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Minding the Data Gap: NOAA's Polar-Orbiting Weather Satellites and Strategies for Data Continuity

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Summary

Concerns have been raised in Congress about the possibility of a "data gap" in the polar-orbiting weather satellite coverage. A near-term data gap could occur if the currently operating polar-orbiting weather satellite, the Suomi National Polar-orbiting Partnership (Suomi-NPP), fails before its successor, the first Joint Polar Satellite System (JPSS-1), is launched and operational sometime in 2017. The Government Accountability Office (GAO) has reported that a polar-orbiting weather satellite data gap would result in less accurate and timely weather forecasts and warnings of extreme weather events, which could endanger lives, property, and critical infrastructure.

The likelihood and duration of a data gap are subject to considerable uncertainty. In testimony provided to the Subcommittees on Environment and Oversight of the House Committee on Science, Space, and Technology on December 10, 2015, the National Oceanic and Atmospheric Administration (NOAA) indicated a high probability (greater than 80%) that the expected lifetime of Suomi-NPP will extend beyond the JPSS-1 launch and commissioning. If Suomi-NPP continues to function until JPSS-1 is fully operational, then no data gap would occur. At the same hearing, the witness for GAO stated that several factors could cause a gap to occur sooner and last longer—potentially up to several years.

NOAA released a new strategy called Polar Follow On (PFO) that would fund the third and fourth JPSS satellites and other contingency options to mitigate the consequences of a data gap. The PFO is NOAA's strategy to transition the current JPSS polar-orbiting weather satellite program from its current "fragile" state to a "robust" state. An independent review team (IRT) for NOAA defined a robust program as one in which two failures must occur before a gap is created and in which an option must be available to quickly return to a two-failure condition if a failure occurs. Conversely, the IRT defines a fragile program as one spacecraft away from catastrophe. NOAA argues that the PFO plan would achieve a resilient and fault-tolerant position by 2023 (implying robustness) and would secure that position through 2038.

NOAA requested $380 million as initial funding for PFO in FY2016. House appropriators did not provide any funding for PFO in H.R. 2578, the House FY2016 appropriations bill for Commerce, Justice, Science, and Related Agencies, and Senate appropriators provided $135 million for PFO in their bill. The Consolidated Appropriations Act, 2016 (P.L. 114-113), however, provides $370 million for PFO in FY2016.

The decision to fund the PFO at $370 million in FY2016 appears to reflect congressional support of the PFO strategy for NOAA's polar-orbiting weather satellite program. However, Congress likely will continue close scrutiny of the program and oversight of cost and scheduling changes, given the program's delays and cost growth since the mid-1990s. In addition to efficient and effective management, the PFO program's success may also hinge on Congress appropriating continued funding to meet program needs without disrupting the cadence of the procurement, construction, launch, and on-orbit checkout schedule. Congressional oversight of the many factors determining robustness versus fragility likely will be a priority for many years. Without robustness, the threat of a polar-orbiting weather satellite data gap would remain.

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The National Oceanic and Atmospheric Administration (NOAA), an agency of the U.S. Department of Commerce, manages the U.S. civilian weather satellite system, which consists of Polar-orbiting Operational Environmental Satellites (POES) and Geostationary Operational Environmental Satellites (GOES). For several years, some have expressed concern about the possibility of a "data gap," which could occur if the newest POES satellite, launched in 2011, fails before its successor is launched and operational sometime in 2017.[1] The Government Accountability Office (GAO) has reported that a polar-orbiting weather satellite data gap would result in less accurate and timely weather forecasts and warnings of extreme weather events, which could endanger lives, property, and critical infrastructure.[2]

POES satellites make 14 orbits per day as the Earth rotates 520 miles below, affording a different view with each orbit. A POES satellite provides two complete views of global weather per day. In contrast, GOES satellites are "parked" 22,300 miles above the equator and orbit at speeds equivalent to the Earth's rotation, so they maintain their positions and continually provide the same geographic view. NOAA operates two GOES satellites—GOES East and GOES West—that fully cover Alaska, Hawaii, the continental United States, and the Atlantic and Pacific Oceans. Combined, the POES and GOES provide much of the data used for weather forecasting and for identifying severe weather, including tropical storms, hurricanes, and snow storms.

This report focuses on NOAA's POES system, now called the Joint Polar Satellite System (JPSS) program. Specifically, it focuses on the circumstances that have led to the potential for a data gap over the next several years and the Administration's strategies to mitigate a data gap and preserve data continuity.

