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SPACE WEATHER NEXT PROGRAM OBJECTIVES

July 2023

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Document Change Record

Version	Description	CCR#	Revised Sections	Date
1	Initial version	-	All	July 11, 2022
2	Final Version	CCR-2022-017	• Added section on user engagement (1.3) • Removed Notional NESDIS Architectural description • Added description of the “Aspirational” nature of the Program Objective requirements • Added aspirational “Objectives” requirements • Replaced “SWNext” with “Space Weather Next” throughout	March 2023
3	ADA 508 Complaint Version		• Corrected administrative errors • Formatted and mitigated for ADA section 508 compliance	July 2023

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1. Introduction

The NOAA National Environmental Satellite, Data, and Information Service (NESDIS) supports NOAA's mission of science, service, and stewardship through its satellite missions, data centers, and data and information products and services as well as use-inspired science. It is an end-to-end responsibility that underpins NOAA's value to the Nation. NESDIS' responsibility is to provide secure and timely access to global environmental data and information from satellites and other sources to promote and protect the nation's security, environment, economy, and quality of life. The continuous global coverage provided by NESDIS generates an uninterrupted stream of information and products. These products and information enable services used across the country in preparation for events that impact our climate, weather, oceans, national safety, and daily lives, and provide essential information for national, regional, and local planners and officials.

NOAA and its predecessor agencies have flown operational space weather-observing instruments as part of their Programs of Record (POR) for five decades, and many research and international missions have augmented this capability. Space weather observations are used by the National Weather Service (NWS) Space Weather Prediction Center (SWPC) to generate alerts and warnings for a global user community that includes satellite operators, airlines, electrical power grid operators, and other businesses and entities that rely on accurate satellite-based navigation services.

The nation's reliance on space weather information and products grows every year, as does the need for advanced and more timely products. The Space Weather Next Program will address the requirement for space weather observations beyond the current POR, POR2025. The Space Weather Next Program will implement a coordinated program to collect all required space weather observations. While working with other NESDIS Offices, the Program will ensure that space weather products are available to meet user requirements through 2050. The Program's scope will include support and coordination for infrastructure and services for communications, data processing, storage, stewardship, and product dissemination as outlined in the following sections.

Space Weather Next assets will observe and measure space and solar phenomena to appropriately aid in forecasting, monitoring, and warning of hazardous space weather events. The Space Weather Next Program will participate in broad user engagement to address the user community needs for both existing and improved space weather forecasting capabilities to ensure the nation continues to be space weather-ready.

1.1. Purpose

This Space Weather Next Program Objectives (PO) document provides the aspirational functional and performance requirements for the Space Weather Next System. The purposes of this document are to:

- Provide a brief summary of background, mission need, and fundamental objectives of the Space Weather Next Program;
- Provide the top-level aspirational performance and functional requirements of the fully implemented Space Weather Next System; and
- Provide a basis for the generation of lower-level requirements and associated documentation.

The nature of Program Objective documents provides the full scope of validated, technically realizable, space weather user needs without regard to budget. As such, the measurement objectives and attributes associated with each observation requirement are those that could be used by the Space Weather Next Program as Project requirements, if funding was available to perform those measurements.

1.2. Background

NOAA Administrative Order (NAO) 212-16, Policy on NOAA Observing Systems Portfolio Management, states that observing systems necessary to support Primary Mission Essential Functions (PMEFs) under the National Continuity Policy Implementation Plan (Homeland Security Council) shall be sustained as top agency priorities. NOAA is responsible for meeting two key PMEFs for the Department of Commerce (DOC) as follows:

- DOC PMEF #2, Provide Satellite Imagery: “Collect and provide the Nation with critical intelligence data, imagery, and other essential information for predictive environmental and atmospheric modeling systems and space-based distress alert systems by operating NOAA-controlled satellites, communications equipment, and associated systems”; and
- DOC PMEF #3, Provide Meteorological Forecasts: “Provide the Nation with environmental forecasts, warnings, data, and expertise critical to public safety, disaster preparedness, all-hazards response and recovery, the national transportation system, safe navigation, and the protection of the Nation’s critical infrastructure and natural resources.”

To support NOAA’s mission, NESDIS developed the NESDIS Level Requirements (NLR), a top-level requirements document that codifies the NESDIS mission and guides the budget decisions. Approved by the Deputy Undersecretary for Operations (DUS/O) and the Assistant Secretary of Commerce for Environmental Observation and Prediction (AS/EOP), the NLR

enables NESDIS to take more responsibility in meeting these requirements. In addition, NESDIS has developed the following six strategic objectives to help meet its goals and objectives:

1. Advance terrestrial observational leadership in geostationary and extended orbits;
2. Advance space weather observational leadership in all applicable orbits to meet mission needs;
3. Evolve Low Earth Orbit (LEO) architecture to enterprise system of systems that exploits and deploys new observational capabilities;
4. Develop an agile, scalable ground capability to improve efficiency of service deliverables and ingest of support data from all sources;
5. Provide consistent ongoing enterprise-wide user engagement to ensure timely response to user needs; and
6. Deliver the best value integrated suite of products and services responsive to user needs.

The Space Weather Next PO provides the requirements to meet the second NESDIS strategic objective. The Space Weather Next Program will cover all aspects of future NOAA space weather observations. It reflects a continuation of current space weather measurements and allows for the acquisition of data from partners and, potentially, commercial ventures. The Space Weather Next Program will provide on-going global leadership in space weather observations. It includes NOAA space weather-measuring assets, including, but not limited to:

- U.S. Government spacecraft;
- Instruments or payloads hosted on commercial/partner spacecraft; and
- Potential use of commercial services and observational data.

If needed, NOAA may obtain space weather data to meet its observational requirements from national and foreign partners including, but not limited to, NASA, DoD, EUMETSAT, ESA, and JAXA (if available).

The Space Weather Next Program will provide comprehensive space weather observations for NOAA and its data users through 2050. The Space Weather Next Program is being developed with an understanding of user needs for the specific space weather observations as well as how the observations would be used together synergistically. Consideration has been given in the development of the observational requirements and the operational concept to how each Space Weather Next Program instrument supports the observations of other instruments. The observational requirements were also developed through the analysis of NOAA data user needs and how the Space Weather Next instruments individually, and in concert, support the production of those products.

1.3. User Engagement

NESDIS defines User Engagement (UE) as an evidence-based discipline that helps us to learn about the needs, challenges, and work environment of those we serve so that we can provide the most useful, usable, and used products and services to our customers. UE draws on techniques of engagement and analysis developed by a variety of social science and related disciplines. UE should inform all aspects of the service delivery cycle. UE activities intend to connect with, and learn from, user communities for the purpose of informing decision making on program-led requirements and enhancements. It extends across mission development to include information gathering on user needs, as well as activities to ensure user readiness.

We can group the space weather user community into two major categories: operational and retrospective. Operational (near real-time) users provide near real-time operational alerts, warnings, and watches to operational end users. Retrospective (non-real-time) users are non-time-critical users involved in trending or research (e.g. academics, researchers, climatologists). End users can fall under either category, depending on how quickly they need the products and services for their decision processes.

NESDIS space weather UE will address three main questions:

1. How do users utilize space weather observations and derived products in their decision-making processes?
2. How do these decisions affect the users' ability to mitigate the impacts of space weather events?
3. What improvements in space weather information could strengthen the users' decision-making processes?

UE for the Space Weather Next Program should include several key components:

1. Collaboration with the NOAA Space Weather Prediction Center (SWPC) and other primary users to understand their current data needs and economic/societal benefits.
2. Collaboration with the NESDIS User Engagement Council, SWPC, and others to prioritize, plan, and conduct user engagements that support this strategy, as well as attend relevant conferences and workshops hosted by NESDIS or partners.
3. Collaboration with the NOAA Office of Chief Economist team to identify the economic and societal benefits for new and existing observational capabilities.

The UE process recognizes the value of users' needs from both the operations and research communities. It also supports a strong Research-to-operation / Operations-to-Research (R2O/O2R) framework. NESDIS space weather functions benefit from many years of active and persistent User Engagement activities performed by NESDIS, NOAA, and other government agencies. These activities have yielded significant insight into the needs of the

user community and elevated interest in, and the priority of, space to the Executive Office of the President and to Congress. These UE activities have resulted in strong budget support for NESDIS, NOAA, and other agencies space weather and heliophysics programs.

1.4. Scope

This document defines the Program Objectives for the Space Weather Next Program. Requirements development is an initial step mandated by NAO 216-108, Requirements Management. This PO document establishes top-level requirements that codify and validate user needs and expectations and provides a basis for generating and prioritizing lower level requirements documents for the Space Weather Next Program.

The scope of the Space Weather Next PO includes all validated requirements allocated to the Space Weather Next Program, without regard to funding or budget. These requirements are derived from NESDIS-REQ-1001.1, NESDIS Level Requirements, and NESDIS-REQ-1002.1, NESDIS Product Baseline, that define the requirements NESDIS must meet to support NESDIS' portion of NOAA's mission. Each requirement includes the rationale for the requirement and provides references to relevant sections in the NLR, the Product Baseline, and the COURL. Requirements are identified by the symbol "[SWN-PO]" to unambiguously define them.

While the requirements in this document include terms such as "shall" and "will," these terms are not intended to specify mandatory actions, removing all agency discretion. NESDIS intends to meet these requirements, but explicitly retains discretion in ensuring that the Space Weather Next Program elements are acquired, developed, and implemented in a manner consistent with NESDIS' long-term vision and strategy. Figures within this PO are intended to be notional, not prescriptive.

1.5. Governing Documents

Governing documents consist of documents that contain provisions or other pertinent requirements directly related to, and necessary for the performance of the activities specified by this document. Only high-level policy directives are included in this section. Other policy directives will be referenced in lower-level documents at the appropriate level.

- NAO 212-16, Policy on NOAA Observing Systems Portfolio Management, Nov 1, 2016
- NAO 216-108, Requirements Management, Oct 24, 2005
- NESDIS-REQ-1001.1, NESDIS Level Requirements Document, Sept 30, 2020
- NESDIS-REQ-1002.2, NESDIS Product Baseline
- NESDIS-PD-1110.1, NESDIS Systems Engineering and Project Management Policy, July 1, 2017

- NESDIS-PLN-1312.1, NESDIS Requirements Management Plan, Sept 9, 2020
- NESDIS-PLN-1314.1, NESDIS Configuration Management Plan, Sept 30, 2020
- NESDIS Memorandum, Establishment of a New Space Weather Program Office in NESDIS, April 17, 2020

1.6. Reference Documents

- NOAA-NASA Satellite Programs and Projects Management Control Plan (MCP)
- NESDIS-ATP-4501.1, Space Weather Next Program (Space Weather Next) Formulation Authorization Document
- NESDIS-PD-1004.1, NESDIS User Engagement Policy
- The National Oceanic and Atmospheric Administration (NOAA) Satellite Observing System Architecture Study, May 2018
- NOAA Space Weather Mission Service Area Operational User Requirements (COURL), Nov. 15, 2017
- NAO 212-13: NOAA Information Technology Security Policy, March 2003
- NOAA Security Manual (https://sites.google.com/a/noaa.gov/ocio-itso/home/itsm-itsbp)
- NESDIS IT Security Policies and Procedures, NESDIS IT Security Handbook
- The Space Weather Operations, Research, and Mitigation (SWORM) Subcommittee Recommendations Version 2.1

2. Organizational Dependencies

2.1. Program and Product Responsibilities

The Space Weather Next Program is responsible to meet the measurement objectives defined in this document and to identify funding to accomplish those objectives. In addition, the Space Weather Next Program budget covers the following functions to ensure that the end-to-end mission need is met. The Space Weather Next Program will work with the Responsible Organizations (Table 1) to provide necessary funding for these functions within the Program budget plan. The Responsible Organization will receive appropriate funding and technical support from the Space Weather Next Program and will be fully responsible for meeting those functional objectives.

Table 1: Program and Product Dependent Responsibilities

Function	Responsible Organization
Enterprise Common Infrastructure (ingest, processing, delivery, archive)	Office of Satellite Ground Services (OSGS)
Enterprise Algorithm Development and Implementation	OSGS/National Centers for Environmental Information (NCEI)
Archive and stewardship for Level-1 products, higher level products, and supporting data	NCEI
Satellite and Data Operations	OSPO

2.2. Requirements Management

The Space Weather Next PO is approved by the NESDIS Assistant Administrator (AA) according to the process outlined in NESDIS-PLN-1314.1, NESDIS Configuration Management Plan. Changes to the Space Weather Next PO are governed by the NESDIS Requirements Management Process defined in NESDIS-PLN-1312.1, NESDIS Requirements Management Plan. The Space Weather Next requirements documents will be reviewed and approved as shown in Table 2. The NESDIS requirements flow for Space Weather is shown graphically in Figure 1. The existing space weather requirements documents, shown in yellow in the figure, flow down directly from the NLR, but are not included in the Space Weather Next Program Objectives document. This Program Objectives document provides the full set of future, or next generation, measurements required to meet the NOAA space weather mission data needs without regard to budget. As such, these measurements are considered aspirational and would be achieved in the event of full funding. Threshold-level requirements, provided for all measurements, identify the lowest acceptable performance for each parameter. Objective-level requirements are provided for those parameters where the users have identified a “Maximum Effectiveness” or “Goal”, beyond which additional

performance cannot be supported by identified user need. In the event that Objective-level performance requirements are not listed for a particular attribute, then Threshold-level performance is acceptable. The designation “Aspirational” indicates a performance requirement that should be satisfied in a fully funded program. This document is reviewed at least every five years and any time new measurements or updated measurement attributes are added or changed.

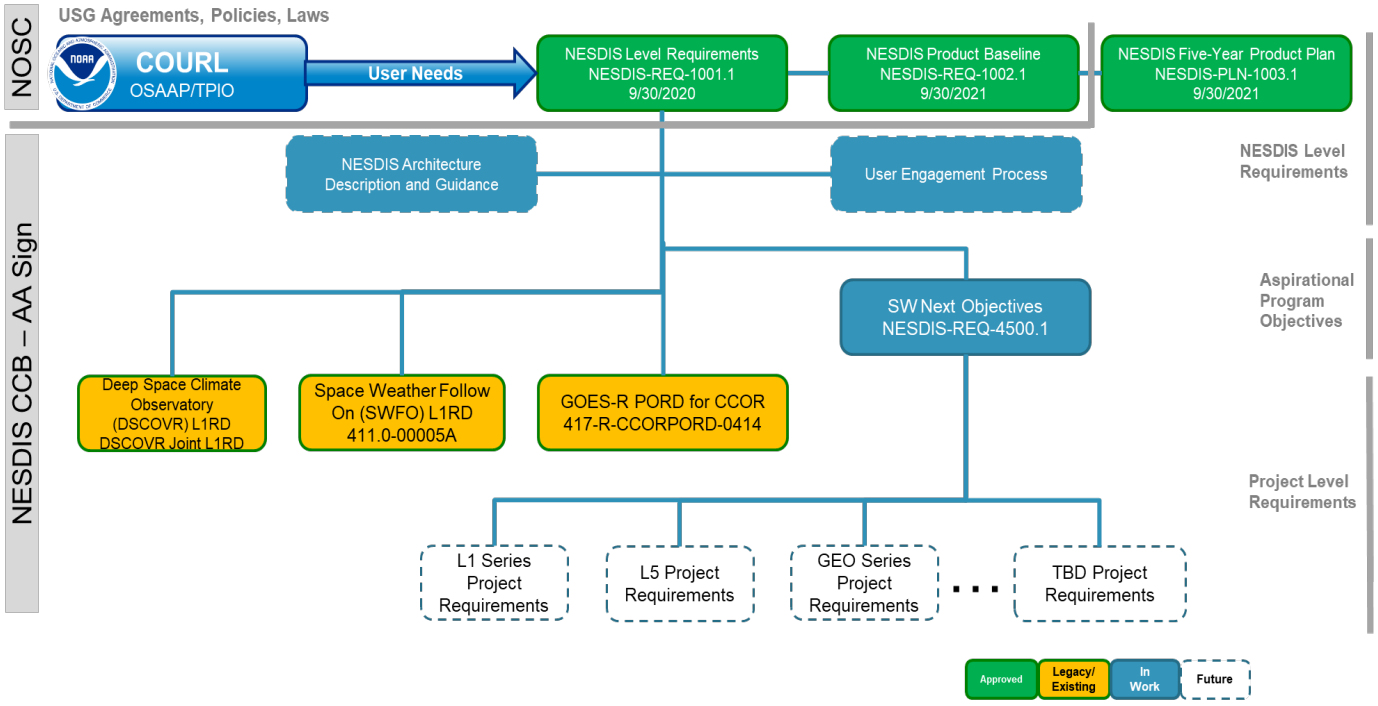
Table 2: Space Weather Next Requirements Document Reviews and Approvals

Requirements Level	**Baseline Document**	**Document Custodian and Control Process**	**Reviewing Body**	**Approving Body**
NOAA/NESDIS	NESDIS Level Requirements Document	Office of System Architecture and Advanced Planning (OSAAP)	NOSC	DUS/O
Program	Space Weather Next Program Objectives Document	OSAAP	NESDIS Executive Council	NESDIS AA
Project	Project Level Requirements Documents	OSAAP	NESDIS Executive Council	NESDIS AA/DAAS
Implementation	Systems/services Implementation Requirements Documents	Program	Space Weather Next Program CCB	NESDIS Space Weather Next System Program Director

Rationale: This Space Weather Next Requirements Document Reviews and Approvals table identifies the hierarchy of requirements documents at the NESDIS level through the Project level. This provides context through each of the requirements documents mentioned and provides an overall framework for the requirements traceability and configuration management.

