U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENVIRONMENT
SUBCOMMITTEE ON OVERSIGHT

HEARING CHARTER

Bridging the Gap: America's Weather Satellites and Weather Forecasting

Thursday, February 12, 2015
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Purpose

The Subcommittees on Environment and Oversight will hold a joint hearing titled *Bridging the Gap: America's Weather Satellites and Weather Forecasting* at 10:00 a.m. on February 12th in room 2318 of the Rayburn House Office Building. Witnesses will provide an update of the operations and development of National Oceanic and Atmospheric Administration's (NOAA) polar-orbiting and geostationary weather satellite programs and discuss recent Government Accountability Office (GAO) reports on the two programs. In addition, the hearing will discuss the use of satellite data in operational and research weather models and prediction methods.

Witnesses

- **Mr. David Powner,** Director, Information Technology Management Issues, Government Accountability Office.
- **Dr. Stephen Volz,** Assistant Administrator, National Environmental Satellite, Data, and Information Services, National Oceanic and Atmospheric Administration.
- **Mr. Steven Clarke,** Director, Joint Agency Satellite Division, National Aeronautics and Space Administration.
- **Dr. Alexander MacDonald,** President, American Meteorological Society; Director, Earth System Research Laboratory, National Oceanic and Atmospheric Administration; and Chief Science Advisor, Office of Oceanic and Atmospheric Research, National Oceanic and Atmospheric Administration.
- **Mr. John Murphy,** Director, Office of Science and Technology, National Weather Service, National Oceanic and Atmospheric Administration.

Background

Recent, faulty predictions about a recent blizzard in the Northeast United States underscore the need for accurate and timely forecasting capabilities to protect lives and property. Other seasonal weather events, such as hurricanes and tornadoes, also represent a challenge for timely, accurate weather forecasts and warnings.

Over the last decade, the Committee on Science, Space, and Technology has monitored the troubled development of NOAA's weather satellite programs, which provide vital input to weather forecasts. These programs include the Joint Polar Satellite System (JPSS), its predecessor, the National Polar-orbiting Operational Environmental Satellite System (NPOESS), and the Geostationary Operational Environmental Satellite System (GOES).

NOAA's satellite systems form the fundamental base for the nation's forecasting ability, providing the majority of the data used in American weather models. A report by the National Research Council found that 80% of the data assimilated into numerical weather models comes from satellites.[1] Satellite data is able to significantly enhance forecasting accuracy. For example, in 2010, data from polar-orbiting satellites helped meteorologists predict the arrival of "Snowmageddon" five days in advance, and early forecasts of Superstorm Sandy's track were aided by polar-orbiting satellites, according to a study by the European Centre for Medium-Range Weather Forecasts.[2,3]

Due to a series of management problems, delays, and increased costs, NOAA's weather satellite programs now face a likely gap in satellite coverage and data. NOAA has recently revised its estimate of the length of a potential data gap from 15 months down to 3 months, but the GAO questioned NOAA's methodology for this estimate. Without this data, the ability of American weather models to accurately predict weather events will be greatly diminished. In its 2013 update on NOAA's satellite programs, GAO noted that, "According to NOAA program officials, a 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."[4]

Satellites provide a plethora of data that are used in many forecasting products. The satellites gather information about the earth's atmosphere, land surface, oceans, and the space environment.[5] Satellites transmit data in a raw format. Processing centers on the ground then format the data to account for calibrations such as time and earth location. Further processing separates the data into specific parameters such as temperature. This data is then used to derive

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[1] National Research Council, national Academy of Sciences, "Fair Weather Report: Effective Partnership in Weather and Cliamte Services," 2003, available at: http://www.nap.edu/catalog/10610/fair-weather-effective-partnerships-in-weather-and-climate-services

[2] NOAA, *Suomi NPP: Improving U.S. Weather Forecast Accuracy from Space*, December 3, 2012, available at: http://www.nesdis.noaa.gov/npp_launch.html

