REPORT TO CONGRESS

SPACE WEATHER FOLLOW-ON (SWFO) PROGRAM

Developed pursuant to: 33 U.S.C. § 878a(c)(2) and Public Law 117-103, as amended

Elsayed Talaat, Ph.D.
Director, Office of Projects, Planning, and Analysis
National Environmental Satellite, Data, and Information Services
National Oceanic and Atmospheric Administration

Stephen M. Volz, Ph.D.,
Assistant Administrator for Satellite and Information Services
National Environmental Satellite, Data, and Information Services
National Oceanic and Atmospheric Administration

Dr. Richard W. Spinrad
Under Secretary of Commerce for Oceans and Atmosphere
and Administrator of the National Oceanic and Atmospheric Administration

33 U.S.C. § 878a(c)(2), AS REFERENCED IN SECTION 104 OF THE CONSOLIDATED APPROPRIATIONS ACT, 2022 (PUBLIC LAW 117-103), INCLUDED THE FOLLOWING DIRECTION:

The first Major Program Annual Report for NOAA's satellite development program shall include a Baseline Report that shall, at a minimum, include—

(A) the purposes of the program and key technical characteristics necessary to fulfill those purposes;

(B) an estimate of the life-cycle cost for the program, with a detailed breakout of the development cost, program reserves, and an estimate of the annual costs until development is completed;

(C) the schedule for development, including key program milestones;

(D) the plan for mitigating technical, cost, and schedule risks identified in accordance with subsection (b)(1)(A); and

(E) the name of the person responsible for making notifications under subsection (d), who shall be an individual whose primary responsibility is overseeing the program.

THIS REPORT RESPONDS TO THIS REQUIREMENT.

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I. EXECUTIVE SUMMARY

The following document is the baseline report required by 33 U.S.C. § 878a(c)(2). This report also responds to the requirements set forth in section 104 of the Consolidated Appropriations Act, 2022, Public Law 117-103.

The Space Weather Follow-On (SWFO) Program completed its Key Decision Point (KDP)-C, which is the decision for the SWFO Program to move into detailed design on December 21, 2021. The KDP-C Decision Memo was approved by the Under Secretary of Commerce for Oceans and Atmosphere with concurring signatures from the Office of Projects, Planning, and Analysis (OPPA) Director, the National Oceanic and Atmospheric Administration (NOAA) National Environmental Satellite, Data, and Information Service (NESDIS) Assistant Administrator, NASA Goddard Space Flight Center Director, and NASA Science Mission Directorate Deputy Associate Administrator.

The congressional baseline for the SWFO Program is $692.8 million. This report documents the analyses and basis for this amount. The report also satisfies the requirement to submit a Baseline Report that shall, at a minimum, include:

A. the purposes of the program and key technical characteristics necessary to fulfill those purposes;
B. an estimate of the life-cycle cost for the program, with a detailed breakout of the development cost, program reserves, and an estimate of the annual costs until development is completed;
C. the schedule for development, including key program milestones;
D. the plan for mitigating technical, cost, and schedule risks identified in accordance with subsection(b)(1)(A); and
E. the name of the person responsible for making notifications under subsection (d), who shall be an individual whose primary responsibility is overseeing the program.

II. PROGRAM PURPOSES AND KEY TECHNICAL CHARACTERISTICS

NOAA, within the Department of Commerce (DOC), is implementing the SWFO Program to provide operational space weather monitoring and forecasting. SWFO observations will characterize the solar wind and other space weather phenomena to provide additional time to protect critical infrastructure from geomagnetic storm damage. It will constantly monitor the Sun to prevent gaps in critical observations for space weather forecasting. The SWFO Program emphasizes:

- Continuity of solar coronal mass ejection (CME) observations consistent with recommendations contained in the 2013 National Academies' Solar and Space Physics, A Science for a Technological Society, and the Office of Science and Technology Policy's (OSTP) National Space Weather Action Plan, October 2015;
- Continuity of solar wind measurements recommended in Solar and Space Physics, A Science for a Technological Society, and the National Space Weather Action Plan; and
- Partnerships called for in the National Space Weather Action Plan.
- Meeting validated requirements of the National Weather Service, Space Weather Prediction Center.