Figure 1: SWO Requirements Document Tree

The green boxes show approved documents, the blue boxes show documents in development, the orange boxes show legacy requirements documents, and the dashed line boxes show notional future project level requirements documents.

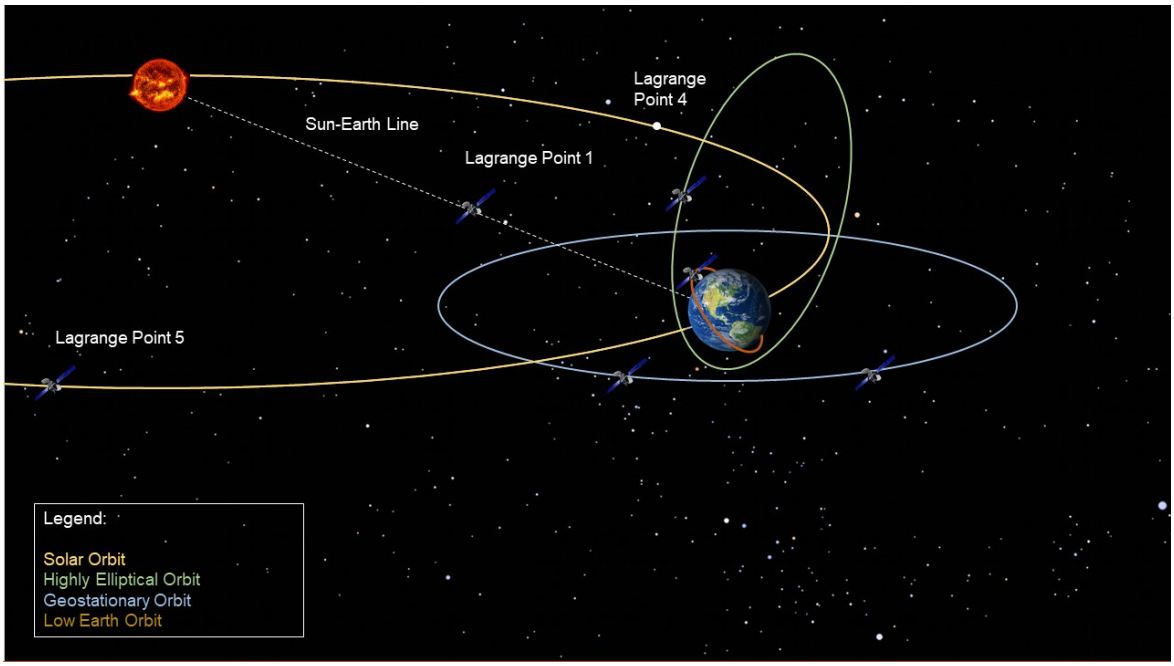


3. Space Weather Next Program Requirements

3.1. Observational Requirements

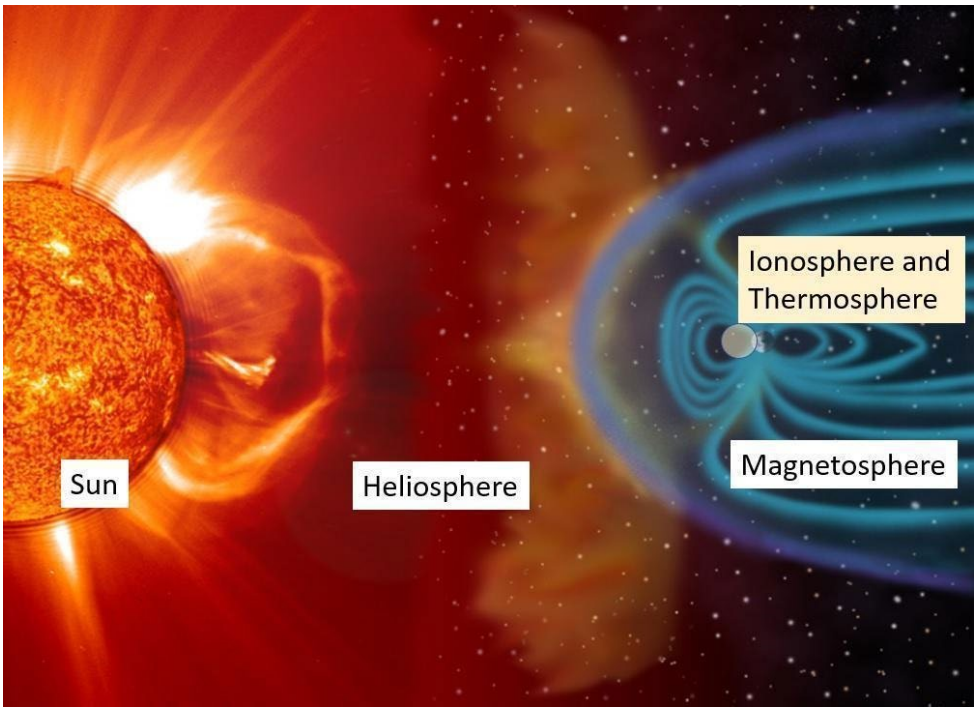
Space weather observations are required from a variety of Earth and solar orbits to appropriately characterize the space weather environment. Figure 2 depicts potential locations and orbits from which measurements are required.

Figure 2: Potential Observational Orbits and Measurement Locations (not to scale)



This section contains the observation requirements for the solar and heliospheric (e.g., solar wind) regions on and around the sun and the magnetospheric, ionospheric, and thermospheric regions around the Earth (Figure 3).

Figure 3: Space Weather Observing Regimes



The Space Weather Next data products assigned as High Availability Product (HAP) are those mission critical products that are essential for the Program to meet its mission goals. The HAP availability requirements will be applied to data products once the system providing the data reaches Full Operating Capability (FOC). Systems provide an Initial Operating Capability (IOC) when data from the system is declared ready for operational use. A system reaches FOC when all services and products meet operational requirements. The HAPs are determined by collaboration among NESDIS leadership, the Program, and data users. Program HAPs will be reevaluated at Program Key Decision Points to determine if they are still required by users and if they are programmatically feasible. Any changes to HAPs will go through the NESDIS requirement management process as defined in NESDIS-PLN-1312.1, NESDIS Requirements Management Plan. All HAP products must be provided by the Program with the high availability defined in the PO for mission success. Product priorities (HAP or non-HAP) are provided (Table 3) to assist decision makers in managing scope and capability against budget and schedule constraints. Changes and/or waivers/deviations to any of these objectives are governed by the NESDIS Requirements Management Process, regardless of priority. Priority numbers were based on the 2016 National Science and Technology Council United States Group on Earth Observations National Plan for Civil Earth Observation, Earth Observation Assessment of the Space Weather Societal Benefit Area. These priorities will be updated by USGEO in 2023.

In this document, solar and heliospheric observations described are measured along the Sun-Earth Line (SEL) and/or Off the Sun-Earth Line (Off-SEL), where SEL is at the L1 or Earth Geostationary orbit locations, and Off-SEL is at a location greater than a 16-degree Earth-Sun-spacecraft angle, preferably at or between the L4 and L5 Lagrange points. Magnetospheric, ionospheric, or thermospheric observations are measured at Geostationary Earth Orbit (GEO), and/or other non-geostationary (Off-GEO) locations (e.g., High Earth Orbit or LEO).

[SWN-PO-101] The Space Weather Next Program shall generate calibrated, navigated, and validated products as identified in Table 3.

Table 3: Space Weather Next Data Products

Product Category	Space Weather Next Data Product	HAP Products	Priority
Solar Observation	Coronal White Light Imagery (SEL)	Yes	5
Solar Observation	Coronal White Light Imagery (Off-SEL)	No	7
Solar Observation	Photospheric Magnetograph Imagery (SEL and Off-SEL)	No	8
Solar Observation	Solar EUV Imagery (SEL)	No	10
Solar Observation	Solar X-ray Irradiance (SEL)	Yes	2
Solar Observation	Solar EUV Irradiance (SEL)	No	16
Heliospheric Observation	Heliospheric Imagery (SEL and Off-SEL)	No	9
Heliospheric Observation	Solar Wind Density (SEL and Off-SEL)	No	17
Heliospheric Observation	Solar Wind Velocity (SEL)	Yes	1
Heliospheric Observation	Solar Wind Velocity (Off-SEL)	No	21
Heliospheric Observation	Solar Wind Temperature (SEL and Off-SEL)	No	18
Heliospheric Observation	Heliospheric Suprathermal Proton Flux (SEL and Off-SEL)	No	19
Heliospheric Observation	Magnetic Field (SEL and Off-SEL)	Yes for SEL No for Off-SEL	4 for SEL 20 for Off-SEL
Heliospheric Observation	Solar Energetic Particles (SEL and Off-SEL)	No	6
Magnetospheric Observation	Magnetic Field (GEO and Off-GEO)	No	11
Magnetospheric Observation	Particle Flux (GEO)	Yes	3
Magnetospheric Observation	Particle Flux (Off-GEO)	No	22

Product Category	Space Weather Next Data Product	HAP Products	Priority
Ionospheric and Thermospheric Observation	Electron Density Profile	No	14
Ionospheric and Thermospheric Observation	Total Electron Content	No	13
Ionospheric and Thermospheric Observation	Ionospheric Irregularities	No	12
Ionospheric and Thermospheric Observation	Ion Drift Velocity	No	25
Ionospheric and Thermospheric Observation	Auroral Imagery	No	24
Ionospheric and Thermospheric Observation	Low Earth Orbit Particle Flux	No	26
Ionospheric and Thermospheric Observation	Upper Thermospheric Density	No	15
Ionospheric and Thermospheric Observation	Thermospheric O/N_2 Ratio	No	23
Ionospheric and Thermospheric Observation	Thermospheric Neutral Winds	No	27

Rationale: The Space Weather Next Program Observational Requirements for calibrated, navigated, and validated (L1b) products are derived from NESDIS-REQ-1001.1 and prioritized according to NESDIS criticality. The product priorities are provided to assist the decision makers in managing the scope and capability against budget and schedule constraints. Changes and/or waivers/deviations to any of these requirements are governed by the NESDIS Requirements Management Process defined in NESDIS-PLN-1312.1, NESDIS Requirements Management Plan, regardless of priority. [REF: NLR-REQ-001]

Note that in the following subsections the formal objectives are written in the text and the table (marked as "reference"), and other similar tables to follow, only act to summarize the objectives unless they are referenced specifically in the objectives. In the event of disagreement between the text and the table, the text supersedes the table. Performance Requirements of the observation parameters listed in this section are the values anticipated to be met for a fully funded Program implementation.

3.1.1 Solar Observation Regime Requirements

3.1.1.1 Coronal White Light Imagery

The Space Weather Next Program will provide Coronal White Light imagery and the observation parameters are summarized for reference only in Table 4 below.

Table 4: Coronal White Light Imagery Observational Parameters

Observation Component	Threshold	Objective
Image Center and Orientation	Sun-centered, Solar North-aligned	
Observational Extent	3–22 R_{sun}	1-35 R_{sun}
Spatial Resolution	50 arcsec	25 arcsec
Intensity Range	1×10^{-11} B_{Sun} to 1×10^{-8} B_{Sun}	
Measurement Accuracy	±10%	
Refresh Rate (or sampling time)	15 min	1 min
Data Latency	30 min (SEL) 60 min (Off-SEL)	5 min (SEL) 5 min (Off-SEL)
Locations	SEL and Off-SEL	

Rationale: Coronal imagery provides unique and critical information about the speed, extent, and direction of coronal mass ejections. These data are required to know if Earth will be impacted by a coronal mass ejection and to generate the inputs to numerical modeling to predict when they will arrive at Earth. Coronal mass ejections are responsible for the most severe geomagnetic storms and typically impact Earth 1–4 days after they erupt from the Sun. [REF: NLR-REQ-001 (Space-Solar); NESDIS Product Baseline, §5.2.26 Solar, Table 28 (Solar); COURL SW Ops User Requirements, Table 3, Solar imagery: Corona, L1 and L5, EORES ID-406929, ID-406930; NESDIS Space Weather Follow On (SWFO) Program Preliminary Level 1 Requirements Document (L1RD), 7.1 Coronal Imaging, ID-SWFO_38; NSOSA SPRWG Final Report, Coronagraph imagery, Appendix E: B1 and B2].

[SWN-PO-103] The Space Weather Next Program shall provide coronal white light imagery with the sun-centered and solar north-aligned view.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar imagery: Corona, L1 and L5, EORES ID-406929, ID-406930]

[SWN-PO-105] The Space Weather Next Program shall provide coronal white light imagery with observational extent from 3 to 22 R_{sun} (Threshold) / 1 to 35 R_{sun} (Objective).

Rationale: [REF: NESDIS SWFO Program Preliminary Level 1 Requirements Document (L1RD), 7.1 Coronal Imaging, ID-SWFO_38; COURL SW Ops User Requirements, Table 3, Solar imagery: Corona, L1 and L5, EORES ID-406929, ID-406930; NSOSA SPRWG Final Report, Coronagraph imagery, Appendix E: B1 and B2].

[SWN-PO-107] The Space Weather Next Program shall provide coronal white light imagery with a spatial resolution of 50 arcsec (Threshold) / 25 arcsec (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Page 13, Solar imagery: Corona, L1 and L5, EORES ID-406929, ID-406930; NSOSA SPRWG Final Report, Coronagraph imagery, Appendix E: B1 and B2]

[SWN-PO-109] The Space Weather Next Program shall provide coronal white light imagery with an intensity range of 1×10^{-11} B_{Sun} to 1×10^{-8} B_{Sun}.

Rationale: [REF: COURL SW Ops User Requirements, EORES ID-406929, ID-406930; NESDIS SWFO Program Preliminary Level 1 Requirements Document (L1RD), 7.1 Coronal Imaging, ID-SWFO_38]

[SWN-PO-111] The Space Weather Next Program shall provide coronal white light imagery with measurement accuracy of ±10%.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar imagery: Corona, L1 and L5, EORES ID-406929, ID-406930; NESDIS SWFO Program Preliminary Level 1 Requirements Document (L1RD), 7.1 Coronal Imaging, ID-SWFO_38]

[SWN-PO-113] The Space Weather Next Program shall provide coronal white light imagery at a refresh rate of 15 min (Threshold) / 1 min (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar imagery: Corona, L1 and L5, EORES ID-406929, ID-406930; NESDIS SWFO Program Preliminary Level 1 Requirements Document (L1RD), 7.1 Coronal Imaging, ID-SWFO_38; NSOSA SPRWG Final Report, Coronagraph imagery, Appendix E: B1 and B2]

[SWN-PO-115] The Space Weather Next Program shall provide coronal white light imagery with a latency of 30 min (Threshold) / 5 min (Objective) for SEL and 60 min (Threshold) / 5 min (Objective) for Off-SEL.

Rationale: [REF: COURL SW Ops User Requirements, EORES ID-406929, ID-406930; NSOSA SPRWG Final Report, Coronagraph imagery, Appendix E: B1 and B2]

[SWN-PO-117] The Space Weather Next Program shall provide coronal white light imagery from both SEL and Off-SEL locations.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar imagery: Corona, L1 and L5, EORES ID-406929, ID-406930; NSOSA SPRWG Final Report, Coronagraph imagery, Appendix E: B1 and B2]

3.1.1.2 Photospheric Magnetograph Imagery

The Space Weather Next program will provide Photospheric Magnetograph Imagery and the operation parameters are summarized for reference only in Table 5.

Table 5: Photospheric Magnetogram Imagery Observational Parameters

Observation Component	Threshold	Objective
Image Center and Orientation	Sun-centered, Solar North-aligned	
Observational Extent	Solar disc from 0–1 R_{sun}	
Spatial Resolution	5 arcsec	1 arcsec
Measurement Range	±6 kG	±10 kG
Measurement Accuracy	±20%	±0.1%
Refresh Rate	3 hr	1 min
Data Latency	1 hr	1 min
Location	SEL	SEL and one or more Off-SEL

Rationale: Continual high-resolution mapping of the solar photospheric magnetic field is required in order to accurately model the solar wind velocity, density, and magnetic polarity values that cause both minor to moderate geomagnetic storming and influence CME arrival time. Since the sensor only measures in the Earth-Sun line direction (i.e. from Earth orbit), it only observes about 30% of the solar magnetic field around the sphere with sufficient accuracy for forecasting. Thus, the model solar wind outputs (velocity, density, temperature) are often inaccurate by as much as 50–100%. In order to more accurately model the solar wind, more accurate global maps of the coronal magnetic field are required, which in turn require global maps of the photospheric magnetic field. This can only be accomplished by measuring the solar magnetic field from one or more vantage points from Off-SEL position. In addition, if the vantage point were to the East of the Earth in its orbit (e.g. at the L5 Lagrange point), the observations could be used to detect sunspot active regions before they rotated onto the Earth-facing disk, potentially giving 5–7 days warning of solar eruptive activity. Solar photospheric magnetograms from a vantage point off the Sun-Earth line would be of use to both space weather forecasters and solar physics researchers. [REF: NLR-REQ-001 (Space-Solar); COURL SW Ops User Requirements, Table 3, Solar Imagery: Magnetogram, L1 and L5, EORES ID-406931, ID-406932; NSOSA SPRWG Final Report, Photospheric Magnetogram Imagery, Appendix E: B5].

