



NESDIS Center for Satellite Applications and Research (STAR)

External Review Report

NESDIS Executive Council Meeting
November 1, 2023



Executive Summary

The NOAA/NESDIS Center for Satellite Applications & Research (STAR) organized a panel-based external review on May 16-19, 2023, to assess the [Quality, Relevance, and Performance](#) of its science portfolio in meeting NOAA's mission, science community and user needs, and broader societal benefit. The review scope was inclusive of STAR's research, applied science, as well as the science enterprise tools and processes that enable them. The panel was also tasked with providing insight on how STAR's strategic vision and implementation could be optimized to anticipate and adapt to future needs. The review planning committee developed a new evaluation framework designed to provide insight on the societal impact of STAR science and activities. The review format was structured as a series of presentations and panel interactions focused on thematic areas of Atmosphere, Ocean, Cryosphere, Land, and Enterprise-Enabling Activities.

The panel was composed of 10 technical experts and leaders from U.S. and EU Government agencies and private industry. The review planning committee included Diversity, Equity, Inclusion, Justice, and Accessibility (DEIJA) as a foundational principle when forming the panel. Panelists convened in a hybrid setting at the National Centers for Weather and Climate Prediction (NCWCP) in College Park, Maryland.

Summary of Opportunities and Recommendations

The overarching opportunities and recommendations are: 1. Strengthen the prioritization process of current products and services, 2. Reduce risk to product sustainability from the current lack of permanent technical support (federal staff) and funding uncertainty, 3. Solidify clear metrics for product usage, relevance, and their impacts, 4. Strengthen partnerships and collaborations to expand and demonstrate STAR's societal impact, and 5. Develop a business plan (or similar) that clearly defines the role that STAR plays in the NESDIS mission for the future of earth observations while continuing to support the National Weather Service (NWS).

STAR Present State

Science Portfolio: STAR is a world-class scientific and technical organization with expertise that results in excellent quality products and services for the global satellite community. Products are relevant by design with a clear focus on preparedness, forecasting, and climate, with current research and development efforts focused on almost every part of the Earth system. STAR's primary user base is internal to NOAA represented by NESDIS and NWS, a secondary user base from NOS and NMFS, and a strong and expansive tertiary external partner base. Many of STAR's current products and services are aligned with NOAA/NESDIS strategic objectives and requirements, but it is unclear whether product creation is primarily driven by requirements, STAR scientists, or by specific end user requests. While STAR products were noted as high quality, there is a lack of metrics of end user usage and satisfaction that could be more systematically collected.

Program Structure and Function: The large number of products and the absence of an overall product management and prioritization plan is *“causing apparent stress to the financial sustainability of [STAR], which can cause impacts to product quality if they cannot be updated or maintained.”* There is a need to clearly define STAR's role in NESDIS operations and

delineate its responsibility in product lifecycle versus other offices, particularly regarding delivery of high priority or operational public facing products.

Partnerships, Education, and Outreach: Many of STAR's strongest partnership efforts are regionally-based and staff dependent. STAR's communication with the majority of the public beyond the scientific community appears to be lacking. To date, community-based user engagement, user education, and training efforts have been within "known" communities and could be expanded to increase positive impact and address broader user needs.

STAR Future Potential State

Ensure Clear Science Product Priorities: The panel recommended that STAR develop a comprehensive and well-defined prioritization process, improved performance metrics, and a strategic approach to product lifecycle management. Maintaining a lean, priority portfolio enables STAR researchers to devote more time on improving collaboration and integration, serving as a testbed for innovative trans-boundary Earth system products, and can help ensure that STAR priorities align with the administration's emphasis on preparing underserved and vulnerable communities.

Solidify the STAR Business Structure: The development of a business plan with a focus on personnel and the roles of various STAR entities, as well as improving efficiency through the standardization and consolidation of administrative tasks. Implementation of the plan will enable STAR to be better able to explain how additional resources and billets will lead to high priority societal outcomes.

Increase Partnerships, Training, Outreach, and User Engagement: Strengthen existing federal partnerships in priority areas by improving staff's understanding through details and continued engagement in workgroups and cooperative relationships. STAR should continue to focus on education and outreach, particularly in engaging with K-12 students and the general public. STAR should consider partnering with NOAA's education office and other outreach programs to sustainably expand its work without overburdening staff. STAR could also rebrand and expand the CoastWatch program to streamline and increase the efficacy of these efforts.

Ensure Internal NESDIS Organizational Efficiency: STAR's new organizational structure should encourage individuals to identify their roles thematically rather than with specific products or services; this will empower them to contribute to prioritization efforts without concerns about specific end user products. It is critical to establish a clear identity for STAR within the larger NESDIS organization. In doing so, STAR can transition away from a product-based office and focus on scientific research and future advancements to address climate change priorities.

Embrace Advanced Technological Opportunities: Focus on attracting the next generation workforce with skills in Artificial Intelligence/Machine Learning. Form a dedicated team with expertise in cloud evolution and edge computing and prioritize transferring existing products to operational offices or cloud systems instead of solely focusing on new product development.

By addressing the panel's recommendations and implementing a comprehensive business strategy, STAR can enhance its position as a leading program in the field of satellite agencies while ensuring long-term success and societal impact in the global Earth System Sciences domain.

**Summary Report of the Review of the NESDIS STAR
Program Office**

**May 16 - 19, 2023
College Park, MD**

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Introduction

In 2022, The NOAA NESDIS and STAR leadership organized a panel-based external program review structure for their Center for Satellite Applications & Research (STAR) Program. The External Review was intended to assess the overall STAR portfolio in meeting NOAA's mission, science community and user needs, and broader societal benefit. The review scope was inclusive of the program's research activities, applied science, as well as the science enterprise tools and processes that enable them. An additional charge to the panel was to gather feedback on how STAR's strategic vision and implementation can be optimized to anticipate and adapt to future needs. The review structure was focused around three main evaluation criteria: Quality, Performance, and Relevance. These evaluation criteria were established through a NOAA Administrative Order¹, which calls for a periodic evaluation of research, development, and transition activities as well as outreach efforts and stakeholder engagement.

The panel was composed of technical experts and leaders from US and EU Government offices and private industry. NESDIS and STAR leadership selected the panel participants to represent organizational partners, stakeholders, and end users of the STAR Program's data and science products. For this review, NESDIS and STAR leadership prioritized the "Relevance" criterion based on the scope of planned presentations as well as anticipated use of the panel's recommendations

The program review was held from May 16 - 19, 2023 at the NOAA Center for Weather and Climate Prediction in College Park, Maryland. The review was held in a hybrid in person/virtual setting, and comprised a series of presentations by STAR leadership and staff focused on core mission areas including: Air, Hydrosphere, Cryosphere, Land, Enterprise, and Ocean. The first three days of the review focused on staff presentations, panel interactions with staff, and panel only discussion time to allow for daily synthesis. On the fourth day, the panel met with NESDIS and STAR leadership to provide a high-level summary of the panel's initial thoughts and reactions from the review.

This final report represents the synthesized panel views based on the review of strategic documents provided in advance of the meeting, panel's engagement with STAR staff and leadership during the program review, interactive panel synthesis sessions, and post-review reflection. The report provides observations and recommendations to the three priority evaluation criteria of Quality, Performance, and Relevance, and is organized into sections based on the Panel's view of the STAR Program's current state, potential future state, and overall summary thoughts.

