October 30, 2023

Version 2.2

Office of Low Earth Orbit Observations (LEO)

NEAR EARTH ORBIT NETWORK (NEON) USER ENGAGEMENT PLAN

NESDIS

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Table of Contents

Note: The NEON User Engagement Plan is intended to be a living document, subject to update as the NEON program deems necessary.

Executive Summary

The Office of Low Earth Orbit Observations (LEO) manages a family of services that collect low Earth orbit observations from National Oceanic and Atmospheric Administration (NOAA) managed missions, partner missions, and leveraged missions. Since low Earth orbit measurements are global and not bound by specific orbits, NOAA benefits tremendously from partnership and leveraged missions in addition to the NOAA managed missions where NESDIS is responsible for end to end procurement and execution of the missions. LEO conducts continuous user engagement efforts to address NOAA's needs, ensure the success of current missions, plan for future missions, and meet the requirements of end users. To meet these needs and ensure that efforts are consistent with those in the NESDIS user engagement framework, this plan was established to outline an approach for conducting user engagement for next generation Near Earth Orbit Network (NEON) missions. This NEON user engagement (UE) plan intends to ensure continuity of the NESDIS satellite program of record and is solely focused on NEON missions. The purpose is to establish a process by which the NEON program will conduct and implement best practices for user engagement specific to NEON projects.

The NEON UE strategy is built on a foundation of time-tested current LEO UE relationships and the implementation of relationships with new users whose needs and requirements can be met by NEON capabilities. This strategy leverages the close collaboration with other NOAA Program UE subject matter experts brought together in the NESDIS UE Council. In the Council, UE activities are evaluated, and assistance is provided to plan, schedule, and execute those activities of most value. Teams of UE personnel from across NESDIS may be formed to work together to make these activities a success. The results of these UE events will be summarized and made available to the Council and other UE partners, which allows for optimal use of scarce UE resources. The NEON program will also seek to partner with other national and international satellite programs and their UE activities. Outcomes from these partnerships will be shared with the broader satellite community to allow them to leverage NEON program efforts. UE activities may focus on common mission areas, similar satellite sensor types, or thematic environmental challenges. Activities will be aligned with a future loosely coupled LEO satellite architecture where missions are built and launched at different times. Therefore, UE activities will need to be planned and executed depending on the stage of development for various NEON missions.

NEON will continue to use information gleaned from these invaluable UE interactions to evaluate program decisions and establish a path forward for next generation low Earth orbit capabilities. This plan provides the overarching structure for current and future NEON UE activities. Mission, sensor, or thematic UE execution plans will be created as needed. In every phase, the mission and requirements of NEON users and stakeholders will be the focus of NEON user engagement. As UE current capabilities are put into increasing operational use, it is

anticipated that the number of NEON users will grow accordingly. A dynamic and adaptable NEON UE strategy will allow the NEON program to adjust their UE objectives and activities to maximize their benefit across the broader user community.

The NEON UE strategy includes the following elements throughout the project life cycle: understanding user needs, working with users to prepare them for NEON data exploitation for mission success (user readiness), and sustaining the users through routine engagement for continuous feedback on product and service refinements to keep up with emerging needs, technologies, and opportunities. As this strategy is applied to the loosely coupled structure of programs under the auspices of LEO, one can see that lessons learned in the project life cycle of previous satellites will be critical to guide UE activities of future satellites. Therefore, the specific implementation of this strategy will be defined, refined, and laid out at the beginning of each new NEON mission.

1. Introduction

Space-based environmental observations in low Earth orbit are essential to the Nation's needs in diverse areas including weather forecasting, disaster management (fires, floods, etc.), and global climate change. The National Oceanic and Atmospheric Administration (NOAA) has a long history of successfully operating polar-orbiting environmental satellites (POES) for more than 50 years. The polar satellite program has been indispensable for life-saving weather and climate forecasts for the United States and NOAA's partners around the world. Over time, these satellites evolved to gather environmental data used for a wide array of applications pertaining to the oceans, coastal regions, agriculture, air quality, fires, and volcanic ash.

The current baseline for NOAA's polar-orbiting observations is the Joint Polar Satellite System (JPSS) program. JPSS includes five polar-orbiting satellites with four or more instruments and a versatile ground system that are expected to provide backbone global observations at 1330 hours Local Time of Ascending Node (LTAN) until at least the year 2040. With the success of the JPSS program, and a strong heritage and global leadership in directing, developing, and operating polar-orbiting weather satellites, NOAA and the Office of Low Earth Orbit Observations (LEO) have begun to look ahead and plan for the next generation of operational satellites. The JPSS program follow-on is the Near Earth Orbit Network (NEON), which is intended to offer substantial improvements in weather forecasting and prediction of high impact weather events and replace previous monitoring and observation capabilities as they reach end-of-life.

LEO has been established to coordinate this effort and to augment the existing fleet as NOAA users and stakeholders demand and expect improved data to keep pace with the increasing reliance on low Earth (polar) orbit observations for protection of life, property, and the Earth's climate. NOAA's low Earth orbit observational requirements are met by the JPSS program (the current ongoing program of record), NEON program, and other low Earth orbit activities managed by LEO. Each multi-mission program has a specific scope and life cycle. The organization of LEO is presented in Figure 1.

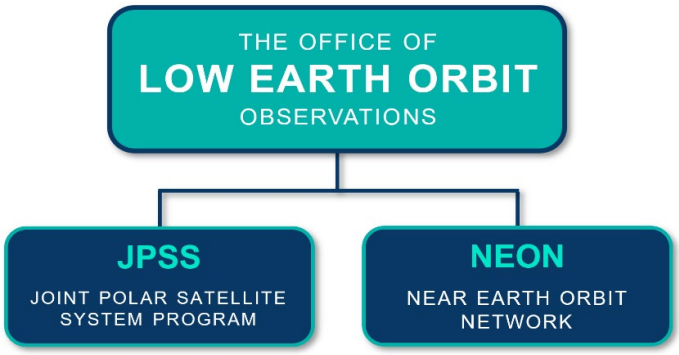

Figure 1. The Office of Low Earth Orbit Observations (LEO) organizational chart.

Earth observations in low Earth orbit are diverse and span the entire region of the electromagnetic spectrum from ultraviolet to microwave radiation using both passive and active techniques. NOAA not only procures and manages missions for critical observations, but also relies on a global partnership with other meteorological and space agencies to augment its mission needs. LEO will manage all observations in low Earth orbit as a portfolio by spearheading the development of new missions to provide continuity and enhance the current observation suite, and by acquiring and exploiting new observations through partnerships with other agencies and the commercial sector. LEO is an integral component of NOAA's efforts to improve the ability to observe and monitor the Earth from space and provide Earth observing data to support its broad user community.

This new LEO organizational structure will have an impact on the NEON UE strategy. A loosely coupled approach to the management of LEO capabilities will motivate an equally loosely coupled set of UE activities. This NEON UE strategy will not only serve current users but also other users that have identified innovative ways to use NEON data and products. The new operational applications of LEO will require close coordination between users and NEON product developers. An effective UE strategy is critical to the success of this interaction. The success of NEON UE efforts is further enhanced by the influence provided by its participation in the NESDIS UE Council. The Council is a critical forum for dialog between key UE programs to accomplish planned UE events and identify new UE opportunities. By working together, UE efforts can multiply the value of satellite data and products for users to meet their operational missions.

The JPSS program, which has been successfully ongoing for over a decade since the launch of the Suomi National Polar-orbiting Partnership (SNPP) satellite on October 28, 2011, has demonstrated the application of mission data across NOAA line offices and around the world in significantly contributing to the protection of life and property through better forecasts than before the mission began. This is testament to the success of JPSS UE activities that have been occurring since well before the SNPP mission began over a decade ago. Building upon this success, the NEON UE plan provides the framework for all manner of NEON UE efforts. Perhaps the most important emphasis is recent efforts to focus UE on mission thematic areas. By increasing this emphasis, new users and their mission needs have been identified, and effective ways to use satellite data and products have been tested and operationally implemented.

The NEON program under the auspices of LEO represents the next series of NOAA observations across all orbital domains through a comprehensive architecture and coordinated program to ensure global Earth observations are available to meet user requirements starting with the current program of record. As the overseer of low Earth orbit satellite programs, LEO focuses on developing and operating directed Earth observing research satellite/instrument missions, continually operating and refining research operations to enable data systems to provide measurements that support NOAA line office needs captured in the NESDIS-Level

Requirements (NLR) Continuity of the Product Baseline. The NLR Continuity of the Product Baseline for NEON and LEO as a whole is generated from the measurements currently provided by JPSS and current non-JPSS partner measurements (e.g., altimetry, scatterometry, microwave imagery). With the help of user input from a robust UE strategy, the NLR and NEON program will evolve to provide measurements needed for new products (e.g., 3-D Winds) and enhanced performance measurements (e.g., improved temporal or spatial resolution).

Additionally, the NEON program is complying with the Weather Research and Forecasting Innovation Act of 2017 through the following activities. NEON will use this UE strategy to help determine the success of this work.

