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

HEARING CHARTER

Looking Back to Predict the Future: The Next Generation of Weather Satellites

Wednesday, September 21, 2022
10:00 a.m. E.T.
2318 Rayburn House Office Building and Online via Zoom

Purpose

This hearing will provide an opportunity to discuss the partnership between the National Oceanic and Atmospheric Administration (NOAA) and National Aeronautics and Space Administration (NASA) in the development, testing, acquisition, launch and management of NOAA's operational weather satellite programs. Furthermore, this hearing will examine how lessons learned from past challenges in recent weather satellite programs are being incorporated into the future goals, architecture, and capabilities for the next generation of weather satellites.

Witnesses

- **Dr. Stephen Volz**, Assistant Administrator, National Environmental Satellite, Data, and Information Services, NOAA
- **Mr. John Gagosian**, Joint Agency Satellite Division Director, NASA
- **Mr. Fred Meny**, Assistant Inspector General for Audit and Evaluation, U.S. Department of Commerce, Office of Inspector General

Overarching Questions

- What are the current roles of NASA and NOAA in the development of NOAA's operational weather satellites?
- What are the lessons learned from the current generation of satellites?
- What are the current procedures employed by the agencies in case of an instrument or system mishap?
- How will solutions to previous instrument or system mishaps help shape the future of weather satellites?
- What is expected from the next generation of NOAA weather satellite programs and how will they differ from, and improve upon, the current satellite programs?
- How are the agencies planning to engage the private sector in the development of the next generation weather satellite architecture?

Background

NOAA's operational weather satellite programs provide essential observational data for short-term and long-term weather forecasts as well as climate research. These satellites play a key role in protecting life and property and helping communities prepare for the impacts of climate

change. NOAA and NASA have partnered to implement the nation's weather satellite programs for more than 50 years.[1] Today, NASA is responsible for the acquisition and development of the space system components of NOAA's weather satellite programs, including the spacecraft, instruments, and launch services. NASA conducts this work on a reimbursable basis, with NOAA providing the funding to NASA for development and acquisition of the NOAA weather satellites. Once a weather satellite is launched and its on-orbit performance is validated by NASA, ownership is transferred to NOAA, who is then responsible for operations. NOAA also leads the overall program management through integrated NOAA-NASA program offices. The NOAA-NASA relationship for the weather satellite programs is detailed in a Management Control Plan and a series of Inter-Agency Agreements (IAAs), which lay out the roles and responsibilities of each agency.[2]

The Committee's previous oversight hearings on NOAA's weather satellites highlighted the potential that the U.S. could face a gap in satellite coverage due to mismanagement, delays, and ballooning costs of the satellite programs. [3] The previous hearings focused on issues raised in the U.S. Government Accountability Office's (GAO) reports following the weather satellite programs being added to their High-Risk List in 2013.[4] NOAA weather satellites were removed from the GAO's High Risk List in 2019 due to NOAA taking the necessary steps to address the potential satellite data gaps that would impact weather forecasting.[5] Although the removal of the satellite programs from GAO's High Risk List demonstrates NOAA's progress in limiting vulnerability in the programs, several issues have been raised since the last oversight hearing in December of 2015 by the Department of Commerce's Office of Inspector General (OIG).

NOAA

NOAA's mission to understand and predict changes in climate, weather, oceans and coasts is directly supported by its satellite programs. Since the launch of the first operational weather satellite more than 50 years ago, NOAA's satellite programs have provided the foundation of the nation's observational and forecasting capabilities. NOAA, as well as the nation's meteorological, climate, and emergency personnel communities, rely on satellite observational data to monitor and accurately forecast regional and global weather and climate. The National Environmental Satellite, Data, and Information Service (NESDIS), a NOAA line office, was established in 1982 as the importance of satellite observational data became more apparent. NESDIS oversees the dissemination of satellite global environmental data and information services. NESDIS accomplishes this by acquiring and managing geostationary operational satellites and polar-orbiting environmental satellites.