In its FY2016 budget justification, NOAA released a new strategy called Polar Follow On (PFO) that would fund two JPSS satellites that would launch in FY2026 and FY2031, as well as other contingency options to mitigate the consequences of a data gap (in the JPSS program, one satellite is currently in orbit and two satellites are under construction and scheduled to launch in FY2017 and FY2022).[3] NOAA requested $380 million as initial funding for PFO in FY2016. House appropriators did not provide any funding for PFO in the House FY2016 appropriations bill for Commerce, Justice, Science, and Related Agencies (H.R. 2578), and Senate appropriators provided $135 million for FY2016 in their bill. The Consolidated Appropriations Act, 2016 (P.L. 114-113), however, provided $370 million for PFO in FY2016. This report discusses issues surrounding the NOAA PFO strategy and next-generation polar-orbiting weather satellites in light of congressional concern over the future of the program.

Background

In the 1990s, the Clinton Administration merged the military and the civilian polar-orbiting weather satellite systems into a single program: the National Polar-orbiting Operational Environmental Satellite System (NPOESS).[4] NPOESS encountered difficulties related to program

[1] A. Thomas Young et al., *NOAA NESDIS Independent Review Team Report*, National Oceanic and Atmospheric Administration (NOAA), July 20, 2012, at http://science.house.gov/sites/republicans.science.house.gov/files/documents/NESDIS_IRT_Final_Report.pdf.

[2] See, for example, U.S. Government Accountability Office (GAO), *Environmental Satellites: Launch Delayed; NOAA Faces Key Decisions on Timing of Future Satellites*, GAO-16-143T, December 10, 2015, p. 3, at http://www.gao.gov/assets/680/674090.pdf.

[3] See NOAA, Joint Polar Satellite System, "JPSS Launch Schedule," at http://www.jpss.noaa.gov/launch_schedule.html.

[4] The decision to merge the programs was a Clinton Administration action under Presidential Decision Directive (continued...)

management,[5] technical challenges, cost growth, and schedule delays. It was ultimately discontinued in 2010.[6]

Following the demise of NPOESS, NOAA and the National Aeronautics and Space Administration (NASA) reorganized their next-generation polar-orbiting weather satellite activities to create the JPSS program separate from the military weather satellite program. NOAA considers Suomi-NPP, launched in October 2011, to be the first next-generation polar-orbiting weather satellite in the JPSS series. Suomi-NPP was originally intended to be part of the NPOESS program and was initially called the NPOESS Preparatory Project satellite. It was designed to be a demonstration satellite to evaluate new instruments, spacecraft, and ground data networks that later were to be part of the NPOESS operational satellites. With the delay and ultimate cancellation of NPOESS, Suomi-NPP took on a different mission and is currently used as an operational satellite, providing weather and climate information as part of the JPSS program.

The life-cycle costs for the two JPSS satellites currently under construction, JPSS-1 and JPSS-2, together with Suomi-NPP, will total approximately $11.3 billion.[7]

The Data Gap

The Suomi-NPP satellite operates in the afternoon orbit,[8] providing full global coverage twice a day. These data increase the timeliness and accuracy of weather forecasts three to seven days in advance of a severe weather event. Other satellites currently in polar orbit, such as EUMETSAT's Metop weather satellites, also provide critical weather information.[9] The current polar-orbiting constellation includes Defense Meteorological Satellite Program (DMSP) satellites that collect

(...continued)

NSTC-2, May 5, 1994. For an explanation of executive orders, of which presidential decision directives are one form, see CRS Report RS20846, *Executive Orders: Issuance, Modification, and Revocation*, by (name redacted) and (name redacted)

[5] The National Polar-orbiting Operational Environmental Satellite System (NPOESS) was a tri-agency program, merging the Department of Defense's (DOD's) Defense Meteorological Satellite Program with the civilian Polar-orbiting Environmental Satellite System that was managed by the National Aeronautics and Space Administration (NASA) and NOAA. Broadly, under the current structure NOAA manages the weather satellite programs and NASA is responsible for building the spacecraft and instruments, supported by industry contractors.

[6] GAO commented on reasons for delays and cost growth within NPOESS in a series of reports. See, for example, GAO reports GAO-02-684T, GAO-03-987T, GAO-06-573T, GAO-07-498, GAO-08-518, GAO-09-564, GAO-10-558, and others.

[7] Email from Sierra Jones, Congressional Affairs Specialist, NOAA Office of Legislative and Intergovernmental Affairs, December 3, 2015.