¹ NAO 216-115A, dated October 3, 2016

Table of acronyms

CI	Cooperative Institute
DAAC	Distributed Active Archive Centers
DEIJA	Diversity, Equity, Inclusion, Justice, and Accessibility
ECMWF	European Centre for Medium-Range Weather Forecasts
EPA	Environmental Protection Agency
ESRI	Environmental Systems Research Institute, Inc.
ESS	Earth System Science
EUMETSTAT	European Organisation for the Exploitation of Meteorological Satellites
GOES	Geostationary Operational Environmental Satellite
NASA	National Aeronautics and Space Administration
NCAI	NOAA Center for Artificial Intelligence
NCEI	NESDIS National Centers for Environmental Information
NESDIS	NOAA National Environmental Satellite, Data, and Information Service
NMFS	NOAA National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOS	NOAA National Ocean Service
NWS	NOAA National Weather Service
OSGS	NESDIS Office of Satellite Ground Services
OSPO	NESDIS Office of Satellite and Product Operations
STAR	NESDIS Center for Satellite Applications and Research
USGS	U.S. Geological Survey

External Review Panelists

Evan Howell - Director, Office of Science and Technology -NOAA/NMFS (*Chair*)

Jessica Hausman - Support Scientist, Physical Oceanography - NASA/Headquarters

Estelle Obligis - Manager, Marine Applications - EUMETSAT

Chiara Piccolo - Satellite Applications Lead - United Kingdom Meteorological Office

Jack Eggleston - Chief, Hydrologic Remote Sensing Branch - USGS

Jean Brodeur - Physical Scientist, Office for Coastal Management - NOAA/NOS

Vijay Tallapragada, Environmental Modeling Center- NOAA/NWS

Sheridan Moore - Senior Consultant - ESRI

Lesley Ott - Climate Scientist - NASA/Goddard Space Flight Center

Barron H. Henderson - Physical Scientist - EPA

NESDIS STAR Present State

Science Portfolio

Overall, the panel recognized the large number of high quality scientific projects, products, and services produced by STAR teams, and recognized the NESDIS role as a key institution serving as one of the world's operational satellite agencies. Based on the review presentations and personal experience from panel members it was shown that STAR is a key innovator and researchers within STAR develop satellite products using deep knowledge of satellite systems and what is needed in the user domain. As the panel was asked to concentrate on the three key areas of quality, relevance, and performance, this section of the review report is structured to respond to these three areas of interest.

Quality

The numerous presentations to the panel highlighted the wide variety of extremely high quality products STAR produces. This was evidenced by the numerous awards, a data catalog housing almost 1,400 unique data products², and over 700 research articles published within the 2018-2022 time period. The panel felt that the scientific capabilities and technical expertise within the program were world class, resulting in excellent quality products and services. STAR houses an internal Calibration/Validation program solely focused on continued quality, and many of the scientific data values produced by this group are considered "best in class" references for next generation satellites. This combination of research expertise and scientific stature provides STAR the ability to exist as an innovative branch within NESDIS and the satellite community that can drive prioritization in satellite products and sensors as well as transformative change in products and data. Overall, the panel felt that the products highlighted in the review were of high quality, yet metrics of end user usage and satisfaction could be more systematically collected.

STAR presented numerous high quality examples during the review identifying how their applied research increases our comprehensive understanding of Earth System Science. The panel noted that many of these products were atmosphere-based due to the strong connection with the National Weather Service, and that there were excellent opportunities to begin to prioritize ocean products through other internal NOAA and external partnerships. This move to a larger number of ocean products aligns with STAR's 2030 vision of a more balanced portfolio. Some examples of quality products and delivery systems highlighted by the panel follow here.

The AerosolWatch program leads the nation in estimating surface pollution indicators from geostationary satellites. As experts in the air quality domain, STAR researchers recognized that

² Complete list is available at <https://www.star.nesdis.noaa.gov/portfolio/productListings.php>

high-quality satellite data can provide a spatial view of air quality that is not possible from surface monitors. They also recognized that the satellite data would need to be fused with surface data to produce a data product that meets air quality needs that relate to human exposure. To achieve this, STAR initiated substantial work to evaluate, calibrate, and bias correct aerosol optical depth from the Geostationary Operational Environmental Satellite (GOES). They then developed methods to fuse these optical depths with surface monitors, and collaborated with external agencies (academic groups, EPA and NASA) to evaluate the quality and usefulness of the data ensuring a functional product. Even more importantly, they collaborated in such a way to ensure that the data would actually be used. A key part of their collaboration is recognizing both the strengths and limitations of the data they produce and effectively communicating that with partner agencies. This represents a clear understanding of needs in the field, a deep understanding of how satellites can help, and a commitment to working with stakeholders to meet needs.

STAR's cryosphere products are cutting edge and provide the ability for extended research opportunities. STAR has a leading role in creating innovative and complex ice products for the global community, with the intent of reducing analysis time by operational ice centers. STAR's numerous ice products provide critical information on a wide array of ice parameters, including ice concentration, thickness, extent, temperature, type, and motion. These are essential parameters for both real time analysis, navigation, and input to system models. Additionally, The fire weather products developed by STAR exhibit a high level of quality and innovation, making them valuable assets for fire weather applications. They have successfully created a series of satellite products that effectively capture rapidly changing fires and their emissions. These products are then integrated into the NWS Community Multiscale Air Quality Model for predicting fine particulate matter of 2.5 microns or less (PM_{2.5}) and ozone as part of the National Air Quality Forecasting Capability. Additionally, their NOAA Satellite Observations of Rapid Changes in Fire Emissions significantly contribute to NWS Operational Air Quality Forecasting Models. NESDIS has also played a crucial role in developing a new algorithm by incorporating both geostationary and polar data, allowing for the generation of hourly fire emissions data, including PM_{2.5}. These products have the potential for carbon monitoring and human health applications, showcasing their versatility and broad utility.

Furthermore, STAR's involvement in product development enables comprehensive monitoring of the entire fire cycle, with specialized products designed to track areas during the pre, active, and post-fire phases. Notably, their contribution extends to quantifying global fire emissions, reflecting their goal of understanding fire impacts on a global scale. Overall, STAR's provision of these high-quality products plays a critical role in helping identify and comprehend the effects of fires, as well as offering active support during fire events. Their efforts significantly enhance fire weather forecasting and support agencies and communities in mitigating the impact of wildfires on air quality and public health.

The Coral Reef Watch (CRW) program was highlighted as it plays a crucial role in monitoring and communicating changes in the coral reef environment, particularly changes that may impact reef usage and closures. The quality and trust in the CRW product was evidenced by CRW's

ability to work closely with partners and decision makers to provide advanced warnings of marine heat stress events and coral bleaching occurrences on Australia's Great Barrier Reef in 2016, 2017, 2020, and 2021-22. The program was also seen as highly responsive to user inquiries, with the ability to provide high quality information about its products and datasets to industry, partners, and students. CRW actively performs outreach and partnering through contributions to the scientific literature, offering an online tutorial and detailed methodology page about its core satellite products, and giving frequent presentations discussing their products, applications, and future scientific advancements.

The CoastWatch program was also highlighted as a critical service team within STAR that plays a pivotal role in facilitating access to satellite data for oceans, coasts, and inland waters. A program strength is in their ability to not only make raw and specialized data products readily available, but to also take an active approach in training users on how to access and analyze core satellite data products. By providing both data and specialized tools for viewing and analyzing the information, CoastWatch ensures that end users can utilize the highest quality data for their specific applications. The emphasis on user engagement also helps identify opportunities to enhance the value of core data products through the development of innovative satellite data-based products. The program's regional node model, centered around a central hub, facilitates national standardization while still allowing flexibility to address regional needs. This approach ensures that users across different regions can benefit from standardized data protocols while tailoring the program to accommodate unique regional requirements. Through these efforts, the CoastWatch program acts as a critical bridge between satellite data and end users, enabling them to make informed decisions and derive maximum value from satellite-based data and products.