[SWN-PO-119] The Space Weather Next Program shall provide photospheric magnetograph imagery with the sun-centered and solar north-aligned view.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Imagery: Magnetogram, L1 and L5, EORES ID-406931, ID-406932].

[SWN-PO-121] The Space Weather Next Program shall provide photospheric magnetograph imagery with observational extent from 0 to 1 R_{sun}.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Imagery: Magnetogram, L1 and L5, EORES ID-406931, ID-406932].

[SWN-PO-123] The Space Weather Next Program shall provide photospheric magnetograph imagery with a spatial resolution of 5 arcsec (Threshold) / 1 arcsec (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Imagery: Magnetogram, L1 and L5, EORES ID-406931, ID-406932; NSOSA SPRWG Final Report, Photospheric Magnetogram Imagery, Appendix E: B5].

[SWN-PO-125] The Space Weather Next Program shall provide photospheric magnetograph imagery with a measurement range of ±6 kG (Threshold) / ±10 kG (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Solar Imagery: Magnetogram, L1 and L5, EORES ID-406931, ID-406932]

[SWN-PO-127] The Space Weather Next Program shall provide photospheric magnetograph imagery with measurement accuracy of ±20% (Threshold) / ±0.1% (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Imagery: Magnetogram, L1 and L5, EORES ID-406931, ID-406932].

[SWN-PO-129] The Space Weather Next Program shall provide photospheric magnetograph imagery at a refresh rate of 3 hr (Threshold) / 1 min (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Imagery: Magnetogram, L1 and L5, EORES ID-406931, ID-406932; NSOSA SPRWG Final Report, Photospheric Magnetogram Imagery, Appendix E: B5].

[SWN-PO-131] The Space Weather Next Program shall provide photospheric magnetograph imagery with a latency of 1 hr (Threshold) / 1 min (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Imagery: Magnetogram, L1 and L5, EORES ID-406931, ID-406932].

[SWN-PO-133] The Space Weather Next Program shall provide a photospheric magnetograph Imagery from one SEL location and (Threshold) and one or more Off-SEL locations (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Imagery: Magnetogram, L1 and L5, EORES ID-406931, ID-406932; NSOSA SPRWG Final Report, Photospheric Magnetogram Imagery, Appendix E: B5].

3.1.1.3 Solar EUV Imagery

The Space Weather Next program will provide Solar EUV Imaging radiances and the operation parameters are summarized for reference only in Table 6.

Table 6: Solar EUV Imagery Observational Parameters

Observation Component	Threshold	Objective
Image Center and Orientation	Sun-centered, Solar North-aligned	
Observational Extent	0–1.5 R_{sun}	
Spatial Resolution	5 arcsec	1 arcsec
Observational Spectral Range	6 Spectral Bands	
Plasma Temperature Range	10^4.9 K to 10^7.2 K	
Solar Feature Identification	Coronal holes, Filaments / Prominences, Active Regions, CMEs, X10 Class Solar Flares	
Signal to Noise Ratio	10	40
Refresh Rate	2 min	10 sec
Data Latency	1 min	10 sec
Location	SEL	

Rationale: Solar EUV imagery provides comprehensive situational awareness of the inner solar corona from images of the inner corona (atmosphere) of the Sun in multiple different EUV spectral bands that were selected to be sensitive to different plasma temperatures for feature and phenomenological discrimination. These images observed from GEO or L1 will reveal details about the distribution, structure and related activity of active regions, filaments, and solar prominences. The interests of space weather forecasters are the boundaries of

coronal holes and how the entire surface of the Sun behaves during solar flares. The locations of certain dynamic events on the solar disk are a major indication of whether the event will have impacts that are felt here on Earth. The locations of certain dynamic events on the solar disk are a major indication of whether the event will have impacts that are felt here on Earth. Higher-level products made from these imagery products by the NOAA Space Weather Prediction Center along with other organizations will provide early warning of potential radiation hazards, such as SEP events, flares, geomagnetic storms and radio blackouts. Spectral Bands with peak wavelengths at 9.4 nm, 13.1 nm, 17.1 nm, 19.5 nm, 28.4 nm, and 30.4 nm, can provide insight on flare location and morphology, Active region complexity, CMEs and quiet regions, Coronal Holes, and Filaments. [REF: NLR-REQ-001 (Space-Solar); NESDIS Product Baseline, 5.2.26 Solar, Table 28 (Solar); NESDIS GOES-R Series Mission Requirements Document (MRD), 3.3.6.3.3 Solar Imagery: EUV, ID-MRD400; COURL SW Ops User Requirements, Table 3, Solar Imagery: Multi-Spectral X-Ray/EUV, EORES ID-406936, ID-406935; NSOSA SPRWG Final Report, Solar EUV Imagery, Appendix E: B3].

[SWN-PO-135] The Space Weather Next Program shall provide solar EUV imagery with the sun-centered and solar north-aligned view.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Imagery: Multi-Spectral X-Ray/EUV, EORES ID-406936, ID-406935]

[SWN-PO-137] The Space Weather Next Program shall provide solar EUV imagery with observational extent from 0 to 1.5 R_{sun}.

Rationale: The expanded field of view, from 1.3 R_{sun} to 5.0 R_{sun} could potentially have strong forecasting benefits via early detection of coronal mass ejections. [REF: COURL SW Ops User Requirements, Table 3, Solar Imagery: Multi-Spectral X-Ray/EUV, EORES ID-406936, ID-406935; NESDIS GOES-R Series Mission Requirements Document (MRD), 3.3.6.3.3 Solar Imagery: EUV, ID-MRD400; NSOSA SPRWG Final Report, Solar EUV Imagery, Appendix E: B3]

[SWN-PO-139] The Space Weather Next Program shall provide solar EUV imagery with a spatial resolution of 5 arcsec (Threshold) / 1 arcsec (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Imagery: Multi-Spectral X-Ray/EUV, EORES ID-406936, ID-406935; NESDIS GOES-R Series Mission Requirements Document (MRD), 3.3.6.3.3 Solar Imagery: EUV, ID-MRD400; NSOSA SPRWG Final Report, Solar EUV Imagery, Appendix E: B3]

[SWN-PO-141] The SW Next Program shall provide solar EUV imagery in 6 narrow-band wavelength channels.(Threshold).

Rationale: [REF: NESDIS GOES-R Series Mission Requirements Document (MRD), 3.3.6.3.3 Solar Imagery: EUV, ID-MRD400; NSOSA SPRWG Final Report, Solar EUV Imagery, Appendix E: B3]

[SWN-PO-142] The SW Next Program shall provide solar EUV imagery to cover the specified range of coronal plasma temperatures from 10^4.9K to 10^7.2K (Threshold)

Rationale: [REF: NESDIS GOES-R Series Mission Requirements Document (MRD), 3.3.6.3.3 Solar Imagery: EUV, ID-MRD400; NSOSA SPRWG Final Report, Solar EUV Imagery, Appendix E: B3]

[SWN-PO-143] The SW Next Program shall provide solar EUV imagery capable of identifying solar features of interest: coronal holes, filaments/prominences, active regions, CMEs, and X10 class solar flares (Threshold).

[SWN-PO-144] The SW Next Program shall provide solar EUV imagery at a signal-to-noise ratio between 10 (Threshold) and 40 (Objective) at the required cadence.

Rationale: SNR ≥ 10 is the international standard that defines digital image quality as "acceptable" [Ref: ISO 12232: Photography – Digital Still Cameras – Determination of Exposure Index, ISO Speed Ratings, Standard Output Sensitivity, and Recommended Exposure Index, Standard, International Organization for Standardization, Geneva, CH, 2019]. The same standard defines SNR of 40 as "excellent".

[SWN-PO-145] The Space Weather Next Program shall provide solar EUV imagery at a refresh rate of 2 min (Threshold) / 10 sec (Objective) for each wavelength range.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Imagery: Multi-Spectral X-Ray/EUV, EORES ID-406936, ID-406935; NSOSA SPRWG Final Report, Solar EUV Imagery, Appendix E: B3]

[SWN-PO-147] The Space Weather Next Program shall provide solar EUV imagery with a latency of 1 min (Threshold) (Objective).

Rationale: [REF: NESDIS GOES-R Series Mission Requirements Document (MRD), 3.3.6.3.3 Solar Imagery: EUV, ID-MRD400; COURL SW Ops User Requirements, Table 3, Solar Imagery: Multi-Spectral X-Ray/EUV, EORES ID-406936, ID-406935; NSOSA SPRWG Final Report, Solar EUV Imagery, Appendix E: B3]

[SWN-PO-149] The Space Weather Next Program shall provide solar EUV imagery from a SEL location.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Imagery: Multi-Spectral X-Ray/EUV, EORES ID-406936, ID-406935]

3.1.1.4 Solar X-ray Irradiance

The Space Weather Next program will provide Solar X-ray Irradiance and the operation parameters are summarized for reference only in Table 7.

Table 7: Solar X-ray Irradiance Observational Parameters

Observation Component	Threshold	Objective
Observational Extent	0–1.3 R_{sun}	
Observational Wavelength Range	0.04–0.4 nm and 0.1–0.8 nm	0.04 -1.6 nm in three or more bands
Flux Range	$1x10^{-9}$–$1x10^{-3}$ W m^{-2}	$1x10^{-9}$–$5x10^{-3}$ W m^{-2}
Measurement Accuracy	20%	10%
Refresh Rate	3 sec	1 sec
Data Latency	30 sec	3 sec
Location	SEL	

Rationale: Solar X-ray Irradiance is critical to quick and early assessment of space weather impacts on Earth. These observations have been made from the operational SEL (L1) or GEO spacecraft. These observations define the magnitude of solar flares and provide the first warning of impending space weather storms. Solar x-rays disrupt communications. X-ray flare magnitude is used to predict solar proton events which also disrupt communications. The Space Weather Prediction Center uses these observations to issue warnings based on increases in Solar X-ray flux, specifically increases by several orders of magnitude from solar flares. These observations drive one of the three NOAA Space Weather Scales (Radio Blackouts) and provide alerts of radio blackouts of terrestrial HF radio communications. These data are essential for driving critical space weather models and products. It is one of the longest records of space weather and provides context for recent events. [REF: NLR-REQ-001; NESDIS Product Baseline, 5.2.26 Solar, Table 28 (Solar); NESDIS GOES-R Series Mission Requirements Document (MRD), 3.3.6.3.2 Solar Flux: X-Ray, ID-MRD398;

COURL SW Ops User Requirements, Table 3, Solar Flux: X-Ray Irradiance, EORES ID-406927; NSOSA SPRWG Final Report, Solar X-Ray Irradiance, Appendix E: B6]

[SWN-PO-151] The Space Weather Next program shall provide solar X-ray irradiance with observational extent from 0 to 1.3 R_{sun}.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Flux: X-Ray Irradiance, EORES ID-406927; NESDIS GOES-R Series Mission Requirements Document (MRD), 3.3.6.3.2 Solar Flux: X-Ray, ID-MRD398]

[SWN-PO-153] The Space Weather Next Program shall provide solar X-ray irradiance through the band range of 0.04 to 0.4 nm and the band range of 0.1 to 0.8 nm (Threshold) / 0.04 to 1.6 nm in three or more bands (Objective).

Rationale: With one channel (0.1–0.8 nm) the primary uses will be achievable. The second XRS channel (0.05–0.4 nm) provides two additional capabilities: 1) a short-term prediction to when the flare will reach its peak magnitude; and 2) the differential temperature and emission measure of the flare using the ratio of these two channels. (Objective) Doubling the maximum wavelength XRS out to 1.6 nm (with three bands) would help to provide separation in spectral coverage to better probe (retrieve) plasma temperature and emission measure. Three bands are required to determine temperature and emission measure. [REF: NESDIS GOES-R Series Mission Requirements Document (MRD), 3.3.6.3.2 Solar Flux: X-Ray, ID-MRD398; NSOSA SPRWG Final Report, Solar X-Ray Irradiance, Appendix E: B6]

[SWN-PO-155] The Space Weather Next Program shall provide solar X-ray irradiance with flux range from 10^{-9} to 10^{-3} W m^{-2} (Threshold) / $1x10^{-9}$ to $5x10^{-3}$ W m^{-2} (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Solar Flux: X-Ray Irradiance, EORES ID-40692]

[SWN-PO-157] The Space Weather Next Program shall provide solar X-ray irradiance with 20% (Threshold) / 10% (Objective) measurement accuracy.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Flux: X-Ray Irradiance, EORES ID-406927; NSOSA SPRWG Final Report, Solar X-Ray Irradiance, Appendix E: B6]

[SWN-PO-159] The Space Weather Next Program shall provide solar X-ray irradiance at a refresh rate of 3 sec (Threshold) / 1 sec (Objective).

Rationale: [REF: NESDIS GOES-R Series Mission Requirements Document (MRD), 3.3.6.3.2 Solar Flux: X-Ray, ID-MRD398; COURL SW Ops User Requirements, Table 3, Solar Flux: X-Ray Irradiance, EORES ID-406927; NSOSA SPRWG Final Report, Solar X-Ray Irradiance, Appendix E: B6]

[SWN-PO-161] The Space Weather Next Program shall provide solar X-ray irradiance with a latency of 30 sec (Threshold) / 3 sec (Objective).

Rationale: X-ray irradiance has an immediate impact on the composition of the ionosphere and health risks to humans in space. Low data latency is required to mitigate these impacts. Current GOES-R system is capable of delivering X-ray Irradiance data within 3 seconds of observation, however, communications protocols within the GOES Rebroadcast System delay data receipt up to 60 seconds. This introduces an unacceptable risk to the user community including human spaceflight. Additional time should be added to calculations of data latency for radio frequency transmission time from the observing system to the ground system, which in the case of measurement from the Lagrange 1 orbit is about 6 seconds. [REF: NSOSA SPRWG Final Report, Solar X-Ray Irradiance, Appendix E: B6]

[SWN-PO-163] The Space Weather Next Program shall provide solar X-ray irradiance from a SEL location.

Rationale: [REF: NSOSA SPRWG Final Report, Solar X-Ray Irradiance, Appendix E: B6]

3.1.1.5 Solar EUV Irradiance

The Space Weather Next program will provide Solar EUV Irradiances and their operation parameters are summarized for reference only in Table 8.

Table 8: Solar EUV Irradiance Observational Parameters

Observation Component	Threshold	Objective
Observational Extent	0–1.3 R_{sun}	
Observational Wavelength Range	5.01–127 nm	2.0 –170 nm
Observational Wavelength Resolution	5 nm	0.1 nm
Daily Average Measurement Accuracy	±20%	±10%
Short-term Averaged Measurement Accuracy	None	±10%
Refresh Rate	30 sec	10 sec
Data Latency	30 sec	5 sec
Location	SEL	

Rationale: Solar EUV irradiance is highly energetic and is absorbed in the upper atmosphere, which not only heats the upper atmosphere, but also ionizes it, creating the ionosphere. Solar EUV irradiance varies by as much as an order of magnitude on time scales of minutes to hours (solar flares), days to months (solar rotation), and years to decades (solar cycle). The highly varying EUV radiation causes the thermosphere and ionosphere to vary by similar magnitudes and time scales. Solar EUV irradiance is used to drive models of the thermosphere and ionosphere. Variations in the thermosphere are directly related to satellite drag and satellite orbit prediction. Satellite collision avoidance at LEO altitudes has become a critical concern as the number of space objects grows exponentially. Variations in the ionosphere impact radio communication and satellite navigation. The ionosphere and thermosphere are highly coupled requiring that both programs be specified and modeled together. Thermospheric and Ionospheric models require complex analysis of the physical drivers of these models. Solar EUV irradiance is one of the three main variable driving forces (along with geomagnetic storms and lower atmospheric tides/waves). The strongest solar EUV line, the Lyman alpha at 121.6 nm, is absorbed by hydrogen in the Earth's Exosphere. To continuously measure the top-of-the-atmosphere solar Lyman alpha irradiance, needed for some atmospheric models, the local time separation between GEO satellites measuring these emmisions should be at least 6-8 hours. [REF: NLR-REQ-001; NESDIS Product Baseline, 5.2.26 Solar, Table 28 (Solar); NESDIS GOES-R Series Mission Requirements Document (MRD), 3.3.6.3.1 Solar Flux: EUV, ID-MRD396; COURL SW Ops User Requirements, Table 3, Solar Flux: EUV, EORES ID-406926; NSOSA SPRWG Final Report, Solar EUV Irradiance, Appendix E: B7]

[SWN-PO-165] The Space Weather Next Program shall provide operational solar EUV irradiance with observational extent from 0 to 1.3 R_{sun}.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Flux: EUV, EORES ID-406926; NESDIS GOES-R Series Mission Requirements Document (MRD), 3.3.6.3.1 Solar Flux: EUV, ID-MRD396]

[SWN-PO-167] The Space Weather Next Program shall provide solar EUV irradiance in the observational wavelength range of 5.01 to 127 nm (Threshold) / 2.0 to 170 nm (Objective).