[8] Meaning that the satellite crosses the equator on the sun-lit side of the Earth at about the same time in the afternoon (local time) during each orbit.

[9] EUMETSAT stands for the European Organisation for the Exploitation of Meteorological Satellites. The EUMETSAT Polar System (EPS) program currently has two satellites in polar orbit, with a third scheduled to launch in 2017. According to EUMETSAT, the organization has entered into an agreement with NOAA to provide instruments for each other's satellites, exchange all data in real time, and assist each other with backup services. See EUMETSAT, "Metop," at http://www.eumetsat.int/website/home/Satellites/CurrentSatellites/Metop/index.html. According to NOAA testimony at a December 10, 2015, hearing, NOAA and EUMETSAT plan to establish a new agreement in December 2015; see U.S. Congress, House Committee on Science, Space, and Technology, Subcommittee on Environment, and Subcommittee on Oversight, Written Statement by Stephen M. Volz, Assistant Administrator, National Environmental Satellite, Data, and Information Service, NOAA, *An Overview of the Nation's Weather Satellite Programs and Policies*, 114th Cong., 1st sess., December 10, 2015.

weather data primarily for use by the Department of Defense.[10] DMSP satellites also provide early- and mid-morning data to NOAA.[11]

Because of NOAA's agreement to share data with EUMETSAT, whose Metop satellites operate in the morning orbit, the data gap risk refers to the afternoon orbit satellite responsibilities. Specifically, the risk of a data gap exists because of the possibility that one or more instruments aboard Suomi-NPP could fail prior to the planned March 2017 launch of JPSS-1 and its six-month period of on-orbit testing or that the JPSS-1 launch could be delayed.[12] The design life for Suomi-NPP is five years (until October 2016), so the data gap could be 11 months if Suomi-NPP fails at the end of its expected life and JPSS-1 launches on time and is operational within 6 months of launch (September 2017). The gap could be longer if Suomi-NPP fails earlier than expected or if JPSS-1 is delayed. It could be shorter if Suomi-NPP operates longer than expected and JPSS-1 launches on schedule.

Figure 1 shows the "flyout" schedule for the JPSS satellites and partner polar-orbiting satellites discussed above. In the figure, the data gap of immediate concern is represented by the white space to the right of the Suomi-NPP bar and to the left of the JPSS-1 bar near the bottom of the illustration. The two bars do not overlap unless the Suomi-NPP mission is extended, as depicted by the dotted arrow extending to the right of the Suomi-NPP bar.

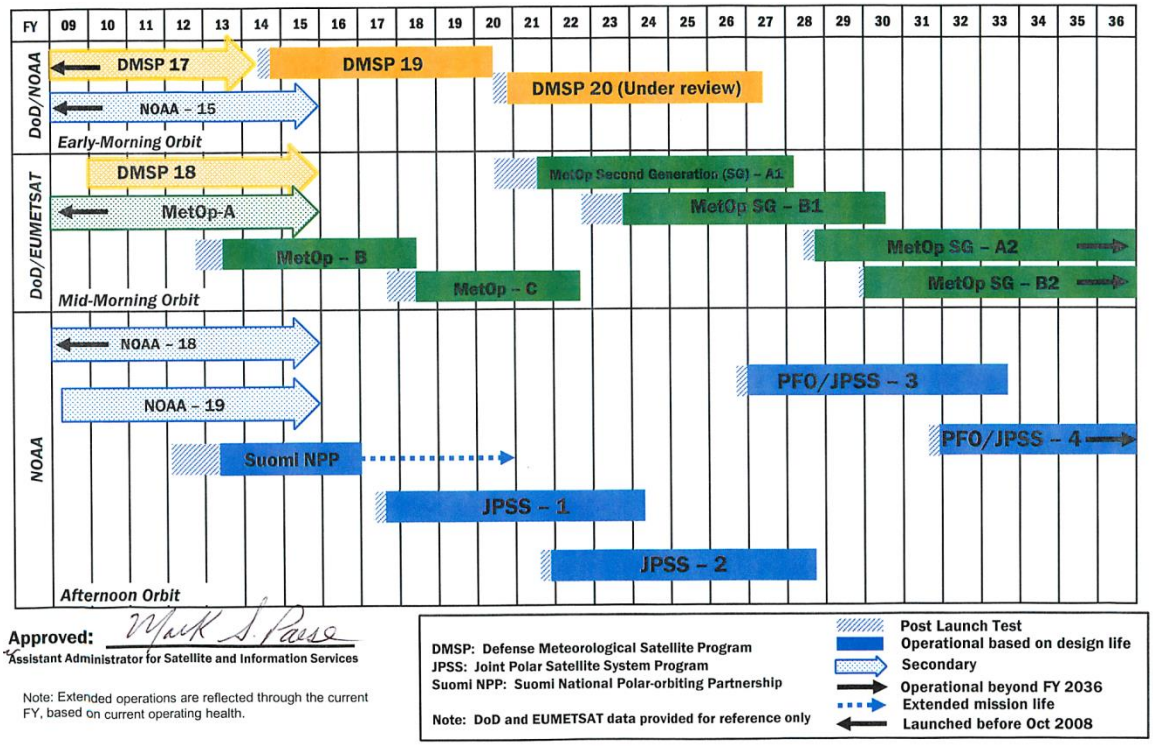
[10] Defense Meteorological Satellite Program Fact Sheet, April 24, 2015, at http://www.losangeles.af.mil/library/factsheets/factsheet.asp?id=5321.