In addition, STAR displayed several examples where researchers have successfully fused satellite data products to provide novel indicators for societal benefit such as critical water (evapotranspiration and drought) and ice products. The Advanced Concepts Enabling Situational and Hazards Awareness via Imagery (ACES-HAI) advanced GeoColor imagery products were a highlighted example of these types of novel products. Finally, the panel underscored the significance of STAR's identity and specialized knowledge in radar applications within the field of remote sensing. By continuing to leverage this expertise, STAR has the potential to bolster its reputation and achieve greater success in this arena.

The panel did have concerns regarding the sheer number of data products listed by the program, and had questions around how STAR was able to maintain and prioritize novel and existing products, review and sunset projects, and how the program created and tracked metrics of product impacts beyond downloads and end user feedback. More detail on these questions and panel suggestions to these observations are included in the *relevance* and *performance* sections of the report below. Improvements to these components of the program would increase the confidence in measuring the quality of all products in the STAR catalog. STAR can keep innovation as a critical component of the program, but it must be part of a business model based on prioritization and metric tracking.

Relevance

In preparation for the review, STAR leadership expressed several key questions to help the panel refine their findings on product relevance for the final report. One area of interest was if STAR's proposed Earth System Science (ESS) portfolio would be optimally suited to address broader societal impacts. The panel felt that this newly proposed ESS portfolio could potentially reach broader societal impacts by balancing the STAR portfolio to include priority ocean products, and a greater focus on integrative and responsive products that provide shape specifically to ESS needs and applications. These could potentially include expansion of the innovative and integrative multi-satellite data products and other novel methods of combining available satellite-based measurements and data series into products that address contemporary global challenges. One panelist remarked that STAR could provide research and data to identify the impact of increasing heat input to the ocean, which has served as a major heat sink to date. STAR could play a critical role in understanding and providing information on how this impact may weather forecasts and blue economy decision-making.

Similar to the section on quality, prioritization was a central discussion point during panel deliberations. For STAR to be effective in diversifying its portfolio to address more ESS goals, STAR must develop a robust prioritization scheme to identify areas for portfolio growth, transfer, or retirement to ensure business continuity. Prioritization is a central concept in the Future State section of this report.

Through the review, the panel felt that many of STAR's current products and services were aligned with NOAA and NESDIS Strategic Objectives Requirements, but it was often unclear if product creation was primarily driven by these requirements, or by specific end user requests. It was evident that STAR products are relevant by design with a clear focus on preparedness, forecasting, and climate. Current STAR research and product development within the program touches almost every part of the earth system. This broad mission focus helps ensure that resulting products are relevant, yet the panel was unsure of the desired niche for STAR. During the presentations it was often unclear if relevance was the primary or secondary driver for product creation. Many of the products appeared to be created through a user request mechanism, which results in STAR making a product and the end user defining the product's "relevance." This works well for a completely user-driven model, but can result in less relevance to the NOAA/NESDIS strategic objectives depending on how many products are created for end users outside NOAA. An improved prioritization process can help ensure that product relevance is a primary driver, and metrics can be used to identify when products lose relevance or can be deprioritized. Panel discussions identified several times the number of STAR products, and panelists had trouble identifying how many STAR products were legacy products that may have been developed by a previous PI and deemed too important to stop. The panel suggests that STAR research experts develop a 3-4 year roadmap to be approved by STAR and NESDIS leadership to ensure that it is consistent with current NOAA and NESDIS strategies.

An additional area of focus to the panel was on how and to what extent STAR's current products and services are prioritized based on resources available and its commitments. This was a key question for the panel, and the topic of STAR resources and current prioritization scheme were central themes in the panel deliberations and recommendations. The panel left the review with an open question on who was driving the prioritization of STAR products. It was unclear to the panel how STAR prioritized what was important in terms of research areas as well as when to advance products through their respective lifecycle. From the review process, panelists felt that product creation, and therefore relevance, has been largely driven by available Line Office funding and individual user meetings. The current STAR resource model was also identified by the panel as a probable reason for the current STAR prioritization process. As presented, approximately 60% of the annual STAR budget³ is directed from entities external to NESDIS. The panel identified this current funding structure as an area of focus for STAR leadership to explore, as a reliance on external transfers can artificially drive external prioritization of STAR work, and does not provide a stable funding mechanism for product longevity. The panel noted that externally-driven prioritization can define sector relevance, but can limit possibilities and hinder independence in priority decision making. This is an issue for any research entity relying on external transfers of funds. The panel discusses areas for suggested improvement and focus in the future state section of the report.

Additionally, STAR's role in the product life cycle was often unclear. It was often difficult to decipher if the STAR products presented to the panel were created from Research and Development projects, products undergoing continued evaluation, or formal operational products. The panel also noted that improvement of current services and development of new ones are proposed internally by STAR researchers. While an improved prioritization process would assist in formal identification of product state (e.g., research, evaluation, operational), it was apparent that STAR will also need to formalize its role and duties in the product life cycle within the overall NESDIS structure. The panel felt that this was a critical component in improving the prioritization process as well as in creating a more formalized business model. Identifying STAR's role within NESDIS could solidify STAR's role as a Research and Development entity within NESDIS, and relieve pressure on STAR to support products through all stages of the product life cycle. A point of consideration is If STAR is focused more on research, then this can result in product relevance driving prioritization. This can be an effective method to develop pilot products and promote innovation, but this should be coupled with a strong decision process to identify when products would advance through the research towards operations and services. The panel did note that in the past product development appeared to have been more from individual team advocacy, with a recent change over the last year to becoming more STAR-centric in decision making, which is a positive trajectory.

The panel also identified that in its current state, STAR's focus is on iterating to the needs of current users. This can be a very sensible priority, but the panel noted that there should also be focus and resources placed on reaching new users, including a vision for examining data prioritization, coverage, and resources to meet the agency's Diversity, Equity, Inclusion, Justice,

³ [STAR Review Briefing Book](#) Page 36

and Accessibility (DEIJA) goals. Overall, the panel felt that STAR would benefit from developing a stronger prioritization process, and identified the need for a better metrics and evaluation system. Ideas for developing these are included in the section on ensuring clear science priorities in the future state section of the report.

The review panel was also asked to ascertain to what extent users are engaged in STAR's research and product development process in order to identify areas where STAR can improve its engagement with the broader user community. During review deliberations, panel members discussed how different researchers described their "user base," and expressed diverse perspectives on how to identify current and potential users for STAR products, which are summarized here. Overall, the panel felt that the primary users were internal to NOAA representing NESDIS and the NWS, with a secondary user base from the National Ocean Service (NOS) and National Marine Fisheries Service (NMFS), and a strong and expansive tertiary external partner base. The NOAA focus to date on NESDIS and NWS represents well the existing missions and NOAA Federal funding streams directed at creating products to meet atmospheric weather, next generation satellite, and climatological data needs. These included climatologists that appeared mainly focused within NESDIS. The secondary internal NOAA users represent the two "ocean" arms of NOAA and STAR identified where existing user relationships exist through Coral Reef Watch, CoastWatch, and individual user relationships, but also identified a growing need to expand these partnerships to balance the internal NOAA portfolio across the earth system. In addition to the internal user base, it was clear that STAR had a strong and extensive external user base that spanned almost every earth science discipline, in many cases across a global spatial scale. This includes the global climate community and air quality community for STAR's emission products, the US Coast Guard, the US Department of the Navy, and the National Ice Center for their ice products. One of the panelists also identified that several of STAR's research and development activities are being used to improve EUM products and services through a collaborative agreement. A good example being the development of polar demonstration products by STAR altimetry experts, and the implementation of this innovative processing in EUMETSAT Sentinel-3 operational products.

