

LOOKING BACK TO PREDICT THE FUTURE: THE NEXT GENERATION OF WEATHER SATELLITES

JOINT HEARING

BEFORE THE
SUBCOMMITTEE ON SPACE AND AERONAUTICS
SUBCOMMITTEE ON ENVIRONMENT
OF THE
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AND TECHNOLOGY
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**LOOKING BACK TO PREDICT
THE FUTURE: THE NEXT GENERATION
OF WEATHER SATELLITES**

WEDNESDAY, SEPTEMBER 21, 2022

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON SPACE AND AERONAUTICS,
JOINT WITH THE SUBCOMMITTEE ON ENVIRONMENT,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Subcommittees met, pursuant to notice, at 10 a.m., in room 2318 of the Rayburn House Office Building, Hon. Don Beyer [Chairman of the Subcommittee on Space and Aeronautics] presiding.

**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.

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.

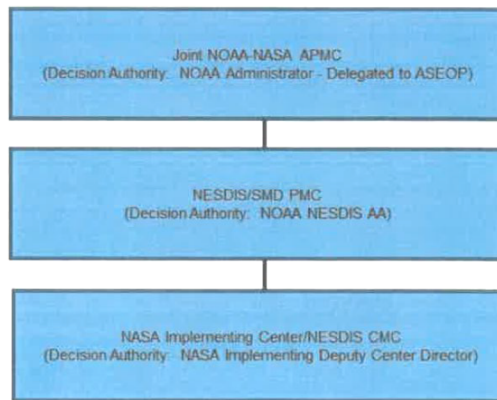


Figure 1: NASA-NOAA Governance Structure

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.

¹²https://www.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-geo-xo>

¹⁸ <https://www.nasa.gov/press-release/goddard/2022/nasa-awards-contracts-for-noaa-geo-xo-spacecraft-phase-a-study>

¹⁹ <https://www.nesdis.noaa.gov/next-generation/geostationary-extended-observations-geo-xo>

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>

Chairman BEYER. Good morning. This hearing will come to order. Without objection, the Chair is authorized to declare recess at any time.

Before I deliver my opening remarks, I wanted to note that, today, the Committee is meeting both in person and virtually, both Members and witnesses. And I want to announce a couple of reminders to the Members about the conduct of this hearing. First, Members and staff who are attending in person may choose to be masked, but it is not a requirement. However, any individuals with symptoms, a positive test, or exposure to someone with COVID-19 should wear a mask while present. Members who are attending virtually should keep their video feed on as long as they are present in the hearing. Members are responsible for their own microphones. And also please keep your microphones muted unless you're speaking.

Finally, if Members have any documents they wish to submit for the record, please email them to the Committee Clerk, whose email address was circulated prior to the hearing.

Good morning, and welcome to today's hearing, "Looking Back to Predict the Future: The Next Generation of Weather Satellites." I want to welcome our witnesses. We're pleased to have you here both in person and virtually.

Today, the Subcommittees on Environment and Space and Aeronautics are meeting jointly, and I want to thank Chair Sherrill for her collaboration on this hearing.

The importance of advanced, reliable weather prediction and understanding of long-term climate trends can't be understated. Devastating winds, storm surges, and flooding in Alaska and Puerto Rico are just recent examples. While weather continues to present serious risks to life and property, we've come a long way from 1900 when a hurricane with 135 mile per hour winds decimated Galveston, Texas, and wiped out 8,000 lives and an estimated 3,600 buildings.

Our Nation's weather satellites in essence are the workhorses that provide imagery and data that feed weather forecast models and predictive tools. These critical satellite capabilities support the Government's core weather services, global users, as well as a thriving commercial weather industry. Today, advanced technologies increased scientific understanding of the Earth system and a burgeoning commercial space industry, providing new options and opportunities for our next generation of operational weather systems. We need to start by looking back to predict the future, and that story begins with NASA (National Aeronautics and Space Administration).

In the early stages of our space program, NASA developed and launched in 1960 the world's first weather satellite, the Television Infrared Observation Satellite, TIROS-1, equipped with two television cameras and two video recorders that proved the value of space-based weather operations. A year later, President John F. Kennedy in a historic May 1961 speech to a joint session of Congress included a request for appropriations that will, quote, "will help give us at the earliest possible time a satellite system for worldwide weather observation."

Following the TIROS satellites led to NASA's Nimbus series, as NASA worked first with NOAA's (National Oceanic and Atmospheric Administration's) precursor and then NOAA to establish a weather satellite system. NASA also developed the first geostationary weather satellite, followed by the first operational Geostationary Operational Environmental Satellite, GOES, in 1975. And today, through a reimbursable arrangement with NOAA, NASA leverages its decades of experience to manage NOAA's satellite and instrument development, acquisition and contracting, and launch services. And once NASA checks out the satellite's on-orbit performance, it has a responsibility to NOAA for operational services.

The benefits of NASA's contributions, however, don't end there. NASA and NOAA can transition instruments initially designed for NASA's cutting-edge space-based Earth science research into NOAA's—NOAA's operational weather systems. The Moderate Resolution Imaging Spectrometer, MODIS, on NASA's Earth science, Terra and Aqua satellites lead to the development of their Visible Infrared Imaging Radiometer Suite, VIIRS, a key instrument on NOAA's current Joint Polar Satellite System (JPSS) series. And NASA's planned Earth science TROPICS (Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats) mission to involve a small satellite constellation could, if successful, provide options for future weather satellite missions and architectures.

NOAA's and NASA's collaboration is long and strong, though the partnership has had its share of changes over time. The challenges and eventual dissolution of the prior tri-agency, NOAA, NASA and DOD (Department of Defense), NPOESS (National Polar-orbiting Operational Environmental Satellite System) weather satellite program, led to NASA's establishment of the Joint Agency Satellite Division (JASD) within the Science Mission Directorate. The division provides a dedicated effort to manage NASA's work for NOAA.

It's clear both NOAA and NASA have learned a lot. Their decades-long relationship has matured to the point where NOAA and NASA jointly chair program management councils. We need to examine the lessons of this partnership, especially as the Federal Government considers equally challenging and important inter-agency efforts, including a space situational awareness, an era—area in which Space and Aeronautics Subcommittee are actively working, working together because reducing miscommunication and facilitating information flow are essential if we are to develop successful systems such as weather satellites, while minimizing cost, schedule, and management challenges.

For example, challenges with the GOES-R program's key instrument, the Advanced Baseline Imager (ABI), on the currently operating GOES-17 satellite led to significant redesign of the instrument for the follow-on GOES-T satellite, which launched 18 months later than planned. Ensuring that lessons learned from previous mistakes are incorporated into future programs is essential to successfully executing NOAA's critical weather forecasting program.

I look forward to hearing from our witnesses on how NOAA and NASA's partnership and decades of experience and lessons will

lead and advance our Nation's next-generation weather satellite systems.

[The prepared statement of Chairman Beyer follows:]

Good morning, and welcome to today's hearing, *Looking Back to Predict the Future: The Next Generation of Weather Satellites*.

I want to welcome our witnesses. We are pleased to have you with us, both in person and virtually.

Today, the Subcommittees on Environment and Space and Aeronautics are meeting jointly, and I want to thank Chair Sherrill for her collaboration on this hearing.

The importance of advanced, reliable weather prediction and understanding of long-term climate trends can't be understated. Devastating winds, storm surges, and flooding in Alaska and Puerto Rico are recent examples.

While weather continues to present serious risks to life and property, we've come a long way from 1900 when a hurricane with 135 mph winds decimated Galveston, Texas and wiped out 8,000 lives and an estimated 3,600 buildings.

Our nation's weather satellites and instruments are the workhorses that provide imagery and data to feed weather forecast models and predictive tools. These critical satellite capabilities support the government's core weather services, global users, as well as a thriving commercial weather industry.

Today, advanced technologies, increased scientific understanding of the Earth system, and a burgeoning commercial space industry are providing new options and opportunities for our next generation of operational weather systems.

We need to start by "Looking Back to Predict the Future", and that story begins with NASA.

In the earliest years of our space program, NASA developed and launched in 1960 the world's first weather satellite, the Television Infrared Observation Satellite—TIROS-1—equipped with two television cameras and two video recorders that proved the value of space-based weather observations.

A year later, President John F. Kennedy, in his historic May 1961 speech to a Joint Session of Congress, included a request for appropriations that "will help give us at the earliest possible time a satellite system for world-wide weather observation."

Follow-on TIROS satellites led to NASA's Nimbus series as NASA worked first with NOAA's precursor, and then NOAA, to establish a weather satellite system.

NASA also developed the first geostationary weather satellite, followed by the first operational Geostationary Operational Environmental Satellite—GOES—in 1975.

Today, through a reimbursable arrangement with NOAA, NASA leverages its decades of experience to manage NOAA's satellite and instrument development, acquisition and contracting, and launch services.

Once NASA checks out the satellite's on-orbit performance, it hands responsibility to NOAA for operational services. The benefits of NASA's contributions, however, don't end there.

NASA and NOAA can transition instruments initially designed for NASA's cutting-edge, space-based Earth science research into NOAA's operational weather systems.

The Moderate Resolution Imaging Spectrometer—MODIS—on NASA's Earth science Terra and Aqua satellites, led to the development of the Visible Infrared Imaging Radiometer Suite—VIIRS—a key instrument on NOAA's current Joint Polar Satellite System series.

And NASA's planned Earth science TROPICS mission—to involve a small satellite constellation—could, if successful, provide options for future weather satellite missions and architectures.

NOAA and NASA's collaboration is long and strong, though the partnership has had its share of changes over time.

The challenges and eventual dissolution of the prior tri-agency—NOAA, NASA, and DOD—NPOESS weather satellite program led to NASA's establishment of the Joint Agency Satellite Division within the Science Mission Directorate. The Division provides a dedicated effort to managing NASA's work for NOAA.

It's clear both NASA and NOAA have learned a lot. Their decades long relationship has matured to the point in which NOAA and NASA jointly chair program management councils.

We need to examine the lessons of this partnership, especially as the Federal government considers equally challenging and important interagency efforts, including in space situational awareness, an area on which the Space and Aeronautics Subcommittee is actively working.

Because reducing miscommunication and facilitating information flow are essential if we are to develop successful systems, such as weather satellites, while minimizing cost, schedule, and management challenges.

For example, challenges with the GOES-R program's key instrument, the Advanced Baseline Imager on the currently operating GOES-17 satellite, led to significant redesign of the instrument for the follow-on GOES-T satellite, which launched 18 months later than planned.

Ensuring that lessons learned from previous mistakes are incorporated into future programs is essential to successfully executing NOAA's critical weather forecasting mission.

I look forward to hearing from our witnesses on how NOAA and NASA's partnership and decades of experience and lessons will lead and advance our nation's next generation of weather satellite systems.

Chairman BEYER. So let me now recognize my friend, the Space and Aeronautics Subcommittee Ranking Member, Dr. Brian Babin, for an opening statement.

Mr. BABIN. Thank you, Mr. Chairman. Thank you for holding today's hearing as well and looking forward to hearing from our witnesses.

One of this Committee's top priorities in recent years has been improving the accuracy of weather forecasting in the United States. NOAA's short- and long-term weather forecasts utilize data from several sources, including a fleet of satellites orbiting above. These satellites in polar and geostationary orbit provide needed observations of the Earth system that are vital in the development of our weather forecasts, as well as monitoring and preparing for extreme weather events.

NOAA partners with NASA for the acquisition and the development of these satellites. NOAA establishes its requirements, and NASA issues contracts to develop these satellites within budget and ensure that they meet the technical specifications laid out by NOAA. NASA is responsible for the launch of these satellites and then turns over responsibility of these operations to NOAA. And though NOAA still has one more geostationary satellite to launch in 2024, the agency has laid out its initial plans for the next generation of geostationary satellites, which will be known as the Geostationary Extended Observation System (GeoXO), or more commonly known as GeoXO. At the same time, NOAA is continuing the deployment of its polar satellites through the Joint Polar Satellite System, with the next satellite JPSS-2 scheduled for launch in November.

And though these systems are currently working well, that was not always the case. A previous system of polar-orbiting weather satellites to be developed in partnership with the Department of Defense, known as NPOESS, was canceled due to cost overruns, technical challenges, and schedule delays. Additionally, the recently launched GOES-T satellite was delayed by more than 18 months because of a needed redesign of its Advanced Baseline Imager, or ABI, due to technical issues experienced by its predecessor, GOES-S.

Both GAO (Government Accountability Office) and the Department of Commerce's Inspector General have engaged in extensive reviews of NOAA's development process for its fleet of weather satellites and have offered a number of recommendations for how best to improve that process. Today's hearing should focus on how well NOAA has implemented these recommendations in the develop-

ment of the current fleet of satellites, as well as what lessons still must be applied to the next generation of weather satellites.

This Committee has a responsibility to ensure that taxpayer dollars are spent in the most responsible manner possible and we are getting the highest value for these satellites. As we consider how best to maximize the use of taxpayer dollars, we must continue to explore ways the Federal Government can partner with private—with the private sector to provide critical data.

We have seen tremendous growth in the capabilities of the commercial satellite industry in recent years. The *Weather Act*, sponsored by Ranking Member Lucas, and the *PROSWIFT Act* both contained pilot programs that allowed NOAA to purchase data from commercial sources. We have seen the commercial sector willing and able to provide data to NOAA. In fact, NOAA recently announced a second request for radio occultation data from commercial weather satellites. Additionally, the agency announced that three companies have received contracts to provide space weather data to the agency.

As we look ahead to the next generation of NOAA's weather satellites, we should consider how we can continue to leverage the innovation and the resources of the private sector as we work to provide the best weather forecast possible.

I want to thank our panel of witnesses for appearing before us today, and I look forward to a very productive discussion on this very important topic. And so with that, I'll yield back, Mr. Chairman.

[The prepared statement of Mr. Babin follows:]

Thank you for holding today's hearing, Mr. Chairman.

One of this Committee's top priorities in recent years has been improving the accuracy of weather forecasting in the United States. NOAA's short and long-term weather forecasts utilize data from several sources, including a fleet of satellites orbiting above.

These satellites, in polar and geostationary orbit, provide needed observations of the Earth system that are vital in the development of our weather forecasts as well as monitoring and preparing for extreme weather events.

NOAA partners with NASA for the acquisition and development of these satellites. NOAA establishes its requirements and NASA issues contracts to develop these satellites within budget and ensure they meet the technical specifications laid out by NOAA. NASA is responsible for the launch of these satellites and then turns over responsibility for operations to NOAA.

Though NOAA still has one more geostationary satellite to launch in 2024, the agency has laid out its initial plans for the next generation of geostationary satellites, which will be known as the Geostationary Extended Observation System, or more commonly known as GeoXO (pronounced Geo-X-O).

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Though these systems are currently working well, that was not always the case. A previous system of polar-orbiting weather satellites to be developed in partnership with the Department of Defense known as NPOESS (In-pose) was cancelled due to cost overruns, technical challenges, and schedule delays.

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In fact, NOAA recently announced a second request for radio occultation data from commercial weather satellites. Additionally, the agency announced that three companies have received contracts to provide space weather data to the agency. As we look ahead to the next generation of NOAA's weather satellites, we should consider how we can continue to leverage the innovation and resources of the private sector as we work to provide the best weather forecasts possible.

I want to thank our panel of witnesses for appearing before us today. I look forward to a productive discussion on this important topic.

Thank you, Mr. Chairman, and I yield back.

Chairman BEYER. And thank you, Doctor.

Mr. BABIN. Yes, sir.

Chairman BEYER. The Chair now recognizes the Environment Subcommittee Chairwoman Mikie Sherrill for an opening statement.

Ms. SHERRILL. Well, thank you so much, Chairman Beyer, and thank you to our Ranking Member, Dr. Babin. It's wonderful to be here today. And to our witnesses, thank you for joining us both in person and virtually. I'm looking forward to hearing about the successes and lessons learned from the current weather satellite programs, as well as learning more about what is to come with the next generation of satellites.

The National Oceanic and Atmospheric Administration's weather satellite programs play a key role in its mission to share Earth observations and scientific data used by the public, private, and academic sectors. Access to this knowledge is critical to communities in becoming resilient and weather-ready. My district and many of my colleagues' districts have seen increasingly frequent and severe weather. Communities such as Little Falls, Woodland Park, and Denville in my district have faced repeated catastrophic and sometimes deadly flooding events such as the high-intensity rainfall from remnants of Hurricane Ida.

I'm interested in hearing from our witnesses today about how observations by these satellites and the next generation after them will give communities like those in New Jersey's 11th District accurate and up-to-date forecasting tools to predict and avoid life-threatening weather, especially extreme rainfall, and confront the ever-worsening effects of the climate crisis.

At the national level, rainfall and flooding like that experienced in New Jersey and other extreme weather events can cause billions of dollars in losses to our communities. NOAA found that by July of this year, the U.S. had already experienced nine weather and climate disasters that exceeded \$1 billion each, and the year is not over yet. We are still in the midst of what is predicted to be an above-average Atlantic hurricane season. And just this past Sunday, Hurricane Fiona made landfall in Puerto Rico, knocking out power to the island and causing catastrophic flooding.

That's why this hearing is so critical. So many aspects of our society and our economy depend on the environmental weather and climate information collected from these satellites. Any potential satellite malfunction or launch delay could cause data gaps that would be devastating to national security, the U.S. economy, and most importantly, public safety.

It has been several years since this Committee has done extensive oversight over our Nation's operational weather satellite programs. Today, we will hear about the successful partnership between NOAA and NASA to develop, launch, and operate the current generation of geostationary and polar-orbiting weather satellites. In fact, earlier this year, we celebrated the successful launch of the third satellite in the GOES-R series, and we look forward to what we hope is another successful launch of the JPSS-2 satellite later this year.

The credit for these recent successes is largely due to our esteemed NOAA and NASA witnesses today and the teams that support their efforts. However, this partnership has not been without its issues, as we've heard. Both the Joint Polar Satellite System and Geostationary Operational Environmental Satellite programs initially faced ballooning costs and extended delays.

Since then, NOAA and NASA have successfully turned around these programs. Despite some challenges, including instrument malfunctions on orbit, the agencies have worked to ensure no disruption in observations and that the same mistakes are not repeated. Continued planning, testing, and adjustments are required to minimize the risk of any potential loss of observational data. I hope to hear about the current contingency plans in case any potential malfunctions or mishaps occur and how NOAA and NASA will work together to address any issues.

As the projected end of service dates for both the GOES-R and JPSS series are expected at the end of the next decade, it's important for NOAA to be developing the capabilities of the next generation of satellites with the help of NASA's expertise. NOAA is taking into consideration new technologies and increasing user needs through input from a variety of stakeholders, while establishing the future satellite architecture in a timely and cost-effective way.

With all these considerations and lessons learned from the current weather satellites, I look forward to hearing from NOAA and NASA about their progress in the next generation of weather satellites. The time is right for discussion on GeoXO, and the future of low-Earth orbit (LEO) and space weather satellites.