[11] NOAA, NASA, and DOD "legacy" satellites provide additional observations for the afternoon and morning orbits, along with the EUMETSAT satellites. These legacy satellites likely will all be decommissioned by FY2022, when JPSS-2 is scheduled for launch, according to NOAA. Email from Sierra Jones, Congressional Affairs Specialist, NOAA Office of Legislative and Intergovernmental Affairs, December 3, 2015.

[12] GAO, *Environmental Satellites: Improvements Needed in NOAA's Mitigation Strategies as It Prepares for Potential Satellite Coverage Gaps*, Testimony before the Subcommittees on Environment and Oversight, House Committee on Science, Space, and Technology, GAO-15-386T, February 12, 2015.

Figure 1. Current and Planned Polar-Orbiting Weather Satellite Missions

(as of April 23, 2015)



Source: National Oceanic and Atmospheric Administration (NOAA) Joint Polar Satellite System, *POES Flyout Chart as of 04/23/15*, at http://www.nesdis.noaa.gov/flyout_schedules.html.

Notes: DMSP 17, 18, 19, 20 are Defense Meteorological Satellite Program polar-orbiting weather satellites; NOAA 15, 18, 19 are NOAA legacy polar-orbiting weather satellites; Metop refers to EUMETSAT polar-orbiting weather satellites; Suomi-NPP, JPSS-1, and JPSS-2 are Joint Polar Satellite System next-generation polar-orbiting weather satellites; PFO is the Polar Follow On program.

The likelihood and duration of a data gap are subject to considerable uncertainty. In written testimony delivered to the Subcommittees on Environment and Oversight of the House Committee on Science, Space, and Technology on December 10, 2015, the NOAA witness stated that "NOAA's annual lifetime analysis report indicates a high probability (greater than 80 percent) that the expected lifetime of Suomi-NPP will extend beyond JPSS-1 launch and commissioning."[13] If Suomi-NPP operated through JPSS-1 launch and commissioning, then no data gap would occur, assuming JPSS-1 was fully operational. At the same hearing, the witness for GAO provided a different scenario:

> As of December 2014, NOAA officials stated that a 3-month gap was likely based on an analysis of the availability and robustness of the polar constellation. However, we reported that several factors could cause a gap to occur sooner and last longer—potentially up to several years. For example, if [Suomi-NPP] were to fail today—exactly 4 years after its launch—the agency would face a gap of about 23 months before the JPSS-1 satellite could be launched and put into operation. Concerns about a near-term gap will remain until the JPSS-1 satellite is launched and operational. Further, if JPSS-1

[13] U.S. Congress, House Committee on Science, Space, and Technology, Written Statement by Stephen M. Volz, Assistant Administrator, National Environmental Satellite, Data, and Information Service, NOAA, *An Overview of the Nation's Weather Satellite Programs and Policies*, December 10, 2015.

> fails on launch, there could be a gap until JPSS-2 is launched and operational in mid-2022.[14]

Those two viewpoints indicate that at the end of 2015, the data gap could range from zero (i.e., best-case scenario and no data gap) to as many as seven years (i.e., Suomi-NPP fails immediately and JPSS-1 fails on launch). For every day that Suomi-NPP continues to function well, the outlook improves; however, the possibility of a multiyear gap draws attention to NOAA's strategy for mitigating such a gap and its long-range planning for polar-orbiting weather satellites over the next several decades.