However, while it was apparent that STAR understood their user base due to internal NOAA and external partner product requests, it was less clear how STAR measured their user engagement beyond tracking website downloads and feature requests. The panel did not identify a clear plan in place for STAR to measure user engagement, including any formal process to create products for users or ability to place value on these requested products. If a process to capture user requirements does exist within STAR, it was not visible to the panel and did not appear to be a part of STAR's main priorities. This current limitation in fully ascertaining the user base for the numerous STAR products can have unintended consequences in prioritizing and defining users and user needs. Currently this prioritization and definition may default to what individual stakeholders request or demand, which will not represent the full user base. This is an area of potential for STAR to consider, and the panel has included recommendations in the future state section of the report.

A final question STAR leadership had around relevance regarded whether the panel identified STAR products and services as being used to inform societal outcomes. The panel did identify several high profile STAR products and services including the fire team's work on carbon emission tracking, the Coral Reef Watch flagship product, CoastWatch's service delivery model, AerosolWatch informing the nation's air quality forecasters, and several of the emerging water quality and ice-related products. The carbon emission work including the potential expansion was highlighted by the panel as a bright spot within STAR and representative of a potential new paradigm for product development within STAR. The panel also remarked that there were other uses for products that were not represented during the review, specifically within the snow and ice product line where the EPA is using sea ice to parameterize emissions in their regulatory models. The panel understands that it is impossible to represent all uses for the number of products within STAR over a three day period. However, it may be worth STAR leadership considering this as they implement their new organizational modeling and strategic implementation as part of improving their user engagement and prioritizing product lifecycle decisions. For example, the panel had several questions around the utility of the water products, and how decision makers were consulted before product creation to ensure utility to end users upon creation and delivery.

Performance

Over the course of the four day review, it was evident to the panel that many STAR researchers were internationally known with active participation in the scientific community. This engagement on global committees and working groups creates a first line ability to understand global user needs and create relevant products based on international engagement and first-hand knowledge of current issues. The panel identified several sectors where STAR was performing well, and some emerging potential areas for engagement. STAR's participation in the international winds working group was highlighted as a successful example, where STAR researchers engage with other weather predictors and data producers to share information. The sea surface temperature community appears to be well covered by STAR, and this may be an area of interest to review and potentially "retire" obsolete products. The fire weather and ice sectors were two other areas highlighted by the panel as existing areas of strength, with a large opportunity for STAR to strengthen engagement in the ocean communities, especially with regard to innovative ocean color products. The air quality area of interest is an area of strength with an opportunity for growth now that additional geostationary satellite capabilities are coming online.

While evaluating the performance aspects of the STAR program, the panel became increasingly unclear on what performance metrics were prioritized by STAR, and this created difficulty in identifying true performance for many STAR products and programs. The performance metrics identified and employed ranged from monitoring downloads and tracking publications to qualitative feedback from end users and working group colleagues, yet very few formal or quantitative performance metrics appeared to be developed or employed by STAR. The panel felt that this was a priority area for improvement, and that STAR should develop stronger performance metrics. The lack of metrics resulted in a perceived inability to measure users,

product usage, and impacts. The panelists noted that the focus on research publications pointed to a running theme on STAR's identity, where the program consistently identified as a research program, while the program was externally employed by NESDIS and other NOAA offices to create applied and directed products. The panel did recognize the high value of publications, yet felt that the publications tracking should not be a primary indicator across the program. The panel noted that an improvement could be to measure or monitor the number of research and development activities leading to improvements in the operational products and services. This method could also be employed to quantitatively measure the impact of respective partnerships, rather than track the number of partners. The STAR program granted over \$260M over the last five years, which provides a large opportunity to report discrete and, where possible, quantitative impacts from these grants. During the review these impacts were mainly described in qualitative terms using anecdotal reporting or stats on effort and not impacts.

The panel spent considerable discussion time with STAR leadership on day four of the review discussing current and potential performance metrics for the program, and identified this as an area of opportunity for improvement. One positive example highlighted by the panel was the clear connection between products, relevance, value, and stakeholders highlighted in the air quality products presented on day 3. The panel recognized that performance is difficult to measure, and suggestions for future performance metric ideas are presented in the future state section of the report.

Science Portfolio Summary Thoughts

Overall, the panel was impressed with the high quality and integrity of STAR's research team and flagship products. It was obvious to the panel that STAR researchers are esteemed and engaged members of the professional global scientific community across numerous disciplines, resulting in the creation of an impressive number of innovative and requested products developed in established and nascent areas of societal focus. However, the sheer number of products contained within the STAR portfolio was an area of concern for the panel, and the need for STAR to prioritize efforts, as well as to create and track stronger metrics for user engagement and product impacts, was identified as an area for improvement.

Program Structure and Function

During the course of the review, the panel identified several areas where STAR had opportunity for improvement in its program structure and function. The panel had specific questions and concerns around how STAR's current program fits into the larger NESDIS organizational structure and the lack of an apparent business plan to accompany the ongoing STAR strategic planning process and reorganization efforts. Here, we summarize the panel's reflection and discussion focused on the trigger areas of quality, relevance, and performance related to STAR's current program structure and function.

Quality

Throughout the review it was apparent to the panel that STAR was a high quality program composed of highly skilled researchers focused on high quality products. All panelists could see that the staff was highly engaged, extremely knowledgeable, and motivated to ensure continuity on as many projects as possible to sustain possible societal impacts. However, as identified earlier in the report, the lack of an overall plan for product management and prioritization is causing apparent stress to the financial sustainability of the program, which can cause impacts to product quality if they cannot be updated or maintained. STAR's current business structure appears to rely heavily on external funding ("soft money"), which is reflected in the extremely high ratio of contract/cooperative institute employees to Federal staff (~5:1). The federal staffing structure also appeared to drive Federal staff to serve in more administrative or program management roles. This can cause issues both in Federal researchers moving away from their trained specialty to provide more oversight than research, as well as in investing heavily in research and development being driven by non-permanent employees who may not be able to sustain product development through time. Aside from the issues in staffing permanent employees, the nature of temporary funding can also cause issues with prioritization, as project-based funding can artificially elevate the prioritization of lower priority projects and products due to the commitments made when receiving external temporary funding. The panel questioned how much independence for prioritization was possible based on STAR's current funding model. Overall, the panel saw opportunities for STAR to solidify its role within NESDIS, improve its prioritization process, and create a solid business plan for the office. These were central areas for improvement, and we expound upon these points in the following sections of the report. These are imperative steps for STAR to succeed in modifying, or potentially expanding, its current scope to create high quality global products within an earth system science portfolio to meet NOAA's Climate Ready Nation and other critical societal goals.

Relevance

There were several discussions throughout the review on STAR's relevance as a NOAA program, and where STAR may best "fit" from an organizational perspective. Here we offer thoughts and perspectives based on those conversations with STAR researchers and leadership during the review. Several times during the review the panel heard the expression "STAR is a research entity housed within an engineering landscape." The panel interpreted this as meaning that STAR's current focus on satellite product research and development may not "fit" within the framework of NESDIS's operational satellite and product delivery system. The panel identified this combination of operational styles, and a large focus of the panel's discussion was on gleaning information on how STAR operated within the NESDIS and greater NOAA context.

Overall, the panel had questions about program delineations within NESDIS, especially with regard to where roles on product operations and delivery existed solely within STAR, or when responsibility shifted between other NESDIS entities and STAR during the product lifecycle. A recurring question during the review was where STAR "fits" within NESDIS, and how decisions were made regarding when to make transfers between STAR and other NESDIS offices. This

highlighted a need for clarity in roles and responsibilities for STAR that would clearly illustrate how these differ from other NESDIS, and NOAA offices. An immediate opportunity was identified in the potential to centralize programmatic management and administrative structure within NESDIS, and this may be possible within the new NESDIS common services office being formed. The panel felt that this may also address concerns around STAR's budget structure, where 40% of the program's current funding comes from sources external to NESDIS. The external funding model is not necessarily an issue if a prioritization process is followed to ensure that projects are created to meet mandates or priority goals. While STAR has internal NESDIS mandates related to instrument calibration and validation, value added satellite data products, and development of next generation satellites, many of STAR's mandates are inherited from entities outside of NESDIS, meaning that they are second order. In this way, STAR meets mandates by developing products within NESDIS, who then delivers these to the respective Line Office to meet their primary mandate. The panel recognized that this is still an effective methodology for STAR to add primary value to greater NOAA mandates and societal needs, but this understanding must be present during the initial project prioritization process to ensure STAR does not overextend their capabilities to ensure quality product delivery while staying relevant to the respective mission.