1. Developing recommendations on how to make the data portfolio of the Administration more robust and cost-effective;
2. Assessing the costs and benefits of moving toward a constellation of many small satellites, standardizing satellite bus design, relying more on the purchasing of data, or acquiring data from other sources or methods;
3. Identifying the environmental observations that are essential to the performance of weather models, based on an assessment of Federal, academic, and private sector weather research, and the cost of obtaining the environmental data;
4. Identifying environmental observations that improve the quality of operational and research weather models;
5. Identifying and prioritizing new environmental observations that could contribute to existing and future weather models; and
6. Developing recommendations on a portfolio of environmental observations that balances essential, quality-improving, and new data, private and non-private sources, and space-based and Earth-based sources.

The newly-defined LEO office will comprise a portfolio of low Earth orbiting satellites and associated ground infrastructure and services, partner missions, and commercial data sources. With this challenge, NEON UE efforts must ensure users are aware of program data and product plans soon enough to provide critical input to help the program evaluate whether its plan will meet user requirements. Maintaining communication with other UE partners and the NESDIS UE Council will help the NEON program use information from other UE activities and ensure its own UE events are successful. Plans for future NEON satellites are shown in Figure 2, below. The NEON program will support the U.S. Department of Commerce's strategic objectives by making use of commercial offerings in spacecraft, launch systems, mission operations, ground operational systems, and product development. NEON will formulate multiple programs and projects to provide:

- Continuity of the product baseline generated from observations currently provided by JPSS satellites, including microwave sounders, infrared sounders, multi-purpose

Visible/Near Infrared (VIS/NIR) observations, radiant energy measurements, and special purpose imagers (i.e., ultraviolet, ocean color, atmospheric chemistry, and ozone).

- Continuity of the product baseline generated from observations currently provided by NESDIS and LEO partner mission observations.
- Passive microwave imaging, radio-occultation, altimetry, scatterometry, radar, and Light Detection and Ranging (LIDAR).
- A scalable, agile, and evolutionary ground infrastructure to manage N+1 satellites for operations and products.
- Evolution of instruments to meet NESDIS aspirational requirements and to support new user requirements using partnerships, commercial, and/or NOAA-developed approaches to provide a truly integrated digital understanding of the Earth's environment for a wide array of applications, such as fire detection, improved weather prediction, and climate change studies.

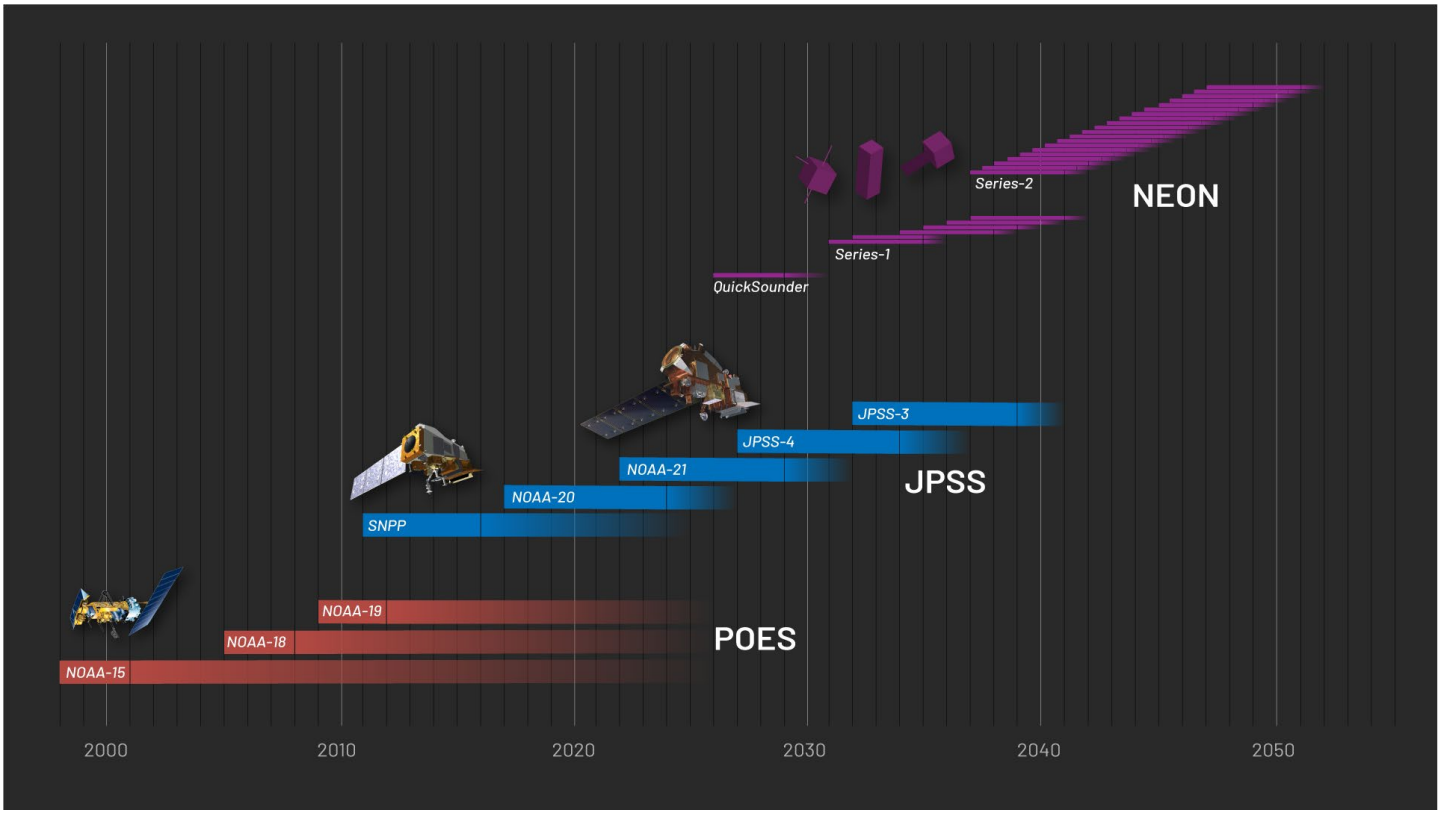

Figure 2. LEO plans for future NEON satellites. While JPSS is part of LEO, the focus of this UE plan is NEON.

One of the challenges is to work closely with users to identify the actions needed to maintain data and product continuity. With the ever present emphasis on climate change this type of continuity is critical. Yet, users have continued to find new ways to use satellite capabilities to meet their unforeseen requirements and new users have stepped up as the value of these capabilities become better known. An effective partnership with other UE efforts and the

NESDIS UE Council will serve the NEON program well. NEON anticipates that new requirements will come from UE events that include input from current and new users.

Engaging with the broad set of future users of low Earth orbit observations under the NEON program is an integral part of ensuring mission success through various stages of the program life cycle. Users want to acquire and provide measurements that are most impactful to their operational mandates. This NEON UE plan describes the approach to continuously interact with the future NEON stakeholders to understand their missions and be able to respond to their future requirements.

2. NEON User Engagement Framework

The NEON UE framework is a multifaceted system that aims to define NEON's UE goals specific to next generation NEON missions. It is designed to engage users and add value to their experience with NEON data and the NEON program. At its simplest, it can be distilled into three main objectives: (1) establish user needs, (2) understand user readiness, and (3) ensure user sustainment, which are described in detail in the following sections.

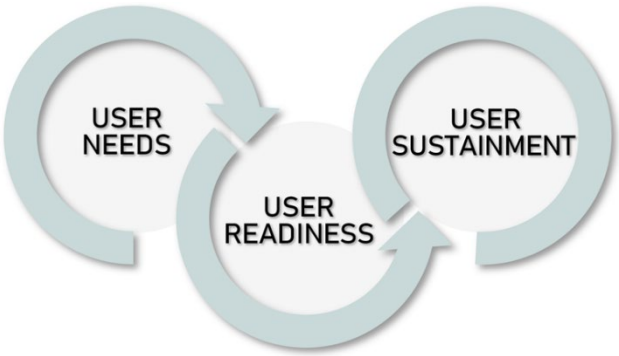

Figure 3. User needs, user readiness, and user sustainment are the three main objectives for the NEON user engagement framework.

For NEON UE to be successful, the NEON program must continuously engage with users. This entails building trusted relationships, connecting NEON capabilities to user needs, considering NEON's capacity to respond, prioritizing product and service development, delivering products that respond to user needs, and following up to evaluate user impact. These elements represent a process, which is described in the NOAA model of service delivery framework that can be visualized in Figure 4. As each element is conducted, interaction must occur between NEON, end users, and various partners, as well as the NESDIS UE Council. It is also likely that elements will co-evolve and loop forward, across, and behind one another to verify needs and capabilities and ensure the provision of the best products and services.

Figure 4. Successful UE requires continuous engagement as described in *A Model of Service Delivery Framework for the NOAA Water Initiative*. To achieve this, the NEON program must (1) continue to build trusted relationships with NEON users and partners; (2) understand the decisions of those users, their use of NEON data, and user's information needs; (3) evaluate user needs through a lens of the NEON program and its partners' capacity; (4) review and prioritize NEON products and services to meet the needs; (5) respond to user needs by developing new, or refining existing, products and services; (6) deliver products and services to users; and (7) evaluate user impact of NEON's tools and services.