Robustness and Fragility: The NOAA NESDIS Independent Review Team Report

A 2013 report issued by a NOAA-chartered independent review team (IRT) stated that the current JPSS program is "fragile."[15] The report also noted that the future polar program is demonstrably not "robust."[16] These terms have specific meanings in the report: "the IRT believes that the definition of a robust program is that two failures must occur before a gap is created and an option must be available to return to a 'two failure' condition if a failure occurs."[17] Conversely, a fragile program is "one spacecraft away from catastrophe."[18] The report elaborates somewhat on these terms and their meaning; for example, the currently fragile JPSS program is also described as a "single string system" in which any number of potential failures could result in a gap with a potential duration of months to years. In contrast, a robust program "requires multiple overlapping spacecraft developed in a manner that allows downstream components and subsystems to be used as spares for the spacecraft being prepared for launch."[19] The IRT report concludes that the ultimate objective of its recommendations should be to establish a robust polar weather program consistent with other programs of critical national importance.

In one of its findings, the IRT report noted that the decision to focus the JPSS program on its high-priority weather mission, and to remove instruments that would measure characteristics of the Earth's climate rather than its weather, is helpful in minimizing the potential for a data gap.[20] More specifically, the report stated that the JPSS program should focus uniquely on four high-priority weather instruments,[21] noting that "this conviction is based upon the belief that nothing should compromise the uninterrupted acquisition of critical JPSS weather data."[22] This focus would apply to future polar-orbiting satellites (i.e., JPSS-2, JPSS-3, and JPSS-4), and the report

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[14] U.S. Government Accountability Office, *Environmental Satellites: Launch Delayed; NOAA Faces Key Decisions on Timing of Future Satellites*, GAO-16-143T, December 10, 2015, pp. 16-17, at http://www.gao.gov/assets/680/674090.pdf.

[15] A. Thomas Young et al., *NOAA NESDIS Independent Review Team Report*: *Assessment Update One Year Later*, November 8, 2013, p. 20, at http://www.nesdis.noaa.gov/pdf/NESDIS%20Update%20IRT%20Final%20Report.pdf.

[16] Ibid., p. 14.

[17] Ibid., p. 16.

[18] Ibid., p. 20.

[19] Ibid.

[20] Ibid., p. 31.

[21] The four instruments are (1) the Advanced Technology Microwave Sounder (ATMS); (2) the Cross-Track Infrared Sounder (CrIS); (3) the Visible Infrared Imaging Radiometer Suite (VIIRS); and the Ozone-Mapping and Profiler Suite-Nadir (OMPS-N). They are discussed further below.

[22] Ibid.

emphasized that inclusion of any non-weather instruments in the JPSS program would create a schedule risk and should not be pursued. A possible consequence of the focus on weather instruments would be the loss of scientific data applicable to climate studies or other scientific pursuits, although it is unclear how that would affect NOAA's overall mission.

The IRT observed that the recommendation from its 2012 report[23] to accelerate the schedules for JPSS-1 and JPSS-2 would not be a solution to the possible data gap between Suomi-NPP's end-of-life date and final on-orbit checkout of JPSS-1.[24] Instead, the 2013 report recommended a "gap-filler" program. Further, the report recommended that the gap-filler "free-flyer" satellite carry only the ATMS and CrIS instruments. If carried out, "a gap filler would be available to launch before [Suomi-NPP] reaches the end of its mission life and would cover a potential gap from a JPSS-1 launch or early spacecraft failure."[25] Additionally, the IRT report observed that a gap-filler plan would move the program closer to the objective of being two failures away from loss of afternoon orbit polar weather data, fulfilling the goal of becoming a robust program.

NOAA Polar Follow On Proposal and Mitigating the Data Gap

NOAA laid out its strategy for addressing the near-term data gap and for achieving long-term continuity of polar-orbiting weather data in its FY2016 budget request. The proposed Polar Follow On (PFO) program is a line item within the Procurement, Acquisition, and Construction account. NOAA requested $380 million for PFO in FY2016.[26] It estimated that out-year costs would total approximately $8.2 billion for PFO through 2038.[27]

The $380 million initial funding request for PFO outlined a three-part strategy for data-gap mitigation. To mitigate the possible loss or degradation of the Advanced Technology Microwave Sounder (ATMS) on JPSS-1—one of four key instruments—NOAA would initiate development of an advanced microwave sounder satellite called the Earth Observing Nanosatellite-Microwave (EON-MW). EON-MW would provide some of the capabilities of ATMS to measure atmospheric temperature and moisture, and it would be hosted on a CubeSat platform.[28] CubeSats are an existing technology, with the potential for expedited launch timelines and cost savings, among other advantages.[29] The NOAA FY2016 budget request included $10 million for EON-MW.