A central point within the STAR/NESDIS relationship was the role of STAR versus other NESDIS offices such as OSGS, NCEI, and OSPO. Throughout the review, the panel was unclear as to the delineation in responsibilities between these offices, especially regarding delivery of high priority or operational public facing products. During the review, the strongest programmatic synergy appeared to exist between STAR and NCEI. Even the role delineation in this relationship was not clear, and several panel members commented that they needed additional clarity on how these two different programs approached the product life cycle, when a product would be created within a specific office, and when decisions to transfer products between offices may occur. One panelist remarked that they were unsure if NCEI served as the storage repository for STAR data, or if NCEI also took responsibility for delivering operational STAR products as well. There was less clarity on role delineation between STAR and OSPO and OSGS. The panel identified the need for NESDIS and STAR leadership to better define the crossover of STAR with these other NESDIS offices and clearly identify STAR's role in the value chain. Clearly defining STAR's role in NESDIS operations and delineating STAR's responsibility in product development and delivery should greatly enhance STAR's relevance within the NESDIS and NOAA value chain.

Performance

The panel noted that many of the points raised in regard to scientific product delivery were also relevant to STAR's program function and structure. Here we sought to add program specific points that STAR can incorporate in their post-review planning to maximize program performance.

The main issue noted by the panel was the lack of an existing business plan for the office. This is a key point that we discuss in the Future State section of this report. The absence of a business plan was most apparent in panel discussions around how to measure STAR's program

performance. The panel felt that this was a key document necessary to advance discussions around future efforts to effectively prioritize new and existing products, form and maintain key stakeholder partnerships, and to stabilize the STAR budget model to support necessary and leadership-directed Federal and non-Federal activities. As was noted earlier in the report, it was difficult for the panel to comprehend the sheer number of products within the STAR portfolio, or to understand which of these were priority products built and subsequently maintained for directed purposes. Additionally, STAR appeared to offer three tiers of service for these products: research and development high assurance (e.g., 99.999% uptime), moderate assurance (70-80% uptime), and low assurance (no uptime guaranteed). This is a unique business model for a self-described research and development program. The panel felt it was essential that STAR review their portfolio to identify legacy products to discontinue as well as operational products to transfer to another NESDIS program organizationally suited for operational product delivery. The panel also questioned how much priority and capability was allowed for STAR to create innovative products. During one review discussion with NESDIS leadership, a comment was made to the panel that there is internal concern that a main focus of STAR was in the detailed and incremental update and research cycle of satellite product algorithm updates and research. It was therefore unclear if time and budget was allotted to innovation as part of the STAR strategic planning and budgeting process, or if innovation was individually motivated and opportunistic.

These review insights provide STAR opportunities for improvements to its program structure and function. The creation of a clear planning process for listing and scheduling development products produced by STAR scientists would provide STAR and NESDIS leadership a clear indication of the development stages and transition needs for individual projects. This can be in the form of thematic roadmaps for product development that would allow for initial management approval and a mid-process review to understand performance and potential helping ensure that product development is intentional and fully funded through the development lifecycle. As noted earlier, STAR and NESDIS leadership can also work closely to identify STAR's responsibilities for products, including a clear indication of when products can and should be transferred to other parts of NESDIS. Having clear and defined roles would potentially help internal NESDIS workflows perform more effectively and help communicate STAR's abilities outside of NESDIS, increasing product impact and relevance. Similar to the performance metrics for scientific products, the panel recommends that STAR work with NESDIS leadership to create trackable performance metrics for program function across NESDIS. These discussions should help clarify roles, reduce redundancy in execution, and stabilize funding to the appropriate entity within NESDIS for each stage of the product lifecycle. The panel noted that even within STAR, it appeared that STAR metrics tracked more of the use and availability, rather than the usability and impact value of products beyond the user who requested it. Additionally, the panel felt that each team within STAR worked with its own approach and tools, with the potential for program efficiency through sharing of data, expertise, and tools. The panel noted that STAR is currently undergoing a reorganization, and may have plans for centralization of some of these planning functions. Along with this potential centralization, STAR may consider the use of the cross line office CoastWatch program in providing expertise for internal skill centralization and synergistic product development planning for the desired earth system

science portfolio. A deeper discussion on these ideas are explored within the Increase Partnerships, Training, Outreach, and User Engagement section of this report.

Partnerships, Education, and Outreach

A major theme during the review was STAR's focus on partnerships, education, and outreach. These were highlighted to the panel both as current activities as well as future goals for improvement within the new STAR strategic planning cycle. Partnerships within the context of the review were presented both in the context of creating and deploying relevant science products and also in building capacity within the scientific community.

The results from the review indicate that while STAR is committed to these goals, there is ample opportunity to strengthen investments and ensure cohesion in these efforts. The panel felt that many of the strongest efforts in this sector were regionally-based and staff-dependent. For example, the partnerships with groups in Wisconsin and Colorado were considered strong, yet they appeared to be mostly driven by staff interest and community proximity to STAR office locations. This raised questions about their opportunistic nature, and the panel was unsure if this was a sustainable or desired model for STAR in the future. The primary partnership with NWS was emphasized during the review, along with clear connections to other federal agencies, including the EPA and Coast Guard. STAR provided other examples of partnerships including collaborations with Chesapeake Bay organizations and states, the Ocean Strategy Working Group, and EUMETSAT. The panel noted that the collaboration with EUMETSAT was ambitious, but had concern that a lack of resources on both sides may hamper concrete technical activities. The panel also noted that interactions with the Ocean Strategy Working Group with ocean components outside of NESDIS remains unclear.

Regarding education and outreach, the panel observed that STAR's communication with the majority of the public beyond the scientific community appeared to be lacking. The panel felt that STAR could increase efforts to make data more easily accessible and user-friendly to the general public. STAR's apparent focus on the scientific community also raised questions about how innovations can connect with new communities and whether PI-level scientists were focusing primarily on their "known" communities rather than expanding their area of impact to address broader user needs. The panel applauded the focus on these community efforts in the User Engagement and User Education and Training presentations and fully supports STAR working with NESDIS and NOAA to maximize the focus of these efforts in conjunction with the implementation of strong, trackable metrics to ensure positive community impact. The panel provides more ideas and suggestions in the "Future State" section of the report, including potential in creating a role for an expanded CoastWatch program to centralize and support user needs, data usage, training, and engagement through their existing formal structure.

NESDIS STAR Future Potential State

The panel envisions a future for STAR that supports its world-class research teams in working at the cutting edge of applied earth systems science, taking a lead role in fulfilling NOAA strategic objectives, and serving the public and users with high quality, accessible products that

are on target to meet societal needs. Below, the panel offers the following recommendations to help STAR continue to harness its considerable scientific capabilities and maximize potential impact in the Earth System Science Community.