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[1] NASA developed and launched the world's first experimental weather satellite, the Television Infrared Observation Satellite (TIROS-1), in 1960, and has since built more than 50 weather satellites, most of which have been operated by NOAA, which was established in 1970.
[2] NOAA-NASA Satellite Programs and Projects Management Control Plan
[3] https://docs.house.gov/Committee/Calendar/ByEvent.aspx?EventID=102960, https://docs.house.gov/Committee/Calendar/ByEvent.aspx?EventID=105208, https://docs.house.gov/Committee/Calendar/ByEvent.aspx?EventID=104278
[4] https://www.gao.gov/products/gao-13-283
[5] https://www.gao.gov/products/gao-19-157sp

NESDIS owns, funds, and manages terrestrial and space weather satellite mission requirements. To satisfy data requirement parameters, NESDIS transitions NOAA's mission requirements to observing system requirements with NASA's technical assistance. NOAA is solely responsible for the development of the ground systems to support its satellite programs.

Figure 1 shows the governance structure between NOAA and NASA for NOAA's satellite programs. [6] NOAA and NASA jointly chair management councils. NOAA serves as the final decision authority, except for the NOAA-NASA Center Management Council (CMC) in which the NASA Deputy Center Director has the final decision authority.

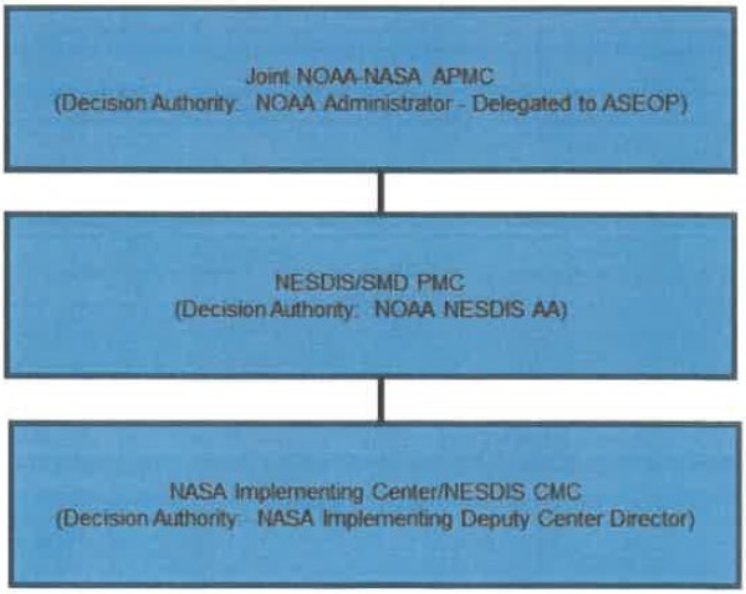

Figure 1: NASA-NOAA Governance Structure

International Partnerships – NOAA's weather satellites are a part of an international partnership agreement that supports an increased, robust global observing system. [7] NOAA is subject to an open data policy with its international partners in an effort to support global models and observations in a more efficient and cost-saving way. The GOES satellite program partners with Japan and Europe's geostationary satellites to monitor atmospheric conditions. [8] Additionally, the U.S partners with multiple countries through various agreements promoting open data sharing which in turn helps the U.S. collect significantly more meteorological and climate data. NOAA continues to expand its partnerships to meet its data needs and to support technological advancements.

Impacts of Spectrum Interference – The Committee has previously conducted oversight of spectrum needs for Earth and space science observations. [9] Increasing interest in and

[6] NOAA-NASA Satellite Programs and Projects Management Control Plan
[7] https://www.nesdis.noaa.gov/partnerships-agreements
[8] https://www.nesdis.noaa.gov/news/international-partners-the-sky-satellite-partnerships
[9] https://docs.house.gov/Committee/Calendar/ByEvent.aspx?EventID=113941

development of high-frequency broadband spectrum access, such as for commercial 5G cellular networks, are causing concerns due to the potential of significant interference with specific radio frequency bands used by NOAA that are necessary to support accurate weather forecasting. NOAA recently published the Spectrum Pipeline Reallocation Engineering Study (SPRES) noting the potential interference issues of spectrum sharing at 1675-1680 MHz between new commercial mobile operators and incumbent NOAA satellite operations.[10] Additionally, the National Academies of Sciences, Engineering, and Medicine released a Congressionally mandated study that reviewed the potential for significant harmful interference due to FCC Order 20-48, which permitted commercial telecommunications operations in spectral bands adjacent to those of the Global Positioning Service (GPS), which are relied upon for a variety of government uses, including Department of Defense activities and NOAA's weather satellites.[11]

