The Success of NOAA's Next-Generation Satellite System Architecture Depends on Sound Requirements Management Practices

FINAL REPORT NO. OIG-22-022-A

JUNE 8, 2022

U.S. Department of Commerce
Office of Inspector General
Office of Audit and Evaluation

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Washington, D.C. 20230

June 8, 2022

MEMORANDUM FOR: Richard W. Spinrad, Ph.D.
Under Secretary of Commerce for Oceans and Atmosphere and NOAA Administrator
National Oceanic and Atmospheric Administration

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

SUBJECT: *The Success of NOAA's Next-Generation Satellite System Architecture Depends on Sound Requirements Management Practices*
Final Report No. OIG-22-022-A

Attached is our final report on our audit of the National Oceanic and Atmospheric Administration's (NOAA's) next-generation satellite system architecture. Our objective was to assess NOAA's progress planning and implementing its next-generation satellite system architecture.

We found the following:

I. NOAA requirements management practices need improvement.
II. NOAA should improve tools in support of observing system portfolio management.

On May 17, 2022, we received NOAA's response to our draft report. In response to the draft report, NOAA concurred with all of the recommendations and described general approaches it intends to take to meet them. NOAA's formal response is included within the final report as appendix E.

Pursuant to Department Administrative Order 213-5, please submit to us an action plan that addresses the recommendations in this report within 60 calendar days. This final report will be posted on OIG's website pursuant to sections 4 and 8M of the Inspector General Act of 1978, as amended (5 U.S.C. App., §§ 4 & 8M).

We appreciate the cooperation and courtesies extended to us by your staff during our audit. If you have any questions or concerns about this report, please contact me at (202) 793-2938 or Kevin Ryan, Director for Audit and Evaluation, at (202) 695-0791.

Attachment

cc: Benjamin Friedman, Deputy Under Secretary for Operations, NOAA
Stephen Volz, Acting Assistant Secretary of Commerce for Environmental Observation & Prediction and Assistant Administrator for Satellite and Information Services, NOAA
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Report in Brief

June 8, 2022

Background

The National Oceanic and Atmospheric Administration's (NOAA's) major environmental satellite systems—i.e., the Geostationary Operational Environmental Satellite-R Series, Joint Polar Satellite System, Deep Space Climate Observatory, and Space Weather Follow On-Langrange 1—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 delivered systems' capabilities. Also contributing to NOAA's success will be decision makers' ability to manage next-generation programs as a portfolio. Portfolio management helps decision makers determine which programs best support goals, provide expected results, and have appropriate resources.

Why We Did This Review

Our audit objective was to assess NOAA's progress planning and implementing its next-generation satellite system architecture.

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

The Success of NOAA's Next-Generation Satellite System Architecture Depends on Sound Requirements Management Practices

OIG-22-022-A

WHAT WE FOUND

We found the following:

I. NOAA requirements management practices need improvement.

II. NOAA should improve tools in support of observing system portfolio management.

WHAT WE RECOMMEND

We recommend that the NOAA Deputy Under Secretary for Operations do the following:

1. Update policies and procedures to ensure user observation requirements are validated in advance of next-generation satellite system acquisitions.
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.
4. Assign responsibility and design a process for determining the relative priority of each NOAA user observation requirement.
5. Ensure that the National Environmental Satellite, Data, and Information Service (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.
6. Ensure that NESDIS revises policies and procedures for assigning requirements to next-generation satellite programs.
7. Ensure that portfolio management tools include accurate and complete data to produce useful information for investment decisions.

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Cover: Herbert C. Hoover Building main entrance at 14th Street Northwest in Washington, DC. Completed in 1932, the building is named after the former Secretary of Commerce and 31st President of the United States.

Introduction

The National Oceanic and Atmospheric Administration's (NOAA's) major environmental satellite systems—i.e., the Geostationary Operational Environmental Satellite (GOES)–R (GOES-R) Series, Joint Polar Satellite System (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.[1]

NOAA has been planning and taking initial steps to build its next-generation satellite systems to ensure continuity of operations and enhance environmental data. In 2018, NOAA published its NOAA Satellite Observing System Architecture study to inform decision making related to its future environmental satellite systems.[2] NOAA's National Environmental Satellite, Data, and Information Service (NESDIS) subsequently developed a strategic implementation plan for fiscal years (FYs) 2022–2027. The plan includes strategic objectives to

- advance satellite observations and architectures;
- develop agile, scalable ground system capabilities;
- engage users to ensure timely response to their needs; and
- deliver best-value integrated products and services.