Ensure Clear Science Product Priorities

To effectively meet STAR's goals of optimizing its portfolio to address broader societal impacts within a larger Earth System Science focus, STAR must start with ensuring clear scientific and product priorities. The panel identified the need to develop a comprehensive and well-defined prioritization process, improved performance metrics, and a strategic approach to product lifecycle management to ensure the effectiveness and impact of the scientific program. The implementation of a clear process would address many of the panel's concerns identified around prioritization. Additionally, STAR leadership should assess the creation of mandates from within NOAA or from outside partners, as these currently seem to be driven by individual researcher interests or connections. While user-driven feedback is essential to inform the prioritization, a rebalancing of top-down and bottom-up prioritization can maximize STAR's overall impact. It is important to note that STAR's unique expertise and adaptability, which appears to morph based on soft money opportunities, can be a valuable component in the prioritization process, considering its specialized experience and scientific skill that other NOAA/external bodies do not possess. This creation of a clear prioritization process would also assess the balance between user-driven and top-down prioritization, as there appears to be an overreliance on the user request system for product creation. The panel also suggests that STAR improve their ability to track user metrics, value, and prioritization of products through the creation of a specific internal STAR group or the use of the Product Portfolio Management (PPM) approach. If STAR follows this approach, the panel emphasizes the importance of enhancing clarity in roles and responsibilities to assist in overall STAR/NESDIS decisions and ensure continual operational capabilities for priority products. The panel identified the establishment of performance metrics as a crucial aspect of measuring the success and impact of STAR products. Specific metrics such as user registration, scorecards for product quality, user usage data, and follow-up on case studies and applications were suggested. These metrics can help inform resource allocation, further product development, and identify products that should be retired. The panel recommends that STAR issue Digital Object Identifiers (DOIs) and fingerprint their data products to ensure product integrity and provenance. In terms of user engagement, the panel felt there was a need for STAR to be able to identify and differentiate between regular users and super users, such as NWS. Differentiating between these end user types can help identify the support level needed for specific products, and STAR can rely on super users to rapidly identify system issues in real time. The panel also felt that employing a user registration system could help with user and usage metrics. The panel noted the need to be careful with information requirements during registration, but felt that this system has been helpful and improved cybersecurity in other data product systems, such as NASA's DAAC and ECMWF's Copernicus. User registration could also help STAR researchers follow up on user case studies and applications to measure product outcomes and impacts based on usage. The opportunity to leverage the capabilities of other areas within NESDIS to track product usage and

metrics of impact would be potentially beneficial, as operational entities typically possess such capabilities in-house.

The new STAR Science Council will play an important role in prioritization. When projects are proposed, the council will be best positioned to examine difficult questions about the value and opportunity costs of the idea; assess alignment with NOAA and NESDIS priorities; explore the relevance of the work to an applied science user base, with particular attention to engagement beyond traditional partners; consider the opportunity costs for undertaking the work, and ensure that operational objectives, staff skill needs, performance metrics, and an expected life cycle are defined. The council should have access to a more systematic collection of data on the performance of tools and services to help with that analysis, relieving the burden on the science teams to invent their own ways to understand who their users are and how much the data is being used. Examining prioritization will be an ongoing process throughout the lifecycle of the projects. While it is important to retain space for science teams to engage in discovery and exploration, with so many existing products and services, it will be important to focus on areas where STAR can make a transformative impact that furthers the highest priority missions, and to consider when it is time to archive or transfer particular data products and services. This future STAR will consider not just whether a potential project for an agency or internal NOAA partner can or should be done, but whether STAR is the best place for it to be done.

The panel also had several recommendations regarding STAR product lifespan and transitions. Primarily, the panel recommended the development of a systematic internal process or organization to determine when to start, stop, or continue data products. The panel identified a STAR leadership desire to considerably reduce the number of active products in the STAR portfolio. Here, performance metrics could also help leverage further development of products or help support the identification of products that could be retired. This approach to portfolio management would also help expand the current view of relevance beyond the user need identified during the product's creation, and create an ongoing practice of evaluating and evolving lines of work via the processes in the prioritization process. The panel noted that STAR could improve in their ability to archive or decommission older products to ensure the maintenance of priority products and help prioritize resources to maintain a streamlined and relevant product portfolio. The panel highly supports the information shared on STAR reorganization, including the addition of more project management units who will concentrate on a portfolio-wide vision and be responsible for the broader STAR enterprise. Finally, a greater emphasis on maintaining a lean, priority portfolio could enable STAR researchers to invest more time on improving collaboration and integration, serving as a primary testbed for robust trans-boundary earth system products. This can also help ensure that STAR priorities align with the administration's emphasis on preparing underserved and vulnerable communities.

Solidify the STAR Business Structure

STAR is unique inside NOAA in that it pursues research and develops products that touch every part of the earth system, providing essential information and services for NOAA, other federal

agencies, external researchers, private sector businesses, and other partners. With success has come rapid expansion and strain on the business operations of the center. A strong, sustainable, future STAR is structured to meet these challenges and allow specialist staff to focus on the highest priority work. To achieve this structure, the panel strongly recommends that STAR leadership invest effort in a formal business plan commensurate with strategic planning efforts. The development of a business plan would address how strategies will be implemented, with a focus on personnel and the roles of various STAR entities, as well as improving efficiency through the standardization and consolidation of administrative tasks. There were several areas that highlighted this need for a new STAR business plan. The review presentations and discussions focused mainly on strategic plans to improve science and research foci. While these strategic planning efforts can assist in some of the prioritization recommendations listed above, these may not address the other programmatic issues identified during the review, including the high percentage of temporary funding, the large number of grant vehicles used to execute research, and the small ratio of federal employees within the office.

One area that needs special attention in the business plan is staffing. With a large portion of the STAR federal workforce eligible to retire soon, and a low ratio of federal to non-federal staff, the business plan must include specific actions to ensure knowledge transfer and the continuity of high priority products. In order to attract skilled, early career talent with many employment options, it will be important to ensure that there are federal positions. In fact, the business plan should explore the balance between federal and contract staff and how they are utilized to support high priority work. The plan should include performance metrics on staff retention, tenure of non-federal staff, and effectiveness of knowledge retention within STAR. The panel recognized that STAR has requested additional billets, and felt that the creation of a clear business plan in coordination with NESDIS leadership would help to articulate a strong business case for increased billets within the program to meet NESDIS and NOAA mission objectives. Staffing objectives should more effectively balance programmatic research and management functions among federal positions, and increase federal jobs and other hiring options to attract and retain diverse talent. The panel notes that while some work is reasonable to contract out, the plan should identify core areas and skills, like the satellite work, and hire federal staff to fill those roles. Another element of the personnel plan should be to consider how to de-emphasize the connection of some staff with individual projects and shift to connecting them to broader themes, empowering them to use their expertise to support the prioritization process rather than incentivizing them to keep trying to “sell” products that are better transferred to others or archived. Currently, a large portion of the workforce is supported via the Cooperative Institutes, and the business plan should provide clarity on how to design those funding opportunities to support the future vision for STAR and align with NESDIS and NOAA priorities.

The staff that spoke to the panel described a vision for STAR that gave them the freedom to focus on using their expertise to develop innovative and integrative science and data products. Beyond prioritization, another important way to free up specialist time for higher priority work is to use the business plan to start the shift from having projects independently develop bespoke administrative systems for processing data, engaging with users, tracking metrics etc. to developing processes and expectations centrally and utilizing specialist staff to fill these roles or

organize the use of NESDIS resources to fill these roles. This plan could also directly tie into the STAR prioritization process to ensure each team has a product roadmap with approved schedules and budget before developing new products and services. This can assist in providing project management clarity and direction to ensure mission relevance of products and help avoid STAR being primarily focused on product development, provide more time and resources for future advancements, and identify priority budgetary needs for innovation or novel product development. One advantage of standardizing and centralizing some administrative and project management is the opportunity to have better, more uniform performance data to feed into prioritization; stronger outcomes and output tracking; reinforcement of the idea that personnel are not identified with one product from beginning to end; and potentially an easier transition from experimental products to mature data products that can be passed on to others. The panel also recommends that STAR coordinate with NESDIS leadership to identify where multiyear memorandums of understanding (MOUs) can be formed with mission partners within NOAA for specialized product development requests to ensure funding through the product life cycle.