3. User Needs

The first objective in establishing a NEON UE framework is capturing user needs to inform mission development.

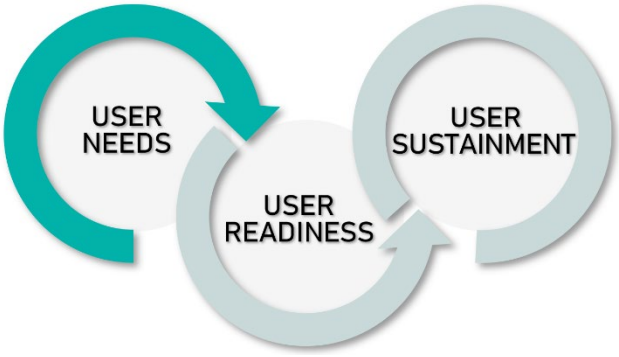

Figure 5. The first objective in establishing a user engagement framework is capturing user needs.

This is accomplished through a series of steps summarized in Figure 6, which leverage the existing LEO and JPSS program resources discussed below. These steps include defining UE goals and user ecosystems, framing user information, conducting user assessments, and mapping information to appropriate mission areas.

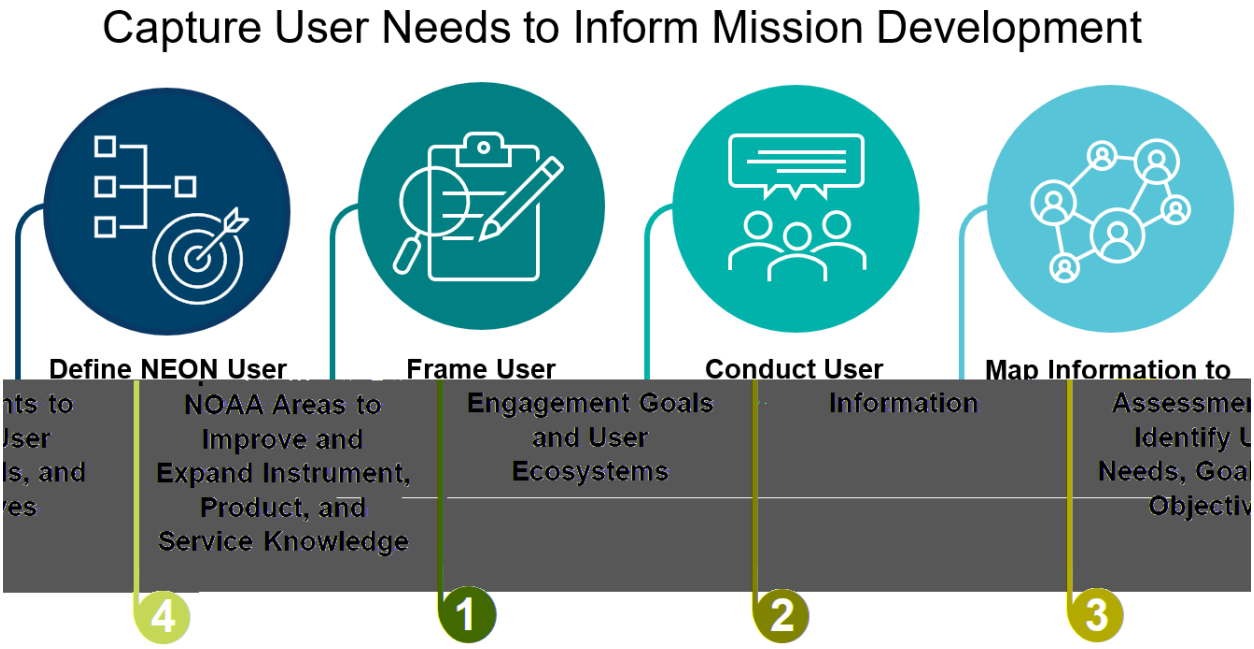

Figure 6. A series of steps required to capture users' needs to inform mission development

An important aspect of the NEON program's approach to a user needs assessment is framing user information. This requires identifying and understanding gaps within end user organizations (i.e., understanding the problem). Such information is used to determine the areas of interest (i.e., user needs) to investigate further. Once the problem and needs are determined, options for an optimal approach for sustained UE can be explored and tested.

Based on over 40 years of experience gained in building, launching, and operating LEO satellites by NOAA, NEON has gained experience in understanding user-specific sectoral decision-making needs that are relevant to next generation missions. NEON will build upon this experience by closely working with users and stakeholders in various thematic areas listed in below for future mission formulation. These thematic areas are consistent with NOAA's Mission Service Areas (MSAs) shown in Figure 7.

- Hurricanes and Tropical Storms
- Fire and Smoke
- Sounding Applications
- Numerical Weather Prediction
- Aviation Weather
- Oceans and Coastal
- Arctic
- Volcanic Hazards
- River Ice and Flooding
- Hydrology
- Training

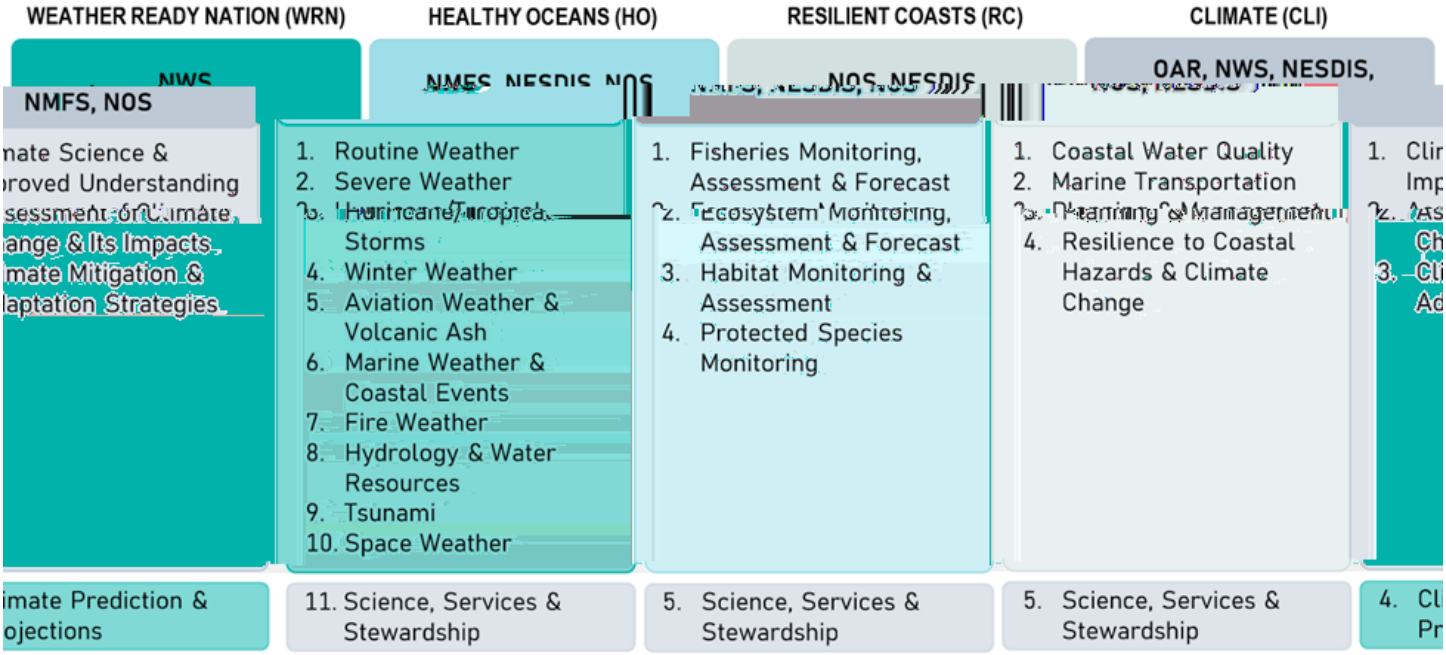

Figure 7. NOAA Mission Service Areas (MSAs) relevant to NEON. Source: NOAA Observing System Integrated Analysis (NOSIA-II) Methodology Report, May 2016. Note the following changes from original: (1) MSAs were re-prioritized to better align with the NESDIS mission; (2) additional NOAA Line Offices were added to each area.

Concentrating on the sectoral users and thematic areas will allow the NEON program to develop an understanding on the specific needs and responsibilities of the NEON end user community. Also, without this focus, users would be binned into common categories, and information that supports user decision framework and timelines could be missed. Determining which users and ecosystems NEON will engage will be re-evaluated throughout the future NEON mission life cycle to meet mission objectives as they evolve. NEON will work collaboratively with other programs such as the GeoXO and NESDIS offices, including the Center for Satellite Applications and Research (STAR), SAE, Office of Satellite and Product Operations (OSPO), Office of Common Services (OCS), and the National Centers for Environmental Information

(NCEI), to conduct UE for various sectors of user communities to enable the exploitation of NEON data in their applications.