[23] A. Thomas Young et al., *NOAA NESDIS Independent Review Team Report*, NOAA, July 20, 2012, at http://science.house.gov/sites/republicans.science.house.gov/files/documents/NESDIS_IRT_Final_Report.pdf.

[24] A. Thomas Young et al., *NOAA NESDIS Independent Review Team Report*, 2013, p. 17.

[25] Ibid., p. 19.

[26] NOAA, *Budget Estimates, Fiscal Year 2016*, p. NESDIS-47, at http://www.corporateservices.noaa.gov/~nbo/fy16_bluebook/NOAA_FY16_CJ_508compliant_v2.pdf.

[27] Estimates only; NOAA notes that future requests would be determined through the annual budget process. Email from Sierra Jones, Congressional Affairs Specialist, NOAA Office of Legislative and Intergovernmental Affairs, December 3, 2015.

[28] CubeSats are small spacecraft built from standardized modules—units that measure 10 centimeters on a side and are often stacked in multiples of three. The Earth Observing Nanosatellite-Microwave (EON-MW) spacecraft would be a 12 unit CubeSat. Dan Leone, "NOAA Cubesat Caught in the Crossfire Between Congress, White House," *SpaceNews*, June 25, 2015, at http://spacenews.com/noaa-cubesat-caught-in-crossfire-between-congress-white-house/.

[29] Thomas Burns, NOAA/NESDIS, *NOAA Perspective on CubeSats*, Presentation to Space Studies Board, National Research Council, June 23, 2015, at http://sites.nationalacademies.org/cs/groups/ssbsite/documents/webpage/ssb_166649.pdf.

A second part of the mitigation strategy would address premature failure of JPSS-2. If JPSS-2 were to fail before its expected lifetime, the PFO strategy would be to launch JPSS-3 with only two instruments—ATMS and the Cross-Track Infrared Sounder (CrIS)—rather than the planned four instruments.[30] The two-instrument satellite proposal appears to respond to the IRT's recommendation for a two-instrument "gap-filler" mitigation strategy. Should that contingency be exercised, the two-instrument satellite would replace the full JPSS-3 mission. The other two instruments, the Visible Infrared Imaging Radiometer Suite (VIIRS) and the Ozone-Mapping and Profiler Suite-Nadir (OMPS-N), likely would fly aboard JPSS-4.

A third component of the mitigation strategy is NOAA's proposal to procure six radio occultation (RO) sensors as part of the COSMIC-2 mission, a joint mission with Taiwan.[31] Data from the RO sensors would help to mitigate the loss or degradation of data from ATMS or CrIS sounders on polar-orbiting weather satellites. In addition to mitigating a potential data gap, NOAA states that the COSMIC-2 satellite system is a cost-effective way of obtaining global atmospheric temperature profiles, which would result in more accurate long-range forecasts.[32] NOAA requested an additional $9.9 million in FY2016 to begin purchase of the second set of six sensors to be launched into near-polar orbit in 2019 (the first set of six sensors have been procured and will be launched into low-inclination orbit in 2016).

Polar Follow On as a Robustness Strategy

The NOAA FY2016 budget justification provides a similar definition to the IRT's for what constitutes a robust polar-orbiting weather satellite program:

> a "robust" architecture has two characteristics: (1) two failures must occur to create a gap in data from ATMS and CrIS and (2) the ability exists to restore a two-failure condition within one year of an on-orbit failure.[33]

The budget request cites the IRT 2013 report recommendation to achieve JPSS robustness as rapidly as possible and to manage JPSS-2, JPSS-3, and JPSS-4 as an integrated program. NOAA testified in front of the House Committee on Science, Space, and Technology on December 10, 2015, that the PFO plan would achieve a resilient and fault-tolerant position by 2023 (implying robustness) and would secure that position through 2038.[34] Further, the NOAA witness stated that the FY2016 budget request of $380 million "represents the minimum funding required to achieve robustness at the earliest possible date." The NOAA testimony also stated that the EON-MW free flyer would test cutting-edge microwave technology on a proven CubeSat platform, which

[30] NOAA refers to ATMS and CrIS as "critical sounders," see NOAA, *Budget Estimates, Fiscal Year 2016*, p. NESDIS-47, at http://www.corporateservices.noaa.gov/~nbo/fy16_bluebook/NOAA_FY16_CJ_508compliant_v2.pdf.