Rationale: [REF: NSOSA SPRWG Final Report, Solar EUV Irradiance, Appendix E: B7]

[SWN-PO-169] The Space Weather Next Program shall provide solar EUV irradiance with observational wavelength resolution of 5 nm (Threshold) / 0.1 nm (Objective)

Rationale: [REF: NSOSA SPRWG Final Report, Solar EUV Irradiance, Appendix E: B7]

[SWN-PO-171] The Space Weather Next Program shall provide solar EUV irradiance with daily-averaged measurement accuracy between ±20% (Threshold) and ±10% (Objective)

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Flux: EUV, EORES ID-406926; NESDIS GOES-R Series Mission Requirements Document (MRD), 3.3.6.3.1 Solar Flux: EUV, ID-MRD396]

[SWN-PO-172] The Space Weather Next Program shall provide solar EUV irradiance with Short-term (5-minute-averaged) measurement accuracy of ±10% (Objective) relative to the range of typical daily solar variability. For wavelengths impacted by the geocorona, the range for comparison is for times when there is negligible geocoronal impact.

Rationale: A separate short-term relative accuracy requirement is needed since short term EUV variability including flares must be well characterized for atmospheric and ionospheric models. Since the daily variability at most EUV wavelengths is less than a few percent, the overall 20% accuracy requirement does result in any net accuracy requirement for the short term variability.

[SWN-PO-173] The Space Weather Next Program shall provide solar EUV irradiance at a refresh rate of 30 sec (Threshold) / 10 sec (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Flux: EUV, EORES ID-406926; NESDIS GOES-R Series Mission Requirements Document (MRD), 3.3.6.3.1 Solar Flux: EUV, ID-MRD396; NSOSA SPRWG Final Report, Solar EUV Irradiance, Appendix E: B7]

[SWN-PO-175] The Space Weather Next Program shall provide solar EUV irradiance with a latency of 30 sec (Threshold) / 5 sec (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Solar Flux: EUV, EORES ID-406926; NESDIS GOES-R Series Mission Requirements Document (MRD), 3.3.6.3.1 Solar Flux: EUV, ID-MRD396; NSOSA SPRWG Final Report, Solar EUV Irradiance, Appendix E: B7]

[SWN-PO-177] The Space Weather Next Program shall provide solar EUV irradiance from a SEL location.

Rationale: [REF: NSOSA SPRWG Final Report, Solar EUV Irradiance, Appendix E: B7]

3.1.2 Heliospheric Observation Regime Requirements

3.1.2.1 Heliospheric Imagery

The Space Weather Next program will provide heliospheric imagery and its operation parameters are summarized for reference only in Table 9.

Table 9: Heliospheric Imagery Observational Parameters

Observation Component	Threshold	Objective
Observational Extent (FOV)	15–100 R_{sun}	10–320 R_{sun}
Spatial Resolution	10 arcmin at inner FOV (15 R_{sun}) 2 degrees at outer FOV (100 R_{sun})	
Measurement Sensitivity	3×10^{-15} B_{Sun} for inner FOV (15 R_{sun}) 3×10^{-16} B_{Sun} for outer FOV (100 R_{sun})	
Measurement Accuracy	±10%	
Refresh Rate	1 hr	30 min
Data Latency	4 hr	30 min
Locations	SEL and one or more Off-SEL	

Rationale: Heliospheric imagery, as white light and potentially polarized, provides the only way to observe the solar wind and coronal mass ejections all the way from the Sun to Earth. Coronal mass ejections drive the most severe geomagnetic storms and their propagation is significantly impacted by structures in the solar wind. Geomagnetic storms are a concern for the electric power grid, satellite operators, GPS users, aviation customers, and many others. [REF: NLR-REQ-001001 (Space – Heliosphere); COURL SW Ops User Requirements, Table 3, Solar Imagery: Heliospheric, L5, EORES ID-406948; NSOSA SPRWG Final Report, Heliospheric Imagery, Appendix E: B10]

[SWN-PO-179] The Space Weather Next Program shall provide heliospheric imagery with an observational extent of 15 to 100 R_{sun} (Threshold) / 10 to 320 R_{sun} (Objective) between Earth and the Sun.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Imagery: Heliospheric, L5, EORES ID-406948; NSOSA SPRWG Final Report, Heliospheric Imagery, Appendix E: B10]

[SWN-PO-181] The Space Weather Next Program shall provide heliospheric imagery with spatial resolution of 10 arcmin at inner FOV and 2 degrees at outer FOV.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Imagery: Heliospheric, L5, EORES ID-406948; NSOSA SPRWG Final Report, Heliospheric Imagery, Appendix E: B10]

[SWN-PO-183] The Space Weather Next Program shall provide heliospheric imagery with measurement sensitivity of 3×10^{-15} B_{sun} for inner FOV and 3×10^{-16} B_{sun} for outer FOV.

Rationale: [REF: NASA STEREO Heliospheric Imagery]

[SWN-PO-185] The Space Weather Next Program shall provide heliospheric imagery with measurement accuracy of ±10%.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Imagery: Heliospheric, L5, EORES ID-406948]

[SWN-PO-187] The Space Weather Next Program shall provide heliospheric imagery at a refresh rate of 1 hr (Threshold) / 30 min (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Imagery: Heliospheric, L5, EORES ID-406948; NSOSA SPRWG Final Report, Heliospheric Imagery, Appendix E: B10]

[SWN-PO-189] The Space Weather Next Program shall provide heliospheric imagery with a latency of 4 hr (Threshold) / 30 min (Objective).

Rationale: [REF: NSOSA SPRWG Final Report, Heliospheric Imagery, Appendix E: B10]

[SWN-PO-191] The Space Weather Next Program shall provide heliospheric imagery from SEL and one or more Off-SEL locations.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Imagery: Heliospheric, L5, EORES ID-406948; NSOSA SPRWG Final Report, Heliospheric Imagery, Appendix E: B10]

3.1.2.2 Solar Wind Density

The Space Weather Next program will provide solar wind density observation beyond the Earth's magnetosphere and its operation parameters are summarized for reference only in Table 10.

Table 10: Solar Wind Density Observational Parameters

Observation Component	Threshold	Objective
Observational Extent	In situ	
Density Range	0.1–150 particles cm^{-3}	0.1–200 particles cm^{-3}
Measurement Accuracy	±10%	
Refresh Rate	1 min	10 sec

Observation Component	Threshold	Objective
Data Latency	5 min for SEL 1 hr for Off-SEL	1 min for SEL 15 min for Off-SEL
Locations	One SEL Location	SEL and one more Off-SEL

Rationale: Solar wind consists of a strongly ionized gas having a proton and electron density that is an important attribute that could be used for solar wind modeling and analysis together with solar wind velocity and temperature. The average solar wind density at the orbit of the Earth is 3-10 particles per cubic centimeter. The solar wind observations provide crucial information required to provide accurate geomagnetic storm warnings. The solar wind is an important driver of the geospace environment and is a critical input to numerical geomagnetic storm prediction models as well as ionospheric storm models. NASA's Advanced Composition Explorer (ACE) and NOAA's Deep Space Climate Observatory (DSCOVR) both provide these data currently, though neither meets current COURL requirements. Solar wind data are used to issue Sudden Impulse Warnings and Geomagnetic Storm Warnings. They are also used as input to predictive models, including the Geospace Model, Ovation Auroral Forecast, Wing-Kp, CTIPe, and WAM-IP. In addition, solar wind information is also used for real-time validation of the WSA-Enlil model. Geomagnetic storm warnings allow the electric power grid to take immediate actions necessary to protect the grid infrastructure from damage. The low-energy proton measurements detect the increases of particle flux that are the precursors of approaching interplanetary shocks. These interplanetary shocks and the coronal mass ejections that drive them are the causes of the largest geomagnetic storms. Besides the SEL (L1) observations, Off-SEL solar wind observations provide 3–7 days lead time of solar wind speed, density and temperature for recurrent solar wind features. *[REF: NLR-REQ-001 (Space – Heliosphere); NESDIS Product Baseline 2.2.23 Heliosphere, Table 25 (Heliosphere); COURL SW Ops User Requirements, Table 3, Solar Wind: Plasma Ion Density L1 and L5, EORES ID-406966, ID-406967; NESDIS SWFO Program Preliminary Level 1 Requirement Document (L1RD), 7.2.1 Thermal Plasma Variables, ID-SWFO_45; NSOSA SPRWG Final Report, Solar Wind, Appendix E: B8 and B9]*

[SWN-PO-193] The Space Weather Next Program shall provide solar wind density observation through in situ measurement.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Wind: Plasma Ion Density L1 and L5, EORES ID-406966, ID-406967]

[SWN-PO-195] The Space Weather Next Program shall provide solar wind density observation with a density range of 0.1 to 150 particles cm^{-3} (Threshold) / 0.1 to 200 particles cm^{-3} (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Wind: Plasma Ion Density L1 and L5, EORES ID-406966, ID-406967; NESDIS SWFO Program Preliminary

Level 1 Requirement Document (L1RD), 7.2.1 Thermal Plasma Variables, ID-SWFO_45; NSOSA SPRWG Final Report, Solar Wind, Appendix E: B8 and B9]

[SWN-PO-197] The Space Weather Next Program shall provide solar wind density observation with measurement accuracy of ±10% (Threshold).

Rationale: [REF: NESDIS SWFO Program Preliminary Level 1 Requirement Document (L1RD), 7.2.1 Thermal Plasma Variables, ID-SWFO_45]

[SWN-PO-199] The Space Weather Next Program shall provide solar wind density observation at a refresh rate of 1 min (Threshold) / 10 sec (Objective) for both SEL and Off-SEL locations.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Wind: Plasma Ion Density L1 and L5, EORES ID-406966, ID-406967; NESDIS SWFO Program Preliminary Level 1 Requirement Document (L1RD), 7.2.1 Thermal Plasma Variables, ID-SWFO_45]

[SWN-PO-201] The Space Weather Next Program shall provide solar wind density observation with a latency of 5 min (Threshold) / 1 min (Objective) for SEL and 1 hr (Threshold) / 15 min (Objective) for Off-SEL.

Rationale: [REF: NSOSA SPRWG Final Report, Solar Wind, Appendix E: B8 and B9]

[SWN-PO-203] The Space Weather Next program shall provide solar wind density observation from one SEL location (Threshold) and one or more Off-SEL locations (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Wind: Plasma Ion Density L1 and L5, EORES ID-406966, ID-406967; NSOSA SPRWG Final Report, Solar Wind, Appendix E: B8 and B9]

3.1.2.3 Solar Wind Velocity

The Space Weather Next program will provide solar wind velocity observation beyond the Earth's magnetosphere and its operation parameters are summarized for reference only in Table 11.

Table 11: Solar Wind Velocity Observational Parameters

Observation Component	Threshold	Objective
Observational Extent	In situ	
Speed Range	200–2500 km sec^{-1}	200–3000 km sec^{-1}
Measurement Accuracy	±10%	±5%

Observation Component	Threshold	Objective
Refresh Rate	1 min	1 sec
Data Latency	5 min for SEL 1 hr for Off-SEL	1 min for SEL 15 min for Off-SEL
Locations	SEL	SEL and one or more Off-SEL

Rationale: One important measure of solar wind is solar wind velocity, which is being used widely for solar wind modeling and analysis together with solar wind density and temperature. [REF: NLR-REQ-001001 (Space – Heliosphere); NESDIS Product Baseline 2.2.23 Heliosphere, Table 25 (Heliosphere); COURL SW Ops User Requirements, Table 3, Solar Wind: Plasma Ion Velocity Vector, L1 and L5, EORES ID-406964, ID-406965; NESDIS SWFO Program Preliminary Level 1 Requirement Document (L1RD), 7.2.1 Thermal Plasma Variables, ID-SWFO_44; NSOSA SPRWG Final Report, Solar Wind, Appendix E: B8 and B9]

[SWN-PO-205] The Space Weather Next Program shall provide solar wind velocity observation through in situ measurement.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Wind: Plasma Ion Velocity Vector, L1 and L5, EORES ID-406964, ID-406965]

[SWN-PO-207] The Space Weather Next Program shall provide solar wind velocity observation with a speed range of 200 to 2500 km sec^{-1} (Threshold) / 200 to 3000 km sec^{-1} (Objective).

Rationale: [REF: NESDIS SWFO Program Preliminary Level 1 Requirement Document (L1RD), 7.2.1 Thermal Plasma Variables, ID-SWFO_44; NSOSA SPRWG Final Report, Solar Wind, Appendix E: B8 and B9]

[SWN-PO-209] The Space Weather Next Program shall provide solar wind velocity observation with measurement accuracy of ±10% (Threshold) / ±5% (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Wind: Plasma Ion Velocity Vector, L1 and L5, EORES ID-406964, ID-406965]

[SWN-PO-211] The Space Weather Next Program shall provide solar wind velocity observation at a refresh rate of 1 min (Threshold) / 1 sec (Objective) for both SEL and Off-SEL locations.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Wind: Plasma Ion Velocity Vector, L1 and L5, EORES ID-406964, ID-406965; NESDIS SWFO Program Preliminary Level 1 Requirement Document (L1RD), 7.2.1 Thermal Plasma Variables, ID-SWFO_44]

[SWN-PO-213] The Space Weather Next Program shall provide solar wind velocity observation with a latency of 5 min (Threshold) / 1 min (Objective) for SEL and 1 hr (Threshold) / 15 min (Objective) for Off-SEL.

Rationale: [REF: NSOSA SPRWG Final Report, Solar Wind, Appendix E: B8 and B9]

[SWN-PO-215] The Space Weather Next Program shall provide solar wind velocity observation from SEL (Threshold) and one or more Off-SEL (Objective) locations.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Wind: Plasma Ion Velocity Vector, L1 and L5, EORES ID-406964, ID-406965; NSOSA SPRWG Final Report, Solar Wind, Appendix E: B8 and B9]

3.1.2.4 Solar Wind Temperature

The Space Weather Next program will provide solar wind temperature observation beyond the Earth's magnetosphere and its operation parameters are summarized for reference only in Table 12.

Table 12: Solar Wind Temperature Observational Parameters

Observation Component	Threshold	Objective
Observational Extent	In situ	
Temperature Range	0.04 MK to 2.0 MK	0.02 to 7.4 MK
Measurement Accuracy	±10%	
Refresh Rate	1 min	10 Sec
Data Latency	5 min for SEL 1 hr for Off-SEL	1 min for SEL 15 min of off SEL
Locations	One SEL	SEL and one or more Off-SEL

Rationale: One important measure of solar wind is solar wind temperature, which is being used widely for solar wind modeling and analysis together with solar wind density and velocity. [REF: NLR-REQ-001 (Space – Heliosphere); NESDIS Product Baseline 2.2.23 Heliosphere, Table 25 (Heliosphere); COURL SW Ops User Requirements, Table 3, Solar Wind: Plasma Ion Temperature, L1 and L5, EORES ID-406968, ID-406969; NESDIS SWFO L1RD, 7.2.1 Thermal Plasma Variables, ID-SWFO_46; NSOSA SPRWG Final Report, Solar Wind, Appendix B8 and B9]

[SWN-PO-217] The Space Weather Next Program shall provide solar wind temperature observation through in situ measurement.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Wind: Plasma Ion Temperature, L1 and L5, EORES ID-406968, ID-406969]

[SWN-PO-219] The Space Weather Next Program shall provide solar wind temperature observation with a temperature range of 0.04 MK to 2.0 MK (Threshold) / 0.02 MK to 7.4 MK (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Solar Wind: Plasma Ion Temperature, L1 and L5, EORES ID-406968, ID-406969; NESDIS SWFO L1RD, 7.2.1 Thermal Plasma Variables, ID-SWFO_46]

[SWN-PO-221] The Space Weather Next Program shall provide solar wind temperature observation with measurement accuracy of ±10%.

Rationale: [REF: NESDIS SWFO L1RD, 7.2.1 Thermal Plasma Variables, ID-SWFO_46]

[SWN-PO-223] The Space Weather Next Program shall provide solar wind temperature observation at a refresh rate of 1 min (Threshold) / 10 sec (Objective) for SEL and Off-SEL.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Wind: Plasma Ion Temperature, L1 and L5, EORES ID-406968, ID-406969; NESDIS SWFO L1RD, 7.2.1 Thermal Plasma Variables, ID-SWFO_46]

[SWN-PO-225] The Space Weather Next Program shall provide solar wind temperature observation with latency of 5 min (Threshold) / 1 min (Objective) for SEL and 1 hr (Threshold) / 15 min (Objective) for Off-SEL.

Rationale: [REF: NSOSA SPRWG Final Report, Solar Wind, Appendix B8 and B9]

[SWN-PO-227] The Space Weather Next program shall provide solar wind temperature observation from one SEL location (Threshold) and one or more Off-SEL locations (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Wind: Plasma Ion Temperature, L1 and L5, EORES ID-406968, ID-406969; NSOSA SPRWG Final Report, Solar Wind, Appendix B8 and B9]

3.1.2.5 Heliospheric Suprathermal Proton Flux

The Space Weather Next program will provide Heliospheric Suprathermal Proton Flux observation beyond the Earth's magnetosphere and its operation parameters are summarized for reference only in Table 13.