Furthermore, stakeholder and user analysis will be ongoing. Figure 8 shows a notional mapping of NEON sensors to NOAA goals, MSAs, and applications. The NOAA Technology, Planning, and Integration for Observation (TPIO) Division derived the analysis data from the NOAA Observing System Integrated Analysis 2-1 (surveyed 2013-2015, with updates to Weather Ready Nation services 2019-2022). This type of analysis will be done as a continuous UE process for all types of missions and measurements under NEON with feedback from stakeholders and users.

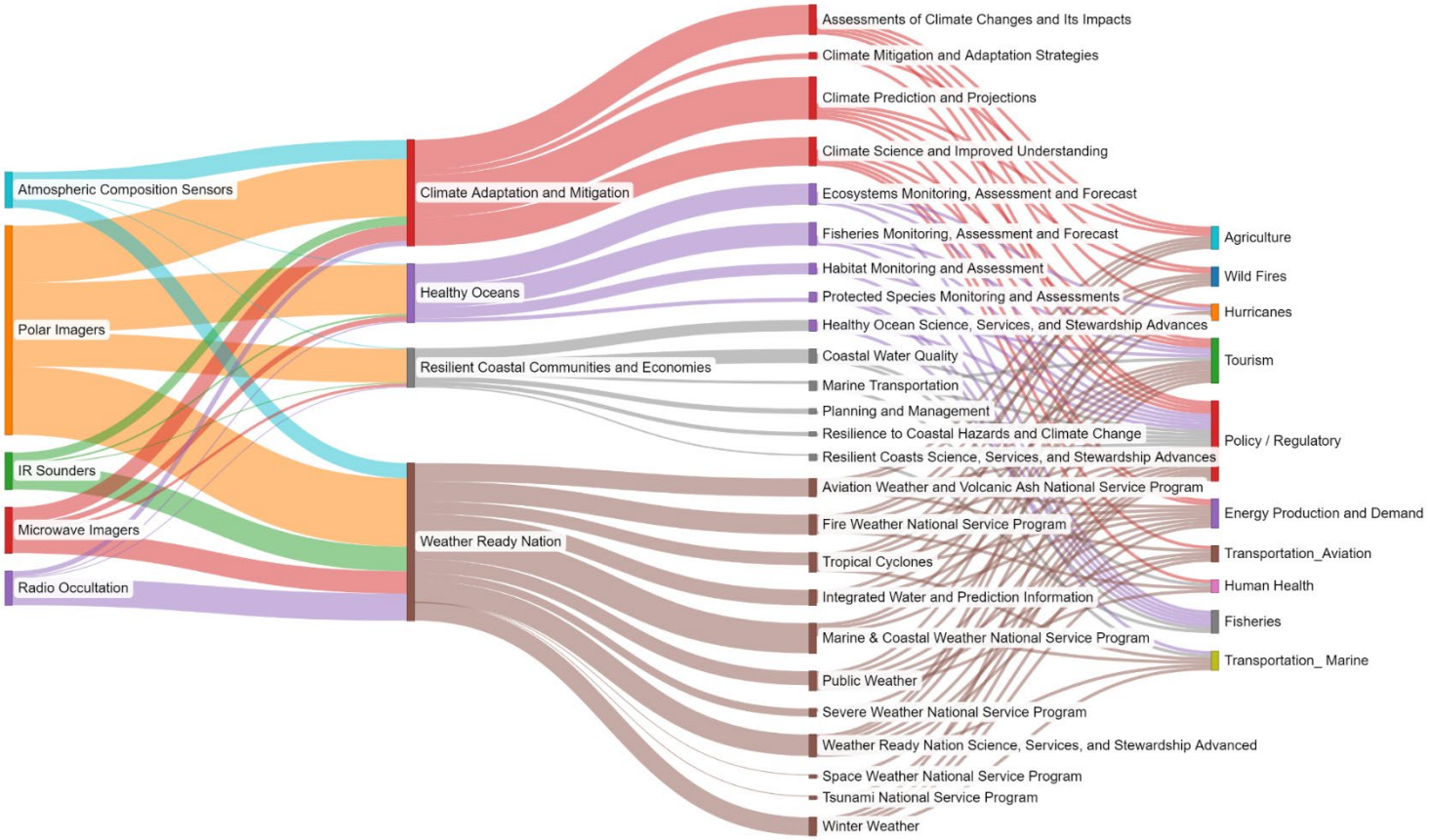

Figure 8. Notional mapping of NEON sensors to NOAA goals, Mission Service Areas (MSAs), and applications.

Building on the established NESDIS framework about users and user ecosystems, the NEON program will set defined goals and intended outcomes for NEON UE by answering the following questions:

- What are the goals of the end users that NEON serves?
- What does NEON want to accomplish with UE?
- What impact does NEON want to have with the information?
- Who are the target users of NEON data and products?

- Where does NEON want to show value?
- Where is the "last stop" for NEON services?

These questions will be framed in agreement with NOAA NESDIS mission areas and vision. NEON's approach to defining and responding to NEON user needs is described in the following sections.

3.1. Identifying User Needs Through User Assessments

LEO began UE for next generation NEON capabilities in 2021. These activities serve as the foundation for defining NEON users and user ecosystems—information necessary to establish user needs. Existing research and reports were reviewed to ensure the capture and consideration of broader user communities as outlined in the NOAA strategic plan. The office also engaged with many internal and external stakeholders, including but not limited to those listed below, and will continue to do so as NEON UE progresses. All stakeholders are encouraged to contact LEO leadership with input at any time; key stakeholders from the following sectors were selected for ongoing engagement that is focused on the thematic areas described above. Note that this list provides only a subset of stakeholders that participate in UE activities.

- U.S. Federal Government Agencies
  - NOAA Line Offices
  - NOAA Cooperative Institutes
  - NOAA Climate Program Office
  - FEMA
  - Bureau of Land Management
  - U.S. Department of Agriculture
- State, Local and Tribal Organizations
- World Meteorological Organization (WMO) Regions III & IV
- Intra-Agency Agreement Partners
- Partners in Academia
- International Satellite Programs
- International User Communities
- Non-Governmental Organizations
- Commercial Industries
- Economic Sectors (Insurance, Real Estate, Energy)
- Other Representatives of the Private Sector

Building on the success of completed and ongoing user engagement activities, the NEON program will partner with other parts of NESDIS to continue to collect information on current and emerging gaps and needs through periodic planned NEON user assessments. Such activities include engaging with existing and new users of low Earth observations at conferences, community meetings, science seminars, and through one-on-one interactions and other opportunities, as well as reviewing relevant academic literature and government reports as they become available. Figure 9 shows the various information sources that NEON has used and will continue to use to identify user problems and existing data gaps, and to determine needs for future missions.

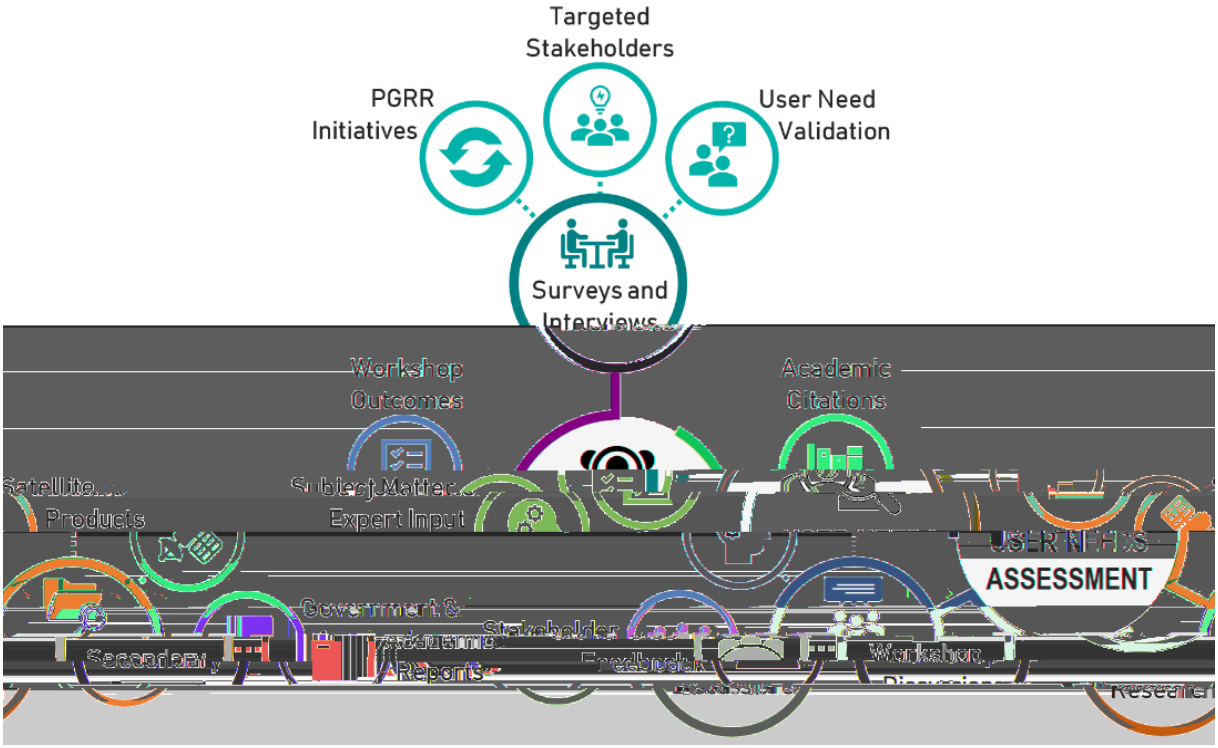

Figure 9. Information sources used to identify and assess user needs.