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 delivered systems' capabilities. Environmental data needed by NOAA line offices, once validated, are known as user observation requirements.[3] A subset of these requirements is assigned to NESDIS programs, which design, acquire, and oversee development of satellite systems to meet the requirements. In some cases, requirements can be fulfilled by multiple systems.

Also contributing to NOAA's success will be decision makers' ability to manage next-generation programs as a portfolio. Portfolio management is a discipline that helps decision makers determine which programs best support goals, provide expected results, and have appropriate resources. A portfolio is a collection of components, such as satellite system programs, that are managed as a group to achieve strategic objectives. Portfolios allow for *trade-space*, which gives management alternative ways to address cost, schedule, or

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[1] We refer to these collectively as legacy programs.

[2] For additional discussion about the study, *see* U.S. Department of Commerce (DOC) Office of Inspector General (OIG), July 9, 2018. *Polar Follow-On: NOAA Must Maintain Cost Efficiencies and Refine Launch Strategy for JPSS-3 and JPSS-4 Missions*, OIG-18-021-A. Washington, DC: DOC OIG, finding III. For the study itself, *see* DOC National Oceanic and Atmospheric Administration. *Future NOAA Satellite Architecture* [online]. https://www.space.commerce.gov/business-with-noaa/future-noaa-satellite-architecture/ (accessed February 22, 2022).

[3] NOAA line offices represent the agency's operating branches and are responsible for managing product and service delivery to meet the agency's customer and stakeholder needs. There are six line offices: (1) National Weather Service, (2) National Ocean Service, (3) National Marine Fisheries Service, (4) Oceanic and Atmospheric Research, (5) NESDIS, and (6) Office of Marine and Aviation Operations & NOAA Corps.

performance uncertainties, both between and within programs. Portfolio management tools can provide methods for integrating, analyzing, and visualizing information in support of decisions to align components with strategic objectives.

Objective, Findings, and Recommendations

Our audit objective was to assess NOAA's progress planning and implementing its next-generation satellite system architecture. To satisfy our objective, we determined the status of next-generation programs, assessed NOAA's requirements management practices, and analyzed observing system portfolio management tools. See appendix A for a more detailed description of our scope and methodology.

We found that NOAA requirements management practices need improvement and NOAA should improve tools in support of observing system portfolio management. The status of next-generation satellite programs is summarized in appendix B.

We concluded that requirements management weaknesses present risks to future satellite systems' architecture, design, integration, and verification—and therefore, NOAA's ability to fulfill its strategic objectives. As well, limitations of NOAA's current tools leave decision makers with incomplete information for making tradeoffs within the satellite observing system portfolio. Addressing these issues will provide greater assurance that next-generation satellite systems meet user needs within cost and schedule constraints.

I. NOAA Requirements Management Practices Need Improvement

We found that NOAA's process for validating user observation requirements is not adequate for next-generation satellite programs' needs. Furthermore, NESDIS programs are developing satellites with more stringent requirement thresholds than those defined in the NOAA user observation requirements dataset. NOAA does not sufficiently distinguish user observation requirement priorities. NESDIS does not have standard definitions for satellite program requirement priorities. Finally, NESDIS has not fully designed and documented its process for assigning requirements to next-generation satellite programs.

A. 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).[4] Validation is an important step in systems engineering to ensure that defined requirements will meet actual user needs.

NOAA's process for validating mission-critical user observation requirements starts with line offices, which provide documentation demonstrating the need for an observation to the Technology, Planning, and Integration for Observation (TPIO)

[4] 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).

division.[5] TPIO maintains a centralized database of user observation requirements (hereafter referred to as the *NOAA dataset*). Together, line office leadership and TPIO staff assess the documents' applicability, prepare a validation summary, and present it to the NOAA Observing Systems Council (NOSC) for its endorsement.[6]

However, this process 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. NOAA officials acknowledged that the validation process can take a long time, though they could not describe actual durations.

NOAA policy does not specify when, in relation to satellite program timeframes, observation requirements must be formally validated. However, the policy does require the NOSC to maintain an accurate and current set of user observation requirements. Line offices are supposed to provide updates to the dataset every 4 years to ensure information is valid and current.[7] However, we found that 76 percent of requirements in NOAA's dataset have not been updated in more than 5 years, and 18 percent of requirements have not been updated in more than 10 years (see appendix C).