Table 13: Heliospheric Suprathermal Proton Flux Observational Parameters

Observation Component	Threshold	Objective
Observational Extent	In situ	
Observational Energy Range	10–2000 keV	5–2000 keV for SEL
Flux Range	$2.48 \times 10^2 * E(keV)^{-1.6}$ to $1.01 \times 10^7 * E(keV)^{-1.6} cm^{-2} ster^{-1} keV^{-1} S^{-1}$	
Measurement Accuracy	(for energy = 2 MeV): ±20% (for flux = 1×10^{-3} /cm^2/s/sr/keV) to ±100% (for flux = 6.34×10^{-6} /cm^2/s/sr/keV)	
Refresh Rate	5 min	10 sec
Data Latency	5 min for SEL 1 hr for Off-SEL	1 min for SEL 15 min for Off-SEL
Locations	One SEL	SEL and one or more Off-SEL

Rationale: Another important measure within the heliosphere is the low energy protons, which gives the flux of low energy protons used for advanced warning of the arrival of solar wind shocks. This requirement refers to the low-energy, or suprathermal, solar particles that cannot be observed inside Earth's magnetosphere without interference from the radiation belts and geomagnetic shielding. It is acceptable for the energy ranges in this requirement and for Solar Energetic Particles (3.1.2.7) to overlap.[REF: NLR-REQ-001 (Space – Heliosphere); NESDIS Product Baseline 2.2.23 Heliosphere, Table 25 (Heliosphere); COURL SW Ops User Requirements, Table 3, Solar Wind: Low Energy Particle Population, L1 and L5, EORES ID-406941, ID-406942; NESDIS GOES-R Series MRD, 3.3.6.1.2 Magnetospheric Electrons and Protons: Low Energy, ID-MRD386; NSOSA SPRWG Final Report, Solar Wind, Appendix E: B8 and B9]

[SWN-PO-229] The Space Weather Next Program shall provide Heliospheric Suprathermal Proton Flux observation through in situ measurement.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Wind: Low Energy Particle Population, L1 and L5, EORES ID-406941, ID-406942]

[SWN-PO-231] The Space Weather Next Program shall provide Heliospheric Suprathermal Proton Flux observation with observational energy range of 10 to 2000 keV (Threshold) / 5 to 2000 keV (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Solar Wind: Low Energy Particle Population, L1 and L5, EORES ID-406941, ID-406942]

[SWN-PO-233] The Space Weather Next Program shall provide Heliospheric Suprathermal Proton Flux observation with flux range of $2.48 \times 10^2 * E(keV)^{-1.6}$ to $1.01 \times 10^7 * E(keV)^{-1.6} cm^{-2} ster^{-1} keV^{-1} S^{-1}$.

Rationale: [REF: NESDIS SWFO L1RD*, 7.2.3 Suprathermal ion Differential Flux, SWFO_48]*

[SWN-PO-235] The Space Weather Next Program shall provide Heliospheric Suprathermal Proton Flux observation with measurement accuracy (for energy = 2 MeV) of ±20% (for flux = 1×10-3 /cm2/s/sr/keV) to ± 100% (for flux = 6.34×10-6 /cm2/s/sr/keV).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Wind: Low Energy Particle Population, L1 and L5, EORES ID-406941, ID-406942]

[SWN-PO-237] The Space Weather Next Program shall provide Heliospheric Suprathermal Proton Flux observation at a refresh rate of 5 min (Threshold) / 10 sec (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Wind: Low Energy Particle Population, L1 and L5)

[SWN-PO-239] The Space Weather Next Program shall provide Heliospheric Suprathermal Proton Flux observation with a latency of 5 min (Threshold) / 1 min (Objective) for SEL and 1 hr (Threshold) / 15 min (Objective) for Off-SEL.

Rationale: [REF: NSOSA SPRWG Final Report, Solar Wind, Appendix E: B8 and B9]

[SWN-PO-241] The Space Weather Next Program shall provide Heliospheric Suprathermal Proton Flux observation from one SEL location (Threshold) and one or more Off-SEL locations (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Wind: Low Energy Particle Population, L1 and L5, EORES ID-406941, ID-406942; NSOSA SPRWG Final Report, Solar Wind, Appendix E: B8 and B9]`1`

3.1.2.6 Heliospheric Magnetic Field

The Space Weather Next program will provide heliospheric magnetic field observation beyond the Earth's magnetosphere and its operation parameters are summarized for reference only in Table 14.

Table 14: Heliospheric Magnetic Field Observational Parameters

Observation Component	Threshold	Objective
Observational Extent	In situ	
Magnetic Field Strength Range (per axis)	±0.1 nT to ±200 nT	±0.1 nT to ±250 nT
Measurement Accuracy	±1.0 nT	±0.1 nT
Refresh Rate	1 sec	0.02 sec
Data Latency	5 min	1 min
Locations	One at SEL	SEL and one or more Off-SEL

Rationale: A magnetometer located at L1 measures the three components of the interplanetary magnetic field (IMF). The orientation and strength of the magnetic field in interplanetary space that encounters Earth's magnetic field is key to whether or not electromagnetic energy from the solar wind is able to couple effectively into Earth's near space environment and to cause intense geomagnetic storms and ionospheric disturbances. Observations of the solar wind and the IMF at L1 location provide a 15 to 60 minute warning time, depending on the solar wind velocity, before a magnetic field and solar wind disturbance arrives at Earth. IMF measured at one or more Off-SEL locations will enhance its observation benefits furthermore. During the most severe events, the IMF, as well as solar wind velocity, density and temperature, are critical input parameters to nearly all models of geomagnetic activity and the multitude of customers affected by intense solar wind conditions. These users include high-profile customers such as the electric power utilities, satellite operators, and users of HF propagation and navigation programs. [REF: NLR-REQ-001 (Space – Heliosphere); NESDIS Product Baseline 2.2.23 Heliosphere, Table 25 (Heliosphere); NESDIS SWFO L1RD, 7.2.2 Vector Magnetic Field, ID-SWFO_47; COURL SW Ops User Requirements, Table 3, Solar Wind: Magnetic Field Vector, L1, EORES ID-406943; NSOSA SPRWG Final Report, Solar Wind, Appendix E: B8 and B9]

[SWN-PO-243] The Space Weather Next Program shall provide heliospheric magnetic field observation through in situ measurement.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Wind: Magnetic Field Vector, L1, EORES ID-406943]

[SWN-PO-245] The Space Weather Next Program shall provide heliospheric magnetic field observation with the magnetic field strength range (per axis) of ±0.1 nT to ±200 nT (Threshold) / ±0.1 nT to ±250 nT (Objective).

Rationale: [REF: NESDIS SWFO L1RD, 7.2.2 Vector Magnetic Field, ID-SWFO_47; COURL

SW Ops User Requirements, Table 3, Solar Wind: Magnetic Field Vector, L1, EORES ID-406943; NSOSA SPRWG Final Report, Solar Wind, Appendix E: B8 and B9]

[SWN-PO-247] The Space Weather Next Program shall provide heliospheric magnetic field observation with measurement accuracy of ±1.0 nT (Threshold) / ±0.1 nT (Objective).

Rationale: [REF: NESDIS SWFO L1RD, 7.2.2 Vector Magnetic Field, ID-SWFO_47; COURL SW Ops User Requirements, Table 3, Solar Wind: Magnetic Field Vector, L1, EORES ID-406943; NSOSA SPRWG Final Report, Solar Wind, Appendix E: B8 and B9]

[SWN-PO-249] The Space Weather Next Program shall provide heliospheric magnetic field observation at a refresh rate of 1 Sec (Threshold) / 0.02 sec (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Wind: Magnetic Field Vector, L1, EORES ID-406943; NESDIS SWFO L1RD, 7.2.2 Vector Magnetic Field, ID-SWFO_47]

[SWN-PO-251] The Space Weather Next Program shall provide heliospheric magnetic field observation with a latency of 5 min (Threshold) / 1 min (Objective).

Rationale: [REF: NSOSA SPRWG Final Report, Solar Wind, Appendix E: B8 and B9]

[SWN-PO-253] The Space Weather Next program shall provide heliospheric magnetic field observation from one SEL (Threshold), and one or more Off-SEL locations (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Wind: Magnetic Field Vector, L1, EORES ID-406943; NSOSA SPRWG Final Report, Solar Wind, Appendix E: B8 and B9]

3.1.2.7 Solar Energetic Particles

The Space Weather Next program will provide solar energetic particles observations and their operation parameters are summarized for reference only in Table 15.

Table 15: Solar Energetic Particle Observational Parameters

Observation Component	Threshold	Objective
Observational Extent	In situ	
Observational Energy Range	0.8–750 MeV protons and for electrons: 0.04-1.0 MeV	0.7 MeV –1.0 GeV protons and for electrons: 0.04-10.0 MeV
Measurement Accuracy	±20%	
Refresh Rate	60 sec	4 sec

Observation Component	Threshold	Objective
Data Latency	5 min	1 min
Locations	One SEL	SEL and one or more Off-SEL

Rationale: Energetic particle measurements in interplanetary space detect the solar energetic particle events that have widespread impacts on critical infrastructure, including satellite anomalies, high-frequency communication outages, and human radiation risks. [REF: NLR-REQ-001 (Space – Heliosphere); NESDIS Product Baseline, 5.2.23 Heliosphere, Table 23 (Heliosphere); COURL SW Ops User Requirements, Table 3, Solar Wind: High Energy Electrons, EORES ID-406939; NESDIS GOES-R Series MRD, 3.3.6.1.3 Magnetospheric Electrons and Protons: Medium and High Energy, ID-MRD388; NSOSA SPRWG Final Report, Energetic Particles (at L1), Appendix E: B11]

[SWN-PO-257] The Space Weather Next Program shall provide solar energetic proton observations with an observational energy range of 0.8–750 MeV (Threshold) / 0.7 MeV–1.0 GeV (Objective).

Rationale: SEPs are higher in the energy scale than suprathermal [or: low-energy] particles and well above the bulk plasma population. The SEP and suprathermal [or: low-energy] energy ranges partially overlap. Such a partial overlap of energy ranges is advantageous for calibration purposes. [REF: NSOSA SPRWG Final Report, Energetic Particles (at L1), Appendix E: B11]

[SWN-PO-258] The Space Weather Next Program shall provide solar energetic electron observations with an observational energy range of 0.04–1.0 MeV (Threshold) / 0.04-10.0 MeV (Objective).

Rationale: [REF: NSOSA SPRWG Final Report, Energetic Particles (at L1), Appendix E: B11]

[SWN-PO-259] The Space Weather Next Program shall provide solar energetic particle observations with measurement accuracy of ±20%.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Wind: High Energy Electrons, EORES ID-406939]

[SWN-PO-261] The Space Weather Next Program shall provide solar energetic particle observations at a refresh rate of 1 min (Threshold) / 4 sec (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Wind: High Energy Electrons, EORES ID-406939]

[SWN-PO-263] The Space Weather Next Program shall provide solar energetic particle

observations with a latency of 5 min (Threshold) / 1 min (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Solar Wind: High Energy Electrons, EORES ID-406939; NSOSA SPRWG Final Report, Energetic Particles (at L1), Appendix E: B11]

[SWN-PO-265] The Space Weather Next program shall provide solar energetic particle observations from one SEL location (Threshold) and one or more Off-SEL locations (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Solar Wind: High Energy Electrons, EORES ID-406939; NSOSA SPRWG Final Report, Energetic Particles (at L1), Appendix E: B11]

3.1.3 Magnetospheric Observation Regime Requirements

3.1.3.1 Magnetospheric Magnetic Field

The Space Weather Next Program will provide Magnetospheric Magnetic Field observations as summarized for reference only in Table 16.

Table 16: Magnetospheric Magnetic Field Observational Parameters

Observation Component	Threshold	Objective
Observational Extent	In situ, 3-axis 0.5°	
Measurement Range	±512 nT	±550 nT
Measurement Accuracy	±1 nT	±0.2 nT
Refresh Rate	10 Hz	50 Hz
Data Latency	60 sec	10 sec
Locations	1 point in GEO over CONUS	1 point in GEO and multiple points globally

Rationale: Magnetospheric magnetic field is the magnitude and direction of the 3D magnetic field within the Earth's magnetosphere. Its measurement is useful to detect geomagnetic disturbances within the magnetosphere. [REF: NLR-REQ-001 (Space-Magnetosphere); NESDIS Product Baseline, §5.2.25 Magnetosphere, Table 27 (Magnetosphere); COURL SW Ops User Requirements, Table 3, Geomagnetic Field: GEO, EORES ID-406916; GOES-R Mission Requirements Document (MRD), Section 3.3.6.2.1, Geomagnetic Field; NSOSA SPRWG Final Report, Geomagnetic field at GEO, Appendix E: B13].

[SWN-PO-267] The Space Weather Next Program shall provide in situ, 3-axis, 0.5° Magnetospheric Magnetic Field observations.

Rationale: [REF: GOES-R MRD, Section 3.3.6.2.1, Geomagnetic Field]

[SWN-PO-269] The Space Weather Next Program shall provide a Magnetospheric Magnetic Field with a Measurement Range of ±512 nT (Threshold) / ±550 nT (Objective)

Rationale: [REF: GOES-R Mission Requirements Document (MRD), Section 3.3.6.2.1, Geomagnetic Field; NSOSA SPRWG Final Report, Geomagnetic field at GEO, Appendix E: B13].

[SWN-PO-271] The Space Weather Next Program shall provide Magnetospheric Magnetic Field observations with a Measurement Accuracy of ±1 nT (Threshold) / ±0.2 nT (Objective)

Rationale: [REF: GOES-R Mission Requirements Document (MRD), Section 3.3.6.2.1, Geomagnetic Field; COURL SW Ops User Requirements, Table 3, Geomagnetic Field: GEO, EORES ID-406916; NSOSA SPRWG Final Report, Geomagnetic field at GEO, Appendix E: B13].

[SWN-PO-273] The Space Weather Next Program shall provide Magnetospheric Magnetic Field observations with a refresh rate of 10 Hz (Threshold) / 50 Hz (Objective).

Rationale: [REF: GOES-R Mission Requirements Document (MRD), Section 3.3.6.2.1, Geomagnetic Field; COURL SW Ops User Requirements, Table 3, Geomagnetic Field: GEO, EORES ID-406916; NSOSA SPRWG Final Report, Geomagnetic field at GEO, Appendix E: B13].

[SWN-PO-275] The Space Weather Next Program shall provide Magnetospheric Magnetic Field observations with a latency of 60 sec (Threshold) / 10 sec (Objective).

Rationale: [REF: GOES-R Mission Requirements Document (MRD), Section 3.3.6.2.1, Geomagnetic Field; COURL SW Ops User Requirements, Table 3, Geomagnetic Field: GEO, EORES ID-406916; NSOSA SPRWG Final Report, Geomagnetic field at GEO, Appendix E: B13]., Section 3.3.6.2.1, Geomagnetic Field

[SWN-PO-277] The Space Weather Next Program shall provide Magnetospheric Magnetic Field observations at 1 GEO locations providing CONUS coverage (Threshold), and multiple locations globally (Objective).

Rationale: Threshold preserves current GOES-R baseline capability. The Objective recognizes the need for a large number of observation points to drive current and future magnetospheric models. [REF: GOES-R Mission Requirements Document (MRD), Section 3.3.6.2.1, Geomagnetic Field; NSOSA SPRWG Final Report, Geomagnetic field at GEO, Appendix E: B13].

3.1.3.2 Magnetospheric Energetic Particles

The Space Weather Next Program will provide Magnetospheric Energetic Particle Flux observations, to include electrons and protons as summarized for reference only in Table 17.

Table 17: Magnetospheric Energetic Particle Flux Observational Parameters

Observation Component	Threshold	Objective
Observational Extent	In situ	
Pitch Angle Resolution	35 degrees	
Energy Range, Electrons: Differential Flux	30 eV–5 MeV	20 eV–10 MeV
Energy Range, Electrons: Integral Flux	>2 MeV	
Energy Range, Protons: Differential Flux	30 eV–750 MeV	10 eV–1.0 GeV
Energy Range, Protons: Integral Flux (GEO)	>500 MeV	
Energy Range, Heavy Ions (Z>=2)	10 MeV/n - 200 MeV/n	1 - 120 keV (O+) 10 MeV/n - 200 MeV/n
Measurement Accuracy	±25%	±10%
Refresh Rate	60 sec	10 sec
Data Latency	60 sec	10 sec
Location	1 point in GEO over CONUS	2 points in GEO plus multiple point globally

Rationale: Magnetospheric energetic particle detectors measure charged particle populations that present hazards to robotic and human space flight and to aircraft flying at high-latitudes or trans-polar routes. These particle populations also have an effect on the chemistry of the upper atmosphere when they are lost to the atmosphere through collisions with neutral gas particles, resulting in additional ionization that hinders radio communication and navigation through absorption and scattering of radio waves. This information is important for military and civilian radio communication; satellite communication and navigation systems; human space flight; high-altitude and high-latitude aviation; and scientific researchers. [REF: NLR-REQ-001 (Space-Magnetosphere); NESDIS Product Baseline, §5.2.25 Magnetosphere, Table 27 (Magnetosphere); COURL SW Ops User Requirements, Table 3, Electrons: Medium & High Energy, GEO; Magnetospheric Electrons: Medium and High Energy, MEO, EORES ID-406957; Magnetospheric Protons: Medium and High Energy, MEO, EORES-ID 406958; GOES-R Mission Requirements Document, Section 3.3.6.1.2, Magnetospheric Electrons and Protons: Low Energy and Section 3.3.6.1.3, Magnetospheric Electrons and Protons: Medium and High Energy; NSOSA SPRWG Final Report, Geospace Energetic Particles, Appendix E: B14, EORES-ID 407218; SWORM 2.1 Recommendations].

[SWN-PO-279] The Space Weather Next Program shall provide Magnetospheric Energetic Particle Flux observations with a Pitch Angle Resolution of 35 degrees.