A future STAR with a strong business plan will be better able to explain how additional resources and billets will lead to high priority societal outcomes. More clear role definition both for STAR, both as an entity and for its components, can provide a stable platform for experimenting with different ways to improve integration of the science and products to an earth systems approach. In this way, STAR can be a leader within NOAA for restructuring to address the high priority task of shifting to an earth systems approach that provides more value for climate change priorities.

Increase Partnerships, Training, Outreach, and User Engagement

As part of the review, STAR leadership asked the panel to identify how they can improve the application and communication of STAR products and services at the scale of individual projects and community accessibility. Partnerships will continue to play a vital role in strengthening collaborations and expanding the societal impact of STAR products. The new balance between top-down and bottom-up prioritization means that STAR will need to maintain a strong focus on user engagement without being too beholden to serving one set of users at the expense of higher priority work or reaching new users. In the short term, STAR can work to strengthen existing federal partnerships in priority areas by working to improve the staff's understanding of their needs through exchanges like details. Building stronger federal-to-federal relationships by gaining a deeper understanding of each agency's needs will be crucial, including enhancing partnerships with agencies such as NASA, the United States Forest Service (USFS), USGS, and stakeholders to foster greater collaboration and knowledge exchange. STAR's continued engagement in specialty workgroups and cooperative relationships can help identify where data and products will be most useful and enable more effective prioritization and utilization. The scalability of STAR's information products opens up opportunities to engage global and regional organizations and uncover new potential collaborations, as the Regional Hourly Advanced Baseline Imager (ABI) and Visible Infrared Imaging Radiometer Suite (VIIRS) Emissions (RAVE) team did with carbon monitoring and human health applications of the fire emissions

products. Of course, while identifying new opportunities, STAR must ensure balance between these potential partnerships and current engagements, and look for ways to leverage agency resources and staff to reduce the burdens of partnership. For example, there is a funded commercial data program at NASA⁴ that can be leveraged as an opportunity for NOAA and NASA to collaborate.

An important NOAA priority in partnerships, training, outreach, and user engagement is DEIJA, and STAR should consider it in every part of the portfolio from staff recruitment to user engagement to science prioritization. The alignment should also be evident in funding opportunities, particularly the Cooperative Institutes. High quality, diverse partnerships and the development of diverse talent are mission critical activities for STAR. The center should build on existing successes that are well aligned with the strategic priorities, leverage other NOAA resources to reduce staff burden and maximize impact, and assess performance on DEIJA objectives. The panel noted an opportunity to increase diversity within STAR leadership, which may be necessary to foster a more inclusive environment and assist with attracting diverse candidates during the hiring process. To strengthen DEIJA recruitment and engagement, a dedicated public affairs or recruitment role could be beneficial. A STAR focus on delivering products to underserved communities will demonstrate a commitment to providing meaningful value and impact beyond simply producing data or products.

It was apparent that education and outreach initiatives are important to STAR, and that this is an area for potential growth to provide important capacity building and identify societal needs. The panel felt that continued focus and direction in education and outreach should be a focal point for STAR, particularly in engaging with K-12 students and the general public. With the majority of the STAR workforce located in the Washington, D.C. Metro area, there is an opportunity to increase local interaction with these audiences. STAR can consider partnering with NOAA's education office as well as other line office education programs like Sea Grant, the National Marine Sanctuaries and National Estuarine Research Reserves, and the various fellowship and scholarship programs offering training, educational experiences etc. In this way, STAR can sustainably expand its educational work without overburdening staff, and raise its profile within NOAA and beyond. The panel emphasizes the importance of outreach to schools at an early stage, particularly in traditionally underrepresented regions. Public awareness of NOAA, extending beyond weather-related topics, will be key for STAR, NESDIS, and the broader NOAA organization. The engagement of younger and more diverse audiences will be vital, and will assist in alignment of outreach goals and promoting inclusivity. By focusing on education and outreach efforts, particularly with K-12 students and the general public, STAR can raise awareness, foster environmental literacy, and encourage broader engagement with NOAA's mission and initiatives.

The existence of a user engagement strategy and a plan to prioritize access is a positive step for the post-prioritization process. However, it is important to strike a balance between customer input and defining priorities to ensure optimal outcomes. When retiring products, providing

⁴ <https://www.earthdata.nasa.gov/esds/csda>

notices or readmes in older data websites and locations can assist users in accessing relevant information. With technology advances, it will be increasingly important to consider access issues and design operations with a variety of users in mind. The panel saw value in STAR's idea to develop data "recipes" that give instructions to users about how to turn the resources into products that meet their needs. Designing and piloting that idea and analyzing how it works for various users could be a significant contribution to NOAA, as many research units are working to try and figure out how to make data relevant and accessible to users of varying skills. To address the panel's recommendations on improving the direction and synthesis of STAR's current training and outreach efforts, STAR may consider elevating the role of the CoastWatch program in this area. STAR may consider potentially expanding and rebranding the CoastWatch program to assist in centralizing user needs, STAR-focused data and product delivery, training, and user engagement to streamline and increase the efficacy of these efforts. The panel felt that STAR leadership should review the current CoastWatch portfolio and identify how they can best leverage CoastWatch's current user engagement, data delivery, training, and outreach processes in a potentially enhanced role within STAR, NESDIS, and NOAA.

Ensure Internal NESDIS Organizational Efficiency

The panel identified that there is significant potential for organizational efficiency and effectiveness regarding STAR's office structure within the larger organization. Recognizing that STAR's current primary focus is on scientific expertise rather than engineering, the panel highlighted a need for a clearer organizational definition of STAR's role within NESDIS, as well as strengthening the role of NESDIS or greater NOAA for information discovery and delivery. The panel was aware that STAR is currently going through an organizational review to create operational and organizational efficiencies. As part of this review, the panel recommends that any new structure should encourage individuals to identify their roles in STAR thematically rather than through primary association with specific products or services. This would empower STAR researchers to contribute to prioritization efforts without concerns about specific end user products. This would also require a current shift in funding sources away from product-based funding to a more holistic thematic portfolio financial support model. Creating a new branch within the Division dedicated to administration, user engagement, metric creation/tracking, planning and prioritization, training, and outreach would additionally help streamline these essential functions within the office, as well as in interfacing within the greater NESDIS organizational structure. As part of this reorganization, the panel supports STAR leadership's plan to create additional project management branches to oversee a broader enterprise and portfolio vision, and incorporate new tools like Smartsheets to develop comprehensive databases for mandates and requirements to enhance organizational efficiency. By clarifying STAR's new role within NESDIS and harnessing the potential of the office's structure, the organization can optimize its performance and impact within the broader context of its scientific mission.

A major discussion point for the panel centered around the identity and expectation of STAR within NESDIS and NOAA. The panel strongly felt that establishing a clear identity for STAR within the larger organization is crucial. There appeared to be a disconnect between the current

perception of STAR as a product-driven entity and the desired direction away from being solely focused on product development in order to provide societal impact through sustained partnerships and research across the Earth System Science portfolio. This potential refinement in STAR's identity and core activities includes the need for leadership to stabilize their current staffing plan to identify critical sustained work that should be maintained by permanent federal staff versus research and development that could be achieved through contracts or cooperative agreements with universities. A more balanced staffing plan of permanent and temporary employees will be essential to maintain scientific excellence and expertise in earth observation while performing continual improvement and program management to maintain critical operational products. Additionally, STAR leadership should review the current division of labor among the different groups within STAR to clarify individual roles, remove any role redundancy, and ensure value add to thematic units and the overall STAR portfolio. Addressing these identity-related items should help define STAR's unique position and contribution within NESDIS and NOAA to solidify STAR's mission goals in Earth System Science, and stabilize the office's funding and staffing needs.