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.

For example, we learned that a working group updated and identified some new observation requirements for the Geostationary Extended Observations (GeoXO)[8] program that have not been validated by the NOAA process. These requirements are intended to delineate more detailed observations for weather and climate prediction, as well as other uses.[9] NOAA has not formally validated these new and updated observation requirements in accordance with its policy. With the program preparing to

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[5] Documentation must show use of data in current operational systems or provide a scientific study or statement from a subject-matter expert that demonstrates the need.

[6] The NOAA Observing Systems Council is the principal advisory body to the Under Secretary of Commerce for Oceans and Atmosphere for matters regarding NOAA's integrated observing systems and data management.

[7] DOC NOAA, July 26, 2017. *Procedural Directive for NAO 212-16, "Policy on NOAA Observing Systems Portfolio Management.*" Silver Spring, MD: NOAA, 3.

[8] GeoXO is the follow-on program to the GOES-R series that will field the next generation of geostationary satellites. See appendix B for more information.

[9] For example, the imager on GeoXO will be designed to detect wildfires four times smaller than the GOES-R series imager can. This requirement will potentially increase the lead time to respond to a blaze before it gets out of control. Other new and notable observations include hyperspectral infrared soundings, ocean color imagery, and atmospheric composition.

baseline its requirements and issue procurements, the formal NOAA validation of these observation requirements may not occur before contract execution.

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

According to system engineering best practices, a requirement must be traceable to its higher-level source requirement.[10] Requirements generally have two types of values: *threshold* (a minimum specification to achieve) and *objective* (a desired specification to achieve). The constraints of 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. Objective values create trade-space that allows programs to better allocate their resources.

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. For example, the GOES-R series satellites' primary instrument requirement for Aerosol Optical Depth specifies a horizontal resolution threshold—critical for system success—of 2 kilometers; however, the requirement from the NOAA dataset specifies 12 to 500 kilometers. We found that 25 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 get improved 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.[11] We previously reported that the GOES-R program's geomagnetic field measurement accuracy requirement had the same threshold and objective values.[12] In response to our recommendation, NOAA

[10] International Council on Systems Engineering. 2015. *Systems Engineering Handbook*, version 4. San Diego, CA: John Wiley & Sons.

[11] We found that JPSS requirements are defined with both threshold and objective values.

[12] DOC OIG, August 12, 2019. *Geostationary Operational Environmental Satellite–R Series: Program Success Requires Added Attention to Oversight, Risk Management, Requirements, and the Life-Cycle Cost Estimate*, OIG-19-022-A. Washington, DC: DOC OIG, finding II.

established distinct threshold and objective values for this requirement. However, other geostationary requirements are still defined with only threshold values.

While threshold values are critical for system success, defining objective values identifies trade-space that allows a program to better allocate its resources. TPIO's internal guidance indicates that trade-space analysis is particularly pertinent in times of significant budget constraints and shortfalls, allowing NOAA to make informed choices that provide the best overall value.

C. 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. NOAA defines three priorities for user observation requirements: mission critical (priority-1), mission optimal (priority-2), and mission enhancing (priority-3).

NOAA line offices are responsible for determining and prioritizing their observation requirements before they are entered into the NOAA dataset. The distribution of priorities for user observation requirements within the NOAA dataset is shown in table 1.

Table 1. NOAA User Observation Requirements

Priority Designation	NOAA User Observation Requirements (count/percent)	Subset of User Observation Requirements Potentially Met by Satellites (count/percent)
Priority-1 (Mission-critical)	1,168 (69.9%)	527 (66.6%)
Priority-2 (Mission-optimal)	425 (25.4%)	223 (28.2%)
Priority-3 (Mission-enhancing)	79 (4.7%)	41 (5.2%)
Total requirements	**1,672**	**791**

Source: Office of Inspector General review of TPIO data

Note: Information is current as of March 24, 2022.

Approximately 70 percent of all NOAA user observation requirements are designated as priority-1. Of the 791 requirements potentially supported by satellite systems, 527 (66.6 percent) are designated as priority-1. By definition, a priority-1 requirement is considered mission-critical, where "limited or loss of access to the data would prevent NOAA from meeting operational mission objectives."[13] NOAA's dataset shows that 91 of its priority-1 requirements are not being fulfilled—although according to TPIO staff, some of these may be explained by incomplete records in the database. However,

[13] DOC NOAA. *NAO 212-16 Handbook*, updated May 16, 2019. Silver Spring, MD: DOC NOAA, 41.