Rationale: The User community seeks continuity with current GOES instrument capabilities. The following Pitch Angle specifications can be used as guidance for instrument development and implementation decision:

- Low energy electrons and protons (30 eV - 30 keV) - 15 degree resolution
- Medium and high energy electrons and protons (30 keV - 4 MeV) - 35 degree resolution;
- High energy protons - two look directions (one east and one west)
- Heavy ions (Z>=2) - one look direction.

[REF: Summary Report: Workshop on Energetic Particle Measurements for the GOES R+ Satellites Held at the NOAA Space Environment Center Boulder, CO October 28-29, 2002: Table 1

[SWN-PO-281] The Space Weather Next Program shall provide Magnetospheric Energetic Particle Flux observations, in an Energy Range of 30 eV–5 MeV (Threshold) / 20 eV–10 MeV (Objective) (differential flux) and >2 MeV (integral flux) for electrons.

Rationale: [REF: Summary Report: Workshop on Energetic Particle Measurements for the GOES R+ Satellites Held at the NOAA Space Environment Center Boulder, CO October 28-29, 2002: Table 1

[SWN-PO-283] The Space Weather Next Program shall provide Magnetospheric Energetic Particle Flux observations in an Energy Range of 30 eV–750 MeV (Threshold) / 10 eV–1.0 GeV (Objective) (differential flux) and >500 MeV (integral flux, GEO only) for protons.

[REF: Summary Report: Workshop on Energetic Particle Measurements for the GOES R+ Satellites Held at the NOAA Space Environment Center Boulder, CO October 28-29, 2002: Table 1

[SWN-PO-287] The Space Weather Next Program shall provide Magnetospheric Energetic Particle Flux observations, to include electrons and protons with a measurement accuracy of ±25% (Threshold) / ±10% (Objective).

Rationale: [REF: GOES-R Mission Requirements Document, Section 3.3.6.1.2, Magnetospheric Electrons and Protons: Low Energy and Section 3.3.6.1.3, Magnetospheric Electrons and Protons: Medium and High Energy; COURL SW Ops User Requirements, Table 3, Electrons: Medium & High Energy, GEO; Magnetospheric Electrons: Medium and High Energy, MEO, EORES ID-406957; Magnetospheric Protons: Medium and High Energy, MEO, EORES-ID 406958; NSOSA SPRWG Final Report, Geospace Energetic Particles, Appendix E: B14, EORES-ID 407218].

[SWN-PO-288] The Space Weather Next Program shall provide heavy ion (Z>=2) flux

observations with an energy range between 10 MeV/nucleon - 200 MeV/nucleon (Threshold) and 10 MeV/nucleon–200 MeV/nucleon plus 1 - 120 keV (O+) (Objective).

Rationale: [REF: NSOSA SPRWG Final Report, Geospace Energetic Particles, Appendix E: B14, EORES-ID 407218]

[SWN-PO-289] The Space Weather Next Program shall provide Magnetospheric Particle Flux observations with a refresh rate of 60 sec (Threshold) / 10 sec (Objective).

Rationale: The User community seeks continuity with the current GOES-R system. The following Magnetospheric Particle Flux observations refresh rate specifications can be used as guidance for system development and implementation decision:

- Low energy electrons and protons (30 eV - 30 keV) - 1 sec
- Medium and high energy electrons and protons (30 keV - 4 MeV) - 1 min
- High energy protons - 1 min;
- Heavy ions (Z>=2) - 5 min.

[REF: GOES-R Mission Requirements Document, Section 3.3.6.1.2, Magnetospheric Electrons and Protons: Low Energy and Section 3.3.6.1.3, Magnetospheric Electrons and Protons: Medium and High Energy; COURL SW Ops User Requirements, Table 3, Electrons: Medium & High Energy, GEO; Magnetospheric Electrons: Medium and High Energy, MEO, EORES ID-406957; Magnetospheric Protons: Medium and High Energy, MEO, EORES-ID 406958; NSOSA SPRWG Final Report, Geospace Energetic Particles, Appendix E: B14, EORES-ID 407218].

[SWN-PO-291] The Space Weather Next Program shall provide Magnetospheric Particle Flux observations with a data latency between 60 sec (Threshold)/ 10 sec (Objective).

Rationale: [REF: GOES-R Mission Requirements Document, Section 3.3.6.1.2, Magnetospheric Electrons and Protons: Low Energy and Section 3.3.6.1.3, Magnetospheric Electrons and Protons: Medium and High Energy; COURL SW Ops User Requirements, Table 3, Electrons: Medium & High Energy, GEO; Magnetospheric Electrons: Medium and High Energy, MEO, EORES ID-406957; Magnetospheric Protons: Medium and High Energy, MEO, EORES-ID 406958; NSOSA SPRWG Final Report, Geospace Energetic Particles, Appendix E: B14, EORES-ID 407218].

[SWN-PO-293] The Space Weather Next Program shall provide Magnetospheric Particle Flux observations at 1 GEO location providing CONUS coverage (Threshold), multiple locations within the magnetosphere globally (Objective).

Rationale: Threshold preserves current GOES-R baseline capability. The Objective recognizes the need for a large number of observation points to drive current and future magnetospheric models. [REF: GOES-R Mission Requirements Document, Section 3.3.6.1.2, Magnetospheric Electrons and Protons: Low Energy and Section 3.3.6.1.3,

Magnetospheric Electrons and Protons: Medium and High Energy; NSOSA SPRWG Final Report, Geospace Energetic Particles, Appendix E: B14, EORES-ID 407218].

3.1.4 Ionospheric and Thermospheric Observation Regime Requirements

3.1.4.1 Ionospheric Electron Density Profiles

The Space Weather Next Program will provide Ionospheric Electron Density (Ne) Profiles (EDP) as summarized for reference only in Table 18.

Table 18: Ionospheric Electron Density Profiles Observational Parameters

Observation Component	Threshold	Objective
Observational Extent	90–1500 km	
Vertical Resolution	10 km	1.5 km
Measurement Range	Ne: 10^{10}–10^{13} electrons m^{-3}	
Measurement Uncertainty	Ne: Less than ±max (3×10^{10} m^{-3}, 10%)	
Quantity of Global profiles per day	12,000	50,000
Median Data Latency	60 min	5 min

Rationale: These observations are valuable for ionospheric specification and modeling. Radio communication and satellite navigation rely on radio waves. Radio wave propagation depends on electron density profiles in the ionosphere. Layers in the ionosphere reflect HF radio waves (3–30 MHz) allowing people to communicate even if they do not have line-of-site connections. There are other potential applications of these data in the detection of earthquakes and tsunamis. [REF: NLR-REQ-001 (Space-Ionosphere); FORMOSAT-7 / COSMIC-2 Joint Level 1 Performance Requirements Document, Table 3-2: Ionosphere and Space Weather Product Requirements; NSOSA SPRWG Final Report, Ionospheric Electron Density Profiles, EORES-ID 407219; COURL SW Ops User Requirements, Ionospheric Electron Density Profiles, and FORMOSAT-7 / COSMIC-2 Joint Level 1 Performance Requirements Document; SWORM 2.1 Recommendations].

[SWN-PO-295] The Space Weather Next Program shall provide Ionospheric EDP observations with an observational extent of 90 to 1500 km.

Rationale: [REF: SWORM 2.1 Recommendations]

[SWN-PO-297] The Space Weather Next Program shall provide Ionospheric EDP observations with a Vertical Resolution of 10 km (Threshold) / 1.5 km (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Ionospheric Electron Density Profiles]

[SWN-PO-299] The Space Weather Next Program shall provide Ionospheric EDP observations with a measurement range of 10^{10} to 10^{13} electrons m^{-3}.

Rationale: [REF: FORMOSAT-7 / COSMIC-2 Joint Level 1 Performance Requirements Document, Table 3-2: Ionosphere and Space Weather Product Requirements]

[SWN-PO-301] The Space Weather Next Program shall provide ionospheric observations with a measurement uncertainty less than the greater of 3×10^{10} m^{-3} or 10%.

Rationale: [REF: FORMOSAT-7 / COSMIC-2 Joint Level 1 Performance Requirements Document, Table 3-2: Ionosphere and Space Weather Product Requirements; NSOSA SPRWG Final Report, Ionospheric Electron Density Profiles, EORES-ID 407219; COURL SW Ops User Requirements, Ionospheric Electron Density Profiles].

[SWN-PO-303] The Space Weather Next Program shall provide Ionospheric EDP observations of 12,000 Global Profiles day^{-1} (Threshold) / 50,000 Global Profiles day^{-1} (Objective).

Rationale: [REF: FORMOSAT-7 / COSMIC-2 Joint Level 1 Performance Requirements Document, Table 3-2: Ionosphere and Space Weather Product Requirements, Table 3-2: Ionosphere and Space Weather Product Requirements].

[SWN-PO-305] The Space Weather Next Program shall provide Ionospheric EDP observations with a median Data Latency of 60 min (Threshold) / 5 min (Objective).

Rationale: [REF: FORMOSAT-7 / COSMIC-2 Joint Level 1 Performance Requirements Document, Table 3-2: Ionosphere and Space Weather Product Requirements].

3.1.4.2 Total Electron Content

The Space Weather Next Program will provide Total Electron Content (TEC) observations as summarized for reference only in Table 19.

Table 19: Total Electron Content Observational Parameters

Observation Component	Threshold	Objective
Observational Extent	90–1500 km	
Measurement Range	1–200 TEC Units vertical equivalent	
Measurement Uncertainty	3 TECU	
Refresh Rate Quantity of Global profiles per day	12,000 observations day^{-1}	50,000 observations day^{-1}
Median Data Latency	60 min	5 min

Rationale: These observations are critical for ionospheric specification and modeling. Radio communication and satellite navigation rely on radio waves. The height-integrated Total Electron Content (TEC) impacts single frequency GPS accuracy. [REF: NLR-REQ-001 (Space-Ionosphere); NSOSA SPRWG Final Report, Ionospheric Electron Density Profiles, COURL SW Ops User Requirements, Ionospheric Electron Density Profiles, and FORMOSAT-7 / COSMIC-2 Joint Level 1 Performance Requirements Document].

[SWN-PO-307] The Space Weather Next Program shall provide TEC observations with an observational extent, altitude range of 90 to 1500 km.

Rationale: [REF: NSOSA SPRWG Final Report, Ionospheric Electron Density Profiles].

[SWN-PO-309] The Space Weather Next Program shall provide TEC observations with a measurement range of 1 to 200 vertical equivalent.

Rationale: [REF: FORMOSAT-7 / COSMIC-2 Joint Level 1 Performance Requirements Document, Table 3-2: Ionosphere and Space Weather Product Requirements].

[SWN-PO-311] The Space Weather Next Program shall provide TEC observations with a measurement uncertainty of 3 TECU.

Rationale: [REF: FORMOSAT-7 / COSMIC-2 Joint Level 1 Performance Requirements Document, Table 3-2: Ionosphere and Space Weather Product Requirements].

[SWN-PO-313] The Space Weather Next Program shall provide TEC observations of 12,000 Global Profiles day^{-1} (Threshold) / 50,000 Global Profiles day^{-1} (Objective).

Rationale: [REF: FORMOSAT-7 / COSMIC-2 Joint Level 1 Performance Requirements Document, Table 3-2: Ionosphere and Space Weather Product Requirements, Table 3-2: Ionosphere and Space Weather Product Requirements].

[SWN-PO-315] The Space Weather Next Program shall provide TEC observations with a median Data Latency of 60 min (Threshold) / 5 min (Objective).

Rationale: [REF: FORMOSAT-7 / COSMIC-2 Joint Level 1 Performance Requirements Document, Table 3-2: Ionosphere and Space Weather Product Requirements].

3.1.4.3 Ionospheric Irregularities

The Space Weather Next Program will provide Ionospheric Irregularities ($\Delta Ne/S4/\sigma_\varphi$) observations as summarized for reference only in Table 20.

Table 20: Ionospheric Irregularities (Scintillation) Observational Parameters

Observation Component	Threshold	Objective
Observational Extent	90–1500 km	

Observation Component	Threshold	Objective
Observational Resolution	25 km	
Measurement Sensitivity Range	ΔNe: 10^9–5×20^{12} electrons m^{-3} S4: 0–1.5 σ_φ (phase): 0.1–20 radians	
Measurement Uncertainty	ΔNe: 5% S4 (amp): 0.1 σ_φ (phase): 0.1 radians	
Refresh Rate Quantity of Global profiles per day	12,000 Global Profiles day^{-1}	50,000 observations day^{-1}
Median Data Latency	60 min	5 min

Rationale: These observations are critical for ionospheric specification and modeling. Radio communication and satellite navigation rely on radio waves. Small-scale plasma structures in the ionosphere create a multi-path for radio waves, which induces scintillation of the radio waves. Severe scintillation conditions can prevent GPS receivers from locking on to the satellite signal and can make it impossible to calculate a position. Less severe scintillation conditions can reduce the accuracy and the confidence of positioning results. There are other potential applications of these data in the detection of earthquakes and tsunamis. [REF: NLR-REQ-001 (Space-Ionosphere); NSOSA SPRWG Final Report, Ionospheric Electron Density Profiles, COURL SW Ops User Requirements, Table 4, Ionospheric Irregularities: Amplitude, EORES ID 406946; and FORMOSAT-7 / COSMIC-2 Joint Level 1 Performance Requirements Document].

[SWN-PO-317] The Space Weather Next Program shall provide ionospheric irregularities observations with an observational extent, altitude range of 90 to 1500 km.

Rationale: [REF: NSOSA SPRWG Final Report, Ionospheric Electron Density Profiles].

[SWN-PO-319] The Space Weather Next Program shall provide ionospheric irregularities observations with an observational resolution of 25 km.

Rationale: [REF: COURL SW Ops User Requirements, Table 4, Ionospheric Irregularities: Amplitude, EORES ID 406946].

[SWN-PO-321] The Space Weather Next Program shall provide ionospheric irregularities observations with a measurement range of plasma density 10^9–5×10^{12} electrons m^{-3}, ionospheric irregularities amplitude S4: 0–1.5 dimensionless units, and ionospheric irregularities phase σ_ϕ: 0.1–20 radians.

Rationale: [REF: NPOESS IORD Para 4.1.6.7.9b Ionospheric Scintillation].

[SWN-PO-323] The Space Weather Next Program shall provide ionospheric irregularities observations with a measurement uncertainty of plasma density 5%, ionospheric irregularities amplitude S4: 0.1 dimensionless units, and Ionospheric irregularities phase σ_ϕ: 0.1 radians.

Rationale: [REF: NPOESS IORD Para 4.1.6.7.9b Ionospheric Scintillation]

[SWN-PO-325] The Space Weather Next Program shall provide ionospheric irregularities observations of 12,000 Global Profiles day^{-1} (Threshold) / 50,000 Global Profiles day^{-1} (Objective).

Rationale: [REF: FORMOSAT-7 / COSMIC-2 Joint Level 1 Performance Requirements Document, Table 3-2: Ionosphere and Space Weather Product Requirements, Table 3-2: Ionosphere and Space Weather Product Requirements]

[SWN-PO-327] The Space Weather Next Program shall provide ionospheric irregularities observations with a median data latency of 60 min (Threshold) / 5 min (Objective).

Rationale: [REF: FORMOSAT-7 / COSMIC-2 Joint Level 1 Performance Requirements Document, Table 3-2: Ionosphere and Space Weather Product Requirements].

3.1.4.4 Ion Drift Velocity

The Space Weather Next Program will provide in situ ion drift velocity observations as summarized for reference only in Table 21.

Table 21: Ion Drift Velocity Observational Parameters

Observation Component	Threshold	Objective
Observational Extent, Latitude Range	70° N - 70° S, all longitudes	Global
Observational Altitude	Between 300–850 km	Between 300–850 km
Observational Horizontal Resolution	Along-Track: 100 km Cross-Track: 30 degrees longitude	Along-Track: 100 km Cross-Track: 15 degrees longitude
Measurement Accuracy	Cross-track ±10 m s^{-1}; Along-track ±15 m s^{-1}	Cross-track ±10 m s^{-1}; Along-track ±15 m s^{-1}
Refresh Rate	60 mins	10 mins
Median Data Latency	60 min	5 min

Rationale: Ionospheric drift velocity measurements are needed for both operations and research in order to monitor plasma transport, and to separate the influence of transport from neutral composition and plasma loss rates. Estimating the effects of the ionosphere on the propagation of radio waves is critical for HF communications, GNSS positioning, navigation and timing applications. Ionospheric drifts are a required measurement for estimating the

ionosphere effects. These data will be assimilated into coupled thermosphere-ionosphere models. The output of the models will provide specification and forecasts of neutral density for satellite orbit prediction and of ionospheric density for communication and navigation. Drift velocity measurements are also useful for observing, and possibly predicting, equatorial F-region irregularities. [REF: NLR-REQ-001 (Space-Ionosphere); NESDIS Product Baseline, §5.2.24 Ionosphere, Table 26 (Ionosphere); NSOSA SPRWG Final Report, Ionospheric Drift Velocity, Appendix E: B19; EORES ID-407223]

[SWN-PO-329] The Space Weather Next Program shall provide ion drift velocity measurements from 70° N - 70° S at all longitudes (Threshold) / Globally (Objective) .