The importance of these satellites providing uninterrupted environmental and weather observations at a time when climate change is causing more severe and frequent extreme weather events cannot be stressed enough. The Department of Commerce's Office of Inspector General's (OIG's) continuous oversight of the satellite programs provides Congress and the public with consistent updates on possible risks these programs may face. I look forward to hearing the OIG's findings of a recent audit on NOAA's progress of the next-generation satellites, as well as any recommendations OIG may have in improving this progress.

Again, thank you to our witnesses for being here today. My colleagues and I are committed to supporting the continued success

of the Nation's operational weather satellites. And with that, I yield back. Thank you, Mr. Chair.

[The prepared statement of Ms. Sherrill follows:]

Thank you, Chairman Beyer, and our witnesses, for joining us today both in person and virtually. I am looking forward to hearing about the successes and lessons learned from the current weather satellite programs, as well as learning more about what is to come with the next generation of satellites.

The National Oceanic and Atmospheric Administration's weather satellite programs play a key role in its mission to share Earth observations and scientific data used by the public, private, and academic sectors. Access to this knowledge is critical to communities in becoming resilient and weather-ready. My district, and many of my colleagues' districts, have seen increasingly frequent and severe weather.

Communities such as Little Falls, Woodland Park, and Denville in my district have faced repeated, catastrophic, and sometimes deadly flooding events, such as the high intensity rainfall from remnants of Hurricane Ida. I am interested in hearing from our witnesses today about how observations by these satellites—and the next generation after them—will give communities like those in New Jersey's 11th district accurate and up-to-date forecasting tools to predict and avoid life-threatening weather—especially extreme rainfall—and confront the ever-worsening effects of the climate crisis.

At the national level, rainfall and flooding like that experienced in New Jersey and other extreme weather events can cause billions of dollars in losses to our communities. NOAA found that by July of this year, the U.S. had already experienced nine weather and climate disasters that exceeded one billion dollars each, and the year is not over yet.

We are still in the midst of what is predicted to be an above average Atlantic Hurricane Season. Just this past Sunday, Hurricane Fiona made landfall in Puerto Rico knocking out power to the island and causing catastrophic flooding. That is why this hearing is so critical. So many aspects of our society and economy depend on the environmental, weather, and climate information collected from these satellites. Any potential satellite malfunction or launch delay that could cause data gaps that would be devastating to national security, the U.S. economy, and most importantly, public safety.

It has been several years since this Committee has done extensive oversight over our Nation's operational weather satellite programs. Today we will hear about the successful partnership between NOAA and NASA to develop, launch, and operate the current generation of geostationary and polar-orbiting weather satellites. In fact, earlier this year we celebrated the successful launch of the third satellite in the GOES-R Series, and we look forward to what we hope is another successful launch of the JPSS-2 satellite later this year. The credit for these recent successes is largely due to our esteemed NOAA and NASA witnesses today, and the teams that support their efforts.

However, this partnership has not been without its issues. Both the Joint Polar Satellite System (or "JPSS") and Geostationary Operational Environmental Satellite (or "GOES") programs initially faced ballooning costs and extended delays. Since then, NOAA and NASA have successfully turned around these programs. Despite some challenges, including instrument malfunctions on-orbit, the agencies have worked to ensure no disruption in observations, and that the same mistakes are not repeated. Continued planning, testing, and adjustments are required to minimize the risk of any potential loss of observational data. I hope to hear about the current contingency plans in case of any potential malfunctions or mishaps, and how NOAA and NASA will work together to address any issues.

As the projected end of service dates for both the GOES-R and JPSS Series are expected at the end of the next decade [2040 and 2039, respectively], it is important for NOAA to be developing the capabilities of the next generation of satellites with the help of NASA's expertise. NOAA is taking into consideration new technologies and increasing user needs through input from a variety of stakeholders while establishing the future satellite architecture in a timely and cost-effective way. With all these considerations and lessons learned from the current weather satellites, I look forward to hearing from NOAA and NASA about their progress on the next generation of weather satellites. The time is ripe for a discussion on GeoXO, and the future of low Earth orbit and space weather satellites.

The importance of these satellites providing uninterrupted environmental and weather observations at a time when climate change is causing more severe and frequent extreme weather events cannot be stressed enough. The Department of Commerce's Office of Inspector General's continuous oversight of the satellite programs provides Congress, and the public, with consistent updates on possible risks these

programs may face. I look forward to hearing OIG's findings of a recent audit on NOAA's progress of the next generation satellites as well as any recommendations OIG may have in improving this progress.

Again, thank you to all our witnesses for being here today. My colleagues and I are committed to supporting the continued success of the nation's operational weather satellites.

I yield back the balance of my time.

Chairman BEYER. Thank you, Chairwoman Sherrill, very much.

Now, the Chair recognizes the Environment Subcommittee Ranking Member, Congresswoman Stephanie Bice, for an opening statement.

Mrs. BICE. Thank you, Chairman Beyer and Chairwoman Sherrill. And thank you to our witnesses for taking the time to share your expertise with us this morning.

When you drive across the State of Oklahoma, you can easily spot many signs of the traditional weather enterprise. You'll see weather stations and their Doppler radars and transmitting towers. You'll see mesonet stations on public and private land that make up our best-in-class State system. And if you can make it to Norman, Oklahoma, you'll see the National Weather Center, the premier hub for Federal, State, and academic research related to weather modeling and prediction.

But all of this is just half of our capabilities. What you can't see are the highly technical instruments orbiting above us in space. To truly understand and monitor their full range of global and national weather patterns, NOAA, NASA, and the National Weather Service collaborate on a fleet of satellites that circle the Earth and collect vast amounts of data critical to weather modeling and forecasting.

Currently, NOAA owns or operates a total of 16 satellites, 10 of which they own and operate themselves. The other six are partnerships in which NOAA is critical to the operations. Many of them are the result of recent efforts and congressional support. In fact, it was just in March of this year that NOAA launched its most recent and most sophisticated satellite known as GOES-18. The GOES program has faced its fair share of challenges, ranging from equipment failures to COVID delays, but I look forward to the launch of the final satellites in this series, GOES-U in 2024. I'm also eager to discuss the lessons learned as we transition to the next generation of satellite systems, GeoXO.

At the same time, it is important that we remember that the design and launch of satellites are just two pieces of the puzzle. In order to truly see the maximum benefits of these efforts, we must ensure that the data is useful to the weather community and that we have adequate ground systems to get the information obtained from space to them. An important part of this will be the development and use of high-performance computing by the weather enterprise. More computing power and better models will allow meteorologists to input large amounts of data, run weather models more times for accuracy, and produce a higher-resolution forecast, ultimately saving lives and property.

Although there is room for improvement and increased support, NOAA should not be alone in this effort. The commercial weather industry has seen tremendous growth over the last decade and has shown the value their partnerships can add to Federal agencies' ex-

isting efforts. Private companies and research institutions have both computing resources and satellite data, both of which NOAA can acquire for use for a fraction of the cost it would take for them to build it out. The commercial weather data program and NOAA has proved these partnerships can be successful and benefits all parties involved.

Additionally, researchers at universities can lead the development of next-generation instruments that can either be added to the commercial satellites or launch on their own dedicated payload. These are the type of cost-effective solutions we should encourage and support to supplement Federal observation efforts.

Again, I want to thank the witnesses for being with us this morning, and I look forward to your testimony. Mr. Chairman, I yield back the balance of my time.

[The prepared statement of Mrs. Bice follows:]

Thank you, Chairman Beyer and Chairwoman Sherrill, and thank you to our panel of witnesses for taking the time to share their expertise with us this morning.

When you drive across the state of Oklahoma, you can easily spot many signs of the traditional weather enterprise. You'll see weather stations with their Doppler radars and transmitter towers. You'll see mesonet stations on public and private land that make up our best-in-class state system. And if you make it to Norman, you'll see the National Weather Center—the premier hub for federal, state, and academic research related to weather modeling and prediction.

But all of this is just one half of our capabilities. What you can't see are the highly technical instruments orbiting above us in space. To truly understand and monitor the full range of global and national weather patterns, NOAA, NASA, and the National Weather Service collaborate on a fleet of satellites that circle the Earth and collect vast amounts of data critical to weather modeling and forecasting.

Currently, NOAA owns or operates a total of 16 satellites—ten of which they own and operate themselves, the other six are partnerships in which NOAA is critical to the operations. Many of them are the result of recent efforts and Congressional support. In fact, it was just in March of this year that NOAA launched its most recent—and most sophisticated—satellite, known as GOES-18.

The GOES program has faced its fair share of challenges, ranging from equipment failures to COVID delays, but I look forward to the launch of the final satellites in the series: GOES-U in 2024. I'm also eager to discuss the lessons learned as we transition to the next generation satellites system, GeoXO.

At the same time, it's important we remember that the design and launch of satellites are just two pieces of the puzzle. In order to truly see the maximum benefits of these efforts, we must ensure that the data is useful to the weather community and that we have adequate ground systems to get the information obtained from space to them.

An important part of this will be the development and use of high-performance computing by the weather enterprise. More computing power and better models will allow meteorologists to input large amounts of data, run weather models more times for accuracy, and produce a higher resolution forecast—ultimately saving lives and property.

Although there is room for improvement and increased support, NOAA shouldn't be alone in this effort. The commercial weather industry has seen tremendous growth over the past decade and has shown the value their partnerships can add to federal agencies' existing efforts.

Private companies and research institutions have both computing resources and satellite data, both of which NOAA can acquire or use for a fraction of the cost it would take for them to build out. The Commercial Weather Data Program at NOAA has proved these partnerships can be successful and benefit all parties involved.

Additionally, researchers at universities can lead the development of next generation instruments that can either be added to commercial satellites or launch on their own dedicated payload.

These are the type of cost-effective solutions we should encourage and support to supplement federal observation efforts.

Again, I want to thank our witnesses for being here today and I look forward to each of your testimony. Thank you, Chairman Beyer, I yield back the balance of my time.

Chairman BEYER. Thank you, Congresswoman Bice.

If there are Members who wish to submit additional opening statements, your statements will be added to the record at this point.

[The prepared statement of Chairwoman Johnson follows:]

Good morning and thank you to Chairs Beyer and Sherrill for holding this important hearing on the future of NOAA's weather satellites.

The importance of NOAA's weather satellites is unquestionable. The ability of the National Weather Service to provide accurate and lifesaving forecasts often starts with data collected by these satellites. This past week, we have seen the devastating remnants of a typhoon pummeling Western Alaska. Despite record storm surge and hurricane force winds, the Weather Service was able to provide timely warnings that allowed Alaskans to evacuate with no injuries or fatalities reported thus far. And earlier this week, Hurricane Fiona caused Puerto Rico to lose power, and flooding due to catastrophic rainfall continues. As we evaluate the devastation caused by this storm on the five-year anniversary of Hurricane Maria, I am hopeful that timely warnings based in part on data from those critical satellites helped to minimize the loss of life in Puerto Rico as well.

These are just a few recent examples of why it is important not only for the public to know the value of these assets but also for Congress to understand how a program of this magnitude is being carried out to ensure its continued success. As these types of once in a lifetime storms become more commonplace due to climate change, it is vital that NOAA's future satellite programs not only maintain current capabilities, but further enhance them to deal with a rapidly changing climate and protect communities most at risk from climate impacts.

In years past, this Committee held oversight hearings to provide insight into weather satellite programs that faced delays and growing costs. This work led to a reconfiguration of NOAA's satellite programs, and further formalized the ongoing partnership between NOAA and NASA. This interagency partnership to develop, launch, and operate these satellites has led to significant overall improvement in program implementation. The current geostationary, or GOES-R series, and polar-orbiting, or JPSS satellites made significant advancements in image quality and detection capabilities from previous programs.

As NOAA and NASA embark on the next generation of weather satellites to follow GOES-R and JPSS, it is important to understand what metrics are being used to develop future programs. That is why the oversight work of the Office of Inspector General at the Department of Commerce is crucial. Having regular, independent, and thorough assessments of the ongoing satellite programs helps to ensure the most successful outcomes possible.

This Committee has done a great deal of work in showing the value of weather and climate data to Americans in their everyday lives. It is important to understand how lessons learned from previous and current satellite development programs can help inform future satellite architectures. I anticipate a robust and enlightening discussion with our witnesses this morning on what to expect in the coming years and decades.

Thank you and I yield back.

Chairman BEYER. At this time, I'd like to introduce our witnesses. Our first witness today is Dr. Stephen Volz. He's the Assistant Administrator of the National Environmental Satellite, Data, and Information Services (NESDIS) at NOAA. Dr. Volz has 35 years of professional experience in aerospace. He's a leader in the international Earth observation community, serving as NOAA's principal both to the Committee on Earth Observation Satellites, CEOS, and at the Coordinating Group of Meteorological Satellites. Dr. Volz is the principal U.S. representative to the International Group on Earth Observations, and he helps leads efforts to coordinate global satellite-based observations among the international space agencies. He serves as the co-Chair of the NOAA Observing Systems Council and is also a member of the NOAA Executive Council.

Our next witness today is Mr. John Gagosian. Mr. Gagosian serves as Director of the Joint Agency Satellite Division at NASA,

which is responsible for the development of space systems supporting operational weather observation requirements of NOAA. His role as Director of JASD, he assesses program and project performance, as well as risk. Prior to joining JASD, Mr. Gagosian represented NASA's Science Mission Director's Astrophysics Division Program Executive for the Exoplanet Exploration Program and the Nancy Grace Roman Space Telescope. Mr. Gagosian also previously served as the Program Executive for the Hubble Space Telescope, Stratospheric Observatory for Infrared Astronomy, and the Cosmic Origins Program.

Our final witness is Mr. Frederick Meny. Mr.—am I saying that right?

Mr. MENY. Yes, you are.

Chairman BEYER. OK, great. Mr. Meny is the Assistant Inspector General for Audit and Evaluation at the U.S. Department of Commerce. He leads the oversight efforts regarding intellectual property, IT (information technology) security, cybersecurity, and satellite and weather systems. Mr. Meny has more than 35 years of Federal Government experience in leading, managing, and directing organization staff, budgets, and IT resources, as well as major systems acquisition and development programs. During his 25 years with the OIG, Mr. Meny has led numerous reviews that improve the 2020 and 2010 decennial censuses, departmentwide acquisitions and grants, First Responder Network Authority management, USPTO's (U.S. Patent and Trademark Office's) patents and trademarks, and NOAA's polar and geostationary satellites and weather systems development and operations.

We are delighted to have all of you here. As you should know, you'll each have five minutes for your spoken testimony. Your written testimony can be much, much longer, and it will be included in the record for the hearing. When you have all completed your spoken testimony, we will begin with the grueling questions. Each Member will have five minutes to question the panel.

So we will start with Dr. Volz, who is here with us virtually. Dr. Volz, the floor is yours.

**TESTIMONY OF DR. STEPHEN VOLZ,
ASSISTANT ADMINISTRATOR,
NATIONAL ENVIRONMENTAL SATELLITE,
DATA, AND INFORMATION SERVICES, NOAA**

Dr. VOLZ. Thank you, sir. Good morning, Chairs Sherrill and Beyer, and Ranking Members Bice and Babin, and all Members of the Committee. And as I've been introduced, Dr. Volz, head of the NOAA's, Environmental Satellite Data Information Service. It's a real honor to be invited to speak to you, and it's a pleasure to talk to you about the successes we've had and about the importance of the information from our satellite observing system to address the challenges from climate change and severe storm events that we are experiencing. We need no greater or more compelling reminder of the importance of our mission than the terrible storms that have made landfall in Puerto Rico and western Alaska in just the last few days.

NOAA has a very unique mission: to understand, predict, and support the health of our oceans and atmosphere. We save lives,

protect property, and enhance the American economy by monitoring and forecasting weather, water, and the climate, informing our citizens every day. We deploy ships and planes buoys, balloons, and drones, and satellites. Satellite data account for around 90 percent by volume of all the data used by NOAA's forecast models, and satellites are essential to develop and to extend essential planetary climate data records, which allow us to understand the changing planet.

But we don't just use satellite data. In fact, NOAA devices plans for the Nation's Environmental Satellite Program, manages their construction, and operates them, while NASA builds and launches them on our behalf. NASA is our longest-standing and closest strategic partner in observing Earth and space. Our agency's missions are complementary. NASA and NOAA both conduct Earth and climate science research and model development. NASA develops new space technologies. NOAA exploits those and other technologies and delivers the observations and information the Nation needs. And that need is great and growing greater.

Our experience with hurricane observations and research has taught us this lesson over the years: that better observations from satellites, geostationary and low-Earth orbit from aircraft and other systems and better research and data simulation all have led to improved forecasts and outcomes for communities in the paths of storms. Since Hurricane Andrew in 1992, we have reduced hurricane track accuracy error by 75 percent and intensity forecast error by 50 percent with these efforts.

We will continue to face hurricanes, stronger and more frequent than in the past, but we're also dealing with significantly more frequent and severe extreme events, including wildfires and flooding. We need to be able to forecast fire and flooding events, as well as derechos and ice storms, with the same level of confidence, not hours, but days in advance to prepare emergency managers and communities to respond. To do this, we need better observations and better models. And NESDIS is working to deliver those improvements with our next-generation satellite observing system, with better and more information, all leading to a better NOAA.

Recently, we completed the NOAA Architecture Study to help define our next-generation missions and integrate NOAA's assets with those of our international and commercial partners. We have demonstrated with our current programs the value of buying instruments and other essential program elements in bulk to reduce mission cost and risk and the value of selectively using different contracting approaches.

NOAA's geostationary satellites provide the only continuous near-real-time observations of the Western Hemisphere. Supporting severe weather and extreme events, watches and warnings, our next-generation Geostationary Extended Observations, or GeoXO mission, will continue and expand the current GOES-R series. GeoXO's first launch will be in 2032, followed by five more satellites with planned observation through 2055. One of GeoXO's advanced capabilities is a hyperspectral infrared sounder. This sounder install will provide significantly improved real-time vertically resolved observations of wind speed and direction. With

these data, experts will be able to better track and monitor storms and to better predict the behavior of fire and smoke.

NOAA's current fleet of low-Earth orbit satellite, JPSS, provides continuous observations, and together with our partners satellites, are the backbone of the global weather forecasting models. NOAA's future LEO satellites will supplement and eventually replace our current JPSS satellites. They will provide more frequent and varied observations and better spatial and vertical resolution, improving modeling and driving higher resolution short- and long-term weather forecasts.

Our Nation's current space weather system includes NOAA observations, along with NASA and other research satellites. And with these, NOAA provides forecasts that help safeguard power grid infrastructure, civil aviation, and spacecraft and astronauts. Space Weather Next will maintain and extend those observations from multiple observing points to improve critical storm forecasts for current users and for the expanding commercial space industry. These observations are required and has been authorized through the *PROSWIFT*.

In conclusion, I'll state we know our citizens need weather and environmental informations to thrive in this changing world. NOAA and NESDIS, we're not only ready to do this, we were created for this mission. And I thank you for your strong and continued support of NOAA's mission and its satellite program, and I'm happy to answer your questions. Thank you, sir, and back to you, Chairman.