[31] Radio occultation makes use of radio signals transmitted by global positioning satellites to sound the global atmosphere—providing information on temperature and water vapor concentration—with precision, accuracy, and vertical resolution over both land and ocean. See University Consortium for Atmospheric Research, *GPS Radio Occultation*, at http://www.cosmic.ucar.edu/ro.html. COSMIC-2 is the acronym for the Constellation Observing System for Meteorology, Ionosphere, and Climate satellites, an international partnership with Taiwan's National Space Organization, the U.S. Air Force, and Brazil. COSMIC-2 is the follow-on to COSMIC-1, which launched in 2006 and has led to improved weather forecasting. See University Corporation for Atmospheric Research, COSMIC Program Office, at http://www.cosmic.ucar.edu/.

[32] NOAA, *Budget Estimates, Fiscal Year 2016*, p. NESDIS-66, at http://www.corporateservices.noaa.gov/~nbo/fy16_bluebook/NOAA_FY16_CJ_508compliant_v2.pdf.

[33] NOAA, *Budget Estimates, Fiscal Year 2016*, p. NESDIS-47, at http://www.corporateservices.noaa.gov/~nbo/fy16_bluebook/NOAA_FY16_CJ_508compliant_v2.pdf.

[34] U.S. Congress, House Committee on Science, Space, and Technology, Written Statement by Stephen M. Volz, Assistant Administrator, National Environmental Satellite, Data, and Information Service, NOAA, December 10, 2015.

potentially could lower costs and enable development of more robust systems in the future. In addition, NOAA testified that the launch of EON-MW in 2019 would provide near-term data-gap mitigation if JPSS-1 experienced problems prior to the launch of JPSS-2, which appears to align with the IRT 2013 report recommendation for a free-flyer satellite gap filler.

Appropriations for the Polar-Orbiting Weather Satellite Program

During congressional debate on appropriations in response to the budget request PFO proposal, Members of the House and Senate expressed concerns about the possibility of a data gap in polar-orbiting weather satellites but appeared to take different positions over the best response.

House Appropriations

House appropriators did not provide any funding for PFO in H.R. 2578, the Commerce, Justice, Science, and Related Agencies Appropriations Act, 2016. The House Appropriations Committee's report accompanying H.R. 2578 instructed NOAA to develop solutions to mitigate possible data gaps in the polar-orbiting satellites and address the fragility of the JPSS program. The report language did not mention PFO, but it stated that the bill would fully fund COSMIC-2 at $20 million for FY2016 and that it "underscores the value of COSMIC data as a potential gap filler for the fragile JPSS program."[35] Further, the committee would have required a plan for the six additional COSMIC satellites, explaining why the launch of the second set of six sensors was delayed to FY2019 and including an analysis of the potential for acquiring RO weather data from private-sector providers.

Senate Appropriations

At the hearing of the Senate Appropriations Committee's Subcommittee on Commerce, Justice, Science, and Related Agencies on February 26, 2015, both Chairman Richard Shelby and Ranking Member Barbara Mikulski expressed concern about whether NOAA would finish existing satellite programs on time and on budget, and about whether a projected gap in polar-orbiting satellite data may impact the U.S. ability to make weather forecasts.[36] In addition to concerns about the near-term data gap, Chairman Shelby also stated that the FY2016 PFO request of $380 million lacked specific detail about the overall cost of the program and that the committee would need more information about spending beyond FY2016.

In a written response to questions from Senator Marco Rubio following the hearing, Secretary of Commerce Penny Pritzker acknowledged the consequences of a data gap, asserting that appropriations at the level of the request in FY2016 were needed to operate Suomi-NPP and to develop JPSS-1 and JPSS-2.[37] Secretary Pritzker also stated that if PFO were not funded at the

[35] U.S. Congress, House Committee on Appropriations, Subcommittee on Commerce, Justice, Science, and Related Agencies, *Commerce, Justice, Science, and Related Agencies Appropriations Bill, 2016*, 114th Cong., 1st sess., May 27, 2015, H.Rept. 114-130, pp. 26-27.

[36] U.S. Congress, Senate Committee on Appropriations, Subcommittee on Commerce, Justice, Science, and Related Agencies, *CJS Subcommittee Hearing: FY16 Department of Commerce Budget*, Hearing to review the FY2016 funding request and budget justification for the U.S. Department of Commerce, 114th Cong., 1st sess., February 26, 2015.