The program goals remain consistent with the 2019 National Space Weather Strategy and Action Plan and the Promoting Research and Observations of Space Weather to Improve the Forecasting of Tomorrow (or PROSWIFT) law established October 21, 2020.

A. Validated Requirements

The SWFO Program will provide operational space-based observation and measurement capabilities for white-light coronal imaging and *in situ* measurement of the solar wind moving toward Earth. These observations support the NOAA National Weather Service (NWS) Space Weather Prediction Center's (SWPC) civil space weather forecasting mission and the Air Force Space Weather Flight Group of 557th Weather Wing's mission-tailored analyses, forecasts and warnings for defense operators. Requirements for these measurements derive from the NOAA Space Weather Mission Service Area Observational User Requirements Document, a subset of the NOAA Consolidated User Observational Requirements baselined by the NOAA Observing System Council in November 2017.

B. Key Technical Requirements

The SWFO Program will include an observatory at the Earth-Sun Lagrange Point 1 (L1) called SWFO-L1 with a Space Weather Instrument Suite for solar wind observations and a compact coronagraph (CCOR) for observing the white-light corona of the Sun to detect CME events. The NOAA SWFO-L1 mission will ensure continuity of space weather data beyond NOAA's Deep Space Climate Observatory and NASA-European Space Agency (ESA) research mission, Solar and Heliospheric Observatory, which are both well past their design life. The program also supports the integration of a CCOR on a Geostationary Operational Environmental Satellite (GOES) spacecraft. Flying a second

CCOR in a geostationary orbit adds operational resilience and reliability to the CME imagery necessary for space weather watches and forecasting.

The SWFO Program will take advantage of a CCOR instrument hosting opportunity on GOES-U scheduled for launch in Fiscal Year (FY) 2024 and a rideshare launch opportunity with the National Aeronautics and Space Administration's (NASA) Interstellar Mapping and Acceleration Probe (IMAP) mission scheduled for launch in FY 2025. Leveraging the IMAP rideshare opportunity is the timeliest and most cost-effective mechanism to ensure space weather forecasting continuity.

CME and solar wind measurements are necessary for NOAA to provide warnings for geomagnetic storms that affect the Earth. The most extreme geomagnetic storms can result in severe impacts to commercial power grids, emergency management systems, GPS, satellites and aircraft. Satellite data, including CME imagery and measurement of solar wind plasma, are critical to providing accurate and early warning of these potentially destructive space weather events.

The NOAA observation requirements, including Key Performance Parameters (KPP) that the SWFO Program is designed to fulfill, are shown in Table 1.

Table 1: NOAA Observational Requirements Fulfilled by the SWFO Program

Observation Requirement	**Observation Vantage Point**	**Instrument Source**	**Operational Legacy**
Coronal White Light Intensity (KPP)	On the Sun-Earth Line One at Lagrange Point 1 (L1), One in geostationary orbit (GEO)	Compact Coronagraph (CCOR)	NASA's SOHO, Large Angle and Spectrometric Coronagraph
Magnetic Field (KPP)	*In situ* at L1	Magnetometer (MAG)	NOAA Deep Space Climate Observatory (DSCOVR), MAG NASA Advanced Composition Explorer (ACE), MAG
Thermal Plasma Ion Velocity (KPP)	*In situ* at L1	Solar Wind Plasma Sensor (SWiPS)	DSCOVR, Faraday Cup ACE, Solar Wind Electron Proton Alpha Monitor (SWEPAM)

Thermal Plasma Ion Density	*In situ* at L1	SWiPS	DSCOVR, Faraday Cup ACE, SWEPAM
Thermal Plasma Ion Temperature	*In situ* at L1	SWiPS	DSCOVR, Faraday Cup ACE, SWEPAM
Suprathermal Ion Differential Flux	*In situ* at L1	Suprathermal Ion Sensor (STIS)	-
Solar Wind Dynamic Pressure	*In situ* at L1	STIS	DSCOVR, Faraday Cup ACE, SWEPAM
X-Ray Flux (Mission Enhancement)	On the Sun-Earth Line at L1	X-Ray Flux Monitor (XFM)	GOES-R Series' Extreme Ultraviolet and X-Ray Irradiance Sensors X-Ray Sensor

The NOAA products derived from SWFO observations and some industry sectors that depend on these space weather observations are shown in Table 2.