[The prepared statement of Dr. Volz follows:]

**WRITTEN STATEMENT BY
STEPHEN M. VOLZ
ASSISTANT ADMINISTRATOR
NATIONAL ENVIRONMENTAL SATELLITE, DATA,
AND INFORMATION SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE**

**HEARING TITLED
“LOOKING BACK TO PREDICT THE FUTURE: THE NEXT GENERATION OF
WEATHER SATELLITES”
BEFORE THE
SUBCOMMITTEE ON ENVIRONMENT
AND THE
SUBCOMMITTEE ON SPACE AND AERONAUTICS
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES**

September 21, 2022

Chairwoman Sherrill, Chairman Beyer, Ranking Members Bice and Babin, and Members of the Subcommittees, I am Dr. Stephen Volz, the Assistant Administrator of NOAA’s National Environmental Satellite, Data, and Information Service (NESDIS). Thank you for the opportunity to participate in today’s hearing. I am pleased to join the other witnesses, John Gagosian, Director of NASA’s Joint Agency Satellite Division and Fred Meny, Assistant Inspector General of the Department of Commerce Office of the Inspector General to discuss NOAA’s next generation of environmental satellites and the importance of these assets for the Nation.

NOAA has a unique mission to understand, predict, and support the health of our oceans and atmosphere. From daily weather forecasts and severe storm warnings to fisheries management, coastal restoration, and data to enhance marine commerce, NOAA’s products and services promote economic vitality, affecting more than one-third of America’s gross domestic product. We work to save lives, protect property, and enhance the American economy through the timely delivery of trusted weather, water, and climate forecasts, analyses, and information.

For decades, NOAA has been at the forefront of the world’s weather and climate enterprise. We are a global leader in measuring, observing, modeling, archiving, and delivering data and information on the Earth’s changing environment with state-of-the-art coastal, marine, terrestrial, aerial, and space-based observing platforms. These measurements form the basis of NOAA’s weather and climate products and services, which afford vital industries—shipping, fishing, agriculture, construction, energy and water resources, and more—the ability to predict and plan

for the future. As an authoritative source for weather and water data, we provide critical predictions and decision support tools

Satellite data sets are essential for NOAA predictions and monitoring across all scales and times, and account for around 90 percent of all data that is used by NOAA's operational forecast models. NOAA has the distinct and important role of planning for, managing builds of, and operating the Nation's operational environmental satellites. Our satellites are relied upon 24 hours a day, seven days a week for weather, ocean, climate, and space weather data by NOAA, as well as individuals, businesses, and all levels of government to protect lives and property within the U.S. and around the world.

NOAA accomplishes this environmental satellite and data mission through strategic partnerships and operational cooperation with a number of Federal, private, and international space organizations. Our longest standing and closest strategic partner in earth observations from space is the National Aeronautics and Space Administration (NASA). [NOAA's Mission](#)¹ is "science, service, and stewardship to understand and predict changes in climate, weather, ocean and coasts; to share that knowledge and information with others; and to conserve and manage coastal and marine ecosystems and resources." [NASA seeks](#)² "new knowledge and understanding of our planet Earth, our Sun and solar system," and "to understand how biological and physical systems work at a fundamental level," with the intent to understand "how and why Earth's climate and environment (are) changing." These complementary missions enable NOAA to address the observation and information needs to meet the operational service delivery demands of the Nation, including among other services, environmental and climate predictions and analysis, and weather and water forecasts, warnings, and information.

NOAA also has strategic partnerships with the Department of Defense, the U.S. aerospace industry, and the international space earth observations community. NOAA benefits from and leverages our partnerships with Cooperative Institutes and Minority Serving Institute Cooperative Science Centers for R2O2R (research to operations to research) and algorithm development to increase the use of NOAA's satellite data to address societal challenges. NOAA has provided integral environmental satellite data since the 1960s and we plan to do so into the future, as our next generation of satellite architecture will extend well into the 2050s and beyond, serving as the national backbone for environmental satellite information. NOAA has benefited from the longstanding support of the U.S. Congress to provide oversight and appropriations for our satellite programs. I am pleased to provide an update on our next-generation satellite architecture plans and discuss the importance of our future environmental data for our Nation.

¹ If the hyperlink is insufficient, here is the weblink: <https://www.noaa.gov/our-mission-and-vision>

² <https://science.nasa.gov/about-us/smd-vision>

NOAA's User Needs

At NESDIS, our satellite data and information has prominently supported NOAA's weather forecasting mission to provide forecasts, watches, and warnings for the protection of life and property.

Our improvements to satellite data and information are focused on meeting the evolving needs for end-use products and services that are provided reliably. Over the past five years, even through the Covid-19 pandemic, NOAA has had meaningful interactions with numerous stakeholders to ensure that we understand the requirements of our primary users. We have also met with the customers of our users to ensure that we understand the downstream needs of our products and services and address future needs.

Every day, we see communities grappling with environmental challenges due to unusual or extreme events that affect their health, security, and economic well being. Below are some examples of regions, populations, and severe events that benefit from observations from NOAA satellites.

Coastal Populations. In 2020, the marine economy accounted for \$361.4 billion, or 1.7 percent of current-dollar U.S. gross domestic product.³ The concentration of people and economic activity at the coasts places pressures on ecologically sensitive coastal ecosystems and leaves residents and visitors vulnerable to coastal hazards such as hurricanes, erosion, sea level rise, and harmful algal blooms.

Underserved Communities. The most severe harm from climate change falls disproportionately upon underserved communities who are least able to prepare for, and recover from, heat waves, poor air quality, flooding, coastal erosion, and other impacts. For example, African American individuals are more likely to live in areas with the highest projected increases in childhood asthma diagnoses and extreme temperature related deaths.⁴

Farmers. Key production regions for food grains in central California and the central U.S. are experiencing severe drought this year. According to the U.S. Department of Agriculture, as of August 2, 2022, drought affected at least 45 percent of the production acreage for barley, cotton, rice, sorghum, winter wheat, and hay.⁵

Arctic. The Arctic is warming two to three times as fast as the global average and warming is projected to continue. Older, thicker sea ice that once covered the central Arctic ocean is now

³ [Marine Economy Satellite Account, 2014-2020](#), Bureau of Economic Analysis, 2022

⁴ [Climate Change and Social Vulnerability in the United States: A Focus on Six Impact Sectors](#), Environmental Protection Agency.

⁵ USDA summary of agricultural products affected by drought. USDA. August 2022.

almost entirely gone.⁶ Extreme events and increasing variability throughout the Arctic impact the safety and well-being of communities within and far away from the Arctic, and carry implications for U.S. national security interests.⁷

Wildfires. Drought and persistent heat set the stage for extraordinary wildfire seasons from 2020 to 2022 across many western states.⁸ Such rapid increase of wildfires has become a major threat to lives, property, public health, electricity supply, water resource quality, and local and regional economies in the western U.S. and beyond.

Floods. Floods are the most common and widespread of all weather-related natural disasters.⁹ In June through August 2022, major flooding or flash floods occurred in six states, as well as Death Valley National Park and Yellowstone National Park.

Heat. Heat is the leading cause of all weather-related deaths in the United States.¹⁰ In summer of 2022, more than 150 million people were placed under heat warnings and advisories.

Harmful Algal Blooms. Harmful algal blooms (HABs) occur when algae grow out of control. These HABs may produce toxic or harmful effects on people, infrastructure, fish, shellfish, marine mammals, and birds. HABs have been reported in every U.S. coastal state, and their occurrence are on the rise, affecting the health of people and marine ecosystems.

NOAA is working to meet these challenges through the provision of trusted and validated data and information as well as user-ready products and services. NOAA must be innovative—leveraging new technological solutions, developing broader business models and partnerships with public and private sectors, and demonstrating organizational agility to adjust to changing needs, opportunities, and risks. We must do this all while meeting our critical mission of delivering environmental observations without interruption.

Solely maintaining current satellite performance and capabilities will not provide the necessary observations to monitor future global climate change and its impacts throughout the Earth system, and will not allow for the monitoring of our important ocean ecosystems. Our communities need better information which is scaled and designed to meet their local and specific needs to address the challenges of increased extreme weather events and environmental changes. New technologies, which are developed by the commercial sector and often demonstrated by NASA research satellites, must be integrated into NOAA's next-generation

⁶ Arctic Report Card: Update for 2021. NOAA. 2021.

⁷ Department of Defense Arctic Strategy. DOD. 2019.

⁸ Wildfire Climate Connection. NOAA.gov. August 2022.

⁹ Severe Weather 101. NOAA National Severe Storms Laboratory.

¹⁰ [Weather Related Fatality and Injury Statistics](#). National Weather Service.

satellite architecture to enable us to more completely deliver to users the most impactful observations and data in support of the NOAA mission.

NOAA's Next-Generation Satellite Architecture

NOAA NESDIS' next-generation satellite programs will provide enhanced observations through the 2050s to meet increasing and evolving needs, contributing both continuous and innovative environmental information to diverse end users. NESDIS will also modernize our information systems architecture by including seamless integration of NESDIS and partner satellite data and in situ, ship, plane, and drone observations. Developing these next-generation satellite architecture and re-engineered information systems takes a decade or longer from concept to launch and full deployment. Scoping of the next generation satellite programs is underway and definitive life cycle costs (LCC) have not been finalized. Arriving at approved program scopes and final LCCs, along with the relevant technological review assessments, will be developed in close coordination and consultation with NASA and the Department of Commerce's Office of Acquisition Management.

NESDIS conducted the NOAA Satellite Observing System Architecture study from 2014 to 2017 to evaluate alternative architectures for its next-generation missions. The study indicated a few key takeaways for consideration in NOAA's next-generation satellite constellation plans, including an integrated system of observations from NOAA and international and commercial partners. NESDIS used this comprehensive assessment to guide the design and development framework for the future architecture, and continues to develop NOAA's next-generation plans based on new information and resource constraints.

Our next-generation plans are also informed by our space engineering experience over past decades, such as the successes of the Geostationary Operational Environmental Satellite (GOES)-R Series and Joint Polar Satellite System (JPSS) programs, the experiences of our domestic and international partners, and the U.S. commercial space sector. For example, the GOES-R program has demonstrated the cost and risk reduction benefits of "bulk buys" of essential program elements such as instruments and space craft; the JPSS program demonstrated the value of selective use of firm fixed price procurements. These lessons learned and coordination activities are focused on delivering reliable and continuous data and information for users.

Further, NOAA relies on the US aerospace industry for support throughout the lifecycle of the satellite acquisition-from instrument and spacecraft bus development, to launch vehicle and services, to development and deployment of the antennas and ground system. NOAA is increasingly assessing the ability of commercially provided data to fill specific mission requirements. Through the Commercial Weather Data Pilot and the Commercial Data Program, NOAA has purchased radio occultation data that are currently being ingested into its weather

forecast models. As the commercial sector demonstrates the ability to deliver data that meets its mission requirements, NOAA will continue to engage and acquire these commercially-based data as part of its overall next generation satellite architecture plans.

To best facilitate user needs across orbits and observations, we are looking at NOAA's future space architecture in three portfolios: geostationary observations, low earth orbit, and space weather observations (see Figure 1). The next-generation enterprise architecture also includes an evolved support system to operate the satellites and use the data. This includes supporting our satellite operators while integrating more and varied observing system elements. It also involves evolving the ground infrastructure into a system that supports all satellites and ensuring the data are reliable and shareable. We will leverage science to transform the "bits and bytes" received from around the world into timely, actionable, and reliable environmental information and to create new data products and services. NOAA's future architecture will also ensure the quality, accuracy, and preservation of the Nation's historical environmental data archives while augmenting this vast repository with new data sets, merged products, and integrated observations from NOAA, U.S., and global observing systems.

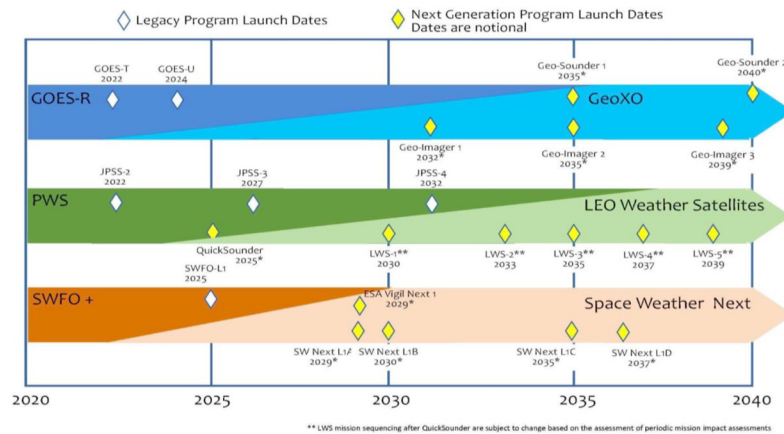


Figure 1: Notional Floyout of NOAA's Next-Generation Satellites

Geostationary Observations. NOAA's Geostationary Earth orbiting (GEO) satellites provide the only continuous observations of weather and hazardous environmental conditions over the Western Hemisphere, from the eastern Atlantic to the western Pacific. Information generated from our GOES system helps protect the lives and property of the one billion people who live and work in the Americas with continuous, near-real-time observations and warnings. NOAA's Geostationary Extended Observations (GeoXO) program is the next generation of GEO

capabilities that will support terrestrial weather prediction and warning, climate adaptation and mitigation, healthy oceans, and resilient coastal communities and economies. As the follow-on program to the current GOES-R Series, GeoXO will provide continuity of critical geostationary data with its first launch in 2032 and planned observations through 2055. Due to the significant capabilities proposed, GeoXO is our largest investment through the 2030s, and due to the criticality of providing continuous observations, GeoXO has an aggressive 11-year development schedule.

The GeoXO pre-formulation phase included extensive, direct user outreach to thousands of end users in many dozens of organizations as well as observation value assessments. It also included Observational System Simulation Experiments (OSSEs) analyses, an analysis of observations relative to the NOAA mission service areas, and consultation with the NOAA Observing System Council to define future observational needs and select the recommended payload instruments for GeoXO. End users require continuity of existing observations for short-term forecasting, severe weather watches and warnings, and monitoring a range of hazardous environmental conditions, such as tropical storms, lightning and winds, flooding, snow, wildfires, volcanic ash, and others. Current and future instruments in NESDIS' geostationary observing system on GOES-R and GeoXO, respectively, support NOAA's weather mission with essential information to inform and protect people and property across the country. These observations, together with the 50 year record of GOES observations, provide an essential climatological data record supporting NOAA and national climate analyses and a range of climate products and services.

Users also seek new observations and NOAA is conducting industry studies to evaluate the technology readiness and costs of potential new instruments. A hyperspectral infrared sounder promises to improve localized forecasts and nowcasting—critical as extreme weather events including storms, tornados, and hurricanes become more frequent and more severe—by enhancing weather forecasting models. An atmospheric composition instrument could provide a new platform to monitor air quality, track dispersion of hazardous emissions (volcanic, smoke, chemical, and radioactive), and monitor greenhouse gasses. A geostationary ocean color instrument could complement instruments in low Earth orbit to expand NOAA's ocean observing system to support the blue economy, increase coastal resilience, and help enable NOAA's oceans, coastal, and fisheries services. This information is also valuable to other non-federal users to better assess ocean productivity and health, ecosystem change, aquaculture and fisheries management, coastal and inland water quality, seafood safety, and hazards such as harmful algal blooms.

Due to the international partnership of GEO satellites, GEO data will be leveraged in innovative global inputs that supplement Low Earth Orbiting (LEO) observations. NOAA observations will be matched with similar satellite missions deployed in the same period by EUMETSAT over Europe and by the Japanese Meteorological Agency and Korean Meteorological Agency over the

western Pacific and Asia, to create a GEO ring of observations. These combined observations will provide global data sets for use by NOAA and our international partners to meet global modeling system and mission service needs. NOAA has previously benefited from acquisition efficiencies as other partners have utilized U.S. instrument vendors to meet their own mission needs.

Low Earth Orbit. LEO satellites from NOAA, NASA, and international partners provide a half century of unbroken climate data records and are the backbone of global weather forecasting models. These satellites detect and monitor hazards such as fires, droughts, floods, poor air quality, coral bleaching events, unhealthy coastal waters, and others. NESDIS collects about half of the LEO data we use every day to meet our ongoing mission needs, with the balance provided by our interagency and international partners. Satellites in the LEO Weather Satellite Program will supplement, and eventually replace, the current JPSS satellites.

The next generation of NOAA LEO satellites will leverage commercial space capabilities for increased flexibility. Together with NOAA's fleet and aircraft observations, NESDIS LEO satellite data will support the missions of all NOAA services, including weather forecasting, fisheries management, ocean and coastal monitoring, and the research that supports these activities. As an example, a distributed constellation of satellites will provide greater diversity in data needed by the weather forecast models to cover all facets of the event under investigation, a resilient system less susceptible to individual satellite failures, and a higher refresh rate for measurements, which enables higher-accuracy weather forecasts and improvements in other key applications.

For accurate forecasts, weather models integrate measurements from microwave (MW), infrared (IR), and radio occultation (RO) sounders on polar satellites. These observations are especially important in polar regions where other observational data are sparse. For example, JPSS provides critical data for nearly all weather forecasting in Alaska, and this is critical for aviation and the maritime industry. Ozone measurements also track the health of the ozone layer.

Improved MW, IR, and RO soundings with more frequent observations and better spatial and vertical resolution have the potential to improve modeling and allow for higher-resolution short- and long-term weather forecasts. NOAA's next-generation LEO satellites would also provide vital data for wind speed, sea surface temperature, and ocean color. Hyperspectral ocean color imagery at improved spatial resolution would improve our understanding of harmful algal blooms and phytoplankton dynamics to give managers tools to mitigate economic impacts. Enhanced atmospheric chemistry sensors for methane, sulfur dioxide, ozone, and others would enable more timely and accurate forecasts of air quality hazards, and would allow us to assess climate change both granularly and holistically. It is important to note that this increased amount

and diversity of data going into forecast models may require the models to adapt and increase their computing power.

NESDIS has determined, through the NSOSA study and user engagement, that the LEO program could serve users by collecting and delivering the following global observations: MW soundings and imagery, hyperspectral IR soundings, RO soundings, visible-IR imaging including day-night band imagery, measurements of atmospheric chemistry including ozone, ocean surface winds, ocean color, radio detection and ranging imagery, 3D winds, and ocean surface height. NESDIS will continue to evaluate and prioritize these data demands as we scope the program.

Space Weather Observations. Space weather observations aid in safeguarding fundamental power grid infrastructure, civil aviation, and on-orbit assets and astronauts. According to the National Research Council, disabled electric power grids and collateral impacts from geomagnetic storms could result in economic and societal costs of up to \$2 trillion per large storm, and it could take four to ten years for full recovery.¹¹ Building on the Space Weather Follow-On (SWFO) program, the Space Weather Next (SW Next) program will reliably provide critical space weather products and services to observe and identify this hazard and support the needs of diverse users across the U.S. and internationally. These users will include the electric power and airline industries, utility and telecommunications companies, commercial and government satellite operators, U.S. and foreign governments, and the space weather research and academic communities.