The NEON data and data products value chain and approaches that will be used to increase the societal benefit of NEON data are broadly summarized in Figure 10 below. User assessments have been and will continue to be conducted according to this value chain framework and aligned with NOAA and NESDIS UE policy.

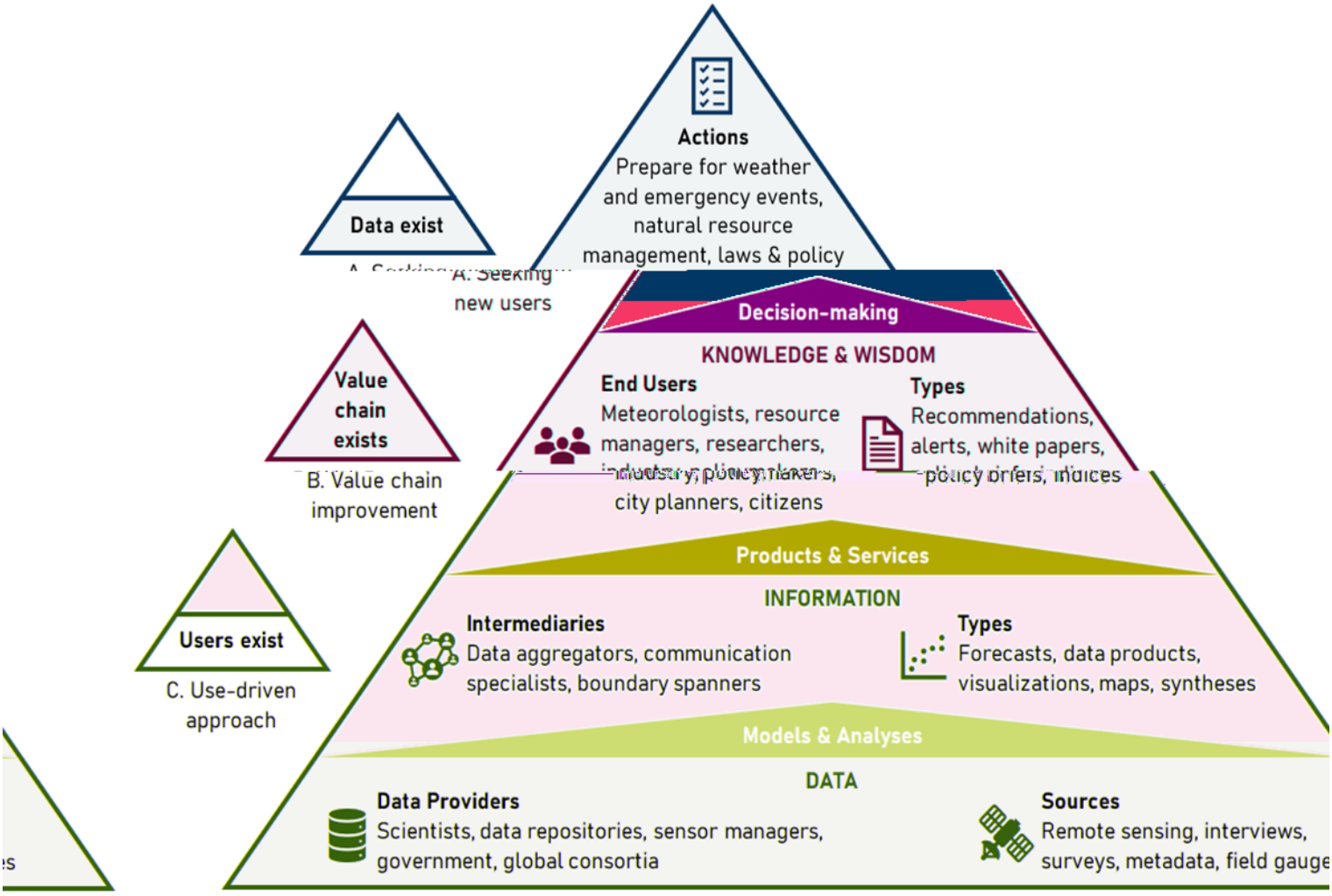

Figure 10. NEON data and data products value chain and approaches that will be used to increase the societal benefit of NEON data. The large triangle represents the NEON value chain, which encompasses data, information, knowledge, and wisdom, as well as actors (end users, intermediaries, and data providers), processes for transforming data along the value chain, examples of data sources, and results from the processes (actions). The three main approaches used to increase the societal benefit of NEON data are represented by the small triangles and include: (A) recruiting new users (data exist but the value chain does not), (B) improving a current value chain (value chain exists); and (C) identifying and/or developing data and data products based on user needs (users exists, but the value chain may or may not exist). This figure is adapted from Virapongse, A. et al. (2020.) Ten rules to increase the societal value of earth observations. *Earth Sci Inform 13*, 233–247, https://doi.org/10.1007/s12145-020-00453-w.

Findings from user assessment activities will inform the following:

- Generating new mission requirements.
- Generating new products and services.
- Enhancing existing products and services.
- Determining data management strategies commensurate with these products and services.
- Retirement and/or divestment of products and services.
- Exploiting commercial, Federal, and international observations and resources.
- Developing new instruments and capabilities.

3.2. Mapping User Needs to Thematic Areas, NESDIS Level Requirements, Measurement Types, and Sensor Specifications

A key component of LEO's overarching strategy in developing its portfolio of low Earth orbiting satellites, partner missions, and commercial data sources is to identify and represent the needs across NOAA. Each user need identified through the NEON user assessment activities summarized in Section 3.1 will be translated into a user requirement. To do so, each need will be mapped to a NESDIS thematic portfolio(s) to inform product, services, and instrument design. Different NESDIS program offices will find different applications for the same user data, which can further expand the reach and impact of the engagement. This detail also further emphasizes the importance of conducting UE from a mission agnostic perspective, allowing user information to map with more freedom and flexibility throughout the organization.

Once user needs are mapped to appropriate future mission portfolios, the need (e.g., a specific spatial and temporal resolution) is translated[1] into actionable guidance, a geophysical or technical requirement that is responsive to the user's environment and reflective of NOAA's responsibility and the unique mission goals of NESDIS.

The process of mapping and translating needs into mission requirements will help future NEON missions understand the instruments and requirements it should move forward with, and to understand the importance of each user requirement to NOAA's key stakeholders and users. For each NEON instrument, the decision criteria requires that it meets the users' needs in each of the NOAA MSAs presented earlier in Figure 7. A notional representation of how various NEON observations are related to NESDIS Level Requirements (NRLs) and geophysical products produced by the missions is shown in Figure 11.

[1] The NESDIS office will have a responsibility to assess needs and provide feedback to the community for how that need might translate to an action or requirement.

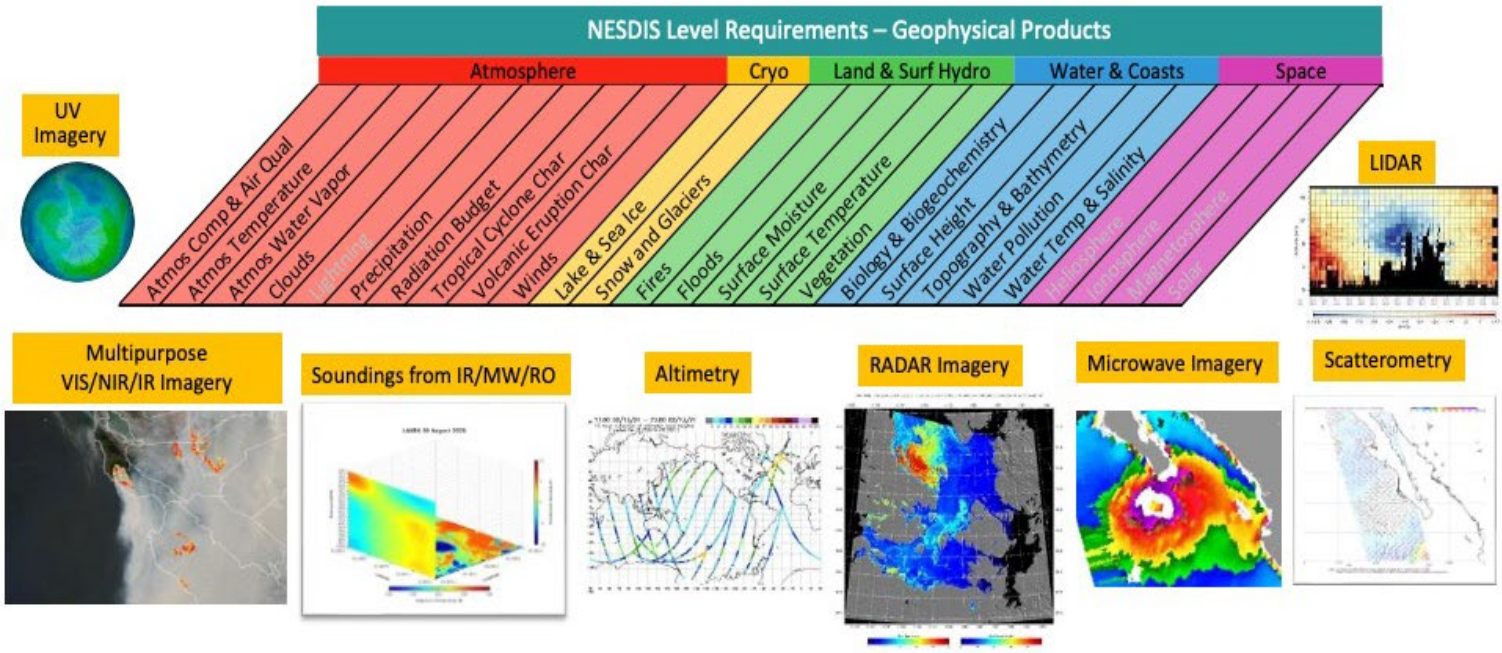

Figure 11. A notional representation of how various NEON observations contribute to most geophysical products in the NESDIS Level Requirements (NLRs).