NASA

Joint Agency Satellite Division (JASD) - NASA manages the acquisition, development, and launch of reimbursable satellite programs, including the NOAA weather satellites, under the Joint Agency Satellite Division (JASD), which was established in 2010 as a division of the Science Mission Directorate. JASD manages the Joint Polar Satellite Systems (JPSS), Geostationary Operational Environmental Satellites R (GOES-R), and the Geostationary Extended Operations (GeoXO) programs out of the Goddard Space Flight Center (GSFC), in Greenbelt, Maryland, where program officials are responsible for the detailed design and engineering to build spacecraft that meet NOAA's requirements. Under JASD management, GSFC officials are also responsible for soliciting, awarding, and managing most of the contracts to industry associated with these programs. NASA's Launch Services Program manages commercial launch services for the weather satellites.

JASD manages the NOAA weather satellite programs at GSFC to ensure that they are largely following NASA's project management and systems engineering requirements that NASA uses for its own space mission development programs. JASD also validates the budgets that NOAA proposes for the programs. NASA and NOAA convene a joint Program Management Council to review programs at lifecycle milestones, and the ultimate decision authority for the programs resides within the Department of Commerce.

Advanced Technology and Research to Operations - While NASA does not conduct strategic technology development for NOAA weather capabilities, the agency supports technology development in the Earth Science Division to advance space-based observations of Earth systems for scientific research. Some of that technology development can have dual applications to weather observations. JASD and NOAA can leverage that technology development to operationalize new or enhanced capabilities for weather satellites, in areas such as sensors, instrumentation, and spacecraft design and operation. For example, NASA's Moderate Resolution Imaging Spectrometer (MODIS), on board the Terra and Aqua satellites, was designed and originally used for NASA's scientific studies of the Earth's climate and climate

[10] https://www.fcc.gov/ecfs/search/search-filings/filing/10906163747708
[11] https://nap.nationalacademies.org/catalog/26611/analysis-of-potential-interference-issues-related-to-fcc-order-20-48

change, but it also led to the development of the Visible Infrared Imaging Radiometer Suite (VIIRS) for the NOAA JPSS satellites.

Maturation of the commercial space industry, especially in areas such as commercial Earth remote sensing and launch capabilities, can also enable new or enhanced capabilities, potentially even at lower costs. After conducting the NOAA Satellite Observing System Architecture (NSOSA) study as an early-stage strategic planning activity for the next generation of weather satellites, NOAA determined that the GeoXO satellites would be able to improve on the GOES-R series with better imaging capabilities and new technologies that have been developed and demonstrated by NASA, international partners, and/or commercial industry, such as hyperspectral infrared sounding, ocean color, and atmospheric composition instruments. NASA has awarded a number of study contracts to commercial firms to develop designs and further refine concepts for such capabilities.

Current Operational Weather Satellite Programs

NOAA's primary operational weather satellite programs are made up of a constellation of geostationary and polar-orbiting satellites. The current GOES-R series and the JPSS programs are interagency efforts between NOAA and NASA. NOAA is responsible for funding, management, and operation, while NASA provides technical expertise, research, spacecraft, and launch resources. GOES-R and JPSS data products enable a broad user community to conduct accurate and timely environmental and weather monitoring.

Geostationary Operational Environmental Satellites (GOES) – The Geostationary Operational Environmental Satellite Program (GOES) was formally established in 1975, with the launch of GOES-1, and GOES-2 through GOES-15 were launched between 1977 and 2010, with each new satellite featuring upgrades to the instrument capabilities and architecture. GOES satellites operate at geosynchronous orbit (GEO), where they match the speed of Earth's rotation, allowing them to stay over one surface location approximately 22,300 miles above Earth.[12] The GOES system consists of two operational satellites in orbit at any given time, GOES-East and GOES-West, with one additional satellite in orbit as a spare. Their fixed position enables continuous monitoring of atmospheric triggers for severe weather events and space weather. The GOES-R Series provides advanced imagery and atmospheric measurements that have supported improved hurricane track and intensity forecasts, increased detection of flood risks and total lightning activity, and better detection and monitoring of fire and smoke hazards. GOES-East monitors the eastern half of the U.S., while GOES-West covers the western half.