Observations and measurements from NESDIS' SW Next program will be combined with complementary data collected by federal and international partners and processed through NESDIS' Office of Satellite Ground Services to provide the necessary information flow for space weather forecasts. This data and information flow will enable NOAA's Space Weather Prediction Center (SWPC), the Office of Space Commerce, and other operational users to deliver actionable information that protects critical power grid infrastructure and civil aviation, and provides essential space situational awareness.

SW Next will maintain and extend space weather observations from a range of different observing points, selected to most efficiently provide the comprehensive knowledge of the sun and the near-earth space environment. These observation points could include LEO, GEO, highly elliptical orbit, Lagrange Point 1 (L1) and, with the European Space Agency, Lagrange Point 5 (L5) orbits. These observations will provide near-real-time coronal mass ejection imagery, solar wind, solar imaging, coronal imagery, solar wind parameters, magnetospheric particles, and ionosphere parameters, and other relevant observations required to support space weather

¹¹ National Research Council 2009. Severe Space Weather Events Understanding Societal and Economic Impacts: A Workshop Report: Extended Summary. Washington, DC: The National Academies Press.
<https://doi.org/10.17226/12643>.

forecasts provided by SWPC. The program supports space weather forecasts as authorized by the Promoting Research and Observations of Space Weather to Improve the Forecasting of Tomorrow (PROSWIFT) Act (P.L. 116-181) and as driven by the National Space Weather Strategy and Action Plan (March 2019). Several complementary projects within SW Next will provide continuity and resiliency of space weather observations from multiple orbits, with launches in the 2020s, early 2030s, and onward. Just as with our LEO portfolio, it is important to note that this increase in the amount and diversity of the data must be accompanied by improvements in our space environment and weather models, requiring the models to adapt and increase their resolution and available computing power.

Space weather observations are needed from a multitude of orbit views, requiring multiple program capabilities to fulfill the necessary architecture. SW Next is therefore pursuing partnerships to augment the SW Next architecture. In addition, SW Next is developing a methodology to understand the impacts of observational capabilities on user needs such as alerts, watches, and warnings. We are engaging with users to better understand how our products and services support end-user decision-making. This process will aid in prioritizing NOAA program requirements and in assessing potential economic and societal benefits. The SW Next program is evaluating its alternatives to determine the most cost-effective architecture to meet user needs and will continue to leverage user engagement to identify and prioritize user needs across the enterprise.

Conclusion

In conclusion, today's investments in NOAA's next-generation satellite architecture will allow us to make the environmental space-based observations needed to make critical weather forecasts and meet the growing needs of the Nation in a changing environment. Our integrated next-generation observing system will leverage new technologies and partnerships at all levels, and combine data from various sources, allowing us to deliver significantly improved products and services to our users. The urgency of our changing environment requires action now to better deliver on the NOAA mission to protect lives, property, critical infrastructure, and our economy.



Stephen Volz

Assistant Administrator for Satellite and Information Services

Dr. Volz has more than 30 years of professional experience in aerospace. As the head of NESDIS, he sets the strategic vision and implementation objectives for the Nation's civilian operational earth observing satellite fleet. Within NOAA he serves as the Co-Chair of the NOAA Observing Systems Council and is a member of the NOAA Executive Council. He is a leader in the international Earth observation community, serving as the NOAA Principal to the Committee on Earth Observation Satellites (CEOS) and to the Coordination Group for Meteorological Satellites (CGMS). He has also served as the NOAA and US Principal to the Executive Committee (ExCom) of the international Group on Earth Observations (GEO). In each of these roles Dr. Volz leads efforts to coordinate global satellite-based observations among international space agency partners and interested users of remote sensing earth observation data to further the development of a Global Earth Observation System of Systems, and to meet the global weather and environmental monitoring and forecasting efforts..



Prior to coming to NOAA, Dr. Volz served as the Associate Director for Flight Programs in the Earth Science Division of NASA's Science Mission Directorate where he managed all of NASA's Earth Science flight missions in operation, development, and conception, and the ground and data systems to support them. Prior to serving as the Flight Program Director, Dr. Volz was the Earth Science program executive for a series of Earth Science missions, including EO-3 GIFTS, CloudSat, CALIPSO, and ICESat, and he led the Senior Review for the Earth Science operating missions. Dr. Volz worked in industry at Ball Aerospace and Technologies Corporation from 1997–2002, where he was the Project Manager for the Space Infrared Telescope Facility superfluid helium cryostat and other flight projects. From 1986–1997 Dr. Volz worked for NASA's Goddard Space Flight Center as an instrument manager, an IT Manager, a systems engineer, and a cryogenic systems engineer on missions and instruments including the Cosmic Background Explorer (COBE), among others.

Dr. Volz is a member of numerous professional societies, including the American Physical Society (M'82), the American Astronomical Society (M'87), the American Geophysical Union (M'02), and the American Meteorological Society (M'08). He is a senior member of the Institute of Electrical and Electronics Engineers (IEEE), an active member of and participant in the Geoscience and Remote Sensing Society (GRSS), and served as a member of the GRSS Administration Committee (AdCom) for the period of 2013–2015.

Dr. Volz has a doctorate in Experimental Condensed Matter Physics from the University of Illinois at Urbana-Champaign (1986), a master's in Physics from Illinois (1981), and a bachelor's in Physics from the University of Virginia (1980). He has more than 20 publications in peer-reviewed journals.

Chairman BEYER. Thank you, Dr. Volz, very much.
We'll now hear from Mr. Gagosian.

**TESTIMONY OF MR. JOHN GAGOSIAN,
JOINT AGENCY SATELLITE DIVISION DIRECTOR, NASA**

Mr. GAGOSIAN. Good morning, Chairs Beyer and Sherrill, Ranking Members Babin and Bice, Members of the Committee. My name is John Gagosian, and I'm the Director of the Joint Agency Satellite Division at NASA headquarters, a unique office charged with overseeing the development and launch of satellite systems to meet NOAA's research and operational mission requirements. Yes, you heard that correctly. We are charged at NASA with meeting NOAA's needs. But I want to emphasize the way our collaboration with NOAA on weather satellites has strengthened our larger partnership with our sister agency. I'll discuss the benefits that our co-operation offers to both agencies and share a bit of what we're looking forward to in the future.

As the Chairs and Ranking Members described so well, since the 1960's, NOAA and NASA have been strategic partners in research and operations, with NASA focused on answering emerging scientific questions, and NOAA focused on using environmental information to safeguard the public and grow our economy. In this relationship, NOAA has long coordinated with NASA in the development of its satellites, taking advantage of NASA's unique expertise in developing and launching space systems.

The two agencies have three integrated joint program offices at NASA's Goddard Space Flight Center in Maryland. NOAA provides overall program management requirements and budget while NASA is responsible for the acquisition and development of mission systems through its rigorous flight program management processes. At Goddard, work is directed by interagency leadership teams and governed by joint agency management councils to ensure close collaboration in every step of project development. In this structure, NOAA maintains programmatic authority and NASA exercises technical authority using a tailored and formally documented process. Following launch, on-orbit checkout and validation by NASA, NOAA takes over operation of its satellites. Together, we have developed the JPSS series, the GOES-R series, and the Discover Space Weather Monitor. We're looking toward the next generation of geostationary satellites, the GeoXO program, which will include the addition of ocean and atmospheric monitoring. We're also working toward a new architecture of low-Earth orbit satellites, starting with Quick Sounder and the future of space weather monitoring with Space Weather Follow-On and Space Weather Next programs.

Throughout this work, both NOAA and NASA can point to many successes that have come through collaboration. The state-of-the-art instruments that NOAA uses in its JPSS series have built upon NASA instruments first developed for the Earth observing system in the 1990's. NASA has also been able to host its own research instruments on JPSS satellites, for example, to monitor ozone and to measure the energy reflected and emitted by the Earth.

NASA missions like TEMPO (Tropospheric Emissions: Monitoring Pollution), monitoring air pollution across America, and

GLIMR (Geostationary Littoral Imaging and Monitoring Radiometer), measuring ocean color along our coasts, have led directly to capabilities plan for NASA—excuse me for NOAA’s GeoXO program. GeoXO will bring new capabilities to address emerging environmental challenges of the future in support of U.S. weather, ocean, and climate operations.

NOAA’s radiation monitors in geostationary orbit are critical sources of data for NASA’s space weather research. They provide key measurements demonstrating that solar variability is driving space weather processes. These measurements are currently performed by the GOES–R series and will be transitioned to the Space Weather Next series in the future.

Indeed, many of NOAA’s operational assets are crucial for NASA’s research, and our common data needs have led to joint work, advancing data assimilation and modeling. Together, NOAA and NASA are leveraging the best innovations across the space industry to reduce costs and improve the capabilities of future missions. Our work toward a network of small low-Earth orbit satellites can improve global coverage, reduced development timelines, and more quickly infuse new technologies. We’ve explored new acquisition strategies that rely on the private sector for mission operations and data transport, and have executed commercial data buys using licensing agreements that allow us to share the data with other government agencies. We have reduced the cost of access to space via secondary payloads, hosted payloads, and new launch vehicles. We also see the potential in cloud computing, artificial intelligence, and machine learning to enable research and improve data products.

In summary, our two agencies’ close collaboration has allowed each of us to accomplish far more than we could have achieved on our own and has amplified the unique benefits that each of us bring to the Nation. We thank you for your support of our joint operations. Thank you for inviting NASA to join this hearing today, and I’d be happy to take any questions.

[The prepared statement of Mr. Gagosian follows:]



National Aeronautics and
Space Administration

Hold for Release Until
Presented by Witnesses

September 21, 2022

**Committee on Science, Space,
and Technology**

United States House of Representatives

Statement by:

John Gagosian, Joint Agency Satellite Division Director, Science Mission Directorate

HOLD FOR RELEASE
UNTIL PRESENTED
BY WITNESSES
Sept. 21, 2022

Statement of
John Gagosian, Joint Agency Satellite Division Director, Science Mission Directorate
National Aeronautics and Space Administration
before the
Committee on Science, Space, and Technology
U.S. House of Representatives

INTRODUCTION

Since the 1960s, NASA and NOAA have been strategic partners in monitoring Earth's complex and interdependent systems, and the Sun and its solar weather, which affects Earth. NOAA and NASA missions, while distinct, have long benefited from coordination and collaboration.

This cooperation includes the joint development of environmental satellite systems, the coordination of research, and advancing models of the Earth system and Earth-Sun interactions. These cooperative efforts, and a shared commitment to open science, provide both agencies with access to more high-quality data than either could collect independently. This accelerates the pace of new discoveries and maximizes the benefit to taxpayers.

Reimbursable Satellite Systems

NOAA has long coordinated with NASA in the development of its satellites, taking advantage of NASA's unique expertise in developing and launching satellite systems to meet NOAA's research and operational mission requirements. Through integrated joint program offices established by the two agencies, NOAA provides overall program management, requirements, and budget, while NASA is responsible for the acquisition and development of space systems and selected elements of ground systems through its rigorous flight program and project management processes.

Each joint agency program, based at NASA's Goddard Space Flight Center, is directed by a NOAA civil servant and governed by joint agency management councils to ensure that interagency collaboration is inherent to every step of project formulation, development, and procurement. Following launch, on-orbit checkout, and validation by NASA, NOAA takes over operation of its satellites.

Joint Polar Satellite System (JPSS)

The JPSS series of polar-orbiting environmental satellites provide critical observations for accurate weather forecasting, reliable severe storm outlooks, and global measurements of atmospheric, terrestrial, and oceanic conditions such as ozone, vegetation health, sea surface temperatures, and more.

Suomi-NPP and NOAA-20 are currently operating in orbit. JPSS-2 is scheduled for launch in November 2022, while JPSS-3 and JPSS-4 are in the midst of assembly and testing.

These satellites carry state-of-the-art environmental observing instruments largely based on heritage NASA instruments first developed for the Earth Observing System in the 1990s. They provide atmospheric temperature and moisture profiles; images of Earth's land, atmosphere, cryosphere, and oceans in infrared and visible spectra; concentrations of ozone and other trace gases in Earth's atmosphere; and (on Suomi-NPP, NOAA-20, and JPSS-3) measurements of the energy reflected and emitted by the Earth. This final measurement is a key climate parameter, and will be performed on JPSS-3 by new NASA-funded instrument known as Libera. This is one example of NOAA and NASA working together to infuse new technologies into our legacy joint programs.

Geostationary Observational Environmental Satellites-R Series (GOES-R)

The GOES-R Series of environmental satellites in geostationary orbit, which are supported by the GOES Program, provide continuous weather imagery and monitoring of meteorological data for the U.S., Latin America, much of Canada, and most of the Atlantic and Pacific Ocean basins. The GOES-R Series satellites provide atmospheric, oceanic, climatic, and solar products, supporting weather forecasting and severe weather warnings, climatologic analysis and prediction, ecosystem management, and safe and efficient public and private transportation. The GOES-R Series satellites also provide a platform for space weather observations. The GOES-R Series program includes spacecraft, instruments, launch services, and all associated ground system elements and operations for four satellites. The GOES-18 satellite was successfully launched this past March, and its data products are already being used by the weather community. In addition, supporting the applications noted above, NASA is also funding its research community to utilize GOES data for a wide variety of other scientific investigations.

Geostationary Extended Observations (GeoXO) Program

NASA and NOAA are working together to establish a new Geostationary Extended Observations (GeoXO) Program, to advance Earth observations from geostationary orbit. As the follow-on to GOES-R, GeoXO will continue to improve GOES-R observations for weather forecasting, while extending observations to include ocean and atmospheric monitoring. GeoXO will bring new capabilities to address emerging environmental challenges of the future in support of U.S. weather, ocean, and climate operations.

NOAA and NASA are working to ensure these critical next-generation systems are in place in the 2030s, when the GOES-R Series is expected to lose its resilience. Instrument definition and design development studies for GeoXO are underway, and the program just completed a very successful System Requirements Review.

Low Earth Orbit Weather Satellites

JPSS has been a very successful program, and it is well on the way to deploying a series of very capable multi-instrument satellites into the early-afternoon polar orbit. However, looking into the future, NOAA and NASA both recognize the great potential of disaggregated architectures to improve resilience, facilitate technology infusion, and take full advantage of tremendous innovations in the commercial satellite marketplace.

NOAA and NASA are collaborating to bring this vision to the Low Earth Orbit (LEO) Weather Satellites program, which will both complement the current JPSS satellites and serve as a follow-on. The first mission in this new program, QuickSounder, will road-test many of the novel management approaches and technical innovations that NOAA and NASA plan to incorporate on later LEO Weather

Satellite missions. For example, we are exploring alternative acquisition strategies, such as making the spacecraft prime contractor responsible for mission operations and data transport. NOAA and NASA are also studying the use of venture-class launch vehicles for LEO missions, in addition to novel approaches to constellation management that maintain data availability while allowing greater risk tolerance on each individual spacecraft. NASA's experience and lessons learned from innovative, forward-leaning programs such as Earth System Science Pathfinder (ESSP) are directly applicable to these future NOAA missions.

Space Weather

NOAA and NASA are also collaborating closely on a series of research and operational missions to monitor, understand, and predict the effects of space weather on the Earth system. These collaborations strongly reinforce the research-to-operations-to-research model that enhances both agencies' efforts.

The Space Weather Follow-On (SWFO) Program is currently in development. It has already delivered a compact coronagraph (CCOR) instrument to the GOES-U mission that will launch in the spring of 2024 and will deploy the SWFO-L1 mission in February 2025. The special relationship between NOAA and NASA was a key factor in providing access to space for SWFO-L1 as a secondary payload on the launch of NASA's Interstellar Mapping and Acceleration Probe (IMAP) mission. Both SWFO and IMAP are well into system development.

NOAA and NASA are now in the process of establishing the Space Weather Next (SW Next) Program to maintain a long-term, sustained national capability for operational space weather observations in a variety of orbit regimes.

Research to Operations to Research (R2O2R)

The benefits of the close partnership between NASA research and NOAA operations flow both ways. Ever-advancing research leads to constantly improving operations and a steadily advancing American weather enterprise. This cycle further feeds back from operations into science research and innovative new data products.

NOAA and NASA have long demonstrated that observations made initially by NASA research spacecraft can improve both terrestrial and space weather forecasts. These collaborations have led to the direct use by NOAA of measurements from NASA research satellites and later decisions to incorporate some NASA-developed measurements into future generations of the NOAA operational spacecraft fleet.

NASA's Tropospheric Emissions: Monitoring of Pollution (TEMPO) mission, expected to be hosted on the private Intelsat 40e satellite, is NASA's first Earth Venture instrument, and its visible spectrometer will be the first space-based instrument to monitor air pollutants hourly across North America during daytime. TEMPO will also serve as a pathfinder for the atmospheric instruments to be placed on GeoXO, which will revolutionize air quality forecasting.

Another Earth Venture instrument, the Geostationary Littoral Imaging and Monitoring Radiometer (GLIMR), will also serve as a predecessor mission for GeoXO. NASA's investment in GLIMR will help to enable GeoXO's ocean color instrument, which NOAA intends to operate in support of uses such as fisheries management, water treatment, identifying harmful algal blooms, and other key economic uses.

NASA Space Weather researchers routinely make use of both NOAA's and NASA's mission data to develop new capabilities. NOAA's radiation monitors in geostationary orbit (GEO) serve as arguably the most important radiation measurement demonstrating that solar variability is driving space weather

processes. Because of their long-term presence at GEO, the GOES series satellites serve as one of the most data-rich sources of information about solar effects on the space environment. NOAA will continue this rich data stream with a series of GEO free flyers under the Space Weather Next Program.

Benefiting from an Innovative American Industry

Both for its science missions and as NOAA's acquisition agent, NASA enables cost-effective approaches to new discoveries and innovation. This includes both traditional contractor relationships, and emerging public-private partnerships, for data acquisition, data analysis, and public engagement. Commercial advances in a number of areas, including standardization, cloud-based ground services, and lower cost access to space, will allow NASA and NOAA jointly to do more.

NASA and NOAA are actively pursuing opportunities to reduce the cost of access to space via hosted payloads, rideshares, and venture-class launch vehicles. For example, NOAA has provided NASA the opportunity to test the Low-Earth Orbit Flight Test of an Inflatable Decelerator (LOFTID) as a secondary payload on the launch of JPSS-2 this November. LOFTID is a public-private partnership to demonstrate an aeroshell for atmospheric re-entry. This technology enables a variety of proposed NASA missions to destinations such as Mars, Venus, Titan, as well as safe return to Earth.

Similarly, we are actively searching for opportunities where commercial entities enable different capabilities or new, service-based, business models. These have enabled everything from a new class of nimble and innovative suborbital payloads to commercial lunar payload deliveries.

NOAA and NASA have both invested significantly in other forward-leaning approaches such as commercial data acquisition. Through its Commercial Satellite Data Acquisition (CSDA) Program, NASA has served in leading roles in interagency coordination on Non-Governmental Data, which includes data acquired from commercial satellite data vendors. The ability to share data among federal agencies, including between NASA and NOAA, has been a priority for the federal government, and most NASA data purchases also include data access for state, local, and tribal governments and non-governmental organizations.

