absence of afternoon polar-orbiting satellite data until 4 months later than planned.

- Multiple projects have been affected by a major shortfall in the availability of high-performance computing for research and development efforts during fiscal year 2014.

Because a potential near-term data gap could occur sooner and last longer than expected, NOAA's ongoing gap mitigation efforts are becoming even more critical. According to Office of Management and Budget guidance, projects that require extensive development work before they can be put into operation are inherently risky and should be prioritized by comparing their costs and outcomes to other projects within a portfolio.[17]

However, the agency has not prioritized or accelerated activities most likely to address a gap because it has been focused on implementing many different initiatives to see which ones will have the most impact. NOAA officials stated that further prioritization among mitigation activities was not warranted because the activities were fully funded and were not dependent on the completion of other activities. We disagree. There are dependencies among projects that would benefit from prioritization. While it makes sense to investigate multiple mitigation options, unless NOAA assesses the activities that have the most promise and accelerates those activities, it may not be sufficiently prepared to mitigate near-term data gaps.

[17]Office of Management and Budget, *Capital Programming Guide: Supplement to Circular A-11, Part 7, Preparation, Submission, and Execution of the Budget* (Washington, D.C.: July 2014).

The GOES-R Program Has Made Development Progress, but Faces Schedule Risks and a Potential Coverage Gap, and Challenges Remain in Mitigation Planning

After spending 10 years and just over $5 billion, the GOES-R program has completed important steps in developing its first satellite, and has entered the integration and test phase of development for the satellite. While the GOES-R program is making progress, it has experienced recent and continuing schedule delays.

As we have previously reported, problems experienced during the integration and test phase often lead to cost and schedule growth.[18] In 2013, we reported that technical issues on both the flight and ground projects had the potential to cause further delays to the program schedule. By the time of our latest report, in December 2014, these and all other major milestones have been further delayed by 5 to 8 months. The GOES-R program cited multiple reasons for these recent delays, including challenges in completing software deliverables and completing communication testing for the spacecraft. In addition to these intermediate delays, NOAA moved the launch commitment date of the first GOES-R satellite to March 2016.

Further, the program's actions to mitigate schedule delays introduce some risks, and could therefore increase the amount of the delay. For example, the program attempted to mitigate delays by performing system development while concurrently working on detailed planning. In addition, the program has responded to prior delays by eliminating selected repetitive tests and moving to a 24-hour-a-day, 7-day-a-week spacecraft integration testing schedule. We have previously reported that overlapping planning and development activities and compressing test schedules are activities that increase the risk of further delays because there would be little time to resolve any issues that arise.[19]

A key element of a successful test phase is appropriately identifying and handling any defects or anomalies that are discovered during testing. While the GOES-R program has sound defect management policies in place and is actively performing defect management activities, there are

[18] See, for example, GAO, *NASA: Assessments of Selected Large-Scale Projects,* GAO-11-239SP (Washington, D.C.: March 2011) and *NASA: Assessments of Selected Large-Scale Projects*, GAO-12-207SP (Washington, D.C.: March 2012).

[19] GAO, *Office of Personnel Management: Improvements Needed to Ensure Successful Retirement System Modernization*, GAO-08-345 (Washington, D.C.: Jan. 31, 2008) and *2000 Census: New Data Capture System Progress and Risks,* GAO/AIMD-00-61 (Washington, D.C.: Feb. 4, 2000).

several areas in which defect management policies and practices are inconsistent. Among the shortfalls are a number of cross-cutting themes, including in performing and recording information pertinent to individual defects, and in reporting and tracking defect information.