Table 2: NOAA Products driven by SWFO Data

Instrument	NWS Forecast Model	Product	Impacted Industry Sector
Compact Coronagraph (CCOR)	Coronal Mass Ejection (CME) Detection	Geomagnetic Storm Watches	All sectors listed below
	Wang-Sheeley-Arge (WSA)-Enlil Model	One to 4-day forecast of Geomagnetic Storms	GPS Systems, Electric Power Transmission, Satellite Communications, Satellite Drag
Magnetometer (MAG) and Solar Wind Plasma Sensor (SWiPS)	Coupled Thermosphere Ionosphere Plasmasphere Electrodynamics Model (CTIPe) Model	Total electron content forecast	GPS Systems, Electric Power Transmission, Satellite Drag
	Geospace/E-Field Model	Thirty to 60-minute advanced warning of geomagnetic activity and storm time	GPS Systems, Electric Power Transmission, HF Radio Communications, Satellite Communications, Satellite Drag
	Magnetopause Model	Warning of Susceptibility to high energy particles, single event upsets,	Satellite Operators especially in GEO orbit
	Oval Variation, Assessment, Tracking, Intensity, and Online Nowcasting (OVATION) Model	Thirty-minute forecast of aurora	GPS Systems, Electric Power Transmission, HF Radio Communications
	Whole Atmosphere Model-Ionosphere Plasmasphere Electrodynamics (WAM-IPE) Model	Two-day ionosphere and thermosphere conditions forecast	GPS Systems, Electric Power Transmission, Satellite Drag
Solar Wind Plasma Sensor only	Relativistic Electron Forecast (REFM) Model	One to three-day forecast of relativistic electrons at geo-synchronous orbit.	Satellite operators at GEO including GPS, telecommunications, and remote sensing satellites.
Suprathermal Ion Sensor (STIS)	Low Energy Ions and Electrons	Geomagnetic Storm Warnings	GPS Systems, Electric Power Transmission, HF Radio Communications, Satellite Communications, Satellite Drag

		Single event upsets	Satellite operators
X-Ray Flux Monitor (XFM)	Track solar activity and solar flares		GPS Systems, HF Radio Communications, Satellite Communications

Acquisition support and joint NOAA/NASA oversight of the SWFO Program is established under the authority of the interagency agreement between NOAA and NASA dated July 29, 2019. Program implementation is proceeding consistent with the acquisition strategy approach agreed to by NOAA and NASA on March 20, 2019. Management processes follow the joint agency processes described in the NOAA-NASA Satellite Program and Projects Management Control Plan (MCP) and the NASA Space Flight Program and Project Management Requirements (NPR 7120.5). The MCP also satisfies the requirements of DOC Scalable Acquisition Project Management Framework.

NOAA and NASA provide joint programmatic leadership for the SWFO Program. Per the MCP, the SWFO Program is reviewed monthly at the NASA Goddard Monthly Status Review meetings chaired by the NASA Goddard deputy center director, and at the NOAA-NASA Agency-level Program Management Council (APMC) meetings chaired by NOAA and NASA Senior leadership. NOAA has responsibility for the program budget, program requirements, Ground Segment Project leadership, operations, data product generation, and product distribution to the operational users. NASA has responsibility for system engineering, safety and mission assurance, SWFO-L1 Flight Project leadership, launch accommodation, launch and interfaces to the Ground Segment.

The Naval Research Laboratory (NRL) is responsible for the development and delivery of two CCOR instruments, one for integration onto the GOES-U spacecraft, and another for integration by NASA onto the SWFO-L1 spacecraft. This work is performed under the authority of an interagency agreement between NOAA and NRL dated June 10, 2019.

ESA is contributing an X-ray flux monitor for integration by NASA to the SWFO-L1 spacecraft under the Letter of Intent to cooperate in Space Weather Monitoring, signed November 14, 2017 and an International Agreement, approved by the State Department at the ESA Council and signed February 22, 2022. X-Ray flux observations are a mission enhancement for SWFO-L1; however, the mission will proceed and launch without the ESA instrument if delivery schedule, integration, or other technical issues threaten the program schedule or cost. NOAA also obtains X-Ray Flux observations using the GOES-R series of satellites.