NOAA should consider whether all priority-1 requirements are equally critical to its mission.

Satellite system acquisition and development programs need clear priorities for performance trades. Satellite programs are often tasked with fulfilling multiple priority-1 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.

We attribute these satellite program challenges to the fact that NOAA has no office or process above the line offices that further distinguishes requirement priorities. While the NOSC functions above line offices, it is not responsible for distinguishing priorities of *observation requirements*. Rather, it is tasked with proposing priorities and investment strategies for *observation-related initiatives* (i.e., the mix of satellite and other observation programs).[14]

With multiple priority-1 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.

Without a clear process above line offices to distinguish priority-1 user observation requirements further, NOAA may not be able to efficiently manage trade-space and efficiently resource next-generation programs. In addition, satellite programs will be challenged to prioritize their requirements so that NOAA's user needs are appropriately met.

D. 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. A comparison of NOAA user observation, GOES-R program, and JPSS program requirement priority definitions is presented in appendix D.

In addition, we found instances where the JPSS and GOES-R programs have assigned priorities to their specific requirements that differ significantly from the corresponding priority of the user observation requirement in the NOAA dataset. For example, the JPSS program has identified its "Vegetation Index" as a program-defined priority-4

[14] *See* DOC NOAA, *NAO 212-16*, 7.

requirement, but the corresponding user observation requirement is a NOAA-defined priority-1 in the NOAA dataset. The GOES-R program's "Ozone Total" requirement is assigned as Tier III by the program, but is a priority-1 requirement in the NOAA dataset.

One explanation for these disparities stems from the fact that NOAA satellite programs are not necessarily the only ones fulfilling user observation requirements. For example, NOAA obtains some similar environmental data from international partners' satellite systems and, in some cases, land-based systems. The GOES-R program's definitions for requirement priorities qualitatively account for this by identifying the system's contribution to fulfilling the requirement (e.g., "Moderate" or "High GOES-R Satellite Contribution"). JPSS definitions do not explicitly account for the contribution the satellite system makes towards fulfilling the NOAA requirement.

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.

E. NESDIS has not fully designed and documented its process for assigning requirements to next-generation satellite programs

NESDIS is changing its process for managing the assignment of requirements to satellite programs and has begun applying aspects of it to the GeoXO program. However, NESDIS has not fully designed, documented, or implemented this new process.

The previous process assigned NOAA user observation requirements directly to satellite programs, which identified the necessary systems and resulting products to meet those requirements. Because of this assignment, and how legacy satellite programs defined requirements, some changes related to satellite system capabilities needed approval from NOAA's Deputy Under Secretary for Operations.

Under NESDIS' new process, as officials described it to us, NESDIS plans to catalog the NOAA user observation requirements it is responsible for in a product baseline. It will then assign those requirements to satellite programs, which will be held responsible for the requirements in the product baseline. NESDIS' intent is to alleviate the need for the Deputy Under Secretary for Operations to approve changes to satellite systems that do not result in changes to the product baseline or NOAA user observation requirements. However, NESDIS' Director of the Office of Systems Architecture and Advanced Planning indicated that parts of the new process needed further definition.

At the conclusion of our fieldwork, NESDIS had not completed documenting certain aspects of the new process, which will also need to account for how it will manage legacy program requirements. Management should develop and maintain documentation of its internal control system.[15] Effective documentation assists in the design of controls.[16]

Recommendations

We recommend that the NOAA Deputy Under Secretary for Operations do the following:

1. Update policies and procedures to ensure user observation requirements are validated in advance of next-generation satellite system acquisitions.
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.
4. Assign responsibility and design a process for determining the relative priority of each NOAA user observation requirement.
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.
6. Ensure that NESDIS revises policies and procedures for assigning requirements to next-generation satellite programs.

II. NOAA Should Improve Tools in Support of Observing System Portfolio Management

According to its policy, NOAA takes an integrated approach to managing its observing system portfolio by aligning management and investment decisions with NOAA strategies. Portfolio management tools can assist in aligning portfolio systems with strategic objectives.[17] Such tools gather, integrate, visualize, preserve, and disseminate outputs of organizational portfolio management. These tools should assist an organization in determining which systems best support organizational goals and provide the anticipated results, and whether systems have appropriate resources.