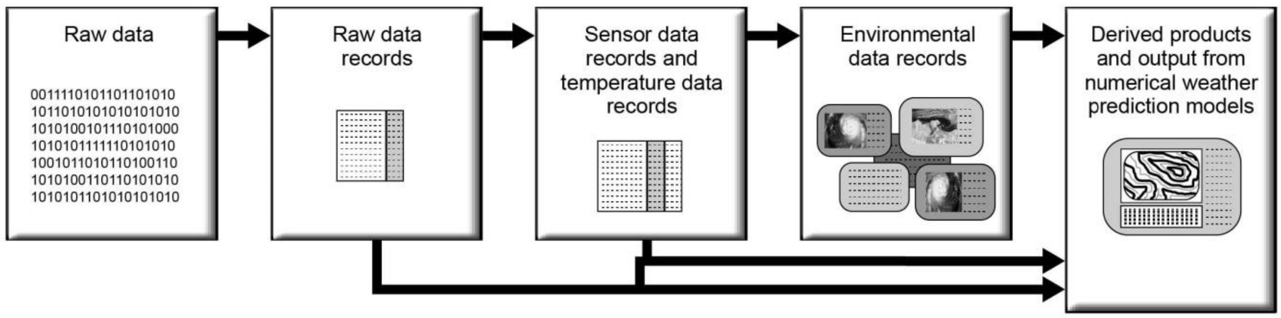
[3] European Centre for Medium-Range Weather Forecasts, "Annual Report: 2012," p.5, available at: http://www.ecmwf.int/publications/annual_report/2012/pdf/Annual-report-2012.pdf

[4] GAO-13-283, February 2013, p. 70.

[5] GAO, "Polar Weather Satellites: NOAA Needs to Prepare for Near-Term Data Gaps," GAO-15-47, January 2015, p.5.

weather and climate products.[6] Combinations of the various data records are used to create forecasts from the numerical weather models. These models are then used by meteorologists to produce forecasts for American citizens.

The figure below from GAO depicts a simple representation of the stages of satellite data.[7]



Source: GAO analysis of NOAA information. | GAO-15-47

GAO Recommendations

JPSS

In its 2015 update, GAO continues to raise concerns about NOAA's polar satellite program, specifically noting that the program is facing an unprecedented gap in satellite data.[8] NOAA has recently revised its estimate of the length of a potential gap from 15 months down to 3 months. GAO notes that this new estimate "was based on inconsistent and unproven assumptions and did not account for the risk that space debris pose to S-NPP's life expectancy."[9]

While the Agency has improved its efforts in contingency plan building, it has yet to address a number of shortfalls, such as assessing costs and impacts of gap mitigation alternatives, as well as tracking potential mitigation efforts.[10] In addition, NOAA has not prioritized the most beneficial and feasible gap mitigation efforts.[11] In order to reduce risks, GAO lists five recommendations for the satellite system in its 2015 report.[12]

1. Track completion dates for all risk mitigation activities.

2. Update the 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

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[6] GAO, "Polar Weather Satellites: NOAA Needs to Prepare for Near-Term Data Gaps," GAO-15-47, January 2015, p.5.
[7] Ibid. p.6.
[8] Ibid, p.42.
[9] Ibid.
[10] Ibid.
[11] Ibid.
[12] Ibid., p. 43.

well as key risks such as the potential effect of space debris on JPSS and other polar satellites' expected lifetimes.

3. Revise the polar satellite contingency plan to address the shortfalls noted in GAO's report, such as identifying the Department of Defense and Japan's plans to continue weather satellite observations. GAO recommends that the plan include: recovery time objectives for key products, completing the contingency plan with selected strategies, identifying opportunities for accelerating calibration and validation of products, providing an assessment of available alternatives based on their costs and potential impacts, establishing a schedule with meaningful timelines and linkages among mitigation activities, and defining completion dates for testing and validating the alternatives.

4. Investigate ways to prioritize mitigation projects with the greatest potential benefit to weather forecasting in the event of a gap in JPSS satellite data and report recommendations to the NOAA program management council; and

5. Ensure that the relevant entities provide monthly and quarterly updates on the progress of all mitigation projects and activities during existing monthly and quarterly management meetings.

GOES

NOAA's Geostationary Operational Environmental Satellite System (GOES) also remains a concern. The program faces challenges in maintaining its schedule due to delays in instrument testing and integration. The program has experienced delays in key milestones which could further delay the scheduled launch of March 2016.[13] GAO notes that, "costs are increasing faster than expected for key program components."[14] NOAA is continuing to monitor defects during its testing phase, but needs to more accurately define defect metrics and track defect resolutions.[15] Further delays in the GOES program, as well as any problems with operational satellites, could lead to a gap in data coverage. In its most recent report, GAO provides four recommendations to help reduce risks to the GOES program:[16]

1. Investigate and address inconsistencies totaling hundreds of thousands of dollars in monthly earned value data reporting for the Geostationary Lightning Mapper (GLM) and the Advanced Baseline Imager (ABI) instruments.