During 2021-2023, LEO conducted several user workshops to assess user needs and to identify how low Earth orbit products and services can be applied to user organizations. The purpose of these workshops was to solicit the type of measurements and observations that are needed from the NEON program to enable development of products and services that meet end users' needs in different thematic areas that are depicted earlier in Figure 7 and Figure 8. These workshops brought together users from industry, academia, government, and research organizations from around the world to share information about applications, existing gaps, and future needs for low Earth orbit observations. The workshops included the NOAA Microwave Sounder Workshop, the NOAA Infrared Sounder Workshop, the UV-VIS-NIR Workshop, a VIS/IR Imagery User Meeting, and a workshop focused on Precipitation Estimation from LEO Satellites: Retrieval and Applications. The information gathered from these workshops will enable and assist LEO's assessment of the impacts of low Earth orbit sensors to society, as well as establishing future NEON mission requirements that will include Key Performance Parameters previously established as essential to meet the NOAA mission. Workshop outcomes are summarized in several technical reports[2].

[2] https://doi.org/10.25923/wkgd-pw75; https://doi.org/10.1175/BAMS-D-22-0054.1; https://doi.org/10.1175/BAMS-D-22-0266.1

3.3. Continuous Assessment Process

The NEON program, in coordination with NESDIS Office of Systems Architecture and Engineering (SAE), continuously assesses the current and projected future ability to ensure NEON capabilities remain focused on user needs through the following activities:

- Working with users to maintain understanding of ongoing user needs and priorities via the user engagement process. This allows the NEON program to:
    - Assisting users with the operational application of current satellite capabilities to meet their mission requirements, and
    - Partnering with SAE to apply a dynamic gap-analysis approach to determine what additional satellite data and products are needed to meet future user requirements.
- Monitoring the status of NOAA, partner, and commercial current and potential operational satellite capabilities and how they may be applicable to the NEON program.
- Tracking the development of scientific and technical innovations that could provide applicable NEON technology.
- Generating rough order of magnitude (ROM) cost estimates in support of budgetary exercises.

Correspondingly, SAE, in coordination with the NEON program, continually assesses NESDIS observational needs and priorities. NEON also participates in the Product Portfolio Management Team (PPMT) to assess the value of partner missions on product performance. Assessment results are shared with NESDIS and stakeholders via standard communications channels.

3.4. Science and Application Traceability Matrix

If the NEON program has determined to develop its own low Earth orbiting satellites (rather than rely on partner missions or utilize commercial data sources) and after the NEON program has determined instrument selection and constellation design, the program will begin to inform NEON instrument and spacecraft design. The program may adapt the Science and Application Traceability Matrix (SATM) for each NEON instrument. The SATM is a tool that starts the product development process and incorporates information from the initial identification of a need through the product development lifecycle. The SATM provides:

- A logical flow from the high-level objectives through science objectives, measurement objectives, measurement requirements, to instrument requirements;
- Traceability of science objectives to user applications;
- Suggested measurement parameters for baseline and goal scenarios of the potential range of products;
- Baseline scenarios support science objectives, and defined goals support additional scientific advancements; and

- Identification of what is most important, the necessary observables, the relative importance of the data, performance targets, user community importance, and justification for performance targets.

SATMs will be used to:

- Assess the baseline of user needs, goals, and objectives with the user community and determine the next steps;
- Inform instrument and spacecraft design;
- Inform product and service development;
- Focus on the most useful, usable, and used products and services; and
- Conduct additional user assessments to inform cost-benefit analysis to support out-year budgets and to inform future portfolios.

NEON will work closely with user communities to mature the SATM and allow NEON to identify and prioritize "high priority" baseline products. SATMs will be used as a tool to select which suite of NEON products the program will produce. The traceability to science applications will be based on NOAA-level requirements and guidance from NOAA TPIO. Below is an example SATM; the actual SATM may differ.

Science Objectives	Science & Applications	Example Physical Parameters	Example Observations	Temporal	Spectral	Spatial	Instrument Requirements
SEVERE WEATHER: Weather nowcasting, forecasting, & prediction	Numerical weather prediction, measuring hurricane intensity, flood forecasting	Temperature and water profiles, sea surface temperature, precipitation	Atmospheric soundings, precipitable water, ocean heat content	3-4 hours	9.14-15.38µm (LWIR) 5.71-8.26µm (MWIR) 3.92-4.64µm (SWIR) 412nm-12µm (VIR-IR) 23.8-183.31 GHz (center frequency)	9 FOVs with 14km diameter spots in 3x3 array; 16km at 165-183 GHz, 32km at 50-90 GHz, 75km at 23-32 GHz	**Temporal:** TBD **Spatial:** TBD **Spectral:** TBD
OCEAN COLOR: Healthy oceans & the Blue Economy	Fish stock assessment, harmful algal blooms, chlorophyll-a concentration	Ocean color, sea surface temperature, ocean currents	Chlorophyll-a concentration, dissolved organic carbon	Daily	410-868nm (VIS-NIR)	FOV 0.08 deg along track and 1.42 deg cross track	**Temporal:** TBD **Spatial:** TBD **Spectral:** TBD
AIR QUALITY: Air quality & aviation hazards	Smoke, dust, ash, and aerosols nowcasting, forecasting, and monitoring	Ozone, aerosol optical depth, volcanic ash detection	Total O_3, tropospheric NO_2, tropospheric SO_2	Hourly	300-345nm (UV) 305-330nm (UV) 354, 388nm (UV) 423-451nm (VIS) 540-650nm (VIS) 400-730nm (VIS-NIR)	8.4km x 4.4km at center of Field of Regard	**Temporal:** TBD **Spatial:** TBD **Spectral:** TBD

NEON will work closely with its NESDIS partners to develop and deliver the most impactful products for use in operations to ensure effective decision making and application. The program will also provide NEON products that are accessible and easy to use through reliable service delivery to assure that customers obtain and retain the most value from NEON products and services.

The service delivery process will be different for NEON satellites than for the JPSS series. The new process will lend to greater accessibility of data, allowing NEON to reach a broader set of users and users within underrepresented groups. The new process will involve:

- Engaging with user ecosystems to uncover technical hurdles to understand how future technology will modify stakeholder and user expectations and system goals;
- Continually engaging with users of NEON data to help prevent reactive responses to future challenges;
- Closely collaborating with the NESDIS Office of Common Services (OCS) and other NOAA line offices that are well suited for the delivery of product, services, and capabilities to ensure successful service delivery;
- Conducting collaborative UE across NESDIS and NOAA (and others as applicable), while leveraging the UE Council through a coordinated UE effort, to ensure successful service delivery through the NESDIS Common Cloud Framework (NCCF) and via commercial satellite radio frequency (RF) broadcast;
- Engaging with user ecosystems to understand acceptable standards for on-orbit data product validation and to support Algorithm Working Groups (AWG), Calibration Working Group (CWG), user readiness, and post-launch readiness; and
- Conducting UE to support the calibration/validation (Cal/Val) steps listed in Figure 12.

Figure 12. NEON calibration/validation (Cal/Val) steps.

NESDIS STAR is responsible for the development and implementation of algorithms for the calibration and validation of sensor and environmental data records (SDR and EDR). For each future NEON mission, STAR SDR/EDR Cal/Val activities will be planned for all Cal/Val phases: pre-launch, early orbit checkout (EOC), intensive Cal/Val (ICV), and long-term monitoring (LTM). The major objective is to evaluate and ensure that the operational SDRs/EDRs meet Beta, Provisional, and Validated Maturity requirements. Beta Maturity designates an early release product that is minimally validated and may have significant errors; it is made available to users to gain familiarity with the data format. During the Beta Maturity

phase, the Cal/Val team works closely with users to receive feedback and make iterative changes to products and algorithms to ensure they are ready for operations.