Achieving this image transformation away from a product-based office will require the creation or solidification of a comprehensive STAR portfolio that includes the status and categorization of products, including research and development, transitional, and operational stages. This would include a clear product lifecycle, including when product transitions would occur between STAR and other entities or are retired. This transition of STAR products will potentially require a NESDIS-level strategic approach to maximize efficiency and effectiveness in this arena. The panel recognized the currently extensive range and number of products supported by STAR, and identified a critical need to curate and identify operational products for handoff to operational offices, both within and outside of NOAA. Based on the review presentations and discussions with STAR leadership, the panel recommends STAR's primary role be in scientific research and product development. As part of a formalized product lifecycle, STAR would transition products to other NESDIS offices and programs whose primary focus is on operational products and services to ensure smoother product access and delivery. This partnership with other operational programs within NESDIS could relieve the need for STAR to maintain current data delivery services and allow more focus and resources to be applied to product research and creation. The panel felt that it was essential to establish a data access center or portal for authoritative datasets to ensure comprehensive data availability, but that this was a function that may be better served within other operational programs within NESDIS.

Overall, the creation of a formal plan for product and knowledge transfer would provide STAR and NESDIS leadership critical information to make prioritization and budget decisions to address both short-term and long-term needs for the program to achieve staffing and budget stability. The panel was concerned that without a formal plan for product and knowledge transition, the program was relying too heavily on continuity from temporary funding and high levels of non-permanent staff support. Furthermore, establishing a process that facilitates the transformation of experimental products into mature data products or algorithms should be guided by clear operational objectives for each new experimental product. By addressing these

organizational considerations, NESDIS can enhance its effectiveness and ensure a more impactful approach to serving its stakeholders and communities.

Overall, focusing on comprehensive training, robust user engagement strategies, and considering the evolving needs of users, STAR can foster a more inclusive and effective approach to data utilization and maximize the impact of its programs.

Embrace Advanced Technological Opportunities

The ideal future STAR will be prepared to stay at the forefront of technology and the panel supports STAR's current plans to incorporate advanced technology methods in existing operations. In this arena, Artificial Intelligence (AI) and Machine Learning (ML) are poised to play a significant role in advancing data analysis products. The panel believes that these methods will be instrumental in low level satellite data retrieval, monitoring, calibration/validation, gridding, and satellite data processing. Recognizing the importance of AI/ML and data science/analytics, STAR should focus on attracting the next generation of talent equipped with these skills, and forming a dedicated team with expertise in cloud evolution and edge computing. Additionally, to facilitate the effective implementation of AI/ML, the development of an advanced technology roadmap is necessary. This roadmap should outline a clear strategy and identify specific areas of activity where dedicated teams can provide support. This roadmap can also identify how to incorporate the NCAI into these planning and subsequent execution processes. NESDIS Leadership can also help identify where STAR research and development methods in AI/ML crosses over with NCAI's mission goals, including the NOAA AI Strategy⁵, and potentially identify organizational process efficiency. By embracing AI/ML technologies, attracting skilled professionals, and establishing dedicated support teams, STAR can harness the power of data analysis to drive innovation, enhance efficiency, and advance its scientific objectives.

Beyond AI/ML, the panel identified cloud technologies as an area of potential inclusion for STAR processes. Cloud computing, including cloud storage and edge computing, is becoming an essential requirement for the next generation of data management. As NOAA partners with big data providers like Amazon Web Services pipelines and Google Earth Engine, numerous opportunities will arise for efficient analysis of large datasets in the cloud. While cloud migration offers significant technological advancements, careful consideration must be given to the impacts on STAR's own system and user experience, and lessons learned from transitions in other agencies can help inform planning. For example, NASA's DAACs have already made progress in migrating to the cloud, demonstrating the feasibility and advantages of this transition. Amazon Web Services is utilized for storage, while Microsoft and Google provide support and algorithms, indicating the versatility and compatibility of different cloud services. To optimize resources, programmers or software engineers with cloud computing expertise should be integrated into every team. This will allow scientists and instrument engineers to focus on their core tasks, while cloud experts will ensure efficient and cost-effective execution of code.

⁵ The NOAA AI Strategy is available at <https://sciencecouncil.noaa.gov/wp-content/uploads/2023/04/2020-AI-Strategy.pdf>

The panel felt that implementing user registration will be essential to mitigate egress charges and prevent excessive data downloads by automated sources. Additionally, user registration can aid in identifying users who may download data indiscriminately based on their familiarity rather than specific needs. Considering the parallel development of on-premises and cloud infrastructure, careful cost modeling is required to simplify the portfolio and account for factors such as egress charges and storefronts.

In addition to technology adoption, STAR leadership will also need to identify efficiency in cloud-based processes and cost management. To optimize efficiency, it will be important to avoid unnecessary costs arising from dependencies resulting from the selection of different vendors for tools and data access. Promoting commonality in tools for processing and calibration/validation can also enhance process efficiency. The panel recommends that STAR prioritize transferring existing products to operational offices or cloud systems instead of solely focusing on new product development. The panel also felt that the incorporation of user experiences will also play a vital role in designing a new system, helping ensure that user needs and requirements are properly addressed during development and maintenance. Overall, the panel felt that emphasizing process efficiency, prioritizing product transfers, incorporating user stories, and leveraging lessons from other agency cloud migration experiences would allow STAR to enhance productivity, cost-effectiveness, and ultimately user satisfaction.

Summary

The panel conducted a review of the STAR (Satellite and Information Service) program over the course of four days in May 2023. The panel recognized the high quality of scientific projects, products, and services produced by STAR teams, which are lauded as key innovators in the field of operational satellite agencies. However, the panel identified potential concerns over the large number of products and how their impact is measured. While STAR staff demonstrated strong thematic teams, the panel had questions about synergistic activities within STAR and program management processes. The panel identified potential risk for product sustainability due to a lack of permanent support and funding uncertainties.

Overall, the panel was impressed with STAR's research team and flagship products, but they identified the need for clearer priorities and metrics for user engagement and product impacts. The need for a business plan was also highlighted as an area of opportunity, which could identify a plan for financial sustainability of the program and sustained quality of STAR products. The panel recommended several areas for improvement in the program's structure and function. They suggested developing a comprehensive prioritization process, improved performance metrics, and a strategic approach to product lifecycle management. This process would include clarity on when to archive or decommission older products to maintain a streamlined and relevant product portfolio.

Partnerships were recognized as a vital way to strengthen collaborations and expand STAR's societal impact, but the focus on partnerships should align with a strong business plan and

prioritization process. Effective user recruitment, engagement, outreach, and education programs were considered essential for STAR's success, particularly in engaging with K-12 students and the general public.

Additionally, the panel recommended evaluating Diversity, Equity, Inclusion, Justice, and Accessibility (DEIJA) activities and aligning them with strategic objectives in all aspects of STAR's portfolio. To achieve organizational efficiency and effectiveness, the panel advised establishing a clearer identity for STAR within the larger NESDIS organization. They emphasized the importance of creating a comprehensive STAR portfolio with a clear product lifecycle and strategic product transitions.

Regarding technology, the panel recommended preparing for AI/ML implementation by developing an advanced technology roadmap. Cloud technologies were identified as essential for data management, and STAR should carefully plan their adoption to avoid unnecessary costs and ensure a positive user experience.

In conclusion, by addressing the panel's recommendations and implementing a comprehensive business strategy, STAR can enhance its position as a leading program in the field of satellite agencies while ensuring long-term success and societal impact in the global Earth System Sciences domain.