[37] U.S. Congress, Senate Committee on Appropriations, Subcommittee on Commerce, Justice, Science, and Related Agencies, *CJS Subcommittee Hearing: FY16 Department of Commerce Budget*, Response to Written Questions (continued...)

requested level for FY2016, then the risk of a data gap following the launch of JPSS-2 would increase. According to the Secretary, full funding of the request was necessary to achieve polar-orbiting weather satellite robustness by FY2023. Despite Secretary Pritzker's warning about fully funding PFO, the Senate subcommittee provided $135 million for PFO in its bill, and directed NOAA to perform an independent cost estimate of the program within 180 days of enactment.[38]

Consolidated Appropriations Act, 2016

The Consolidated Appropriations Act, 2016, funds the PFO at $370 million, $10 million less than the Administration request.[39] The bill states explicitly that it does not include funding for EON-MW, for which the Obama Administration had requested $10 million for FY2016. By implication, the remainder of the proposal is fully funded. The published explanatory statement states that it retains report language contained in S.Rept. 114-66 and H.Rept. 114-130, discussed above, so that the Senate requirement for an independent cost estimate of PFO and the House requirement for a plan for the second series of six RO sensors in the COSMIC-2 program are maintained.

Outlook

Funding the PFO at $370 million in FY2016 appears to reflect congressional support of the PFO strategy for NOAA's polar-orbiting weather satellite program. However, Congress likely will continue close scrutiny of the program and oversight of cost and scheduling changes, given the history of NPOESS and JPSS since the mid-1990s.

In addition to efficient and effective management, the PFO program's success likely will also hinge on Congress appropriating funding to meet program needs without disrupting the cadence of the procurement, construction, launch, and on-orbit checkout schedule. The multiyear satellite development process could be challenged by the annual appropriations process, which in recent years has included one or more continuing resolutions (CRs) enacted after fiscal year-end on September 30. Often, the CRs maintain funding levels at previous fiscal year levels for months into the new fiscal year. If that were to occur, appropriators might consider adding language to the CR(s) that adjusts funding specifically to meet program needs for satellite development and prevent major delays in program development. That type of language was included for NOAA in the FY2016 CRs, for example.

By denying funding for EON-MW in the FY2016 omnibus appropriations bill, Congress effectively disagrees with the Administration's proposal to build a free-flyer EON-MW satellite to mitigate a possible data gap after the launch of JPSS-1. The House appears to favor the use of RO technology as a near-term data-gap mitigation measure. The next set of RO sensors currently are

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Submitted by the Hon. Marco Rubio to the Hon. Penny Pritzker, at http://www.commerce.senate.gov/public/_cache/files/81a1d6f5-e357-48fd-a640-2f70aede7a21/3C6BEFE3C57EA88BB7305747616B9306.pritzker-penny-3-3-15-hearing-rubio-qfr-responses.pdf.

[38] U.S. Congress, Senate Committee on Appropriations, Subcommittee on Commerce, Justice, Science, and Related Agencies, *Departments of Commerce and Justice, and Science, and Related Agencies Appropriations Bill, 2016*, 114th Cong., 1st sess., June 16, 2015, S.Rept. 114-66, p. 44.

[39] P.L. 114-113, plus the explanatory statement published in the Congressional Record, Explanatory Statement Submitted by Mr. Rogers of Kentucky, Chairman of the House Committee on Appropriations Regarding House Amendment No. 1 to the Senate Amendment on H.R. 2029, *Congressional Record*, daily edition, vol. 161, part II (December 17, 2015), p. H9736.

planned as the COSMIC-2 program; however, appropriators in the House asked NOAA to investigate sources of RO data that could be provided by the private sector. Several hearings conducted in 2015 by the House Science and Technology Committee explored the use of commercial data in the NOAA weather enterprise, and NOAA appears to be actively examining the feasibility of commercial data services.[40]

If Suomi-NPP remains fully functional for 11 months past its design life and JPSS-1 launches and passes its on-orbit checkout on the current schedule, there will be no data gap in the afternoon orbit coverage, despite the fragility of the current program. The path to a robust program, however, will take many years. If Congress continues to support and fund PFO and if NOAA implements the program as planned, then the polar-orbiting weather satellite system could achieve robustness by 2023. Given that the rubric of robustness and fragility threads through the PFO proposal and in congressional report language accompanying appropriations legislation, congressional oversight of the many factors determining robustness versus fragility likely will be a priority for many years.

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[40] See, for example, testimony by Stephen M. Volz, Assistant Administrator, National Environmental Satellite, Data, and Information Service, NOAA, at the hearing in the House Committee on Science, Space, and Technology, *An Overview of the Nation's Weather Satellite Programs and Policies*, 114th Cong., 1st sess., December 10, 2015.