2. Address shortfalls in defect management identified in this report, including the lack of clear guidance on defect definitions, what defect metrics should be collected and reported, and how to establish a defect's priority or severity.

[13] GAO, "Geostationary Weather Satellites: Launch Date Nears, but Remaining Schedule Risks Need to be Addressed," GAO-15-60, January 2015, p.40.
[14] Ibid.
[15] Ibid.
[16] Ibid, p. 41.

3. Reduce the number of unresolved defects on the GOES ground system and spacecraft.

4. Add information to the GOES satellite contingency plan on steps planned or underway to mitigate potential launch delays, the potential impact of failure scenarios in the plan, and the minimum performance levels expected under such scenarios.

Satellite Data Gap and Components of Weather Legislation

Due to the potential for gaps in satellite coverage and data, the Committee remains committed to the tenants of weather focused legislation to address shortcomings in weather forecasting abilities.

The Weather Forecasting Improvement Act (last year H.R. 2413 introduced by Environment Subcommittee Chairman Jim Bridenstine) prioritizes the mission of NOAA on the protection of lives and property, and makes more of its funds available to improve weather-related research and operations through advances in observational data, modeling, and computing capabilities. The bill directs NOAA to use quantitative, cost-benefit assessments in deciding how to obtain data for forecasts. It also directs NOAA to prepare a report outlining the options for commercial opportunities to obtain space-based weather observations.

Historical Context

National Polar-orbiting Operational Environmental Satellite System

In the 1960s, the United States began operating two polar-orbiting meteorological satellite systems: one managed by NOAA and another by the Air Force. Polar-orbiting satellites transverse the globe from pole to pole, with each orbit defined by the time of day they pass over the equator: early morning, late morning, and afternoon. Unlike geostationary weather satellites, which offer persistent coverage over an area, each polar-orbiting satellite makes approximately 14 orbits per day and is able to view the entire Earth's surface twice per day.

In 1994, as part of the Clinton-Gore Administration's Reinventing Government initiative, a Presidential Decision Directive required NOAA and the Department of Defense (DOD) to merge the civilian and military polar-orbiting satellite systems into one program, the National Polar-orbiting Operational Environmental Satellite System (NPOESS). To manage the program, DOD, NOAA, and NASA formed a tri-agency Integrated Program Office. Overall responsibility for the management of the system and satellite operations was assigned to NOAA. The DOD was responsible for acquisition of the sensors, satellite bus, and launch vehicle, while NASA was responsible for facilitating the development and incorporation of new technologies.[17]

By 2009, the life-cycle cost estimate of NPOESS had ballooned to at least $14.9 billion for four new satellites, the first of which was projected to launch in 2014. In June 2009, an

[17] GAO, "Polar-Orbiting Environmental Satellites: Changing Requirements, Technical Issues, and Looming Data Gaps Require Focused Attention," GAO-12-604, June 2012, p.12.

Independent Review Team (IRT) determined that the NPOESS program had a low probability of success.[18]

Joint Polar Satellite System

In February 2010, the Office of Science and Technology Policy announced that the program would be split, with NOAA and the DOD creating their own programs, establishing requirements, and transferring existing NPOESS contracts to new programs.[19] Satellites flying in orbits to collect early-morning observations would be developed and launched by DOD, while NOAA's Joint Polar Satellite System would collect observations in the afternoon orbit. These orbits provide adequate coverage of the earth during various times of the day and collect information for weather models.

In 2010, NOAA estimated that the life cycle costs of the JPSS program would be approximately $11.9 billion. Though data monitoring requirements for the program had not changed, NOAA's JPSS program office made plans to remove key requirements to keep the program within the prescribed budget. Meanwhile, DOD decided to terminate its program and reassess its requirements.[20]

The following table from GAO[21] compares the planned costs, schedule and scope of the three programs over time.