The GOES-R series (GOES-R through GOES-U) includes the Advanced Baseline Imager (ABI), a significant advancement in imaging from the previous generation of GOES. GOES-16 (GOES-R) was launched in 2016 to assume GOES-East operations; GOES-17 (GOES-S) was launched in 2018 to assume GOES-West operations. Post-launch testing revealed degraded image quality from GOES-17 due to a loop heat pipe anomaly on the ABI instrument. In March of 2022, GOES-T was launched as a replacement following an 18-month delay to correct the ABI issue.

[12] https://www.noaasis.noaa.gov/GOES/goes_overview.html#:~:text=The%20GOES%20satellites%20operate%20from,GOES%20East%20or%20GOES%20West.

Following the first phase of post-launch testing, GOES-T maneuvered into position and was renamed GOES-18. The satellite is now undergoing second phase post-launch testing. GOES-18 is expected to take over full GOES-West operations on January 3, 2023. GOES-U, the final GOES satellite in the GOES-R program, is anticipated to launch in April of 2024. The mission lifetime of the GOES-R series extends through 2040.[13]

Joint Polar Satellite System (JPSS) –The JPSS program was established to carry out the civilian polar orbiting mission. The JPSS mission will be made up of a total of five polar-orbiting environmental satellites, which each circle Earth in a north-south orbit 14 times daily, providing global-wide meteorological, atmospheric, oceanic, and terrestrial observations. JPSS satellites carry instruments that collect environmental measurements such as sea and land surface temperatures, moisture levels, thermal radiation, vegetation, clouds, rainfall, snow and ice cover, fire locations and smoke plumes, atmospheric temperature, water vapor and ozone. NOAA's National Weather Service utilizes JPSS data to provide accurate short-term, seasonal, and long-term forecasting.

Two polar orbiting satellites are currently in orbit and operated by NOAA. The Suomi National Polar-orbiting Partnership (Suomi NPP) satellite was launched in October 2011 and is owned by NASA, and NOAA-20 (formerly named JPSS-1) launched in November 2017. JPSS-2, scheduled to launch from Vandenberg Space Force Base on November 1, 2022, was delayed due to an equipment anomaly during the Visible Infrared Imaging Radiometer Suite (VIIRS) thermal vacuum testing. Engineers determined the issue resulted from test equipment movement caused by temperature fluctuations. After modifications, the system tested with expected performance.[14] JPSS-3 and -4 are anticipated to launch in 2026 and 2031, respectively. The operational lifetime of the JPSS series is expected through 2039.

Next Generation Operational Weather Satellite Programs

NSOSA Study – Following the passage of the Weather Research and Forecasting Innovation Act of 2017,[15] NOAA conducted and published NOAA Satellite Observing System Architecture Study Report (NSOSA Study)[16] in May 2018 to develop recommendations for future satellite data needs. The NSOSA Study found cost advantages of having a mix of commercial hosted payloads and traditional U.S. Government satellites to support GEO instruments. Additionally, the study found that disaggregating instruments onto multiple smaller satellites could improve affordability and provide enhanced capabilities and showed that there is an increased value of evaluating multiple business models for the future of satellite architecture. NOAA plans to leverage the NSOSA study in future satellite development.

Next Generation Satellites – The Geostationary Extended Observations (GeoXO) satellite system is the next generation of geostationary satellite program that will follow the GOES-R Series.

[13] https://www.nesdis.noaa.gov/s3/2022-04/GEO%20Flyout%20January%202022%20signed.pdf
[14] https://www.nesdis.noaa.gov/news/noaas-jpss-2-mission-has-new-launch-date#:~:text=NOAA%20and%20NASA%20are%20now%20targeting%20November%201%2C,test%20equipment%20anomaly%20during%20thermal%20vacuum%20%28TVAC%29%20testing.
[15] https://www.congress.gov/115/plaws/publ25/PLAW-115publ25.pdf
[16] https://www.regulations.gov/document/NOAA-NESDIS-2018-0053-0002

GeoXO will improve, expand, and develop new technologies for monitoring ocean and atmospheric conditions. NOAA has proposed a three-satellite constellation for GeoXO with a Geo-Central satellite with unique instrumentation in addition to the traditional GEO-West and GEO-East.[17] On July 26, 2022, NASA, on behalf of NOAA, announced the awarding of contracts to two firms to develop the GeoXO spacecraft concept and define its potential performance risks, costs, and development schedule.[18] The outcome of these contracts will be used to set the performance requirements for the spacecraft implementation contract. On August 25, 2022, NOAA announced that GeoXO can proceed toward its implementation phase of the mission, which is scheduled for late 2022.[19] The first GeoXO anticipated launch is in the early 2030s.