The STAR team facilitates the Cal/Val maturity review process for all the xDR products. Each product's Cal/Val maturity status is determined by evaluating algorithm performance with truth data sets and comparing performance against requirements. The review panel will be comprised of NEON program and project scientists, NESDIS collaborators, NOAA customers (i.e., National Weather Service (NWS), National Ocean Service (NOS), National Marine Fisheries Services (NMFS), Office of Oceanic and Atmospheric Research (OAR)), external users, Low Earth-orbiting Requirements Working Group (LORWG) advisors, product development managers, the STAR Program Manager, and others as appropriate. Following Cal/Val maturity science reviews, the review board will assess the product performance and make an overall assessment of each algorithm, approving the maturity status according to the criteria for Beta, Provisional, and Validated Maturity. Based on the assessment, the review board may also recommend further actions to the respective Cal/Val teams to achieve the desired product maturity status.

Preparing for the future is important and the NEON program will engage with the NEON user community to understand how best to conduct post-launch activities to support:

- Product and service evaluation and evolution;
- The understanding and documentation of societal impacts across user ecosystems;
- Assessments to understand NEON's return on investment; and
- Internal assessments to prepare for the next generation of NOAA low Earth orbit satellites.

4. User Readiness

The second objective in establishing a NEON UE framework, user readiness, builds on the foundation of user needs to support activities that optimize the customer experience.

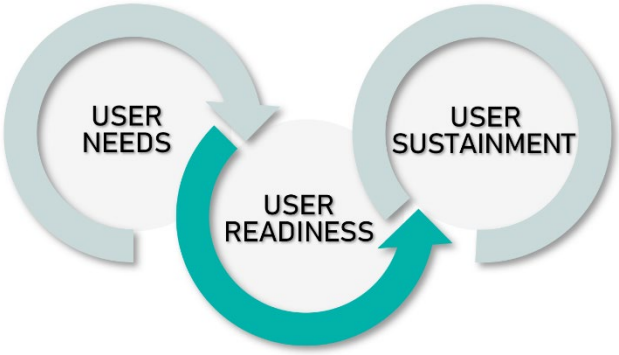

Figure 13. The second objective in establishing a user engagement framework is capturing user needs.

In this stage, NEON will focus on:

- Processes and actions to exchange information from program to user to expand existing knowledge of NEON user needs;
- Understanding all dimensions of preparedness; and
- Understanding of the intent and scope for the execution of readiness management.

Additional UE will provide more detail to help determine how satellite products can be used to meet the needs identified in the first stage of this process (described in Section 3). Multi-billion dollar satellite programs must ensure they have worked with users to identify the resources they need to put data and products to operational use as quickly as possible. This requires close collaboration between developers and users to allow the former to understand how particular needs can be met by specific products, and the latter to establish and maintain a readiness structure and procedures that can be effective across the life of the satellite program. As part of this, NEON will engage with:

- The NESDIS User Engagement Council (UEC) to ensure resources and knowledge across the organization are being fully utilized;
- NESDIS Office of System Architecture and Advanced Planning (OSAAP) and OCS to carefully identify which user ecosystems to engage with to optimize portfolio development; and
- NESDIS Enterprise Satellite Proving Ground Program (SPG) for product development and customer experience.

Readiness management is broken down into four focus areas: (1) data readiness management, (2) product readiness management, (3) infrastructure readiness management, and (4) planning and management of continuity of critical satellite capabilities. Note that not all areas will apply to every phase of every NEON mission. However, these four areas provide a framework for the NEON program to work with its users to ensure they are ready to quickly and effectively put satellite capabilities to operational use. To handle each of these focus areas, new methods of UE are often required. Here, lessons learned from the user needs assessments described in Section 3 (e.g., interactions at conferences, workshops, seminars), provide a critical starting point. User engagement in this second stage, user readiness, takes on a different set of values.

4.1. Data Readiness Management

Data readiness management is the critical first step upon which the other user readiness areas are built. User engagement during this step provides the user with information about the type of data anticipated in the new system and the size of data that would be available. To do this may require identifying current data that can serve as a proxy for future capabilities. The success of this stage

depends on users and developers effectively linking readiness to user needs. The objectives of data readiness management are for users to:

Assess the readiness of their systems to receive the new data;

- Determine whether their current infrastructure is sufficient to handle these new data types and data sources or if new infrastructure is needed; and
- Evaluate these data and data products to ensure that they can be successfully applied in their operational environment to meet their needs and expectations.

The NEON program recognizes that it may be difficult to assist every current user in evaluating their data preparedness. NEON should survey its user community to identify users willing to establish and execute a data readiness strategy. An effective strategy requires developers and users to identify key communication and data nodes and determine whether new satellite systems can viably use these nodes with reasonable resources. This will help NEON increase its understanding on how data and products will be used and the operational value they bring from operational applications.

NEON will work with the identified NEON users to determine if their current structure is sufficient to test with proxy data or if additional capabilities are needed during the testing period. This may require answering such questions as:

- What are the most central tasks that must be accomplished to get the job done?
- Within a task, what are your challenges or barriers to success?
- What have you tried already to solve the problem(s)?
- What can you do to overcome the challenges?

Finally, user success metrics must be defined to assess how users view success. User success metrics can be derived from understanding the value the data will provide to the user (their uncertainty, the outcome of their decision, the cost, and the price of a secondary solution), the level of satisfaction a user has utilizing the data to accomplish a specific task or application, and the level of importance the data are to the user. The outcomes of success metrics will inform how products are generated and delivered and the overall customer experience.

4.2. Product Readiness Management

The second focus area of user readiness is product readiness management. Product readiness management has two phases. The first phase involves the products that NEON provides to its general user community. The second phase involves unique user products that include NEON data or products. In the user needs stage (described in Section 3), the program will work with NEON users to create product requirements, which will be documented in the NEON program's Level-1 Requirements Document (L1RD). Pre-launch and early post-launch activities focus on

these L1RD products to ensure the user will receive the products they have requested. The method of product delivery is a critical consideration early in the process.

Currently, JPSS data users receive products and services through a variety of sources, including direct broadcast and other delivery services operated by NESDIS and non-NESDIS sources, such as OSPO, NOAA's Comprehensive Large Array-data Stewardship System (CLASS), various universities, NGOs, and commercial entities. NESDIS OCS holds the requirement to provide distribution and access services for LEO data through the NCCF.

The NEON program, in collaboration with OCS, will consider engaging the user community to understand data access including:

- Understanding distribution needs including latency, volume, and format;
- Understanding impacts on user and NEON Concepts of Operations (ConOps);
- Supporting the development of enterprise solutions to generate the maximum impact of data;
- Informing users of NOAA data about NESDIS timelines and user readiness activities; and
- Communicating service delivery process expectations with user ecosystems.

4.3. Infrastructure Readiness Management

The third focus area of readiness management is infrastructure readiness management. It involves the management of technical and operational components, including hardware, software, policies, processes, data, facilities, and equipment to ensure business effectiveness. The purpose is for users to determine the changes that are necessary on their end to be ready for the new technology. At this stage, the NEON program will focus UE activities on technological advancements to help NEON users stay informed, become prepared, and adapt to change. This type of UE builds off existing user needs and centers on users developing new infrastructure and transforming existing infrastructure to meet future needs. NEON will structure UE around understanding what NEON users need to ensure that user interfaces have elements that are easy to use, access, and understand.

A critical component of user readiness is to assist the users as they consider the software and hardware needed to integrate new NEON data into their operating systems and spaces. NOAA and users of NOAA data may develop their own Level 2+ (L2+) algorithms. NEON will engage with these developers to support their processes to achieve product maturity fit for operational use prior to NEON launch. L2+ algorithm developers external to NOAA (e.g., commercial, international, or academic sectors) may run their algorithms independently of NOAA systems and make their products available through the cloud or other delivery paths. For those L2+

algorithm developers who are part of NOAA, there are different entry points for algorithm development depending upon the maturity of the algorithms.

4.4. Planning and Management of Continuity of Critical Satellite Capabilities

The fourth focus area of readiness management is the planning and management of continuity of critical satellite capabilities. This step has two objectives. The first is to ensure that the current satellites provide the consistent data needed to maintain a robust set of climate data records. Climate data are essential inputs for the management of public finances and government assets, such as electricity grids, buildings and roads, and services like emergency response and assistance. Climate data are also essential for agriculture, public health, marine ecosystems, water resources, and every other sector. Climate information services are essential for adapting to climate variability and change and are relevant to every sector of the U.S. economy. For example, current JPSS satellites fly the same sensors to maintain data and product continuity. Next generation NEON satellites may have different sensors with different capabilities. However, they will maintain a link to the previous generation's satellite data and products that are used to produce the decades of data that maintain continuity in climate records. NEON users must ensure the infrastructure they use for the satellite data and products are maintained and operate effectively throughout the lifetime of the NEON program. Any software or hardware upgrade the user considers must be made with an eye on what is needed to keep leveraging these satellite capabilities for mission requirements. The same procedures that test the receipt of satellite data and algorithm execution of a newly launched satellite in the current series can be used to test user satellite capability readiness, as well.