NOAA uses output from a variety of tools in support of its portfolio management efforts. However, we determined that some tools lack key information for current and future

[15] U.S. Government Accountability Office, September 2014. *Standards for Internal Control in the Federal Government*, GAO-14-704G. Washington, DC: GAO, p. 29. Available online at https://www.gao.gov/assets/gao-14-704g.pdf (accessed March 3, 2022).

[16] *Ibid*.

[17] Project Management Institute. 2017. *The Standard for Portfolio Management*, Fourth Edition. Newtown Square, PA: PMI, 15.

systems, such as costs and complete catalogs of system capabilities. In other cases, tools produce inaccurate results. The tools' provisions and associated limitations or issues are as follows:

- NOAA has a gap analysis tool that performs direct comparisons of its observing system capabilities and user observation requirements. The tool then calculates a score depicting how well a current observing system measures each requirement attribute. While this is an important tool to determine how well observing system capabilities are performing to meet NOAA's mission, we determined that it does not provide an accurate depiction of requirement fulfillment in all cases. We observed that when an attribute is missing or not provided in the correct units (e.g., accuracy units entered in degrees Kelvin rather than a percentage), that attribute is skipped in the scoring without any indication that the attribute was not considered in the overall assessment. In addition, the tool could not score 150 of 791 satellite requirements because of missing attributes or other data needed to perform the calculation.
- NOAA has a value tree assessment tool that includes a model built to analyze capability cost, overall impact, and value of observing system architectures. However, we determined that when this tool was built in 2015, it did not include all current NESDIS systems (in particular, GOES-R, JPSS, and DSCOVR) because they were not yet operational. Additionally, NOAA is in the process of doing its first update of the tool and has no plan to include future systems, such as GeoXO, since they will not be operational yet. Of the systems entered in the tool, none includes full life cycle costs. Instead, only some incurred costs for development and operations are included. Without including sufficient information for current and planned systems, which could include rough order of magnitude estimates, NOAA cannot use the tool to analyze existing and new architectures in support of trade-space decisions.
- NOAA also performs Observing System Experiments (OSEs) and Observing System Simulation Experiments (OSSEs), which are scientific value assessments of observing system data in numerical weather prediction models. OSEs determine impacts to a forecast model by removing existing observations from a particular system. By design, OSEs study impacts of existing systems on the forecast. OSSEs use simulated observations from one or more proposed or new observing systems with existing observations to determine impacts to forecasts, which can be used for future system planning. However, the limitation of these experiments is that they are not designed to consider cost information in their analysis.

While NOAA uses other information in addition to these tools to make investment decisions, it continues to expend resources to use, maintain, and update some of these tools. However, without accurate and complete information, these tools cannot effectively inform investment decisions for next-generation systems to provide the greatest benefits at the lowest cost.

Recommendation

We recommend that the NOAA Deputy Under Secretary for Operations do the following:

7. Ensure that portfolio management tools include accurate and complete data to produce useful information for investment decisions.

Summary of Agency Response and OIG Comments

In response to our draft report, NOAA concurred with all recommendations and described general approaches it intends to take to meet them. NOAA also suggested minor changes for technical accuracy, which we reviewed and incorporated into the final report where appropriate.

We are pleased with NOAA's response to the report and look forward to reviewing its action plan for implementing the recommendations.

Appendix A: Objective, Scope, and Methodology

Our objective was to assess NOAA's progress planning and implementing its next-generation satellite system architecture. To satisfy our objective, we determined the status of next-generation programs, assessed NOAA's requirements management practices, and analyzed observing system portfolio management tools. We announced this audit on November 9, 2020, and completed our fieldwork in February 2022.

To determine the status of next-generation programs, we reviewed documentation of satellite system initiatives to understand where each was in its system development life cycle. We interviewed personnel from the GeoXO, Low Earth Orbit (LEO), Space Weather Follow On, and Common Ground Services (CGS) programs to determine plans and analyses that have been conducted for each of those initiatives. We observed the mission concept review for GeoXO in June 2021 to gain deeper insight into its planning activities.