Conclusion

NASA and NOAA maintain complementary and synergistic programs that provide critical data, information, and services to the nation. NOAA provides consistent, reliable access to global environmental data, modeling, and decision support for operational and decision-maker use, enabling a range of services and products, while NASA focuses on satellite system development and launch, technology development, and data collection to address open scientific questions and to support applications of that science.

**John Gagosian, Joint Agency Satellite Division Director, Science Mission Directorate,
National Aeronautics and Space Administration**



John Gagosian serves as Director of the Joint Agency Satellite Division (JASD), which is responsible for the development of space systems to support the operational weather observation requirements of the National Oceanic and Atmospheric Administration (NOAA).

Previously, he served as Deputy Director of JASD starting in 2019. Prior to joining JASD, Mr. Gagosian represented the Science Mission Directorate's Astrophysics Division as Program Executive for the Exoplanet Exploration Program and the Nancy Grace Roman Space Telescope. In this role he assessed program/project performance and risks, made strategic and budgetary recommendations, and served as the Division Director's primary interface with program/project management.

Mr. Gagosian also previously served as Program Executive for the Stratospheric Observatory for Infrared Astronomy (SOFIA), the Hubble Space Telescope (HST), and the Cosmic Origins (COR) Program. He chaired the Large Mission Study (2020), an internal NASA study intended to improve SMD's cost and schedule performance on large strategic missions.

Prior to coming to NASA Headquarters in 2010, Mr. Gagosian served as Associate Chief of the Mission Engineering and Systems Analysis (MESA) Division at NASA's Goddard Space Flight Center. In this role, he helped to manage an organization with seven branches and more than 200 civil servants engaged in a wide variety of disciplines including mission systems engineering, navigation, mission design, attitude control systems, and propulsion systems.

During his 19 years at Goddard, Mr. Gagosian also served as Head of the Guidance, Navigation, and Control (GN&C) Systems Engineering Branch; Solar Dynamics Observatory (SDO) GN&C Systems Engineer; Triana Gyroscopic Upper Stage Nutation Control System (NCS) Lead Engineer; Mission Integration Manager for the second generation of Tracking and Data Relay Satellites (TDRS); and Propulsion Engineer on the Tropical Rainfall Measuring Mission (TRMM).

Mr. Gagosian received a Bachelor's Degree in Aerospace Engineering from Princeton University.

Chairman BEYER. Mr. Gagosian, thank you very much.
And next, we'll hear finally from Mr. Meny. The floor is yours, sir.

**TESTIMONY OF MR. FRED MENY,
ASSISTANT INSPECTOR GENERAL
FOR AUDIT AND EVALUATION,
U.S. DEPARTMENT OF COMMERCE,
OFFICE OF INSPECTOR GENERAL**

Mr. MENY. Thank you. Thank you, Chairman Beyer, Chairwoman Sherrill, Ranking Members Babin and Bice, and Members of the Subcommittees. Thank you for the opportunity to testify today.

NOAA's satellites are vital to the Nation and its ability to collect weather and climate data for warnings and forecasts. As an Assistant Inspector General for the U.S. Department of Commerce, Office of Inspector General, my office has oversight responsibility of the NOAA satellite programs. We have conducted many audits of these programs that made numerous recommendations to improve their efficiencies and effectiveness.

The cooperation of both NOAA and NASA leadership and staff has facilitated our oversight, and I am very pleased to join my fellow witnesses today to discuss the next generation of weather satellites. My written testimony summarizes challenges pertinent to this hearing in our Fiscal Year 2022 "Top Management and Performance Challenges" report, as well as results from two recent audits. This morning, I would like to offer three observations from that work.

First, delivering fully capable satellite systems on orbit is a technical challenge that requires adherence to sound system engineering and mission-assurance practices. However, the need to stay on schedule can sometimes lead NOAA to make risk-based decisions to deviate from those best practices. NOAA aggressively manages its launch schedules to mitigate potential data gaps. However, we have found that an overly schedule-driven approach can sometimes have negative performance effects when critical testing or other steps are modified to stay on schedule.

In our latest audit of the GOES-R program, we found that NESDIS is planning launches of those satellites sooner than its policy requires. This results in more frequent launches and therefore higher costs over time. To justify this practice, we recommend that NESDIS conduct a cost-benefit analysis and update its governing policy accordingly.

Our second observation is that NOAA policies and procedures need to be fully aligned to the needs of users of satellite data. User needs, well-defined and validated, become requirements that form the basis for systems architectures, design, integration, and verification. In our recent audit of NOAA's efforts to plan and implement its next generation of satellite systems, we found the need for improvement in NOAA's requirements management policy and practices. Most notably, NOAA's process for validating user observation requirements must be updated to meet the needs of next-generation satellite programs. The current defined process is not timely.

NOAA also needs to ensure distinction between requirement threshold and objectives. These minimum and desired specifications create trade space that provide flexibilities in allocating resources. In addition, NOAA leadership must further distinguish the priorities of its user observation requirements. Satellite programs are often responsible for multiple mission-critical or priority-one requirements. This can be a challenge for program managers who need to understand which requirements take precedence for risk-based decisions.

My third and final observation is that NOAA satellite programs have had success avoiding potential data gaps, as well as applying lessons learned. The same program offices will also manage the acquisition and development of the next generation of satellites. To seek new efficiencies, NOAA should reassess many of their programmatic assumptions. We have often questioned such assumptions in our work, leading to recommendations and greater assurance that taxpayers dollars are well spent.

In conclusion, NOAA satellite programs are vital to the Nation and require continued oversight. This hearing is an important effort in ensuring their success. Right now, my office has audits underway assessing space weather follow-on, GeoXO, polar weather satellites. As always, once our final reports are issued, I look forward to sharing our results with you and your staff.

This concludes my statement. I would be happy to respond to any questions.

[The prepared statement of Mr. Meny follows:]



Testimony of

Frederick J. Meny, Jr.
Assistant Inspector General for Audit and Evaluation

U.S. Department of Commerce
Office of Inspector General

before a hearing of the

Committee on Science, Space, and Technology
Subcommittee on Space and Aeronautics and Subcommittee on
Environment
U.S. House of Representatives

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

September 21, 2022

Chairwoman Sherrill, Chairman Beyer, Ranking Members Bice and Babin, and Members of the Subcommittees:

I appreciate the opportunity to testify today about results from our oversight of National Oceanic and Atmospheric Administration (NOAA) satellite programs. I would also like to convey Inspector General Peg Gustafson's gratitude for your continued interest in our work. Our mission is to improve the Department's programs and operations through independent and objective oversight.

Today I will summarize two challenges to NOAA's satellite programs described in our Top Management and Performance Challenges (TMC) report, which we prepare annually as required by the Reports Consolidation Act of 2000.¹ I will also provide highlights of two recent audits that illustrate these challenges and provide recommendations to address them.

Our TMC report identifies what we consider, from an independent perspective and based on our oversight, the Department's most significant management and performance challenges. Given the scale and importance of NOAA's satellite enterprise, we have identified satellite program-related challenges in TMC reports for many years. In our FY 2022 report, we published this challenge as *Challenge 2: Maintaining Continuity, Managing Risks, and Leveraging Investments to Improve Satellite Data, Products, and Services*.² Today, I will focus on two areas of that challenge:

- Managing technical challenges with polar and geostationary satellites
- Planning and implementing next-generation satellite systems to continue observations and meet future needs

In the first area, NOAA satellite programs face inherent technical challenges given the complexity of the systems and their need to be highly reliable. Addressing these challenges requires disciplined systems engineering and mission assurance processes to identify and manage risks. We noted that the Joint Polar Satellite System (JPSS)-2 satellite would undergo environmental testing in FY 2022. This testing can reveal build and workmanship deficiencies that require corrections, potentially further delaying the schedule. JPSS-2's launch was planned for September 2022 but later slipped to November 2022 as the program resolved testing issues. We also viewed the on-orbit testing of NOAA's Geostationary Operational Environmental Satellite (GOES)-T satellite as a challenge to prove the effectiveness of design changes driven by performance problems observed on its two predecessor missions, GOES-R and particularly, GOES-S (now GOES-16 and -17, respectively). Performance problems on orbit put at risk NOAA's ability to provide critical environmental observations for monitoring severe storms, weather and climate forecasts, and other uses.

The second challenge area I want to summarize relates to NOAA's efforts to plan and build its next generation of satellites. These systems will continue key observations and potentially provide new observations that are important to NOAA's mission. NOAA is now planning and

¹ 31 U.S.C. § 3516(d).

² OIG-22-001, Challenge 2

formulating follow-on programs in geostationary and low-earth orbits (LEOs, including polar), space weather observations, commercial weather data buys, and ground systems. To do this, NOAA must have sound processes in place to identify and manage its observing requirements. These processes must anticipate and ultimately validate NOAA's needs in the 2030s timeframe.

My staff have conducted many performance audits of NOAA satellite programs, and two recent reports further illustrate these challenges and provide recommendations to improve NOAA's programs and operations. The first is:

Redesigned GOES-T is Ready for Launch, but NOAA Should Reassess Its Assumptions for Satellite Launch Planning and Storage (OIG-22-015-A), January 20, 2022

This audit's objective was to assess the GOES-R Program's progress in achieving launch readiness for the GOES-T mission. To satisfy our objective, we examined technical performance challenges and changes to technical, schedule, and cost baselines since GOES-S (GOES-17) launched in March 2018. Our findings of particular relevance to this hearing were:

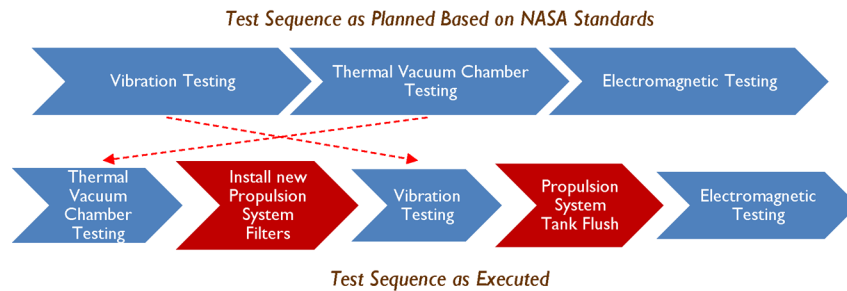
The Program Works Toward the Earliest Achievable Launch Dates at Potentially Increased Development Risk

The Program's commitment agreement with NOAA requires the Program to work toward the earliest achievable launch dates for its satellite missions. The intent of the agreement is to minimize the risk of a satellite coverage gap. However, aggressive planning dates can also increase pressure on schedules within the Program and potentially cause decisions to be predominantly schedule-driven, which can impact technical or cost performance.

During GOES-T satellite acceptance testing, the Program made changes to the spacecraft propulsion system and test campaign (see figure 1). This means that the GOES-T satellite configuration that entered the test campaign was not the same configuration that will launch and fly on orbit, which is not aligned to the NASA rule to "test as you fly—fly as you test." This rule holds that testing of all critical mission-operation elements (such as the propulsion system) as they will be flown greatly reduces the risk of negative impacts upon mission success, whether from partial or full loss of capability.³

Further, the Program deviated from its test campaign that was based on NASA standards. In doing so, the test sequence as executed did not simulate a general mission profile from liftoff to orbit. If defects are not detected at the system level, they may potentially cause hardware anomalies that—in extreme cases—could cause an operational failure.

³ National Aeronautics and Space Administration Goddard Space Flight Center, June 30, 2016. Rules for the Design, Development, Verification, and Operation of Flight Systems, GSFC-STD-1000G. Greenbelt, MD: NASA, Rule 1.09.

Figure I. GOES-T Test Sequence as Planned and Executed

Source: OIG analysis of Program test information

Our review found that changes to the planned testing campaign were predominantly a schedule-driven decision, which we attributed to the National Environmental Satellite, Data, and Information Services' (NESDIS') and the Program's stated approach of aggressively managing schedules toward the earliest possible launch dates to mitigate the risk of potential data gaps. If the Program does not assess the effectiveness of aggressive schedule management, it may make schedule-driven decisions without a full accounting of risks and tradeoffs. Overall, a schedule-driven approach focused on an earliest achievable launch date has been a contributing factor toward negative effects on the GOES-R series and could affect future programs if continued.

We also discussed the negative effects of schedule-driven approaches in prior reports. In 2017, we discussed a more than \$1 million test mishap that could have catastrophically impacted the GOES-16 satellite, partially due to inadequate task planning and an aggressive, compressed schedule.⁴ In 2019, we reported on Advanced Baseline Imager (ABI) integration and test anomalies, which occurred after the Program chose not to adhere to the "test as you fly—fly as you test" rule.⁵ These anomalies preceded the launch of GOES-17, which has had ABI performance problems and is unable to fully meet its requirements. Since that report, the Program shared lessons learned that stated launching the GOES-17 ABI before understanding the root cause of unstable test performance at the time was a regrettable choice.

⁴ OIG-17-013-A, finding I.

⁵ ABI is the primary instrument on GOES-R Series satellites, generating imagery of the Western Hemisphere not duplicated by any other U.S. satellite platform. It provides forecasters with high-resolution images to track storms and offers a wide range of applications related to weather, oceans, land, climate, and hazards such as fires, volcanoes, hurricanes, and tornadoes. See OIG-19-022-A, finding I.

Recommendation

To address this finding, we recommended that the NOAA Deputy Under Secretary for Operations ensure that the Assistant Administrator for Satellite and Information Services does the following:

1. Conduct an analysis of alternatives or similar assessment to determine whether to continue the Program's approach of managing schedules toward the earliest possible launch dates.

NESDIS Is Planning GOES Launches Sooner Than Its Policy Requires Without Analyzing the Costs

In 2011, NESDIS issued its geostationary satellite launch and spare call-up policy, which established objective criteria for determining contingency launch dates and on-orbit spare activation for the GOES system. It set an 80 percent probability of maintaining mission availability⁶ for a two-operational-satellite system—i.e., two-imager coverage by GOES-East and GOES-West satellites. The policy requires a GOES system composed of two operational satellites and one on-orbit spare.

NESDIS plans for higher launch frequency than its policy requires

Since 2018, NESDIS has been using a 93 percent threshold of two-imager coverage in its constellation availability planning scenarios and preliminary launch date considerations for GOES-R series and its follow-on system, GeoXO.⁷ Although the 80 percent policy and GOES-R series requirement remain officially unchanged, the Program told us 93 percent has become NOAA's expectation. However, NESDIS and the Program were unable to provide any documented analyses as the basis of this determination, including any analyses of differential value between older GOES-N series and newer GOES-R series satellite imagers.

NESDIS planners stated that targeting a higher availability threshold (or probability) results in a higher launch frequency and therefore higher costs. In figure 2, the notional relationship of a higher availability threshold to an accelerated launch schedule is shown.

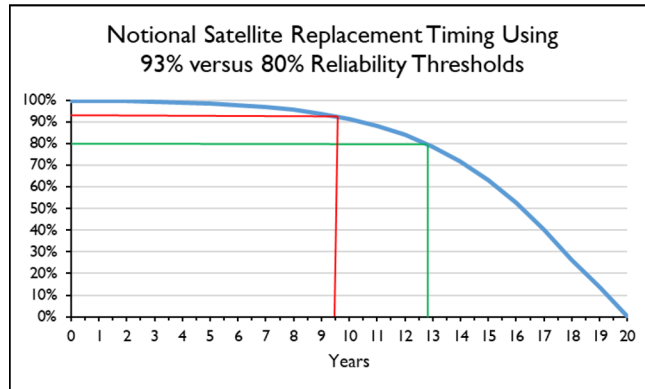
For this example, targeting a 93 percent minimum probability value instead of an 80 percent value to determine when to launch a satellite would result in needing a launch in year 9 instead of nearly year 13.

NESDIS planners explained that they based the justification for using the 93 percent value on NOAA Satellite Observing System Architecture analyses during the 2014–18 timeframe by balancing cost with historical observational performance. However, NOAA could not provide detailed analysis of this cost relationship.

⁶ For Key Performance Parameter cloud and moisture imagery.

⁷ Geostationary Extended Observations.

Figure 2. The Effect of a Higher Coverage Threshold on Launch Timing



Source: OIG analysis of NOAA and Program data

Note: Although only a notional representation, the curve is similar to an actual GOES reliability curve and illustrates the reason that launch cadence may be higher for a higher coverage threshold.

NESDIS and the Program offered another explanation for the desire to exceed the policy threshold, which is that NOAA seeks to launch the newest technology as soon as ready and able. Since both the older GOES-N series and newer GOES-R series satellites have been fulfilling the geostationary policy requirements,⁸ we asked NESDIS if it could show the level of data exploitation or the impact and value to its customers' mission performance by using the newest technology versus the older. NESDIS did not have that type of data, but it and the Program told us the user community prefers the newest imager data, such as that from the ABI on the GOES-R series.

NESDIS acknowledged targeting a higher coverage probability in its planning and the higher costs associated with more frequent launches. However, the 93 percent value is not consistent with standing geostationary policy and Program requirements, which target 80 percent availability. Further, NESDIS has not formally documented its deviation from the policy or quantified the costs, performance benefits, and exploitation of GOES-R series data over GOES-N series data.

NESDIS has not accounted for the potential value of unused spares

In addition to satellite development and launch costs, the higher launch frequency may also lead to other costs associated with having more satellites on orbit than required. With the launch of GOES-T, there are now five GOES on orbit—two more than NESDIS policy requires—that are

⁸ For instance, GOES-15 has been filling in the gaps created by degraded GOES-17 ABI performance.

capable of meeting critical cloud and moisture data requirements.⁹ We found that NESDIS has not accounted for the potential value of unused satellite capability that can result from overlapping individual satellite lifetimes due to launching multiple on-orbit spares.¹⁰

NESDIS may be able to improve the affordability of its geostationary constellation by more carefully accounting for the value of its operating satellites and reducing the amount of satellites stored on orbit. Efficient exploitation of satellite life can help foster less aggressive development schedules and mitigate increased development risk.

Recommendations

To address these findings, we recommended that the NOAA Deputy Under Secretary for Operations ensure that the Assistant Administrator for Satellite and Information Services does the following:

2. Conduct a cost-benefit analysis of selected geostationary coverage availability thresholds and update its geostationary launch policy as appropriate.
3. Determine the cost of operating spare satellites on orbit versus alternative options, including consideration of constellation longevity and satellite development risks, to help inform optimal acquisition and launch strategies.

The second report I would like to discuss is:

The Success of NOAA's Next-Generation Satellite System Architecture Depends on Sound Requirements Management Practices (OIG-22-022-A), June 8, 2022

NOAA's major environmental satellite systems—i.e., GOES-R Series, JPSS, Deep Space Climate Observatory (DSCOVR), and Space Weather Follow On-Lagrange 1 (SWFO-L1)—are expected to provide observations for earth and space weather into the late 2020s or the early 2030s.