Rationale: [REF: FORMOSAT-7 / COSMIC-2 Joint Level 1 Performance Requirements Document, Table 3-2: Ionosphere and Space Weather Product Requirements]

[SWN-PO-331] The Space Weather Next Program shall provide ion drift velocity measurements with an observational altitude between 300 and 850 km.

Rationale: [REF: FORMOSAT-7 / COSMIC-2 Joint Level 1 Performance Requirements Document, Table 3-2: Ionosphere and Space Weather Product Requirements]

[SWN-PO-333] The Space Weather Next Program shall provide ion drift velocity measurements with an observational horizontal resolution of 100 km (Along-Track) and 30 degrees longitude (Threshold) / 15 degrees longitude (Objective) (Cross-Track).

Rationale: Requirement only applies to in situ observations from a LEO spacecraft. [REF: FORMOSAT-7 / COSMIC-2 Joint Level 1 Performance Requirements Document, Table 3-2: Ionosphere and Space Weather Product Requirements; SWORM 2.1 Recommendations]

[SWN-PO-335] The Space Weather Next Program shall provide ion drift velocity measurements with a measurement accuracy of ±10 m/s (cross-track) and ±15 m s^{-1} (Along-Track).

Rationale: [REF: FORMOSAT-7 / COSMIC-2 Joint Level 1 Performance Requirements Document, Table 3-2: Ionosphere and Space Weather Product Requirements]

[SWN-PO-336] The Space Weather Next Program shall provide ion drift velocity measurements with a Refresh Rate of 60 min (Threshold) / 10 min (Objective).

[SWN-PO-337] The Space Weather Next Program shall provide ion drift velocity measurements with a median data latency of 60 min (Threshold) / 5 min (Objective).

Rationale: [REF: FORMOSAT-7 / COSMIC-2 Joint Level 1 Performance Requirements Document, Table 3-2: Ionosphere and Space Weather Product Requirements; SWORM 2.1 Recommendations]

3.1.4.5 Auroral Imagery

The Space Weather Next Program will provide auroral imaging observations for the UV range and for the visible range as summarized for reference only in Table 22.

Table 22: Auroral Imagery Observational Parameters

Observation Component	Threshold	Objective
Observational Extent	>60 degrees N latitude	>60 degrees N/S latitude
Observational Spatial Resolution	50 km	10 km
Observational Band Pass Range	135–180 nm (two or more_bands) 400–650 nm	110–180 nm (two or more_bands) 400–650 nm
Refresh Rate	20 min	1 min when observed from >60 N/S degrees latitude.
Data Latency	60 min	1 min

Rationale: The objective is to observe the auroral oval over the CONUS, though both poles are of interest. These observations provide specification of the intensity and location of the aurora. White-light image data provides qualitative information. UV image data provide information on the energy deposition into the thermosphere and ionosphere. Spatial, temporal, and energy information are used in models of the thermosphere and ionosphere. Location and intensity of the aurora can be used for situational awareness by power grids, airlines, and other users of impacted technologies located in the polar region. The location of the aurora is a good indicator of where navigation and communication issues will occur. It is also a good proxy for the location of the most severe ground induced currents in electric power grids. The intensity of the aurora is a direct measure of the energy input into the upper atmosphere. Auroral heating of the upper atmosphere expands the neutral atmosphere and raises the ionosphere. This will impact satellite orbit prediction and radio communication. [REF: COURL SW Ops User Requirements, Table 3, Multi-Spectral Auroral Imagery; NSOSA SPRWG Final Report, Auroral Imaging: Multi-Spectral Auroral Imagery, Appendix E: B16, EORES-ID 407220]

[SWN-PO-339] The Space Weather Next Program shall provide auroral imaging observations with an Observational Extent >60 N degrees latitude and all longitudes (Threshold) / >60 N/S degrees latitude and all longitudes (Objective).

Rationale: [REF: NSOSA SPRWG Final Report, Auroral Imaging: Multi-Spectral Auroral Imagery, Appendix E: B16, EORES-ID 407220]

[SWN-PO-341] The Space Weather Next Program shall provide auroral imaging observations with an Observational Spatial Resolution of 50 km (Threshold) / 10 km (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Multi-Spectral Auroral

Imagery]

[SWN-PO-343] The Space Weather Next Program shall provide auroral imaging observations with an observational band pass range of 400–650 nm.

Rationale: Measurements should be taken as "white-light" continuum observations [REF: NSOSA SPRWG Final Report, Auroral Imaging: Multi-Spectral Auroral Imagery, Appendix E: B16, EORES-ID 407220]

[SWN-PO-345] The Space Weather Next Program shall provide multi-spectral auroral imaging observations with two or more spectral bands in the 135–180 nm (Threshold) / 110–180 nm (Objective) observational band pass range.

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Multi-Spectral Auroral Imagery; NSOSA SPRWG Final Report, Auroral Imaging: Multi-Spectral Auroral Imagery, Appendix E: B16, EORES-ID 407220]

[SWN-PO-347] The Space Weather Next Program shall provide auroral imaging observations with a Refresh Rate of 20 min (Threshold) / 1 min (Objective) when observed from >60 N/S degrees latitude.

Rationale: [REF: NSOSA SPRWG Final Report, Auroral Imaging: Multi-Spectral Auroral Imagery, Appendix E: B16, EORES-ID 407220]

[SWN-PO-349] The Space Weather Next Program shall provide auroral imaging observations with a data latency of 60 min (Threshold) / 1 min (Objective).

Rationale: [REF: NSOSA SPRWG Final Report, Auroral Imaging: Multi-Spectral Auroral Imagery, Appendix E: B16, EORES-ID 407220]

3.1.4.6 Low Earth Orbit Particle Flux

The Space Weather Next Program will provide global in situ Low Earth Orbit Energetic Particle Flux observations, to include electrons and protons, and heavy ions as summarized for reference only in Table 23.

Table 23: Low Earth Orbit Particle Flux Observational Parameters

Observation Component	Threshold	Objective
Altitude range	150–900 Km	
Pitch Angle Resolution	35°	
Energy Range, Electrons	30 eV–5 MeV	10 eV–1 GeV
Energy Range, Protons	30 eV–200 MeV	5 eV–250 MeV
Measurement Accuracy	±25%	±10%

Observation Component	Threshold	Objective
Temporal Resolution	1 min	10 sec
Refresh Rate	12 hrs	3 hrs
Data Latency	60 min	5 min

Rationale: Low Earth Orbit particle detectors measure charged particle populations that present hazards to robotic and human space flight and to aircraft flying high-latitude or trans-polar routes. LEO measurements indicate the latitudinal and longitudinal extent of the energetic particle populations and indicate the locations of energy deposition into the ionosphere and upper atmosphere. These populations also have an effect on the chemistry of the upper atmosphere when they are lost to the atmosphere through collisions with neutral gas particles, resulting in additional ionization that hinders radio communication and navigation through absorption and scattering of radio waves. This information is important for military and civilian radio communication; satellite design and operation; human space flight; high-altitude and high-latitude aviation; and scientific researchers. [REF: NSOSA SPRWG Final Report, Geospace Energetic Particles, Appendix E: B14, EORES-ID 407218; SWORM 2.1 Recommendations].

[SWN-PO-350] The Space Weather Next Program shall provide global low Earth orbit particle flux observations within an altitude range of 150 - 900 km (Threshold).

Rationale: [REF: NSOSA SPRWG Final Report, Geospace Energetic Particles, Appendix E: B14, EORES-ID 407218]

[SWN-PO-351] The Space Weather Next Program shall provide global low Earth orbit particle flux observations with a pitch angle resolution of 35° (Threshold).

Rationale: [REF: SWORM 2.1 Recommendations]

[SWN-PO-353] The Space Weather Next Program shall provide global low Earth orbit particle flux observations with an energy range of 30 eV–5 MeV (Threshold) / 10 eV–1 GeV (Objective) for electrons.

Rationale: [REF: NSOSA SPRWG Final Report, Geospace Energetic Particles, Appendix E: B14, EORES-ID 407218]

[SWN-PO-355] The Space Weather Next Program shall provide global Low Earth Orbit Particle Flux observations with an Energy Range of 30 eV–200 MeV (Threshold) / 5 eV–250 MeV (Objective) for protons.

Rationale: [REF: NSOSA SPRWG Final Report, Geospace Energetic Particles, Appendix E: B14, EORES-ID 407218]

[SWN-PO-357] The Space Weather Next Program shall provide global low Earth orbit particle flux observations with a measurement accuracy of ±25% (Threshold) / ±10% (Objective).

Rationale: [REF: NSOSA SPRWG Final Report, Geospace Energetic Particles, Appendix E: B14, EORES-ID 407218]

[SWN-PO-358] The Space Weather Next Program shall provide global low Earth orbit particle flux observations with a temporal resolution for each observing platform of 1 min (Threshold) / 10 sec (Objective).

Rationale: [REF: NSOSA SPRWG Final Report, Geospace Energetic Particles, Appendix E: B14, EORES-ID 407218]

[SWN-PO-359] The Space Weather Next Program shall provide global low Earth orbit particle flux observations with a refresh rate of 12 hrs (Threshold) / 3 hrs (Objective).

Rationale: [REF: NSOSA SPRWG Final Report, Geospace Energetic Particles, Appendix E: B14, EORES-ID 407218]

[SWN-PO-361] The Space Weather Next Program shall provide global low Earth orbit particle flux observations with a data latency of 60 min (Threshold) / 5 min (Objective).

Rationale: [REF: NSOSA SPRWG Final Report, Geospace Energetic Particles, Appendix E: B14, EORES-ID 407218]

3.1.4.7 Upper Thermospheric Density

The Space Weather Next Program will provide Upper Thermospheric Density data product as summarized for reference only in Table 24.

Table 24: Thermospheric Density Observational Parameters

Observation Component	Threshold	Objective
Observational Extent	Global	
Observational Altitude Range	150–500 km	
Observational Horizontal Resolution	250 km	100 km
Measurement Range (Atmospheric Density)	2.0×10^{-17} to $2.5 \times 10^{-11} gcm^{-3}$	8.5×10^{-18} to $5 \times 10^{-9} gcm^{-3}$
Measurement Uncertainty	±15%	
Refresh Rate	90 mins (per location)	60 mins (per location)
Data Latency	1 hr	30 mins

Rationale: Thermospheric density measurements near 400 km altitude are needed for assimilation into global ionospheric/atmosphere forecasting and specification models. There is no current capability, implying high priority for improvement. The thermosphere and ionosphere are highly coupled and thermospheric variations instantly manifest themselves as variations in the ionosphere. Monitoring the variability of the thermosphere is critical for satellite drag specification and forecast and radio wave propagation through the ionosphere. These data will be assimilated into thermosphere and ionosphere models. The output of the models will provide specification and forecasts of neutral density for satellite orbit prediction and of ionospheric density for communication and navigation. The increase in LEO satellites and debris has grown exponentially and will continue to grow making these observations more and more critical. [REF: COURL SW Ops User Requirements, Table 3, Neutral Density Profiles; NLR-REQ-001 (Space-Ionosphere); NESDIS Product Baseline, §5.2.24 Ionosphere, Table 26 (Ionosphere); NSOSA SPRWG Final Report, Upper thermospheric density, Appendix E: B18, EORES ID-407222]

[SWN-PO-363] The Space Weather Next Program shall provide global Upper Thermospheric Density data product.

Rationale: [REF: NSOSA SPRWG Final Report, Upper thermospheric density, Appendix E: B18, EORES ID-407222]

[SWN-PO-365] The Space Weather Next Program shall provide Upper Thermospheric Density data product with an observational altitude range of 150 km to 500 km (Threshold) 100 km to 750 km (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Neutral Density Profiles]

[SWN-PO-367] The Space Weather Next Program shall provide an upper thermospheric density data product with an observational horizontal resolution of 250 km (Threshold) / 100 km (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Neutral Density Profiles; SWORM 2.1 Recommendations; NPOESS IORD, Para 4.1.6.7.10 Neutral Density Profile]

[SWN-PO-369] The Space Weather Next Program shall provide Upper Thermospheric Density data product with a measurement range of 2.0×10^{-17} to $2.5 \times 10^{-11} gcm^{-3}$ (Threshold) 8.5×10^{-18} to $5 \times 10^{-9} gcm^{-3}$ (Objective).

Rationale: [REF: NPOESS IORD, Para 4.1.6.7.10 Neutral Density Profile]

[SWN-PO-371] The Space Weather Next Program shall provide Upper Thermospheric Density data product with a measurement uncertainty of ±15%.

Rationale: [REF: NPOESS IORD, Para 4.1.6.7.10 Neutral Density Profile]

[SWN-PO-373] The Space Weather Next Program shall provide Upper Thermospheric

Density data product with a refresh rate of 90 mins (Threshold) / 60 mins (Objective).

Rationale: [REF: NSOSA SPRWG Final Report, Upper thermospheric density, Appendix E: B18, EORES ID-407222]

[SWN-PO-375] The Space Weather Next Program shall provide Upper Thermospheric density data product with a data latency of 60 min (Threshold) / 30 min (Objective).

Rationale: [REF: NSOSA SPRWG Final Report, Upper thermospheric density, Appendix E: B18, EORES ID-407222]

3.1.4.8 Thermospheric O/N2 Ratio

The Program will provide height-integrated Thermospheric O/N_2 Ratio data product as summarized for reference only in Table 25.

Table 25: Thermospheric O/N2 Ratio Observational Parameters

Observation Component	Threshold	Objective
Observational Extent	Dayside	Dayside
Observational Altitude Range	150–600 km	
Observational Horizontal Resolution	250 km	100 km
Measurement Uncertainty	±10%	
Refresh Rate	1 hr	15 mins
Data Latency	1 hr	30 mins

Rationale: The composition of the thermosphere is primarily atomic oxygen, molecular nitrogen, and molecular oxygen. The thermosphere and ionosphere are highly coupled, and thermospheric composition variations manifest themselves as variations in the ionosphere electron density. O/N_2 ratio is the most important parameter for plasma loss rates in specification and forecast using numerical ionospheric models. These data will be assimilated into thermosphere/ionosphere models. The output of the models will provide specification and forecasts of neutral density for satellite orbit prediction and of ionospheric density for communication and navigation. [REF: COURL SW Ops User Requirements, Table 3, O/N_2 Ratio; NSOSA SPRWG Final Report, Thermospheric O/N_2 ratio (height integrated), Appendix E: B17, EORES ID-407221; SWORM 2.1 Recommendations]

[SWN-PO-377] The Space Weather Next Program shall provide height-integrated thermospheric O/N_2 ratio data product on Earth's dayside (Threshold) and (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, O/N_2 Ratio, EORES ID-407221]

[SWN-PO-379] The Space Weather Next Program shall provide a height-integrated thermospheric O/N_2 ratio data product with an observational altitude range of 150 to 600 km (Threshold).

Rationale: [REF: NPOESS IORD Para 4.1.6.7.10 Neutral Density Profile]

[SWN-PO-381] The Space Weather Next Program shall provide a height-integrated thermospheric O/N_2 ratio data product with an observational horizontal resolution of 250 km (Threshold) / 100 km (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, O/N_2 Ratio]

[SWN-PO-383] The Space Weather Next Program shall provide a height-integrated thermospheric O/N_2 ratio data product with a measurement uncertainty of ±10% (Threshold).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, O/N2 Ratio]

[SWN-PO-385] The Space Weather Next Program shall provide height-integrated thermospheric O/N_2 ratio data product with a refresh rate of 1 hr (Threshold) / 15 min (Objective).

Rationale: [REF: SWORM 2.1 Recommendations]

[SWN-PO-387] The Space Weather Next Program shall provide height-integrated thermospheric O/N_2 ratio data product with a data latency of 1 hr (Threshold) / 30 min (Objective)

Rationale: [REF: NSOSA SPRWG Final Report, Thermospheric O/N_2 ratio (height integrated), Appendix E: B17, EORES ID-407221]

3.1.4.9 Thermospheric Neutral Winds

The Program will provide Thermospheric Neutral Wind profiles as summarized for reference only in Table 26.

Table 26: Thermospheric Neutral Wind Observational Parameters

Observation Component	Threshold	Objective
Observational Extent	Global	Global
Observational Altitude Range	100–300 km	90 - 500 km
Observational Horizontal Resolution	250 km	15 km
Measurement Range	100 - 1000 m s^{-1}	0 - 1500 m s^{-1}
Measurement Uncertainty	Max of ±10 m s^{-1}	Max of ±2 m s^{-1}
Refresh Rate	12 hr	3 hr

Observation Component	Threshold	Objective
Data Latency	90 mins	15 mins

Rationale: The ionosphere and thermosphere compose a dynamic, nonlinear and closely coupled system. Changes in thermospheric neutral winds, temperature, and composition have profound effects on both regions via momentum, chemical, and energy coupling. Rationale: [REF: COURL SW Ops User Requirements, Table 3, Neutral Thermospheric Winds; NPOESS IORD, Para 4.1.6.8.10 Neutral Winds]

[SWN-PO-389] The Space Weather Next Program shall provide Global Thermospheric Neutral Wind profiles (Threshold) and (Objective)

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Neutral Thermospheric Winds; NPOESS IORD, Para 4.1.6.8.10 Neutral Winds]

[SWN-PO-391] The Space Weather Next Program shall provide Global Thermospheric Neutral Wind profiles with an observational altitude range of 100 to 300 km (Threshold) / 90 to 500 km (Objective).