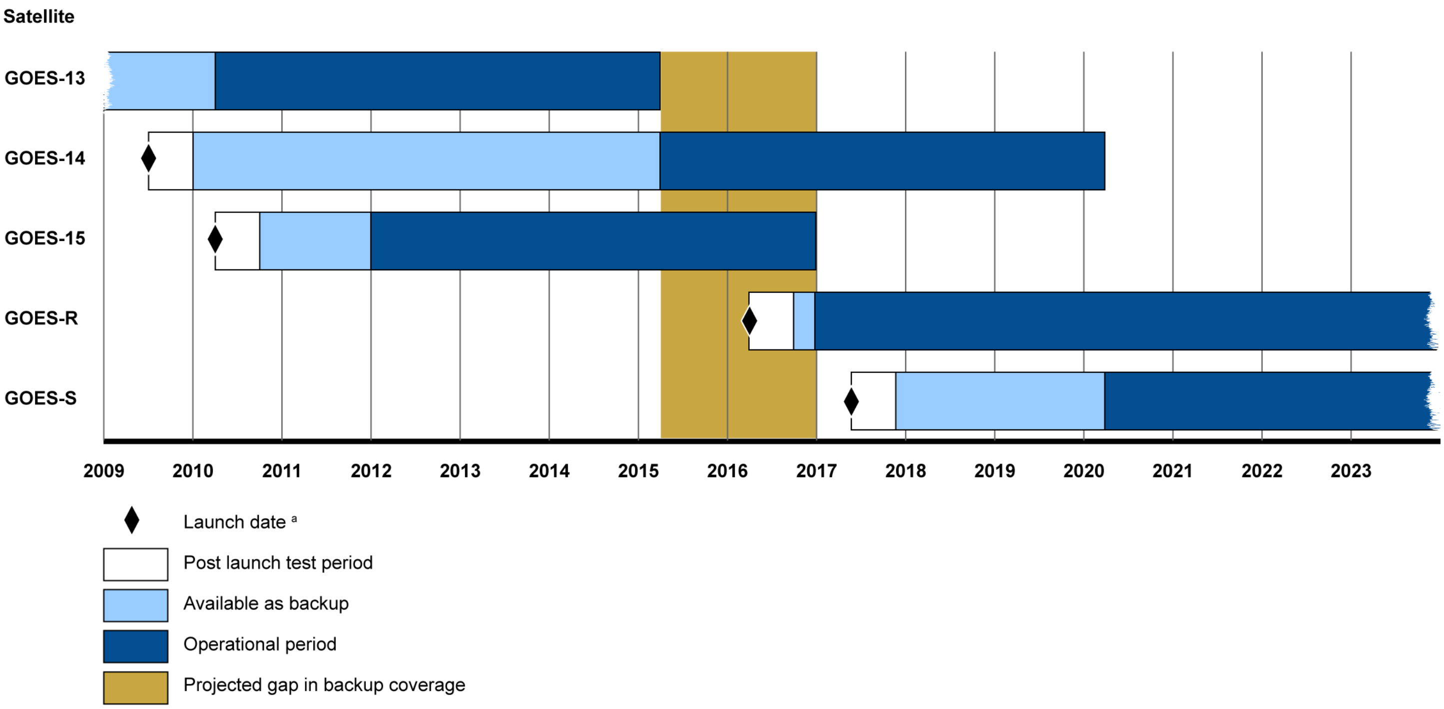
The GOES-R program has also not efficiently closed defects on selected components. Specifically, data for the GOES ground system shows that 500 defects remained open as of September 2014. Defect data for the spacecraft show that it is also taking an increasing amount of time to close hardware-related defects. Until the program addresses shortfalls in defect management and reduces the number of open defects, it may not have a complete picture of remaining issues and faces an increased risk of further delays to the GOES-R launch date.

The program is now reaching a point where additional delays in starting end-to-end testing could begin to adversely affect its schedule. As of August 2014, program officials could not rule out the possibility of further delays in the committed launch date.

GOES-R Faces a Gap in Backup Satellite Coverage

GOES satellite data are considered a mission-essential function because of their criticality to weather observations and forecasts. Because of the importance of GOES satellite data, NOAA's policy is to have two operational satellites and one backup satellite in orbit at all times. However, NOAA is facing a period of up to 17 months when it will not have a backup satellite in orbit. Specifically, in April 2015, NOAA expects to retire one of its operational satellites (GOES-13) and to move its backup satellite (GOES-14) into operation. Thus, the agency will have only two operational satellites in orbit—and no backup satellite—until GOES-R is launched and completes an estimated 6-month post-launch test period. Figure 5 shows the potential gap in backup coverage, based on the launch and decommission dates of GOES satellites.

Figure 5: Potential Gap in Geostationary Operational Environmental Satellite Coverage, as of April 2014



Source: GAO analysis of NOAA data. | GAO-15-386T

During the time when no back-up satellite would be available, there is a greater risk that NOAA would need to either rely on older satellites that are beyond their expected operational lives and may not be fully functional, rely on a foreign satellite, or operate with only a single operational satellite. Due in part to the risks mentioned above, NOAA is also facing an increased risk of further delays to the March 2016 GOES-R launch date. Any delay to the GOES-R launch date would extend the time without a backup to more than 17 months.