NOAA has been planning and taking initial steps to build its next-generation satellite systems to ensure continuity of operations and enhance environmental data. The success of NOAA's next-generation satellite systems relies on a solid foundation of requirements, which form the basis for architecture, design, integration, and verification. Requirements management is important to ensure alignment between user needs and the delivered systems' capabilities.

⁹ GOES-14, GOES-15, GOES-16, GOES-17, GOES-T (-18). This does not include the potential capability of GOES-13, which NOAA transferred to the DOD in 2019.

¹⁰ See a depiction of the notional value of spare satellites in orbit in OIG-22-015-A, appendix C.

This audit's objective was to assess NOAA's progress planning and implementing its next-generation satellite system architecture. Our primary finding was that NOAA requirements management practices need improvement. Notably,

NOAA's process for validating requirements is not adequate for next-generation satellite programs' needs

NOAA's policy defines user observation requirements as documented and validated user needs. The policy states that these requirements are captured independently from observing technologies (e.g., instruments on satellite systems).¹¹ Validation is an important step in systems engineering to ensure that defined requirements will meet actual user needs.

However, NOAA's formal process for validating user observation requirements is inadequate for new or updated observation requirements assigned to next-generation programs, given those programs' timeframes and the length of time NOAA takes to validate user observation requirements. We found that 76 percent of NOAA's user observation requirements have not been updated in more than 5 years, and 18 percent of requirements have not been updated in more than 10 years.¹²

As a result, satellite programs are forced to define or update their own requirements through user engagement and value assessments and make decisions based on these unvalidated requirements. If the NOAA process to validate those requirements subsequently results in changes to the programs' already established requirements, it could force programs to modify contracts and prolong schedules. It may also be too late in acquisition life cycles to change program requirements, resulting in delivered capabilities that do not fully satisfy user needs.

Recommendation

To address these findings, we recommended that the NOAA Deputy Under Secretary for Operations do the following:

- I. Update policies and procedures to ensure user observation requirements are validated in advance of next-generation satellite system acquisitions.

NESDIS programs are developing satellites with more stringent requirement thresholds than those defined in the NOAA dataset

A system engineering best practice is to ensure a requirement can be traced to its higher-level source requirement. Requirements generally have two types of values: threshold (a minimum specification to achieve) and objective (a desired specification to achieve). The constraints of

¹¹ DOC NOAA, October 15, 2016. Policy on NOAA Observing Systems Portfolio Management, NAO 212-16. Silver Spring, MD: NOAA, 4. Available online at https://www.noaa.gov/sites/default/files/legacy/document/2020/Jun/NAO_212-16_UNSEC_Signed.pdf (accessed February 22, 2022).

¹² See OIG-22-022-A, appendix C.

each lower-level requirement threshold should not exceed the constraints of the higher-level requirement's threshold. Otherwise, more stringent lower-level requirements can lead programs to deliver systems that are more expensive and complex than originally intended. More stringent requirements can, however, be specified as objective values to establish goals for programs' improved performance, if resources are available. Maintaining a distinction between threshold and objective values creates *trade-space* that allows programs alternatives to address cost, schedule, or performance uncertainties.

We identified a significant number of legacy satellite program requirement thresholds that are more stringent than their corresponding user observation requirement thresholds in the validated NOAA dataset. Twenty-five percent of GOES-R requirement thresholds and 33 percent of JPSS requirement thresholds are more stringent than their corresponding user observation requirement thresholds. NOAA officials explained that the satellite programs' stricter thresholds stemmed from a desire to procure what was believed to be technologically achievable to improve performance.

Given that many next-generation system requirements derive from legacy systems' capabilities, it is likely that this condition—until it is addressed—will extend to next-generation satellite system requirement thresholds. However, if thresholds for next-generation system requirements exceed NOAA user observation needs, next-generation programs would limit their trade-space and potentially incur higher costs and prolonged schedules in the pursuit of such thresholds.

Additionally, GOES-R and GeoXO requirements documents lack objective values for their requirements in all but one instance.¹³ While threshold values are critical for system success, defining objective values identifies trade-space that allows a program to better allocate its resources. NOAA's internal guidance indicates that trade-space analysis is particularly pertinent in times of significant budget constraints and shortfalls and allows for informed choices that provide the best overall value.

Recommendations

To address this finding, we recommended that the NOAA Deputy Under Secretary for Operations do the following:

2. Ensure that next-generation satellite programs do not define more stringent requirement thresholds than corresponding thresholds in the NOAA dataset.
3. Ensure that next-generation satellite programs include requirement objective values that are different from thresholds.

¹³ We found that JPSS requirements are defined with both threshold and objective values.

NOAA does not sufficiently distinguish user observation requirement priorities

While it may not be feasible to implement all requirements within programmatic constraints, requirements prioritization ensures that implementation efforts focus on the most critical requirements first. Well-defined requirement priorities can assist NOAA in determining trade-space between implementation efforts.

Satellite system acquisition and development programs need clear priorities for performance trades. Satellite programs are often tasked with fulfilling multiple priority-I (mission-critical) user observation requirements. Since NOAA does not further distinguish among these mission-critical requirements, satellite programs can be challenged to determine which ones should receive precedence within their trade-space.

With multiple priority-I requirements assigned to programs, NESDIS tasks working groups to further interpret requirement priorities in support of program formulation efforts. However, these working groups find it difficult to rank the priorities of requirements for a program. For example, members of a requirements working group for the GeoXO program told us that their biggest challenge was competing line office priorities, and the working group did not recommend a set of prioritized requirements for the program.

Recommendation

To address this finding, we recommended that the NOAA Deputy Under Secretary for Operations do the following:

4. Assign responsibility and design a process for determining the relative priority of each NOAA user observation requirement.

NESDIS does not have standard definitions for satellite program requirement priorities

When NOAA user observation requirements are assigned to NESDIS' satellite programs, the programs assign their own priorities to their requirements. We found that satellite programs define their requirement priorities differently than NOAA's user observation requirements and are not consistent between programs. While there is a degree of alignment between the definitions, satellite programs—specifically GOES-R and JPSS—use distinct terminology both from the NOAA dataset and each other.

Requirements should remain consistent as they flow from top-level sources to the programs delivering capabilities to meet them. Absent a NESDIS standard for how satellite programs define requirement priorities, stakeholders are left to interpret inconsistent definitions from a variety of programs and risk misunderstanding the importance and relative contributions of programs' capabilities.

Recommendation

To address this finding, we recommended that the NOAA Deputy Under Secretary for Operations do the following:

5. Ensure that NESDIS standardizes requirement priority definitions for next-generation programs, to include information about the extent to which its programs contribute to meeting NOAA user observation requirements.

As these reports demonstrate, NOAA satellite programs face challenges that must be managed to maintain continuity of their important environmental observations. To better position the next generation of satellite programs for success, NOAA needs to improve its requirements management practices across its mission areas so that satellite programs can efficiently align their delivered systems' capabilities.

Finally, given their importance to the nation and their costs, NOAA satellite programs require independent and objective oversight. My team continues to assess aspects of these programs and has benefited from NOAA's and NASA's cooperation over the years. I look forward to continuing sharing the results of our work with you and your staff.

This concludes my prepared statement, and I will be pleased to respond to any questions.

Frederick J. Meny, Jr.

Frederick J. (Fred) Meny, Jr. became the Assistant Inspector General for Audit and Evaluation of the U.S. Department of Commerce on October 28, 2018. He leads the oversight efforts regarding intellectual property, IT security, cybersecurity, and satellite and weather systems. Mr. Meny has more than 35 years of federal government experience in leading, managing and directing organizations' staff, budgets, and IT resources, as well as major systems acquisition and development programs.

During his 25 years with the OIG, Mr. Meny has led numerous reviews that improved the 2020 and 2010 decennial censuses, department-wide acquisitions and grants, First Responders Network Authority management, USPTO's patents and trademarks, and NOAA's polar and geostationary satellites and weather systems development and operations. His interactions with the executive branch and Congressional leadership on OIG reports have strengthened stakeholder oversight and departmental efforts in meeting its missions, as well as increased OIG resources for audit reviews.

Prior to joining the OIG, Mr. Meny gained more than a decade of hands-on experience in acquiring complex systems as a federal civilian for the U.S. Department of Defense. He successfully managed the acquisition development for thousands of communications security systems for the joint services, as well as unique large-scale computer meteorological and oceanographic systems for the Navy.

Mr. Meny was born and raised in Pittsburgh, Pennsylvania. He received his Bachelor of Science in Electrical Engineering from West Virginia University and has certifications in Program Management from the Defense Systems Management College and The George Washington University.

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Chairman BEYER. Mr. Meny, thank you very much.

We will now begin our round of questions, and I will begin.

Dr. Volz, just listening to Mr. Meny, one of the things he said was that NOAA requires the program to work toward the earliest achievable launch dates for its satellite missions. And this is in order to minimize the risk of a satellite coverage gap, but that the aggressive planning dates can also increase pressure on schedules and lead to lots of bad decisions along the way. How do you respond to this pressure between the earliest possible launch and the need to do things right the first time?

Dr. VOLZ. So thanks for the question, sir. And I certainly—I would say our primary focus when we look at the timeliness and the timeline for launching our missions is to assure the continuity of information to our users. Nothing's more important than making sure there's no gap in the information that goes into our weather forecasts or the emergency managers from our geostationary satellites. There will always be a tension between continuing testing versus meeting the launch date.

And I would contend with—argue with the argument, we don't go to the earliest possible launch date. We're constantly looking at the health of our on-orbit constellation, and we're managing the system of observations we need. So for example, for the GOES-R series, we have a policy which requires two satellites in orbit operating GOES-East and GOES-West. And we have a flight spare in the middle of the of the Nation—of the sky between the two so we have no more than a few—a few-hour delay. If we lose a satellite, we can turn the other one on. So we make sure we maintain that on-orbit readiness, and that's what drives our launch readiness for our birds that are being developed on the ground.

So there will always be tension between the desire to do—for thorough testing and meet the launch dates, but we are driven by our need for continuity. And it's a constant balance, and the program managers know that. And we don't cut corners for testing. As you yourself stated up front, we delayed the launch of GOES-18 by a little over a year as we had to correct a problem we noticed on GOES-17. We did that knowing we had a healthy constellation, which allowed for that timeliness, that delay in order to fix the instrument on the ground and yet not have a gap in our performance. We're constantly making these decisions on a—all the time as we look at our satellite constellation. Thank you.

Chairman BEYER. Thank you, Dr. Volz, very much.

Mr. Gagosian, one of the things you wrote is—and talked about is the—that you're exploring alternative acquisition strategies, such as making the spacecraft prime contractor responsible for mission operations and data transport. This feeds in so much to the work that we're doing on the Committee, especially the Space Subcommittee, on how—the explosion of the commercial sector and how much can be meaningfully moved to the commercial sector without sacrificing quality and at big cost. Can you expand on this a little bit? Do you see our weather satellites ultimately being managed by the commercial sector?

Mr. GAGOSIAN. Thank you for the question, sir. So we're exploring a lot of different strategies for program management and acquisition, primarily now with the Quick Sounder project, which is the

initial mission under the next-generation low-Earth orbit weather satellites. So we issued a request for information several months ago to the private sector looking at ideas for how to execute, as I explained, a mission where the contractor is responsible for operations and data transport, basically delivering data to NOAA for processing and distribution. So we're looking at these techniques because we know that our commercial partners have best practices that they developed over the years for efficient operations. And we're going to take the lessons that we learned from Quick Sounder and apply those to planning future missions under the LEO program, which one of the visions for that program is a disaggregated constellation of smaller satellites, as I also referred to in my testimony, sir.

Chairman BEYER. Thank you, Mr. Gagosian.

Mr.—Dr. Volz, one more question. The—some of—much of the testimony is all about ever-better data, you know, better satellites, more sophisticated, better instruments and the like. Is it just about data or how much is also about theory and modeling and going beyond being able to measure things more carefully to actually thinking differently about the data that you have?

Dr. VOLZ. And that's a great way—a great question to ask it that way. It's not about better data. It's about better information and better understanding, and that requires better data, but it also requires better understanding of what you're observing and the understanding of the Earth system. And that's a great example where NASA and NOAA work together whereas—where NASA does exploration missions to understand processes that drive different effects of the Earth, and NOAA is looking at how those processes affect our ability to forecast and predict phenomena that are of impact to our communities and our world.

So it is the—we are—there's a push-pull. The improved models identify what they—we understand and the need for greater resolution in the information. So as we go to a higher-resolution model, we might need better, higher-resolution data. And the better data, the understanding of processes, drives the modelers to look at a different way to analyze and predict the phenomenon we're trying to forecast. So it requires both. It requires consistent and continuous improvement on both sides.

And with the NOAA side, as we look at these new satellites and GeoXO, for example, we're actively working with the National Weather Service, Ocean and Atmosphere Research Group, to understand what the models need and how the models need to improve and develop over the coming years so they're ready to use the data when we provide it and not just to—not to leave the data untapped and unvalued as it gets delivered to them. So it takes both in coordination, and we're doing that very carefully as we look forward to these next-generation satellites.

Chairman BEYER. OK. Thank you very much.

I now recognize the distinguished Ranking Member of the Space Subcommittee, Dr. Babin.

Mr. BABIN. Thank you, Mr. Chairman. I appreciate it.

As Dr. Volz noted, the scoping of next-generation satellite programs is underway, and definitive lifecycle costs have not been finalized yet. It's important to note that lifecycle costs can change in

both good and bad ways. For example, the GOES program increased by 8 percent in 2020, while at the same time the Polar Follow-On program decreased by 9.7 percent.

My question is for all three of you witnesses, and I think it's very simple. How do your agencies and programs ensure that the most accurate lifecycle cost analysis is put in front of Congress so that we can know exactly what we're getting? Basically, how do we avoid starting what might seem like a minor endeavor but watch it suddenly balloon into a major cost program that's far too—too far along to abandon?

Dr. VOLZ. Well, if I may take the answer first—

Mr. BABIN. Yes, sir. Dr. Volz.

Dr. VOLZ [continuing]. Chairman Babin. I think that's a great question. And I would say that we don't see any of our programs as minor or any of the endeavors as minor. We treat them all as—we're looking at building systems that will be operating for 20 to 30 years, so fully recognizing that it's not just the cost of a thing, a spacecraft or something, but it's the cost of the system and the impact of that system, so fully recognizing that and looking at the best of modeling techniques that we have for cost and schedule modeling that's been developed over many years.

I spent 25 years with NASA developing and working on missions with different ways of doing cost estimating and programming, and we have a very rigorous combined NOAA-NASA approach to doing cost estimation and assessments, which are really accurate at determining the cost of space assets. And on the NOAA side, we have a long operational tail that we have to quantify as well. As we said, GeoXO is going to be operating into the early 2050's.

So our models are varied but actually look at those different pieces very accurately. And as we go through, for example, GeoXO is coming up for a mission commitment in the next—in the coming months, we have numerous independent assessments, as well as our grassroots bottoms-up assessments by the program team, which allow for a rigorous discussion of the pros and cons of different modeling approaches.

And I think your own example of a slight—an 8 percent increase in one and a 9 percent decrease in the other reflected our ability to continuously revisit the lifecycle cost not as an emergency after we have a problem, but as a routine best practices. And we do that throughout the program, even after we start with an initial cost basis.

And I'll turn to my colleagues, to John and to Fred, for other comments. Thank you, sir.

Mr. BABIN. Mr. Meny.

Mr. MENY. Thank you, Chair.

Mr. BABIN. I don't—I don't think your mic is on. There we go.

Mr. MENY. Oh, thank you, Ranking Chair.

The lifecycle cost estimates for any program are extremely important, as you know. And as I said earlier, the understanding of user observation requirements and what those requirements are is very important as well. That drives what will be allocated to a satellite program or another platform of how you will get that data. So understanding that baseline is extremely important. GOES-R, as you

brought up earlier, initially in its development, there was a hyperspectral sounder on it—hyperspectral sounder—hyper-environmental spectral—spectrum sounder on that satellite. However, it was not technology-ready to be flown, and it was dropped from that program.

GeoXO is going to be bringing a similar, you know, approach involved here for the extended orbits, so it's extremely critical to understand what that actual baseline will look like and how those development costs and technology readiness associated with the capabilities it's going to deliver is laid out.

It's also important to test assumptions. We had reports on JPSS where we hit them up early with recommendations on looking at GAO's lifecycle cost estimates and changing assumptions. So following that guidance is extremely important.

Mr. BABIN. Thank you. Mr. Gagorian?

Mr. GAGOSIAN. Yes, thank you. If I may, I'd also like to echo what Dr. Volz said about having a variety of different cost models that are run early in a program. They all have different assumptions and techniques that are used. And so by having a suite of different models, we're able to, let's say, you know, determine a cost target early on that has some realism to it. But really, I want to fall back on the NASA process, which is not to validate the cost estimate and really commit to the cost until what we call key decision point C, which is after the preliminary design review occurs on the system.

So we have a standing review board fully review the design. They look at all the risks. They do what's called a JCL analysis, a Joint Confidence Level analysis. And by the time we get to that key decision point, we have been able to shake the design out and come up with a much more confident number as to what the cost will be.

Mr. BABIN. Thank you very much. And, Mr. Chairman, my time has expired even though I have several other questions.

Chairman BEYER. Mr. Vice—Ranking Member—if it's OK with you, I hope we'll do a second round.

Mr. BABIN. OK, good.

Chairman BEYER. In the meantime, let me recognize the distinguished gentlelady from Oregon, Ms. Bonamici.

Ms. BONAMICI. Thank you very much to the Chairs and Ranking Members and to the witnesses.

In northwest Oregon where I'm honored to represent the 1st District we are experiencing the effects of severe weather patterns that cause more intense heat waves actually and longer fire seasons. And just this month, the combination of high winds, extraordinarily low humidity fueled wildfires in Oregon that caused evacuations of some communities and also two of our regional power utilities conducted planned shutoffs that affected more than 40,000 Oregonians.

So as we invest in climate adaptation strategies to reduce the consequences of extreme weather, the need for accurate and timely and consistent data is essential, especially for resiliency efforts in those vulnerable communities.

So, Dr. Volz, in the Pacific Northwest we rely on quality data about the ocean to support industries like our fisheries, protect ma-

rine life to build resilient communities. So in addition to operating the Nation's weather satellites, as you know, the National Environmental Satellite, Data, and Information Services, NESDIS, is home to the National Centers for Environmental Information, NCEI, which serves as a repository for many of the domestic and international sources of environmental and climate data and information services to inform climate change and mitigation and adaptation.

So, Dr. Volz, how does NESDIS, through its weather satellites and NCEI, how does NESDIS support the broader landscape of NOAA's climate change mitigation and adaptation efforts? And how can next-generation weather satellites integrate with ocean monitoring systems?