The second objective of the planning and management of continuity of critical satellite capabilities is to identify future satellite capabilities that allow users to respond to unforeseen changes in mission requirements. NEON UE activities provide the opportunity for users to communicate gaps in current low Earth orbit capabilities and the capabilities they need to meet mission requirements. These activities provide the foundation for the new generation of satellites (NEON, partner, or commercial operated). New capabilities will be identified early in the acquisition phase where everything from different satellite channels to new scanning strategies can be considered and those that bring the most value are selected. End users must be kept aware of what new capabilities are coming and be provided with as much technical information as possible on these capabilities. This will allow them to make their own plans to fund and acquire any new infrastructure needed to ensure they are prepared to receive and put the new satellite data and products into operations. New capabilities will be evaluated with proxy data pre-launch, and then again with the new data and products after NEON sensors have been thoroughly calibrated and validated.

5. User Sustainment

The third objective in establishing a UE framework is user sustainment, which starts when the first NEON satellite has reached launch and users are receiving the data and products as defined by NEON user communities.

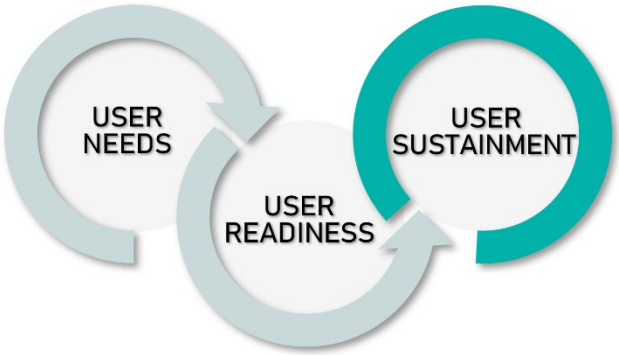

Figure 14. The third objective in establishing a user engagement framework is capturing user needs.

During the user sustainment stage, users communicate whether data and products continue to meet their needs. Users are often the first to know if there are problems with data or products. Maintaining a strong and continuous UE program allows the users to understand how to report problems and work with developers to find a solution. A second aspect of user sustainment is the operational applications of data and products. Often, once users begin to use the data and products operationally, they find new ways to apply these capabilities to their missions. Strong UE allows users to introduce these ideas and work with developers to evaluate and test new applications to determine the applications with the most value. Current applications provide critical continuity for users, and new applications allow them to respond quickly and effectively to new missions not anticipated in the early phases of the satellite program.

One of the biggest challenges at this stage occurs when satellite instruments age and their data and products become so degraded that they are no longer usable. A dynamic UE process is critical in responding to this challenge with an effective solution to the problem or identifying an alternative approach to get the data. It is anticipated that users and developers will continue to work on smaller problems, perhaps making changes in algorithms and testing the results. However, at some point an effective fix will not be possible simply due to the life span of satellite instruments. Developers will then work with users to identify operational impacts of the permanent loss of data and products and will propose solutions to mitigate these losses.

Training is also an area of emphasis during the user sustainment phase. Some early career users will need a basic understanding of satellite data and products and their applications. Other users may change jobs or locations and need to become familiar with their new job's mission requirements and how satellite data and products can be applied. As well, new applications of data, once proven, must be codified in training materials so others within the user community

can understand their value. A strong training foundation must be maintained for the life of current satellite programs, as current programs provide critical knowledge that can be leveraged in the acquisition phase of next generation satellites.

6. Plan Implementation Strategy

The NEON UE plan provides the strategic direction for specific UE activities. Activities may differ depending on the stage a particular NEON mission is in (e.g., user need, user readiness, or user sustainment) and whether it is a NEON, partner, or commercial operated mission. Information and lessons learned can flow in multiple directions. The user relationships and collaboration efforts for one mission in a particular stage can provide a foundation for another mission in a different phase. New environmental challenges, such as higher sea surface temperatures in 2023, can call for a reevaluation of satellite products to determine how far back changes can be traced. This results in new actions in an earlier mission phase and new UE activities to ensure users' voices are heard. Current and new NEON UE activities include those planned by the NEON program, those done in collaboration with GeoXO and other satellite programs, events planned in partnership with forums planned by the user, and still others tied to external events such as national or international conferences and workshops. The planning, scheduling, and execution of these activities will be guided by their foundational objectives. As emphasized earlier in this document these objectives should stem from close interaction between NEON UE decision makers and their UE partners in coordination with the UE Council. Some activities will be easy to plan, while others may require a detailed planning effort. As UE activities are considered, it may be determined that established activities that have proven to be valuable are worth continuing. The joint GOES-LEO workshops at the American Meteorological Society's Annual Meetings are examples of this type of valuable and long-standing UE activity. Other engagement events could have a much narrower focus and set of objectives and may only need to be done once. The NOAA Microwave Sounder Workshop held in 2021 is an example of this type of one-off event. Every year one can anticipate changes in the old and new UE activities.

A cornerstone of this NEON UE plan is solid collaboration with various NESDIS UE efforts, the value of which cannot be overstated. For example, over the years, LEO activities have leveraged lessons from GEO activities and vice versa. This has led to the organization of many joint LEO-GEO UE efforts; it is anticipated that NEON and GEO will collaborate on UE activities in the future. By sharing details of UE activities, each program can encourage the other to evaluate how activities can be used for multiple purposes. User time is a precious resource and by engaging users in a careful and measured way, satellite programs can get the information they need quickly and effectively. A good first step in this collaboration is for NESDIS programs to maintain a detailed UE calendar and share these calendars with others. Another approach is sharing planned UE activities with other NESDIS programs through the UE Council.

The NEON program will continue to look to the future with new satellite sensors and capabilities. This requires continued communications with current users and being attentive to additional new users and their requirements. A solid, well-functioning UE program is key to the success of these efforts. The NEON UE plan provides the path to this type of program and sustained, successful engagement. Each year, opportunities for UE will be evaluated and planned as a part of future NEON mission preparation and readiness. Specific opportunities will be identified, planned, and scheduled as a continuous process and these events will be broadly communicated through the established NESDIS communication pathways and channels.

7. Glossary of Terms (Draft)

NOTE: The terms in this glossary are in draft format and under review and consideration by the UE Council as part of a broader effort to coordinate terms across NESDIS UE plans and policy. They are subject to change as guidance from the UE Council is received.

Data Readiness Management allows scientists, engineers, and managers to understand the status of a project, and to identify where investments are necessary to extract the value from data.

Concept of Operations (ConOps) describes the overall high-level concept of how the system will be used to meet stakeholder expectations, usually in a time sequenced manner. It describes the system from an operational perspective and helps facilitate an understanding of the system goals. It stimulates the development of the requirements and architecture related to the user elements of the system. It serves as the basis for subsequent definition documents and provides the foundation for long-range operational planning activities.

Customer experience is "The public's perceptions of and overall satisfaction with interactions with an agency, product, or service."[3] Section 280.7 of OMB Circular A-11 establishes seven domains for measuring customer experience.[4]

Ecosystem is defined as a community of individuals and organizations focused on a particular topical area.

Framing is a set of concepts and theoretical perspectives on how individuals, groups, and societies organize, perceive, and communicate about reality.

Infrastructure Readiness Management is the management of both technical and operational components—including hardware, software, policies, processes, data, facilities, and equipment—for business effectiveness.

Mapping is defined as a method for communicating user focused information based on mission needs and the purpose of the information.

NESDIS Common Cloud Framework (NCCF) is a low latency operational distribution service.

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[3] This definition is taken from "Executive Order on Transforming Federal Customer Experience and Service Delivery to Rebuild Trust in Government," December 2021.

[4] These domains include Overall: (1) Satisfaction, (2) Confidence/Trust; Service: (3) Quality; Process: (4) Ease/Simplicity, (5) Efficiency/Speed, (6) Equity/Transparency; and People: (7) Employee Helpfulness.

NESDIS Level Requirements (NLR) are requirements that define customer expectations in the context of the NESDIS mission, strategic plans, Mission Essential Functions (MEFs), policies, and regulations.

Product Readiness Management is the process by which products are developed and provided to users and users contribute to product requirements.

User is defined as one that is trying to make decisions or execute a process or a set of core tasks, and for whom NESDIS information is, or could be, an input to that process.

User or customer is defined as a person, group, or organization who accesses and applies information, products, or services[5].

User Assessment is defined as a set of methods, skills and tools utilized to uncover how a person perceives a system (product, service, or a combination of).

User Needs is the collection, exchange, and assessment of user information where users identify an initial understanding of needs and capabilities and use gaps across different areas of society.

User Readiness is the processes and actions to exchange information from a program to a user to expand existing knowledge of user-needs, to understand all dimensions of preparedness, and to develop a complete understanding of the intent and scope for the execution of readiness management.

User Sustainment is a systematic process of transfer of ownership from NEON UE to NESDIS's Product Portfolio Management and Programs as the NEON program starts the transition to prepare for the next generation of satellites.

Value chain is a conceptual model first coined by Harvard Business School professor Michael Porter in 1985 to describe the steps required to turn raw materials into a completed product or service in the marketplace. The value chain concept can be applied not only to the production of tangible goods but also to intangible goods, such as data and information. Value chains not only trace the value of NOAA information impacting society, but they identify the decision makers benefiting from the process.

[5] C.f Guidelines and Best Practices for Efficient Execution of NOAA's Service Delivery Framework, March 2022.