NESDIS is in the process of developing a mission plan for low Earth orbit (LEO) observing satellites which could offer an opportunity to launch smaller and more cost-effective satellites more frequently to enhance global observations. The LEO satellite program will provide the opportunity for NESDIS to have a disaggregate approach to meet future observation needs by focusing on one instrument per small satellite versus the current architecture of large satellites with multiple instruments. Additionally, the program is expected to provide increased supportive data to the GEO satellite program by providing higher resolution and more frequent observations. NESDIS completed its first review milestone for the LEO satellite program in March 2021.[20] The anticipated launch date of the first LEO program Government satellite is the late 2020s. NOAA's current next-generation strategy also includes the Space Weather Observations Program (SWO).

Department of Commerce Office of Inspector General audits of NOAA Satellite Programs

The Department of Commerce's Office of Inspector General (OIG) conducts independent reviews and audits of NOAA's satellite programs in order to prevent tax dollar waste, mismanagement, and inefficiency, and reports its findings to the public and Congress. A 2018 OIG audit report revealed technical challenges with satellite ground system upgrades, resulting in prolonged schedules.[21] Another 2018 OIG report highlighted NOAA's failure to provide development costs to Congress, as well as incomplete pre-launch satellite storage plans, underdeveloped launch plans, immature technical baselines, uncertain timelines, and other programmatic issues.[22] Furthermore, a 2020 OIG report found that JPSS failed to sufficiently conduct a baseline review, adequately surveil contract risks, or optimize contractor performance.[23] NOAA responded to all report recommendations with necessary remedies.

In 2022, the OIG published two reports in relation to NOAA's satellites that evaluated the launch readiness of NOAA's GOES-T mission as well as NOAA's progress in the next-generation satellite programs. The January 2022 audit report, *Redesigned GOES-T is Ready for Launch, but*

[17] https://www.nesdis.noaa.gov/next-generation/geostationary-extended-observations-geoxo
[18] https://www.nasa.gov/press-release/goddard/2022/nasa-awards-contracts-for-noaa-geoxo-spacecraft-phase-a-study
[19] https://www.nesdis.noaa.gov/next-generation/geostationary-extended-observations-geoxo
[20] https://www.nesdis.noaa.gov/s3/2022-05/PWR_SAB_071220212_As_Delivered-remediated.pdf
[21] https://www.oig.doc.gov/OIGPublications/OIG-18-024-A.pdf
[22] https://www.oig.doc.gov/OIGPublications/OIG-18-021-A.PDF
[23] https://www.oig.doc.gov/OIGPublications/OIG-20-047-A.pdf

NOAA Should Reassess Its Assumptions for Satellite Launch Planning and Storage, found that the GOES program works towards conducting the earliest launch possible without considering development risk and potential costs nor analyzing any possible tradeoffs of longer ground storage for the GOES satellites versus in-orbit storage.[24] The report was published prior to the successful launch of GOES-T. Each report provides recommendations by the OIG in which NOAA has the opportunity to review and respond to said recommendations. NOAA concurred with the recommendations. The July 2022 audit report by OIG, *The Success of NOAA's Next-Generation Satellite System Architecture Depends on Sound Requirements Management Practices,* found that NOAA's management of satellite program requirements and tools needs updating for the success of the next generation of weather satellites.[25]

Additional Reading

- National Space Policy, https://www.space.commerce.gov/policy/national-space-policy/

- NOAA Commercial Space Policy, https://www.noaa.gov/organization/administration/nao-217-109-noaa-commercial-space-policy

[24] https://www.oig.doc.gov/OIGPublications/OIG-22-015-A.pdf
[25] https://www.oig.doc.gov/OIGPublications/OIG-22-022-A.pdf