To assess requirements management, we identified applicable criteria from NOAA and National Aeronautics and Space Administration policies and industry best practices for systems engineering, project management, and business analysis. We met with personnel from TPIO and line offices to understand the user observation requirements prioritization process. We compared the process for requirements prioritization to industry best practices. We compared NOAA's definitions of requirement priorities with existing program definitions. To identify requirements thresholds and objectives that legacy programs needed to achieve, we reviewed the legacy programs' requirements documents and compared them to corresponding requirements in the NOAA dataset. We compared GeoXO program requirements with user observation requirements in the NOAA dataset to determine which were validated by NOAA's process.

To analyze NOAA's portfolio management tools, we met with TPIO personnel to understand what tools are available to NOAA leadership and programs. TPIO demonstrated how each tool functioned and provided us with results for existing programs, which we analyzed. We found discrepancies and discussed these discrepancies with TPIO to understand the limitations of each tool.

In addition, we assessed NESDIS' internal controls significant within the context of our objective. We found that NESDIS had not documented its new process for managing requirements of next-generation programs, as described in finding I.E.

In satisfying our objective, we reviewed computer-processed data provided by TPIO. The data represented output from a gap analysis tool, in which we found the scoring calculations could be inaccurate when attributes were missing or not provided in the correct units, as described in finding II. We identified these attributes and confirmed with TPIO that issues related to missing or incorrect requirement attributes in the tool may provide inaccurate scoring data. Although these requirement attributes were direct output from the NOAA dataset into the tool, we did spot check several requirements to ensure that they matched. We compared GOES-R and JPSS requirements to the NOAA dataset to determine the percentage of satellite program requirements that were stricter than corresponding user observation requirements, as described in finding I.B.

Although we could not independently verify the completeness and reliability of all the information we collected, we compared it with other available supporting documents to determine data consistency and reasonableness. Based on these efforts, we believe the information we obtained is sufficiently reliable for this report.

We conducted our review from November 2020 through February 2022 under the authority of the Inspector General Act of 1978, as amended (5 U.S.C. App.), and Department Organization Order 10-13, as amended October 21, 2020. We performed our fieldwork remotely.

We conducted this performance audit in accordance with generally accepted government auditing standards. These standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objective. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objective.

Appendix B: Status of Next-Generation Programs

NESDIS is planning its next generation of satellite systems that will continue key observations and potentially provide new observations that are important to its mission. It is now planning and formulating follow-on programs in geostationary and LEO, space weather observations, ground systems, and commercial weather data. The following comprise NESDIS' next-generation satellite system architecture efforts:

- GeoXO Program – This follow-on program to the GOES-R series will field the next generation of geostationary satellites. A single NESDIS program office manages both GOES-R and GeoXO. NESDIS is working to provide GeoXO observations by the early 2030s as GOES-R series satellites near the end of their operational lifetimes. GeoXO is the most mature of NESDIS' next-generation programs. On November 9, 2021, following the program's Milestone 1 review, the Deputy Secretary of Commerce formally approved the initiation of the program. The program is now in the definition phase of its life cycle. During this phase, the program will refine mission requirements; detail acquisition strategies, schedules, cost estimates, resource planning, and risk management; and confirm technology readiness. An important effort will be to validate GeoXO requirements, particularly those beyond the observations of the legacy GOES programs.
- LEO – In FY 2022, NESDIS plans to initiate the LEO Weather Satellites program, intended both to complement its current JPSS satellites and serve as a follow-on program. While the program is still in the early stages of planning, NESDIS is planning to use JPSS-like sensors in a small satellite format. The current plan includes developing a small satellite—known as QuickSounder—as a bridge mission between JPSS and the next generation of polar satellites. The plan for QuickSounder is to use an existing engineering model of the Advanced Technology Microwave Sounder (one of the primary instruments on JPSS-era satellites). This will allow NOAA to launch a proven instrument as early as 2024 and give the program time to plan its next satellite system.
- Space Weather Observations – NESDIS has deployed space weather monitoring and warning capabilities in deep space, geostationary, and low earth orbits. SWFO-L1 is a bridge mission between DSCOVR and Space Weather Next (SW Next).[18] SWFO-L1 is planned for an FY 2025 launch. SW Next is currently in the early preformulation phase and will start development next year. NESDIS is planning an SW Next mission launch in FY 2028 so that its observations will overlap with SWFO-L1. While some GOES satellites host instruments to observe space weather, NESDIS decided that it was not feasible within the current plans for GeoXO missions to include space weather instruments.