Dr. VOLZ. So thank you, Ms. Bonamici, for the excellent question. And the other piece that we often forget when we talk about NESDIS is the information services that you mentioned, the National Centers for Environmental Information. So the primary function of the NCEI is the archiving and retention of all of the global climate environmental observations that we make and split the archiving and storage, but it's the utilization of those data which are so key. So are the ocean observation systems, the ocean observation data that we have and collect are part of NCEI's, and these are through our partnerships with the National Ocean Service and the National Marine Fishery Service are key information parameters for those services to determine the changes in migration—fish migration species, the changes in the ocean, the dynamics in the ocean environment. So we work closely with them for the archiving of their data and the integration of their data with other datasets that we get from other sources, as well as satellites and other partners.

So the—looking forward, as you mentioned, the changes that we're seeing in the environment, whether it's ocean heat waves, heat events, such as the hot blooms that have occurred, are a key part of our forecasting requirements, that we understand those better and forecast those better because of their impacts on the fisheries and the economies [inaudible].

Ms. BONAMICI. We had a hearing yesterday on the Arctic, and we heard that they're having trouble with harmful algal blooms up there, sometimes for the first time.

I want to follow up. Earlier this month, as you know, NOAA and Department of Interior launched a portal for climate mapping, resilience, and adaptation. So how is this data distributed? How would a more cohesive climate service benefit the mission of NESDIS? And we heard in the testimony earlier that NOAA needs to better align data with the needs of users. Is that something you're working on?

Dr. VOLZ. It is, and it is an important piece. It's not just having the data, but it's getting it to the user. So we have had a number of interactive sessions with communities around the Nation and in the regions to try and understand the data use needs that they have at the NOAA level, the NESDIS level through our Regional Climate Service Directors and our Regional Service Divisions. We're working directly with State and locally—users of our data to provide and improve the delivery of our services.

It is a scaling challenge for us as we are changing the way that we deliver data to our users. And one of the initiatives we started is to move all of our data into a cloud-based format, our NESDIS Common Cloud Framework, which allows for much easier, more rapid dissemination of data to different users. That just opens the portal. It doesn't tailor the data to the users as well as we need to. And that's part of our ongoing activity is through user engagement to define the best way to provide the data to those multiple users through our regional and local interactions with the communities.

Ms. BONAMICI. And what's causing the scaling challenge? Is it funding? Is it work force? Is it technology, what—why is it—

Dr. VOLZ. The technology—it's the application of technology, No. 1, because we do have the ability to use the cloud in a way to disseminate the data better, but there's also the—it's a strong—it's a need for better and more engagement with the communities and through work force growth in the RISA (Regional Integrated Sciences and Assessments), which are the the science organizations out of OAR, Office of Atmospheric Research, and our Climate Service Directors is actually engaging in setting up a larger framework of dynamic interactions with the local communities to—in order to tailor those climate products, which are different from the WFO (Weather Forecast Office), the weather products, as we see that is definitely the growth area over the coming years as part of a climate service that we will be setting up and establishing and delivering.

Ms. BONAMICI. Thank you so much. I see my time is expired. I think I heard from down at this end of the dais that there may be another round, which is a good thing because I have more questions. Thank you. I yield back.

Chairman BEYER. OK. Excellent. I figured you would.

Let me now recognize the Congresswoman from Oklahoma, Mrs. Bice.

Mrs. BICE. Thank you, Mr. Chairman.

Dr. Volz, as I mentioned in my opening statement, data processing, distribution, and assimilation are a critical and often overlooked part of satellite operations. I think a low-hanging fruit to increasing access is transitioning to capabilities to the cloud. I know this has been an emphasis at NOAA for a couple of years, but I'm concerned that the—that NOAA tends to prefer owning and managing their own hardware internally when running things rather than running things through a commercial cloud software provider, which is oftentimes a cheaper and more efficient solution and comes with less headaches. Can you tell me more about NOAA's current cloud capabilities related to satellite data and your outlook on the future of cloud services with next-gen satellites?

Dr. VOLZ. Thank you, ma'am, for the question. And yes, I'm happy to. The—it is not an either/or. It's not we do it in-house or we use the cloud. It's going to be a combination of both. And what we have specifically done within NESDIS is to engage with the cloud service providers, several of them, to—in order to move our data to a cloud environment for easier access and dissemination. Now, that doesn't solve the usability problem because you have to understand how to use the data as well as how to get it. But it is

a way that we are moving the accessibility to our cloud—to our satellite data directly to a cloud-based environment.

Now, on the—across NOAA, there are a number of different activities happening with the—there's the NODD (NOAA Open Data Dissemination Program), which the NOAA Open Data Distribution Network that NOAA is trying to do writ large, I think there is a general understanding within NOAA the need to move dissemination—or accessibility to our global datasets to a cloud environment, while still having a large portion of in-house processing and require-capabilities that are necessary for the dedicated weather forecast modeling and forecast development. So it's a combination of both, and it is a big part of our FY20—our budget initiative is asking for access to funds to develop a more rapid dissemination and migration to cloud environment within NESDIS.

Mrs. BICE. Thank you for that. And to follow up, in a previous hearing, there was a conversation around collaboration with NOAA and DOE (Department of Energy). DOE has some of the most powerful supercomputing capabilities of any agency in government. And so can you talk a little bit about what type of relationship and how that's going?

Dr. VOLZ. So not in great detail, but I'm happy to take that question for the record. I would note that even as we move more data to the cloud for dissemination, the need—as we have more complex data and better models of ecosystems in the larger environment, we will need the increased access to high-performance computing to demonstrate the models which are more complex taking in these new data sets. So the—our—NOAA is working with DOE, and I'll be happy to take that for the record to get some comments back to you on the progress of those coordinations with the DOE.

Mrs. BICE. I would appreciate that. I think that with DOE's capabilities—supercomputing capabilities, there is an opportunity for collaboration rather than sort of reinventing the wheel and spending additional resources that may be able to be utilized for other technologies, including new satellites. So I thank you for that question, and will submit that for the record.

To follow on that, the National Weather Center in Norman is home to both the Advanced Radar Research Center and the National Severe Storms Laboratory. Additionally, the NEXRAD (Next-Generation Radar) Radar Operation Center is a frequent collaborator just down the road. And while today's hearing is certainly focused on weather satellites, we can't forget that the next-gen of ground-based radars are also being developed.

Dr. Volz or Mr. Gagosian, with the understanding that satellites take years to develop, build, and launch, as well as the fact they can't be moved from orbit for upgrades, how does NASA and NOAA ensure that space-based instruments complement ground radar and account for potential improvements to terrestrial observations?

Dr. VOLZ. So let me take that first, John, and then I'll turn it over to you for addition. So, within NOAA, we have the NOAA Observing Systems Council whose primary focus—and I'm one of the co-Chairs, along with the National Weather Service Director and the OMAO, the Office of Marine and Air—Aviation, our co-Chairs, we look at the whole system of observations that NOAA has, including ground, space, ocean, et cetera. And the complementarity

of the ground-based radars with the space-based assets are understood and reviewed as a part of the general investment strategies we have. And I'll note for an example, they actually back each other up. If you go back to the incident with Hurricane Maria over Puerto Rico several years ago, the one National Weather Service radar system was knocked out by the hurricane. And during that period of time before we got a temporary replacement in place, we used proxy satellite data as an equivalent radar system to provide the winds in the radar forecasting—the weather forecasting for the island until we could have a ground-based system assessed. So they do complement each other even though they are different. But we are focused on the delivery of service and not only continuity only of a particular technology asset.

And John, I don't know if you had anything you wanted to add to that.

Mr. GAGOSIAN. So my organization is not really involved in the development of the ground-based radars, but one thing we are doing—we're working with NOAA on is reducing the development timeline for new space systems. So Quick Sounder is really a pathfinder for that. We're trying to close the gap that way.

Mrs. BICE. Perfect. Thank you. Mr. Chairman, I yield back.

Chairman BEYER. Thank you, Congresswoman, very much.

Now, let me introduce the—Congress greatest champion for travel to Mars, Mr. Perlmutter from Colorado.

Mr. PERLMUTTER. I was just coming in to kind of settle in and listen, Mr. Chairman, but if—I'm happy to pass and come back to me or I can fake it. What would you like me to do?

Chairman BEYER. If you would prefer that we come back to you—

Mr. PERLMUTTER. Please.

Chairman BEYER [continuing]. After Mr. Feenstra, we'd be happy to do that.

Mr. PERLMUTTER. Sure.

Chairman BEYER. So the only—

Mr. PERLMUTTER. Now, we'll see if he's ready.

Chairman BEYER. He's been here for a while. Mr. Feenstra from Iowa, the floor is yours, sir.

Mr. FEENSTRA. Well, I'd just like to say thank you, Chairwoman Sherrill and Chairman Beyer, and Ranking Member Bice and Babin, for holding this hearing today. And I really want to thank the witnesses for their participation.

The collaboration between NOAA and NASA on weather satellites is vital for my district. It's important that we understand what's happening at a very quick time. I have seen this time and time again. In December, we had significant storms move through Iowa. Two years ago, we had the derecho that was unheard of at the time. And there's still a lot of concerns. I was excited to tour the National Weather Service Forecast office on my August recess, and I started understanding the importance of weather radar, both ground and satellite.

And that is my question here is, as we move forward, it seemed when I was at the National Weather Service that they were having a difficult time disseminating tornadoes that were F-0, F-1s. And—and, you know, it was pretty late that—that they could start

seeing F-2s and so forth. But it just seemed what was happening was they could see it at—at 8,000 feet and higher, but at lower levels they could not.

So my question to Dr. Volz would be is there a way that we can start using satellite radar and satellites to disseminate some of these ground—these lower ground tornadoes that start at 0—or start at F-0 or F-1s that turn out to be F-3 or 4s? Do you see any research going down that path when it comes to satellites?

Dr. VOLZ. So that's a great question, sir, and appreciate asking and knowing how sensitive that region of the country is to hurricanes or earthquakes or tornadoes as they occur. And you've identified one of the key challenges we have in—from observations in real—near real time, which has to be geostationary, is really looking down through the atmosphere and getting to the lower levels of the atmosphere. And that is probably one of the primary benefits we're going to see from our geostationary hyperspectral infrared sounder. The imagery we have right now can be blocked by clouds and has limitations in the vertical disseminate—vertical accuracy or resolution of events, whereas the hyperspectral sounder will allow us to be much more accurate in measuring the wind speeds and direction at multiple levels of the atmosphere, exactly the phenomenon you were identifying in your trip to the—for the WFO.

So the research is going on based on airborne research and other research on how to model these events and how to see them from space. Our sounder that will be launched as part of GeoXO, will be the great—will be our improvement in the technology, but we're working with our partners in Europe, who are flying a similar sounder in a couple of years and hoping to be able—and benefiting from their experience so that we can develop products and use them soon and right away when we have our systems on orbit. So it is a key piece of what we can do with the next-generation GeoXO and is an example of what we acknowledge, what we don't know now that we now know how to understand better, and that's why we're putting these into our program.

Mr. FEENSTRA. I thank you for those comments. That's very important. I'm glad to hear that as we move forward. I mean, technology is so critical and so it's research.

Dr. Volz, on that same vein, obviously, in Iowa, agriculture is paramount. It's probably our most important economic engine that we have. And that being said, we have a lot of agricultural producers that go down this path. It also includes precision ag. And do you see any collaboration when you look at precision ag and new weather satellites that could work together in—in some capability to help agriculture? Is that—anything in that area on the radar?

Dr. VOLZ. Yes, and I think that's a key piece of our mission objective is not just to tell you when the—when it's going to rain or not rain but also to give you a time-based understanding of the environment you're dealing with. In our research into seasonal and sub-seasonal forecasting, that would be a value to agriculture in the broad base but also locally about the precipitation outlooks looking beyond the next week or 10 days to the season so you have an idea of is it—will it be wetter or drier, which can impact the choice of your seed crops, what you're going to put in that year, what particular type of seeds that you want to plant. But from an

ecosystem point of view as well, what are the forecasts in the near term for humidity and soil moisture over the coming weeks so that you can again decide to tailor the application of fertilizer or of irrigation to maximize the effects of the performance of your crops.

So these are tailored better information products that are possible with better integration of the observations and the modeling that are taking place within ocean and atmospheric research right now, but also, through better datasets that we use in NASA doing some of their research product development as well, understanding ecosystem health as a part of—and using satellite data for that.

So I think we definitely have a strong customer in the agriculture community and not at the regional level but at the—almost at the crop and field level. We can provide these kinds of tailored and specific information.

Mr. FEENSTRA. Yes, well, Dr. Volz, thank you for that information, and hopefully, we can continue to work collaboratively on that.

And with that, I yield back.

Chairman BEYER. Thank you, Mr. Feenstra, very much.

If the head coach of the congressional softball team is prepared—

Mr. PERLMUTTER. I'm readier. Let's put it that way.

Chairman BEYER. I recognize the gentleman from Colorado.

Mr. PERLMUTTER. Yes, I was down—we're asking questions of the CEOs of the biggest banks downstairs in Financial Services. So I—but I said, no, I got some scientists I got to go talk to.

So I guess my first question—I know Ms. Bonamici was asking in this area, and I am sorry if I repeat her question, but just, you know, obviously, wildfires have been a huge stressor in Colorado and the West. And I am just curious what you all at NOAA and those at NASA, what roles you're playing to assist our wildfire-fighting efforts. So I'll start with NOAA if you like.

Dr. VOLZ. Sure, thank you, Representative Perlmutter, and thanks for the question. Yes, the wildfires are right on everybody's front page. And I would say that one thing we've learned from GOES-R series of satellites, we've revolutionized the way that we address and serve the fire mission from space. Often, the first call that a constituent might get that there's a fire in their neighborhood comes from the NOAA Weather Forecast Office because they have the image directly from GOES-R. So we recognize the value of early and accurate detection and pinpointing of locations of fires, which come from our geostationary satellites. And we realize that with—and our next generation—so we're continuing to working that with the fire managers on providing that information in the most effective and efficient way.

Our next generation has been tailored to improve that with higher spatial resolution and better choice of bandwidth or frequencies so that we can see the initiation of fire more accurately and precision. And we've realized that the return on value of an investment, that is significant. The sooner you get to a fire, the sooner—the better chance you have to contain it and to reduce the impact of a large fire.

So part of it is the—is better observations. The other part is getting that information directly to the users in the right way. And

we've had a number of workshops with State and local fire emergency managers to get the information not—they don't need a GOES image. They need a pinpoint location, so they tailor the information products in real time so that they can accurately work with them and address it quickly. So GOES—

Mr. PERLMUTTER. So are you all part of the firefighting team? I mean, do you have somebody stationed up in Boise? You know, are you—do you have somebody out of your Colorado offices that's dedicated to that?

Dr. VOLZ. We work with—we—our weather forecast offices are now actively participants with every region around the country in dealing with the fire seasons when they occur. But, for example, with CAL FIRE (California Department of Forestry and Fire Protection) we have—we work with the FEMA (Federal Emergency Management Agency)—we work with FEMA but also with—through our weather forecasts offices with—during emergency management of fire events and during fire season. So yes, it is distributed. The information is sent directly to all of our WFOs, and we work directly with the emergency managers in the different regions on responding to fires in anticipation of those.

Mr. PERLMUTTER. OK. Is—does NASA play any role in this, in the firefighting efforts?

Mr. GAGOSIAN. So what Dr. Volz is describing is the operational role of NOAA. NASA is more oriented around, you know, the research side, understanding the dynamics, the conditions. And if you want, I can take a question for the record to tell you what kinds of space-based and/or air-based assets we're using for that.

Mr. PERLMUTTER. I'd appreciate it because what we found in Colorado there—California and Colorado, I think Oregon, too, is also using sort of Defense Department assets through a—what is it, fire guard or something like that to help us, you know, as quickly as possible pinpoint these things, then take the data developed by NOAA and the Weather Service to figure out where it's going to go and how quickly it's going to get there and how to maintain it. So I would appreciate that.

I guess, Dr. Volz, I have another question probably out of left field. The Office of Space Commerce (OSC) how is it—and for anybody want to talk about it, is it folding into NOAA and the Commerce Department well? How is that working? Because we're kind of moving some responsibilities out of NOAA directly into that Office of Space Commerce.

Dr. VOLZ. So the Office of Space Commerce is not moving out of NOAA. It's moving from NESDIS to NOAA, to—both still within NOAA, but to—directly responding to—reporting to the Under Secretary of Commerce Dr. Spinrad.

Mr. PERLMUTTER. That's what I meant. Thank you.

Dr. VOLZ. So it is—that transition is still in work, and it's moving along well. Richard DalBello, who is the Director of OSC, who's actually here with me this week at the International Astronautical Congress working with a lot of international and technology partners on space commerce and space situational awareness. So that is an ongoing activity that is moving along well. And it is—it may be a little bit out of left field, but it's still—when—if you wanted to start talking about space weather, key—we're key part—com-

patriots in understanding the near-Earth environment of the low-Earth orbit where space commerce and space situational awareness is going to be a key activity.

Mr. PERLMUTTER. All right, thank you very much. I'll go down and talk to those CEOs now.

Chairman BEYER. Thank you, Mr. Perlmutter.

Let me recognize the gentleman from Cape Canaveral, Congressman Posey.

Mr. POSEY. Thank you, Chairman Beyer, for holding this hearing on the next generation of weather satellites.

Dr. Volz, currently there is no geostationary orbit sounding capability over the United States. With all the recent flooding, what are we doing to accelerate prioritizing the development of that critical technology?

Dr. VOLZ. So thank you, sir, for the question. And the Hyperspectral Infrared Sounder, which is a key component of the GeoXO program, as Fred Meny mentioned earlier on, it had been conceived of for the earlier GOES-R but was deemed not sufficiently ready for the implementation in '24—2004. It is now, and we are—I've actually had steady contracts with vendors to build this into our program, and we fully expect and hope that will be a part of our—located centrally over the United States in our GeoXO constellation, providing hyperspectral infrared sounding over the United States. We are working with our European partners to be flying a similar instrument in about 2 years to understand the application of that instrumentation from—for weather forecasting and all the other applications we might see. So we're looking forward to having that available for you and for all of our customers here to better understand storms and weather across the United States.

Mr. POSEY. I'm certainly glad to hear that. And as a follow up to the first question, specifically, how do you protect American innovation and ensure that the American geostationary orbit sounding technology will remain on the weather satellites of our international partners such as Japan and South Korea, enabling the full sharing of this data?

Dr. VOLZ. That's a great question. And we have benefited, as you're implying, over the last 30 years that Japan and our Korean colleagues have used U.S. vendors and U.S. instruments to fly the imagers, for example, that are flying right now. And that common instrumentation is a—really is a great space and timesaver because we have the same observations from East—Western Africa to Central Asia from the same instruments and the same measurements. And it helps our U.S. industry as well.

We have been working closely with our partners, Japan Met Agency and Korean Met Agency, to encourage them to follow and they have followed our lead in the past. The sooner we get our systems designed and—defined and initiated, the greater the likelihood we'll be able to maintain and continue that coordinated development with our Asian partners who have been key participants with us over the past. They have their own timelines, and they're eager to get going on geostationary observations for this next generation as well, so it's a race to the—to get the start going as soon as we can. And we hope to see GeoXO confirmed within our own

department in December of this year with the path forward defined.