Figure 1: Temporal Comparison of NPOESS and JPSS

[18] NOAA, NESDIS, "Joint Polar Satellite System," Fiscal Year 2011 Budget Highlights," Available at: http://www.corporateservices.noaa.gov/nbo/fy11_budget_highlights/JPSS_Budget_Highlights.pdf

[19] Office of Science and Technology Policy, Restructuring the National Polar-Orbiting Operational Environmental Satellite System, 2010, Available at: http://www.whitehouse.gov/sites/default/files/npoess_decision_fact_sheet_2-1-10.pdf

[20] GAO-12-604, June 2012, p.12.

[21] GAO, "Polar Weather Satellites: NOAA Needs to Prepare for Near-Term Data Gaps," GAO-15-47, January 2015, p.12.

Key area	NPOESS after it was restructured (as of June 2008)	NPOESS prior to being disbanded (as of February 2010)	JPSS program (as of May 2010)	JPSS program (as of June 2012)	JPSS program (as of September 2013)
Life cycle	1995-2026	1995-2026	2010-2024	2010-2028	2010-2025
Estimated life cycle cost	$12.5 billion	$13.95+ billion[a]	$11.9 billion (which includes about $2.9 billion spent through fiscal year 2010 on NPOESS)	$12.9 billion (which includes about $3.3 billion spent through fiscal year 2011 on NPOESS and JPSS)	$11.3 billion (which includes about $4.3 billion spent through fiscal year 2012 on NPOESS and JPSS)
Number of satellites	4 (in addition to S-NPP)	4 (in addition to S-NPP)	2 (in addition to S-NPP)	2 (in addition to S-NPP)	2 (in addition to S-NPP)
Number of orbits	2 (early morning and afternoon; would rely on European satellites for midmorning orbit data)	2 (early morning and afternoon; would rely on European satellites for midmorning orbit data)	1 (afternoon orbit) (DOD and European satellites would provide early and midmorning orbits, respectively)	1 (afternoon orbit) (DOD and European satellites would provide early and midmorning orbits, respectively)	1 (afternoon orbit) (DOD and European satellites would provide early and midmorning orbits, respectively)
Launch schedule	S-NPP by Jan. 2010 First satellite (C1) by Jan. 2013 C2 by Jan. 2016 C3 by Jan. 2018 C4 by Jan. 2020	S-NPP no earlier than Sept. 2011 C1 by March 2014 C2 by May 2016 C3 by Jan. 2018 C4 by Jan. 2020	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	S-NPP—successfully launched in Oct. 2011 JPSS-1 by March 2017 JPSS-2 by Dec. 2021
Number of sensors	S-NPP: 4 sensors C1: 6 sensors C2: 2 sensors C3: 6 sensors C4: 2 sensors	S-NPP: 5 sensors C1: 7 sensors[b] C2: 2 sensors C3: 6 sensors C4: 2 sensors	S-NPP: 5 sensors JPSS-1 5 sensors[c] JPSS-2: 5 sensors	S-NPP: 5 sensors JPSS-1: 5 sensors JPSS-2: 5 sensors Free flyer-1 and-2: 1 sensor and 2 user services systems[d]	S-NPP: 5 sensors JPSS-1: 5 sensors JPSS-2: 5 sensors[e] No free flyers[f]

Source: GAO analysis of NOAA, DOD, and task force data. | GAO-15-47

[a]Although the program baseline was $13.95 billion in February 2010, we estimated in June 2009 that this cost could grow by about $1 billion. In addition, officials from the Executive Office of the President stated that they reviewed life cycle cost estimates from DOD and the NPOESS program office of $15.1 billion and $16.45 billion, respectively.

[b]In May 2008, the NPOESS Executive Committee approved an additional sensor—Total and Spectral Solar Irradiance Sensor—for the C1 satellite.

[c]The five sensors are the Advanced Technology Microwave Sounder, Clouds and the Earth's Radiant Energy System (CERES), Cross-Track Infrared Sounder, Ozone Mapping and Profiler Suite, and Visible Infrared Imaging Radiometer Suite. 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.

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

[e]In its fiscal year 2014 budget request, NOAA transferred responsibility for two sensors to NASA—the Radiation Budget Instrument (formerly known as CERES) and OMPS-L and plans to accommodate these sensors on the JPSS-2 satellite as long as they do not impact the likelihood of mission success.

[f]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 (SIDAR) 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.