[18] Lagrange points are positions in space where the gravitational forces of the Sun and Earth allow satellites to orbit in a constant pattern. Lagrange point 1 is 1 million miles from Earth, in a direct line between the Sun and Earth, affording an uninterrupted view of the Sun.

- CGS – Ground services are critical to acquiring, processing, and managing the environmental data from satellite missions and deriving value from the investments other organizations have made in the space segment. NESDIS' CGS program is working to develop cloud-based product portfolio management services. CGS plans to support blended products, such as combining sea surface temperature data from different satellite platforms (e.g., geostationary and polar).
- Commercial Data Program – Legislation has required NOAA to explore the viability of using environmental data from commercial sources in support of its mission. After multiple pilot efforts, NOAA began using commercially acquired radio occultation data in forecast models in May 2021. NOAA is continuing to explore the use of other environmental data through various outreach efforts to industry.

Appendix C: Latest Updates to NOAA User Observation Requirements Documents

Table C-1. Validation Dates of Mission-critical User Observation Requirements

NOAA User Observation Requirements Grouping	Number of Mission-critical Requirements	Date of Last Validation
Tropical Cyclones	47	7/12/2021
Marine Weather	88	7/12/2021
Integrated Water Prediction and Information	85	10/28/2019
Space Weather	56	12/12/2017
National Marine Fisheries Service Supplemental	23	2/24/2016
National Ocean Service Supplemental	24	2/24/2016
National Weather Service Supplemental	2	2/24/2016
Oceanic and Atmospheric Research Supplemental	114	2/24/2016
Oceanic and Atmospheric Research Airborne	116	11/12/2013
National Marine Fisheries Service Airborne	19	8/30/2013
National Ocean Service Airborne	26	8/30/2013
NESDIS Airborne	2	7/25/2013
National Weather Service Airborne	7	7/2/2013
NESDIS Ocean In Situ	5	12/7/2012
National Marine Fisheries Service Ocean In Situ	203	12/7/2012
National Ocean Service Ocean In Situ	66	12/7/2012
Oceanic and Atmospheric Research Ocean In Situ	70	12/7/2012
National Weather Service Ocean In Situ	2	6/27/2013
Surface Weather	12	2/7/2012
Environmental Modeling	79	1/5/2012
Local Forecasts and Warnings	25	10/4/2011
Aviation Weather	55	8/16/2010
Air Quality	3	3/30/2010
Tsunami	9	5/18/2009
Geodesy	7	3/16/2009
Marine Transportation	23	3/16/2009

Source: NOAA User Observation Requirements Documents

Appendix D: Comparison of Requirement Priority Definitions

Table D-1. NOAA, GOES-R, and JPSS Requirement Priority Definitions

NOAA Dataset Definitions	GOES-R Program Definitions	JPSS Program Definitions
Mission Critical (Priority-1): This user requirement captures environmental data for products and services that are critical to NOAA's mission. Limited or loss of access to this data would prevent NOAA from meeting operational mission objectives and result in unsatisfactory mission performance.	Tier IA: Key Performance Parameters (KPPs) – Inability to meet threshold-level requirement is cause for system reevaluation or termination	Priority-1 (KPP/Critical): KPPs essential to system success
	Tier IB: NOAA Program Priority-1 and High GOES-R Series Satellite Contribution	
	Tier II: NOAA Program Priority-1 and Moderate GOES-R Series Satellite Contribution	
Mission Optimal (Priority-2): This user requirement captures environmental data for products and services that are not critical to NOAA's mission but provide significant improvement to operational capability.	Tier III: NOAA Program Priority-2/3 and Moderate GOES-R Series Satellite Contribution	Priority-2 (Supplemental High): Products with critical impact to NOAA line office operations and/or outcomes
Mission Enhancing (Priority-3): This user requirement captures environmental data needed to enhance the state of knowledge, or to assess the potential for an operational capability.		Priority-3 (Supplemental Low): Products with high impact to NOAA line office operations and/or outcomes
[Not defined]	[Not defined]	Priority-4: Products with lower impact to NOAA line office operations and/or outcomes

Source: NAO 212-16 and GOES-R and JPSS Level-1 requirements documents

Appendix E: Agency Response

UNITED STATES DEPARTMENT OF COMMERCE
Deputy Under Secretary for Operations
National Oceanic and Atmospheric Administration
Washington, D.C. 20230

MAY 17 2022

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

FROM: Benjamin P. Friedman
Deputy Under Secretary for Operations
National Oceanic and Atmospheric Administration

SUBJECT: *The Success of NOAA's Next-Generation Satellite System Architecture Depends on Sound Requirements Management Practices*
Draft Report

The Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) is pleased to submit the attached response to the draft report on next-generation satellite system architecture. We reviewed the report and concurred with the recommendations.