The GOES-R Satellite Contingency Plan Shows Improvement, but Continues to Lack Details in Key Areas

Government and industry best practices call for the development of contingency plans to maintain an organization's essential functions—such as GOES satellite data—in the case of an adverse event.[20] In September 2013, we reported on weaknesses in the contingency plans for NOAA's geostationary satellites.[21] NOAA has improved its plan to mitigate gaps in satellite coverage. In February 2014, NOAA released a new satellite contingency plan in response to these recommendations. This plan improved upon many, but not all, of the best practices. Specifically, the plan improved in six areas and stayed the same in four areas.

GOES-R program officials stated that it is not feasible to include strategies to prevent delays in launch of the first GOES-R satellite in the contingency plan, because such strategies are not static. While actively managing the program to avoid a delay is critical, it is also important that NOAA management and the GOES-R program consider and document feasible alternatives for avoiding or limiting such a launch delay. Until NOAA addresses the remaining shortfalls in its GOES-R gap mitigation plan, the agency cannot be assured that it is exploring all alternatives or that it is able to effectively prepare to receive GOES information in the event of a failure.

Implementation of Recommendations Should Help Mitigate Program Risks

Both the JPSS and GOES-R programs continue to carry risks of future launch delays and potential gaps in satellite coverage; implementing the recommendations in our December 2014 reports should help mitigate those risks. In the JPSS report released in December, we recommended, among other things, 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 on JPSS and other polar satellites expected lifetimes;

[20]See GAO, *Year 2000 Computing Crisis: Business Continuity and Contingency Planning*, GAO/AIMD-10.1.19 (Washington, D.C.: August 1998); National Institute of Standards and Technology, *Contingency Planning Guide for Federal Information Systems,* NIST 800-34 (Gaithersburg, Md.: May 2010); Software Engineering Institute, *CMMI® for Acquisition, Version 1.3* (Pittsburgh, Pa.: November 2010).

[21]GAO-13-597.

- revise its existing contingency plan to address shortfalls noted in the 2014 report, such as identifying DOD's and Japan's plans to continue weather satellite observations, including recovery time objectives for key products, completing the contingency plan with selected strategies, and establishing a schedule with meaningful timelines and linkages among mitigation activities; and

- investigate ways to prioritize mitigation projects with the greatest potential benefit to weather forecasting in the event of a gap in JPSS satellite data.

In the GOES report released in December, we recommended that NOAA, among other things,

- add information to the GOES satellite contingency plan on steps planned or underway to mitigate potential launch delays.

For both reports, NOAA agreed with our recommendations and identified steps it plans to take to implement them. Specifically, with regard to the JPSS report, NOAA stated that it will make the necessary changes to its gap mitigation report and establish a process to prioritize mitigation projects. With regard to the GOES report, NOAA stated that it would add information to the GOES satellite contingency plan on steps planned or underway to mitigate potential launch delays.

In summary, NOAA has made progress on both the JPSS and GOES-R programs, but key challenges remain before the new satellites are launched and operational, and it is important that the agency take action to ensure that potential near-term gaps in satellite data are minimized or mitigated.

On the JPSS program, NOAA has recently completed significant development activities and is working to launch its next polar-orbiting environmental satellite as soon as possible. However, the program continues to face increasing costs and schedule delays on key components. Further, the program's estimate of a 3-month potential gap in satellite data may be overly optimistic because it was based on inconsistent and unproven assumptions and did not account for key risks. NOAA has made improvements to its polar satellite gap contingency plan, but has experienced delays in executing key mitigation activities, and has not prioritized or accelerated activities most likely to address a gap.

On the GOES-R program, progress in moving through integration and testing has been accompanied by challenges in maintaining its schedule on major milestones and controlling costs for key components. Further schedule delays could affect the committed launch date of the first GOES satellite. NOAA could experience a gap in satellite data coverage if GOES-R is delayed further and one of the two remaining operational satellites experiences a problem. NOAA has made improvements to its geostationary satellite contingency plan, but the plan still does not sufficiently address mitigation options for a launch delay.

Faced with an anticipated gap in the polar satellite program and a potential gap in backup coverage on the geostationary satellite program, NOAA has taken steps to study alternatives, establish mitigation plans, and improve its satellite contingency plans. However, these plans do not yet sufficiently address options to mitigate such gaps. Until NOAA prioritizes mitigation activities with the greatest potential to reduce the impact of gaps in weather forecasting, it may not be sufficiently prepared to mitigate them.

Chairman Bridenstine, Ranking Member Bonamici, Chairman Loudermilk, Ranking Member Beyer, and Members of the Subcommittees, this completes my prepared statement. I would be pleased to respond to any questions that you may have at this time.

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