By 2011, NOAA and NASA had established separate but co-located JPSS program offices, each with different roles and responsibilities. NOAA is responsible for programmatic activities related to the JPSS satellite development, including managing requirements, budgets, and interactions with satellite data users. NASA is responsible for the development and integration of sensors, satellites, and ground systems.

The joint NASA and NOAA JPSS team launched the Suomi National Polar-orbiting Partnership (S-NPP) satellite in October 2011, the first of a new generation of satellites. S-NPP will collect remotely-sensed land, ocean and atmospheric data during the afternoon orbit.

Geostationary Satellite System

In addition to polar-orbiting satellites, NOAA also operates Geostationary Observational Environmental Satellites (GOES). NOAA's GOES satellites operate from a geosynchronous orbit 22,300 miles above the Earth, which means they orbit the equatorial plane of the Earth at a speed matching the Earth's rotation. This vantage point allows the satellites to essentially ‘hover’ continuously over one position on the surface of the earth, and serve as a fixed eye on the continental United States though with limited coverage of the Earth’s poles.

The GOES system operated by NOAA utilizes two satellites – one fixed on the eastern United States and the other on the western United States. At any given time, the GOES system also includes a third on-orbit ‘spare’ called into duty either as an emergency back-up to the primary satellites, or naturally sequenced into operations once an older satellite’s service has degraded.

The next-generation of the GOES satellites, known as the GOES-R, is under development. GOES-R is expected to significantly improve weather data and will be able to transmit that data at faster rates more frequently. Both improvements will enhance the quality and timeliness of information to the user.

Life cycle cost estimates for the GOES-R series now stand at $10.86 billion through 2036 – an increase of $3.2 billion over the estimate for a two satellite system in 2007. The first of the series is scheduled to launch in March 2016.[22]

The following table illustrates key changes to the program since August 2006.

Figure 3: Key Changes to the GOES-R Program[23]

	August 2006 (baseline program)	September 2006	November 2007	February 2011	August 2013
Number of satellites	4	2	2	4	4
Instruments	• Advanced Baseline Imager • Geostationary Lightning Mapper • Magnetometer • Space Environmental In-Situ Suite • Solar Imaging Suite (which included the Solar Ultraviolet Imager, and Extreme Ultraviolet/X-Ray Irradiance Sensor) • Hyperspectral Environmental Suite	• Advanced Baseline Imager • Geostationary Lightning Mapper • Magnetometer • Space Environmental In-Situ Suite • Solar Ultraviolet Imager • Extreme Ultraviolet/X-Ray Irradiance Sensor	No change	No change	No change
Number of satellite products	81	68	34 baseline 34 optional	34 baseline 31 optional	34 baseline 31 optional
Life cycle cost estimate (in then-year dollars)	$6.2 billion – $11.4 billion (through 2034)	$7 billion (through 2028)	$7.67 billion (through 2028)	$10.86 billion (through 2036)[a]	$10.86 billion (through 2036)
Estimated launch dates for GOES-R and GOES-S	GOES-R: September 2012 GOES-S: April 2014	GOES-R: September 2012 GOES-S: April 2014	GOES-R: December 2014 GOES-S: April 2016	GOES-R: October 2015 GOES-S: February 2017	GOES-R: by March 2016 GOES-S: by June 2017[b]

Source: GAO analysis of NOAA data. | GAO-15-60

[a]Based on NOAA’s fiscal year 2012 budget estimate, $7.64 billion of this cost estimate was for the first two satellites in the series, GOES-R and GOES-S. The cost for the remaining two satellites—GOES-T and GOES-U—was estimated at $3.22 billion.

[b]Program documentation shows that the launch commitment dates were changed to the first quarter of 2016 and the second quarter of 2017, respectively. The launch dates in this chart reflect the latest month in which launch can occur and still meet the launch commitment dates.

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[22] GAO, “Geostationary Weather Satellites: Launch Date Nears, but Remaining Schedule Risks Need to be Addressed,” GAO-15-60, January 2015, p.8.

[23] Ibid.

Additional Reading

- Government Accountability Office, "Polar Weather Satellites: NOAA Needs to Prepare for Near-Term Data Gaps," GAO-15-47, January 2015, Available at: http://www.gao.gov/products/GAO-15-47

- Government Accountability Office, "Geostationary Weather Satellites: Launch Date Nears, but Remaining Schedule Risks Need to be Addressed," GAO-15-60, January 2015, Available at: http://www.gao.gov/products/GAO-15-60