We appreciate the opportunity to review and respond to your draft report. If you have questions, please contact Tanisha Bynum-Frazier, Director, Audit and Information Management Office on (301) 467-0832.

Attachment

Department of Commerce
National Oceanic and Atmospheric Administration
Response to the OIG Draft Report Entitled
The Success of NOAA's Next-Generation Satellite System Architecture Depends on Sound Requirements Management Practices
(April 2022)

General Comments

The National Oceanic and Atmospheric Administration (NOAA) appreciates the opportunity to review the Office of Inspector General's (OIG) draft report on next-generation satellite system architecture. NOAA reviewed the report and concurs with the OIG's recommendations. Responses to the seven recommendations as well as some recommended changes to factual/technical information are provided below.

NOAA Response to OIG Recommendations

Recommendation 1: That the NOAA Deputy Under Secretary for Operations update policies and procedures to ensure user observation requirements are validated in advance of next-generation satellite system acquisitions.

NOAA Response: NOAA concurs. The National Environmental Satellite, Data, and Information Service (NESDIS) through its Office of System Architecture and Advanced Planning (OSAAP) will coordinate a NOAA-wide review and update current policies and procedures to ensure that, to the extent feasible, user observation requirements are validated in advance of next-generation satellite system acquisitions.

Recommendation 2: That the NOAA Deputy Under Secretary for Operations ensure that next-generation satellite programs do not define more stringent requirement thresholds than corresponding thresholds in the NOAA dataset.

NOAA Response: NOAA concurs. OSAAP will work with the next-generation satellite programs to ensure that program threshold requirements are aligned with NOAA user observation requirements, which could include updating the user observational requirements themselves.

Recommendation 3: That the NOAA Deputy Under Secretary for Operations ensure that next-generation satellite programs include requirement objective values that are different from thresholds.

NOAA Response: NOAA concurs. OSAAP will work with the next-generation satellite programs to ensure that they include requirement objective values that are different from thresholds in the program-level requirement documents.

Recommendation 4: That the NOAA Deputy Under Secretary for Operations assign responsibility and design a process for determining the relative priority of each NOAA user observation requirement.

NOAA Response: NOAA concurs. NOAA will appoint a responsible and appropriate

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organization to take the lead on designing and implementing a process for determining the relative priority of NOAA user observation requirements.

Recommendation 5: That the NOAA Deputy Under Secretary for Operations 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.

NOAA Response: NOAA concurs. NESDIS will develop a standard set of requirement priority definitions for next-generation satellite programs, which will include the extent to which its programs contribute to meeting NOAA user observation requirements.

Recommendation 6: That the NOAA Deputy Under Secretary for Operations ensure that NESDIS revises policies and procedures for assigning requirements to next-generation satellite programs.

NOAA Response: NOAA concurs. OSAAP will finalize and document the policies and procedures for assigning user observation requirements to next-generation satellite programs.

Recommendation 7: That the NOAA Deputy Under Secretary for Operations ensure that portfolio management tools include accurate and complete data to produce useful information for investment decisions.

NOAA Response: NOAA concurs. OSAAP will continue to survey existing observing systems portfolio management tools, and will develop recommendations to implement improvements and updates to the observing systems portfolio management tools it uses to produce useful information to support investment decisions related to its next-generation satellite programs.

Recommended Changes for Factual/Technical Information

Page 6, Table 1, 3rd column title:
The current title reads "Subset of User Observation Requirements Met by Satellites (count/percent)". The word "Met" is perhaps too strong. Suggest changing to "Potentially Met".

Page 6, section C, 3rd paragraph, 2nd sentence:
The current sentence begins "Of the 791 requirements supported by satellite systems…" The word "supported" is perhaps too strong. Suggest changing to "potentially supported".

Page 16, Table C-1, Source:
The source currently listed at the bottom of the table is "NOAA Program Observation Requirements Documents". Suggest that it be updated to read "NOAA Observation User Requirements Documents" as this is a more broad and accurate term.