Mr. POSEY. Well, that's great. You know, other agencies are rapidly increasing their low-Earth orbit satellites to advance capabilities and achieve more frequent global refresh. You know, what is NOAA's plan for moving out on the next generation of low-Earth orbit?

Dr. VOLZ. I'll start and John can finish. The—we are already in a rapid acceleration of low-Earth orbit assets, and one of the key hallmarks of NOAA's program is that it's not just NOAA satellites we use, it's everybody's if they have good data that we can use. And we now incorporate data from 20 or so different agencies and national partners into our numerical weather forecasting based on interagency partner agreements. So we already are disaggregated. NOAA is working with its Quick Sounder approach to complement the JPSS program with a series—upcoming series of small satellites focused on individual observations, and that's part of what John Gagosian was saying about the innovation is not just in technology, but it's in the implementation approach, which allows for a rapid refresh, new technology infusion, and as—and integration into our programs and utilization of commercial assets when they're available. And that's a key part of our overall program.

Mr. POSEY. Do you think it's possible to accelerate launches, move—move it up even faster?

Dr. VOLZ. Yes, it could. It is, sir. I think the the Quick Sounder approach that we've initiated just this year is targeting a 2025 launch. And with additional funds—with the appropriate funding and the positive outcome of this program, we're looking at the second half of this decade, we should—we could be launching the next generation of complementary missions from SmallSats out of the NOAA program.

Mr. POSEY. Well, that's really great. And I see my time is about to expire, so I yield back, Mr. Chairman. Thank you.

Chairman BEYER. Thank you, Congressman Posey.

I will now do a second round of questions for the stalwarts who are hanging in. Let me begin.

Mr. Meny, we just heard a lot about, you know, the next-generation satellites and GOES-R, GeoXO. One of your recommendations was that the next-generation satellite programs don't define more stringent requirement thresholds than the corresponding thresholds in the dataset. Tell us more about that. Is there the notion that we're overdesigning based on what we can actually use?

Mr. MENY. Thank you for the question, Chairman. The situation is that NOAA's policy on their user observation requirements is to look and revalidate those observation requirements at least every 4 years. In our work, we found that 76 percent of those observational requirements haven't been revalidated in over 5 years, and 18 percent haven't been revalidated over 18 years. So when you look at that process, it's hard for the user observation requirement to transcend down into what is being built on a satellite. So typically, the satellite programs are putting together their specifications and their thresholds, which is, you know, what, you know, the minimum requirement is, is much higher than what is in the user observation data base.

So what we're saying in that case is, one, the policy for looking at those requirements should be refreshed and updated to be more accurate if that's the need; and then, two, if in fact the threshold requirement, the minimum requirement is what is acceptable, maybe that should be an observation—excuse me, an objective requirement and have a lower tradeoff, a smaller like requirement underneath that so there's a trade space. We found that in the GOES magnetometer recently, the one that was—had a problem in development. Its actual mission was meeting much higher—it was supposed to be a much higher—much higher requirements than what was actually in the prior series, which they fell back to do. And that's in the GOES-R program, the only requirement that has a difference between the threshold and objective values.

Chairman BEYER. Great. Thank you very much.

Dr. Volz, I'd love you to respond to it, but let me also throw a question on top of that, which is you had said that 90 percent of all data used by NOAA's operational forecast is coming from satellites right now. I'd love to know about the relevance of the extensive network of ground-based weather observation right now. How relevant is that 10 percent?

Dr. VOLZ. It's absolutely essential, sir. So the 90 percent/10 percent is not a valuation of 90 percent value, 10 percent value. Without the ground datasets, the satellite datasets would be unmoored, unconnected to ground calibration and validation, so it is essential that we have both. But the—what the satellites provide is that global picture, especially over the oceans and sparsely—with places where we don't have ground calibration validation to give you that global picture, which is essential for doing the long-term forecast. But the ground datasets, the ASUS networks, the Weather Service, the balloons, the airborne are absolutely necessary to have a well-performing system, but we need both in other words.

Back to Mr. Meny's point, I fully agree that our requirements validation process that identifies a certain refresh rate is not being satisfied. We did not meet that. However, we did not rely on archaic requirement sets as the basis for definition of the GeoXO. Recognizing this was a problem, we actually went out and extensively researched and communicated with the end users and the internal NOAA users on how they want to and expect to use observations from GEO (geostationary), from GOES, from geostationary and built that into our requirements definition process, recognizing that we don't have the refresh rates that we need, but we are working in parallel to improve that. Through the—as we go to each program, we're looking to upgrade and update the requirements datasets. But I fully agree with his point that we need to accelerate the refresh approach that we have for our requirements, and that's one of the objectives, again, through our NOAA Observing Systems Council that we are—we're championing within NOAA to make sure that we do this more systematically, but we—rather do everything at once, we're focused on the ones where we have to make investments and making sure those investments are based on well-validated requirements, which we do believe we have for GeoXO.

Chairman BEYER. Great, thank you.

Mr. Gagosian, do you have any short follow up to that?

Mr. GAGOSIAN. Very short, I just wanted to point out that for all of our design reviews for GeoXO and all of our lifecycle reviews, we have now specific criteria for user engagement to make sure that the kind of user engagement that Mr. Meny was describing is actually occurring.

Chairman BEYER. Great. Thank you very much. Let me recognize the Ranking Member of the Committee.

Mr. BABIN. Yes, thank you. I'm glad to come back through with a second—second round. I appreciate it.

I have an additional question for Dr. Volz and for Mr. Meny, NOAA and the Inspector General's Office. Will the Department of Defense's future weather plans include flying the Visible Infrared Imaging Radiometer Suite, or VIIRS, instrument? VIIRS was the source of a lot of problems during the development, and the taxpayers invested a lot of money to ensure that it met both NOAA and DOD requirements. Despite early issues, it has returned tremendous scientific and operational results. NOAA flies VIIRS on JPSS right now to the benefit of DOD. And it is my understanding that DOD recently decided not to fly VIIRS in the early morning orbit, which it is responsible for after the breakup of NPOESS. DOD has a much larger budget than NOAA. That's an understatement. So it's a little odd that NOAA may be carrying DOD's water in this instance.

Furthermore, I wonder if there would be any discrepancies with data continuity if DOD was to fly a different sensor or a gap in coverage if they don't fly any sensor at all. Can each of you elaborate on the benefits of the DOD flying VIIRS?

Dr. VOLZ. Thank you, sir.

Mr. BABIN. Dr. Volz, yes, sir, you first.

Dr. VOLZ. [inaudible] question. So, yes, the VIIRS—VIIRS was a beast to build. It was—as you mentioned, I think MODIS was the precursor and we ended up building VIIRS. It is a very capable instrument with multiple—and it turned out to be the greatest producer of products that NOAA—that the JPSS program produces. Many, many applications have been benefited from that. And we will be flying VIIRS through the 2040's on JPSS-1, -2, -3 and -4. The key is need for imagery in the morning orbit is—does not require the full breadth of what VIIRS provides. It requires a fairly narrow slice of that. There was larger objectives for VIIRS.

So the fact that the DOD is not flying a VIIRS in the morning orbit is certainly meeting still—but still meets their—as far as I understand it, and you should—we need to have the DOD confirmed this—meets their mission objectives without covering the full spectrum of what the VIIRS does provide. So we need VIIRS for what it does for us in the afternoon orbit. In fact, the Europeans are flying a similar instrument called METimage, which will be flying on their second generation in the morning orbit. So between EUMETSAT (European Organization for the Exploitation of Meteorological Satellites) and NOAA, we will have two orbital coverages, not exactly the same instrument but close.

And the DOD is going with a different approach for their specific mission objective, which really was one of the reasons for the default—the failure of NPOESS was that the divergence of requirements led to different missions and different observations in dif-

ferent orbits. I don't think we're carrying the water for the DOD. I think VIIRS is a product—a service suite that services us but many others, and we hope to benefit from their observations in their orbits as well when they are flying their disaggregated imagery in the coming years.

Mr. BABIN. OK. Thank you.

Mr. Meny?

Mr. MENY. Thank you for the question. Unfortunately, we haven't looked at that, so I'll have to take that for the record to come back. However, I do understand the concern about what we're doing for other services when they have a larger budget than what Commerce has. So——

Mr. BABIN. Right.

Mr. MENY [continuing]. We'll take a look at it, but for their orbit and picking up VIIRS, I don't have any information I can provide right now, but I'd be happy to take your question for the record.

Mr. BABIN. OK. That's good. I think I'll just yield back to you, Mr. Chairman. Thank you. Thank you all.

Chairman BEYER. Thank you, Dr. Babin, very much.

Mr. BABIN. Yes, sir.

Chairman BEYER. I recognize the Congresswoman from Oregon, Ms. Bonamici.

Ms. BONAMICI. Thank you, Mr. Chairman.

There have been a couple of hearings in this Committee that the reaction was this is incredibly alarming. And one of them was yesterday about the Arctic and the melting permafrost and the other one was about spectrum, so that's what I'm going to ask about. This Committee has had a long history of bipartisan concern about harmful interference in the radio spectrum that can undermine the performance of scientific instruments such as NOAA weather satellites. Last summer, this Committee held a hearing to examine the potential radiofrequency interference that could possibly deteriorate weather forecasting capabilities, as well as opportunities to mitigate, sorry, any harmful interference.

So, Dr. Volz, why can interference be so harmful and challenging to mitigate for the types of measurements that NOAA satellites collect, especially for passive remote sensing? And what are your concerns for future radiofrequency interference with the Earth remote sensing satellite operations, including any actions or developments at the domestic or international level?

Dr. VOLZ. So thank you, Congresswoman Bonamici, for the question related to the spectrum. The reason that passive—that use of—the active use of the spectrum from terrestrial sources is a problem for us in some areas is that we rely on with our passive instruments, microwave in particular, looking for the passive emission of signals from natural sources in various bands through what are called transparent or atmospheric windows, things that are not attenuated by the atmosphere. And a couple of those, they happen to be those places where the atmosphere doesn't attenuate radio frequencies are the best places for radiofrequency uses as well, so there's conflict already between the passive window and the active use of that. And we saw this in a couple of the microwave soundings like at 24 gigahertz and in the 50 gigahertz range where those are windows that we use because they reveal temperature and

pressure profiles in the atmosphere all the way down to the ground. And now those are where you might see 5G application. You sell that spectrum for other use.

So what the problem is, if there's an active source, it interferes with the passive, and the active source can be much larger and time varying, and it raises the noise level of our signals and eliminates the value of the observation. So that is a concern for us, for all of the observers of the passive observations of the planet, of the Earth. And it is—and there have been a lot of ongoing activity on how to co-use and—how to use—how to co-incident or co-reside in the same spectrum and nearby.

And I think that is—we have ongoing conversations with the World Radio Conference, the WRC, as we call it, to try and find the right separations between active use and passive use, and I think we have it at a better place now in the coordination and discussion on what are the allowable uses in parallel bands, but it requires a careful coordination going into the global application.

Ms. BONAMICI. Well, I'm going to ask Mr. Gagosian then. How does NASA incorporate radiofrequency interference mitigation technologies into the development of weather satellites?

Mr. GAGOSIAN. So when you're looking at how to mitigate, we are working with NOAA on some studies for instruments that we could fly to measure the ground-based interference sources. So we've come up with concepts, and at this point, really, it's a tradeoff, right? There's certain investment that would be required versus the impact—the potential impact on the observations. And Dr. Volz can confirm this, but it's—I think it's up to NOAA to really do that—sort of that trade, right, to assess the cost versus the benefit of that type of instrument. But we have collaborated with them on those studies.

Ms. BONAMICI. Terrific. Thank you. I yield back. Thank you, Mr. Chairman.

Chairman BEYER. Thank you, Congresswoman.

Now, finally, I recognize the Congresswoman from Oklahoma, Mrs. Bice.

Mrs. BICE. Thank you, Mr. Chairman. I actually don't have any additional questions, so—

Chairman BEYER. All right. Well, thank you. Then I believe we are done. Good.

Well, before we bring the hearing to a close, thank you very much for hanging in through these long 90 minutes, all our witnesses for being here in person and virtually. And thank you for the work you do. The weather, whether you live in Oklahoma or Oregon or even Virginia and Texas, it's incredibly important. And knowing and being able to predict what's going to happen today, tomorrow, next week is essential. So thank you very much for all that you do.

The record will remain open for two weeks for additional statements from the Members or for any additional questions the Committee may ask for the witnesses. The witnesses are excused, and the hearing is now adjourned.

[Whereupon, at 11:29 a.m., the Subcommittees were adjourned.]

Appendix

ANSWERS TO POST-HEARING QUESTIONS

ANSWERS TO POST-HEARING QUESTIONS

Responses by Mr. John Gagosian

National Aeronautics and Space Administration

Mary W. Jackson NASA Headquarters
Washington, DC 20546-0001



December 15, 2022

Reply to Attn of: OLIA:AR:dac

The Honorable Don Beyer
Chairman
Subcommittee on Space and Aeronautics
Committee on Science, Space, and Technology
U.S. House of Representatives
Washington, DC 20515

Dear Chairman Beyer:

Please find enclosed NASA's responses to the set of written questions submitted after the September 21, 2022, hearing entitled, "*Looking Back to Predict the Future: the Next Generation of Weather Satellites*."

We hope the information is useful to you.

Sincerely,

A handwritten signature in black ink that reads "Alicia Brown". The signature is written in a cursive, flowing style.

Alicia Brown
Associate Administrator
for Legislative and Intergovernmental Affairs

Enclosure

SHERILL #1. How has the partnership between NOAA NESDIS and NASA's Joint Agency Satellite Division (JASD) evolved as the GOES-R Series and JPSS programs have progressed?

- To what extent has the partnership been as integrated as it is now?
- What makes this partnership successful?
- What, if any, opportunities are there to make the partnership even stronger?
- How do you anticipate the roles and responsibilities of JASD to change, if at all, as your agencies develop the next generation of weather satellites?

A: The NOAA/NASA partnership has evolved over several decades, but the current governance model was essentially defined 12 years ago when the Joint Agency Satellite Division (JASD) was established. This governance model has provided stability over more than a decade as new program directors and agency leaders have come on board.

There is a decades-long history of NASA and NOAA successfully collaborating through reimbursable cost partnerships to develop and launch NOAA's weather satellites, including the Joint Polar Satellite System and Geostationary Operational Environmental Satellite programs, as well as the Polar Orbiting Environmental Satellite and Television Infrared Observation Satellite programs before that.

The key to success has been to maintain clearly defined authorities for each agency, while integrated teams of NOAA and NASA technical staff use their particular skills to collaborate and solve technical challenges. Under the partnerships, NOAA provides mission requirements, strategic direction, and budget, while NASA is responsible for the acquisition and development of space systems, launch, and, for specific programs, development of ground systems. Program offices, established through interagency agreements, are based out of NASA's Goddard Space Flight Center (GSFC) and directed and staffed jointly by NOAA and NASA with reporting to the leadership of both agencies. A NOAA civil servant generally serves as program director and a NASA civil servant generally serves as deputy director. NOAA benefits from the adoption of the NASA Science Mission Directorate's rigorous flight program and project management processes, joint oversight by both NOAA and NASA authorities, and access to NASA GSFC facilities, networks, and procurement processes and expertise.

NASA and NOAA will continue to build on these many years of successes co-managing integrated program offices as we look forward to kicking off the development of the next generation of weather satellites, including the Geostationary Extended Observations and low Earth orbit Weather Satellites programs. Both agencies are excited to bring new capabilities to the Nation and to do so in innovative ways. By continuing to innovate we will attract top technical talent, which will ensure mission success and strengthen our partnership even further. JASD's fundamental role is not expected to change, but we will continue to ensure that our oversight processes are appropriate for new missions taking new approaches.

Questions for the Record from the House Science Committee Joint Environment and Space/Science Subcommittees Hearing (Sept. 21, 2022)

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

NASA Witness John Gagosian, Science Mission Directorate, Joint Agency Satellite Division

BEYER #1. During the question-and-answer portion of the hearing, in response to a question from Ms. Bonamici about radiofrequency interference, Dr. Volz mentioned the conflict in the 24 GHz band with 5G applications, where NASA and NOAA have raised concerns about harmful interference with weather and climate satellite passive remote sensing observations. The Federal Communications Commission (FCC) is still working to finalize implementing regulations for the new users of the 24 GHz band. Does NASA remain concerned about harmful interference to its satellites operating in the 23.6 GHz band?

A: NASA remains greatly concerned that U.S. Earth observing missions with passive remote sensors utilizing the 23.6-24 GHz frequency band will experience significant data signal degradation as a result of interference from out-of-band emissions associated with the 5G signal in the adjacent 24.25-27.5 GHz band. These weather missions include NASA’s Global Precipitation Measurement and the NASA-NOAA Suomi National Polar-orbiting Partnership. The 5G signal interference is expected to worsen in the years to come as the deployment of new 5G base stations and related infrastructure that utilize this frequency band increases.

When the FCC auctioned and set technical rules for the 24.25-27.5 GHz band in 2018, it acknowledged ongoing international analyses were underway to determine the out-of-band emission limits that would be necessary to protect passive sensors onboard weather satellites and indicated that technical rules might be revisited once international studies were completed. At the World Radiocommunication Conference 2019 (WRC-19), the International Telecommunication Union cited the results of international analyses in adopting out-of-band emissions limits around the 24.25-27.5 GHz band in order to protect passive remote sensing in the 23.6-24 GHz band.

The National Telecommunications and Information Administration, on behalf of the executive branch, has formally proposed these more stringent limits, but to date, the FCC has not adopted them. NASA supports the U.S. adoption of the WRC-19 limits in order to protect NASA and Federal partner missions from 5G signal interference and degradation. NASA also continues to advocate for the development of technologies to reduce out-of-band emissions from the 5G signal to better protect passive sensors onboard satellites. NASA notes that the window for an FCC decision to modify the out-of-band emissions limits for the 24.25-27.5 GHz band may be closing, as placement of new constraints on 5G infrastructure post-deployment could require expensive and potentially untenable retrofitting or equipment replacement.

BEYER #2. In your response to Congressman Perlmutter’s question during the hearing regarding NASA’s role in wildfire response and resiliency efforts, you stated that NASA has “space-based and/or

air-based assets [you're] using for" wildfire research. Please describe NASA's assets and how they are utilized in wildfire research.

A: A number of NASA's Earth observing satellites provide data that is used by the NASA Disasters Program to provide partners with data, mapping, and imagery to help provide situational awareness and inform decision-making before, during, and after disasters, including wildfires. NASA also operates a fleet of aircraft and airborne sensors that contribute to risk reduction, response, and recovery from wildland fires. The NASA Disasters Mapping Portal houses the products which can be used by decision makers and the public. Additional information can be found in a program one pager at the link below which also provides links to other products including links to the NASA Disasters Mapping Portal Product Guide.

<https://appliedsciences.nasa.gov/sites/default/files/2022-07/NASA%20Disasters%20Wildfires%20One%20Pager%205-20-22.pdf>