Rationale: [REF: NPOESS IORD, Para 4.1.6.8.10 Neutral Winds]

[SWN-PO-393] The Space Weather Next Program shall provide Thermospheric Neutral Wind profiles with an observational horizontal resolution of 250 km (Threshold) / 15 km (Objective).

Rationale: [REF: COURL SW Ops User Requirements, Table 3, Neutral Thermospheric Winds; NPOESS IORD, Para 4.1.6.8.10 Neutral Winds]

[SWN-PO-394] The Space Weather Next Program shall provide Thermospheric Neutral Wind profiles with a measurement range of 100 to 1000 m s^{-1} (Threshold) / 0 to 1500 m s^{-1} (Objective).

Rationale: [REF: NPOESS IORD, Para 4.1.6.8.10 Neutral Winds]

[SWN-PO-395] The Space Weather Next Program shall provide Thermospheric Neutral Wind profiles with a measurement uncertainty of the maximum of ±10 m s^{-1} (Threshold) / ±2 m s^{-1} (Objective).

Rationale: [REF: NPOESS IORD, Para 4.1.6.8.10 Neutral Winds]

[SWN-PO-397] The Space Weather Next Program shall provide Thermospheric Neutral Wind profiles with a refresh rate of 12 hr (Threshold) / 3 hr (Objective).

Rationale: [REF: NPOESS IORD, Para 4.1.6.8.10 Neutral Winds]

[SWN-PO-399] The Space Weather Next Program shall provide Thermospheric Neutral Wind profiles with a data latency of 90 min (Threshold) / 30 min (Objective).

Rationale: [REF: NPOESS IORD, Para 4.1.6.8.10 Neutral Winds]

3.2. Ground Segment Requirements

3.2.1 Space Weather Products

[SWN-PO-401] The Space Weather Next Program shall make available the data from the observational objectives defined in this PO that can be used, along with data from other remote / in-situ observations, to generate the Space Weather product sub-categories shown in Table 27.

Table 27: Level 2 Space Weather Product Sub-Categories

Space Weather Product Sub-Categories
Solar Products
Heliospheric Products
Magnetospheric Products
Thermospheric Products
Ionospheric Products

Note that product sub-categories (defined in Appendix C of NESDIS-REQ-1001.1), where Space Weather Next radiances will contribute to these products as needed by the algorithms.

Rationale: The above geophysical products contribute to the following analytical product areas: Solar, Heliospheric, Magnetospheric, Thermospheric, and Ionospheric products. NESDIS Common Cloud Framework might be utilized to generate Product sub-types. [REF: NLR-REQ-001]

3.2.2 Data Transfer Requirements

[SWN-PO-403] The Space Weather Next Program shall transfer all L0-L1b observations to the NESDIS NCCF.

Rationale: The NCCF will provide the infrastructure for data ingest, product generation, product distribution, archive, and stewardship in the Space Weather Next Program timeframe. [REF: NLR-REQ-002, NLR-REQ-003]

3.2.3 Information Technology Security Requirements

[SWN-PO-405] The Space Weather Next systems Program shall comply with NOAA information technology security policies and procedures.

Rationale: Compliance with the NOAA Information Technology Security Policy is required for the protection of all IT resources including computers, networks, telecommunication systems,

applications, data, and information. [REF: NAO 212-13; NOAA Security Manual; NESDIS IT Security Policies and Procedures, IT Security Handbook]

3.3. Availability Requirements

The Space Weather Next Program will satisfy the availability objectives as summarized for reference only in Table 28.

Table 28: Availability Requirements

Requirement	Threshold	Objective
Operational data availability, HAP L0	90%	95%
Operational data availability, non-HAP L0	50%	90%
MaxTTRS for failed instrument, HAP L0	3 weeks (If online spare is available) 2 years (if online spare is not available)	
MaxTTRS for failed instrument, non-HAP L0	1 year (If online spare is available) 4 years (if online spare is not available)	
Maximum Data outage, HAP L0	24 hours per year 2 hours per occurrence	
Maximum Data outage, non-HAP L0	75 hours per year 24 hours per occurrence	
MaxTTRS, HAP Product Generation	10 minutes	

Rationale: The availability objectives define the degree to which a system, product, or component is operational and accessible when required for use. The various availability objectives in this section ensure that the Space Weather Next Program is capable of performing the assigned mission at any given time. [REF: GOES-R L1RD; NSOSA Study]

[SWN-PO-409] The Space Weather Next program shall achieve a probability of 90 percent (Threshold) / 95% (Objective), for maintaining availability of operational data for the specified operational coverage area for HAP L0 data once Final Operating Capability is achieved.

Rationale: Once a Space Weather Next data acquisition system is operational, the Space Weather Next System shall maintain an operational availability of 90% for HAP L0 data. This includes either building and flying a series of satellites (where operational status is achieved after post-launch test) or acquiring the requisite data by other means, including obtaining operational partner data and/or purchasing operational commercial data. The HAP availability requirements will be applied to data products once the system providing the data reaches Full Operating Capability (FOC). Systems provide an Initial Operating Capability (IOC) when data from the system is declared ready for operational use. A system reaches FOC when all

services and products meet operational requirements. [REF: NLR-REQ-001, NLR-REQ-002, NLR-REQ-003]

[SWN-PO-411] The Space Weather Next program shall achieve a threshold probability of 50%, objective probability of 90%, for maintaining operational availability of operational data for the specified operational coverage area for non-HAP L0 data.

Rationale: Once a Space Weather Next data acquisition system is operational, the Space Weather Next System shall maintain an operational availability of 50% for non-HAP L0 data. This includes either building and flying a series of satellites (where operational status is achieved after post-launch test) or acquiring the requisite data by other means including obtaining operational partner data and/or purchasing operational commercial data. [REF: NLR-REQ-001, NLR-REQ-002, NLR-REQ-003]

[SWN-PO-413] In the event of a failure of an instrument requiring replacement, where a replacement is available, the SW Next System Maximum Time to Restore Service (MaxTTRS) shall not exceed 3 weeks for HAP L0 data.

Rationale: Once a Space Weather Next data acquisition system is operational, the Space Weather Next System shall maintain a threshold operational availability of 90% for HAP L0 data. An operational spare instrument to provide HAP L0 data may be part of the data acquisition system. If the operational instrument that provides HAP L0 data fails, the operational spare, or suitable replacement data, shall be made operational within 3 weeks.

[REQ-SWN-PLR-415] In the event of a failure of an instrument requiring replacement, where a replacement is not available, the SW Next Program Maximum Time to Restore Service (MaxTTRS) shall not exceed 2 years for HAP L0 data.

Rationale: Once a Space Weather Next data acquisition system is operational, the Space Weather Next Program shall maintain a mission availability of 90% for HAP L0 data. An operational spare instrument to provide HAP L0 data may be part of the data acquisition system. If the operational instrument that provides HAP L0 data fails, and the operational spare or suitable replacement data is not available, the MaxTTRS for the HAP L0 data shall not exceed 2 years.

[REQ-SWN-PLR-417] In the event of a failure of an instrument requiring replacement, where a replacement is available, the MaxTTRS for the non-HAP L0 data shall not exceed 1 year.

Rationale: Once a Space Weather Next data acquisition system is operational, the Space Weather Next Program shall maintain a mission availability of 50% for non-HAPL0 data. An operational spare instrument to provide non-HAPL0 data may be part of the data acquisition system. If the operational instrument that provides non-HAP L0 data fails, the MaxTTRS for the non-HAP L0 data shall not exceed 1 year.

[REQ-SWN-PLR-419] In the event of a failure of an instrument requiring replacement, where a replacement is not available, the MaxTTRS for the non-HAP L0 data shall not exceed 4 years.

Rationale: Once a Space Weather Next data acquisition system is operational, the Space Weather Next System shall maintain an operational availability of 50% for non-HAP L0 data. An operational spare instrument to provide HAPL0 data may not be part of the data acquisition system. If the operational instrument that provides non-HAP L0 data fails, a replacement to provide the non-HAP L0 data shall be made operational within 4 years.

[SWN-PO-421] When operational, the Space Weather Next Program shall provide continuous sensor data for ground generation of the HAP L0 data with outages less than 24 hours per year and no single outage exceeding two (2) hours.

Rationale: This is the acceptable downtime for HAP L0 data.

[SWN-PO-423] When operational, the Space Weather Next Program shall provide continuous sensor data for ground generation of non-HAP L0 data with outages less than 75 hours per year and no single outage exceeding 24 hours.

Rationale: This is the acceptable downtime for non-HAP L0 data.

[SWN-PO-425] The MaxTTRS for the Space Weather Next HAP operational product generation capability shall not exceed 10 minutes.

Rationale: To ensure Space Weather Next HAP generation, assuming operational input data sources, the Space Weather Next HAP product generation capability needs to recover from failure in less than 10 minutes.

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Appendix A: Glossary

Analyses: An interpretive message and imagery derived from geophysical products.

Aspirational: Indicates a performance requirement that should be satisfied in a fully funded program.

Availability: The measure of the probability that a system is operationally capable of performing an assigned mission at any given time. Operational availability is a measurement of how long a system has been available to use when compared with how long it should have been available to be used. Operational availability is a management concept that evaluates the following: Diagnostic down time, Criticality, Fault isolation down time, Logistics delay down time, Corrective maintenance down time.

B/B_{sun}: The ratio of brightness to the brightness of the Sun; a measurement used in coronagraph photometry.

Continuity: Services that NESDIS intends to continue producing for the foreseeable future.

Dayside: The side of a planet that faces towards the sun around which it orbits.

Data Product: Observations and measurements acquired by satellites and other sources – processed to any level (e.g., L1b, L2) or format before distribution to users. This includes products to support real-time needs, such as weather forecasting, and non-real-time needs, such as monitoring the environment and capturing trends.

Data Type: An attribute that describes the type of data products.

Environmental Data: Recorded and derived observations and measurements of the physical, chemical, biological, geological, and geophysical properties and conditions of the oceans, atmosphere, space environment, sun, and solid earth, as well as correlative data, such as socioeconomic data, related documentation, and metadata. Media, including voice recordings and photographs, may be included.

Field of View: The entire angular expanse visible through an optical instrument at a given time.

Full Operational Capability (FOC): Represents the completion of a development effort and all services and products meet operational requirements.. This is usually preceded by an initial operating capability phase.

Global Coverage: Global coverage denotes the observation of all points on the Earth or its atmosphere at least once per given time period.

High Availability Products (HAP): The mission critical products that are essential for the program to meet its mission goals.

Initial Operational Capability (IOC): The state achieved when a capability is available in its minimum usefully deployable form and data from the system is declared ready for operational use.

Instrument: Remote sensing or in situ measurement device for data collection.

Irradiance: Refers to energy measured by a detector as coming from any possible direction with units such as W m^{-2}.

Latency: The time from the collection of the last measurement needed for a product through the time that the data is converted to Level 1b and made available for retrieval by the end user through the user portal (e.g., NCCF).

Level-0 – reconstructed unprocessed instrument data at full resolution; and any and all communications artifacts (e.g., synchronization frames, communications headers) removed.

Level-1a – level-0 data with all supplemental information appended for use in subsequent processing

Level-1b – level-0 data with radiometric and geometric correction applied to produce parameters in physical units

Level-2 – derived environmental variables at a comparable temporal and spatial resolution to the Level 1 source.

Level-2+ – all level 2 and higher products

Low-resolution Solar Disk: The GOES-R XRS solar disk imaging capability (1 arcmin for a Class X1 flare).

Mission: The overall goal or purpose of an organization or organizational unit.

Measurement Accuracy: Measurement accuracy is defined as the closeness of agreement between a measured quantity value and a true quantity value of a measurand (i.e., the quantity intended to be measured) (ISO-JCGM 200, 2008), and is often limited by calibration errors. From: Biomechanics and Gait Analysis, 2020. Unless otherwise stated, Measurement Accuracy may average daily.

Objective Parameter: Represents the upper limit of desirable performance that the Program should strive to achieve in a fully funded environment.

Observational Extent: For remote sensing measurements, the entire region to be measured or observed. For optics this can be equivalent to or greater than the instrument field of view; for in situ measurements, this is the location of the measurement.

Observing System: One or more sensing elements that directly or indirectly collect biological, physical, chemical, and/or socioeconomic observations of the Earth and space. Sensing elements may be deployed as individual sensors or in constellations and may include instrumentation or manual observations. Observing system platforms may be mobile

or fixed and may be located in atmospheric, freshwater, marine, space, or terrestrial environments.

Operational Products: Data, information, user support, and reports that NESDIS generates and provides to the user community for the foreseeable future. They are originally derived from user requirements, user requests, operational precedence, congressional mandates, and documented user interaction.

Pitch Angle: The pitch angle of a charged particle is the angle between the particle's velocity vector and the local magnetic field.

Process: A set of activities used to convert inputs into desired outputs to generate expected outcomes and satisfy a purpose.

Project: A specific investment that has defined goals, objectives, requirements, life-cycle cost, a beginning, and an end. A project yields products or services that directly address NESDIS' strategic needs.

Program: A strategic investment that has defined goals, objectives, architecture, funding level, and a management structure that supports one or more projects.

Radiance: Energy measured by a detector as coming from a specific direction, which is expressed per unit solid angle (e.g., W m^{-2} sr^{-1}).

Refresh: The time interval between successive collections of measurements of the same parameter of the location or region being observed from the same observation point.

Report: An authoritative document that describes the state of the environment based on data and is provided with expert review. Reports offer explanatory information and are written for non-experts.

Requirement: A statement of a function to be performed, a performance level to be achieved, or an interface to be met.

Requirement Attribute: The properties of a requirement that capture important additional information about a requirement. Examples of requirement attributes are: latency, refresh, and geographic coverage.

Service: The provision and distribution of data, products, information, user support, and reports in support of NOAA's mission.

Solar north-aligned: Images of the Sun or solar corona are rotated so the north pole of the solar rotation axis, 'specified by Helioprojective-Cartesian coordinates, is straight up in the image.

Sun-centered: Images of the Sun or solar corona are translated so the 'geometric center', specified by Helioprojective-Cartesian coordinate origin (Θ=0, Φ=0), is centered in the image.

Small Satellites: Satellites with wet masses below 500 kg.

Suprathermal: Whether ions or electrons, refers to particles with energies that lie above the bulk solar wind ion or electron energies.

System: The combination of elements that function together to provide the capability required to meet a need. The elements include all hardware, software, equipment, facilities, personnel, processes, and procedures needed for this purpose.

Threshold Parameter: Represents the lower limit of acceptable performance that the Program should strive to achieve in a fully funded environment.

Appendix B: Acronyms

Table 29: Acronyms

Abbreviation	Definition
AA	Assistant Administrator
AS/EOP	Assistant Secretary of Commerce for Environmental Observation and Prediction
CONUS	Conterminous United States
COOP	Continuity of Operations Plan
COURL	Consolidated Observation User Requirement List
DAAS	Deputy Assistant Administrator for Systems
DOC	Department of Commerce
DoD	Department of Defense
DUS/O	Deputy Undersecretary for Operations
EORES	Earth Observation Requirements Evaluation System
ESA	European Space Agency
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EUV	Extreme Ultraviolet
GEO	Geostationary Earth Orbit
GOES	Geostationary Operational Environmental Satellite
HEO	High Earth Orbit
JAXA	Japan Aerospace Exploration Agency
L0	Level 0 data product
L1	Lagrange Point 1 (Sun-Earth)
L1b	Level 1b data product
L1RD	Level 1 Requirements Document
L2	Level 2 data product
L4	Lagrange Point 4 (Sun-Earth)
L5	Lagrange Point 5 (Sun-Earth)
LEO	Low Earth Orbit

Abbreviation	Definition
MaxTTRS	Maximum Time to Restore Service
MCP	Management Control Plan
MRD	Mission Requirements Document
NAO	NOAA Administrative Order
NASA	National Aeronautics and Space Administration
NCCF	NESDIS Common Cloud Framework
NCEI	National Centers for Environmental Information
NESDIS	National Environmental Satellite, Data, and Information Service
NLR	NESDIS Level Requirements
NOAA	National Oceanic and Atmospheric Administration
NOSC	NOAA Observing Systems Council
NSOSA	NOAA Satellite Observation System Architecture
OSAAP	Office of System Architecture and Advanced Planning
OSGS	Office of Satellite Ground Services
OSPO	Office of Satellite and Product Operations
PMEF	Primary Mission Essential Function
PO	Program Objectives
POR	Program of Record
R2O/O2R	Research-to-operation / Operations-to-Research
REQ	Requirement
SEL	Sun-Earth Line
SPRWG	Space Platform Requirements Working Group
SWO	Space Weather Observation Program
SWFO	Space Weather Follow-On
SWO	Space Weather Observations
SWORM	Space Weather Operations, Research, and Mitigation
SWPC	Space Weather Prediction Center
TEC	Total Electron Content

Appendix C: Table of Symbols

Table 30: Table of Symbols

Symbol	Description
R_{sun}	Solar Radius (Radius of Sun)
B_{sun}	Brightness of Sun
keV	Kilo electron volt; the energy that an electron gains when it travels through a potential of one thousand volt
nT	Nano tesla
O/N_2	Oxygen to molecular nitrogen ratio
MeV	Mega electron volt
N_e	Electron density; number of electrons per unit volume (cubic meter)
ΔN_e	Change in electron concentration
S_4	Ionospheric scintillation index, amplitude
σ_ϕ	Ionospheric scintillation index, phase

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