III. PROGRAM LIFE CYCLE COST ESTIMATE

On October 31, 2019, NOAA baselined the budget for the Life Cycle Cost (LCC) of the SWFO Program at $692.8 million through FY 2029, as reflected in the DOC Milestone 2/3 Decision Memorandum (Appendix D). The SWFO Program Resource Baseline plan is shown below in Table 3. The SWFO Program reserves assessment from KDP-C is shown. The “reserves” row depicts the funds available in the current fiscal year to address unexpected problems. The “percent reserves” row is calculated as current year reserves divided by current year

development costs after removal of items not subject to reserve requirements. The program does not hold development reserves against non-development costs such as agency withholds and program management overhead. Other costs for which reserves are not held include costs of launch site integration for the SWFO-L1 spacecraft and the fixed price for accommodation of CCOR-1 on the GOES-U spacecraft.

Development phase began with the development of the CCOR instrument by the Naval Research Laboratory. The Operations phase will begin with CCOR on GOES-U once launched in calendar year (CY) 2024 followed by SWFO-L1 launch as a ride share on NASA IMAP in FY 2025. Funding for the Operations phase will include satellite command and control by the NOAA Office of Satellite and Product Operations; product development and long-term data stewardship by the National Centers for Environmental Information; and product development and dissemination to users by the NWS SWPC. At this time, the role of OPPA as overall program manager will end and will be assumed by OSPO.

Table 3: SWFO Program Resource Baseline at November 2021 KDP-C ($K)

	FY 2016-2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026-2029	Total
Development	213,800	146,900	136,200	96,500	22,500	-	615,900
Operations				700	18,700	57,500	76,900
LCC	213,800	146,900	136,200	97,200	41,200	57,500	**692,800**
Cost-to-go basis for reserves* [A]	39,297	109,066	59,531	60,221	28,650	0	296,765
Reserves [B]	15,509	10,442	30,460	18,470	415	-	75,296
% Reserves against development [B ÷ A]	39.5%	9.6%	51.2%	30.7%	1.4%	-	25.4%

* The cost-to-go basis for reserves does not include costs for withholds, the 4-month IMAP launch delay, the accommodation of CCOR on GOES-U, operations & sustainment, program management, or launch site integration, Additionally, in FY 2025, the cost-to-go basis exceeds the development budget in FY 2025 because the program plans to utilize carryover funding.

A. Impacts of the Coronavirus Disease 2019 (COVID-19) Pandemic

The ongoing COVID-19 pandemic has impacted SWFO Program schedule and cost. We anticipate a high potential for additional costs stemming from labor shortages and supply chain disruption. In 2020 pandemic evacuation orders forced work-stoppage with resulting schedule delays and labor cost of $3.9 million for CCOR-1 manufacture at NRL.

The NASA IMAP program suffered similar issues in 2020 resulting in an announced 4-month launch delay from October 2024 to February 2025. This resulted in an unanticipated and unplanned cost to the SWFO Program for elongation of the SWFO-L1 schedule, which is estimated to be approximately $30 million as reported at the joint APMC in June 2021.

No program reserves have yet been encumbered for the development schedule extension into 2025 caused by the COVID-19 global pandemic events; instead, the program will use any remaining reserves carried forward into 2025 to cover the COVID-related expenses.

At this time, with the ability to roll current year reserves forward into subsequent fiscal years, the overall reserves posture is sufficient to complete development within the allocated LCC, and the program will continue to assess reserves in each annual budget cycle. As a launch rideshare, SWFO-L1 launch is determined by the IMAP program launch date, SWFO Program management meets regularly with their counterparts at the NASA IMAP Program to coordinate launch requirements and to maintain schedule awareness.

B. Key Decision Point-C Cost Confidence, November 2021

In November 2021, the SWFO Program completed KDP-C, culminating a series of NOAA/NASA management reviews that recommended retaining the development cost and schedule baselined at MS 2/3. The milestone decision authority found that SWFO has sufficient funding reserves, per NASA guidelines, to be ready for launch in February 2025. Funding risk is during Phase E, with risk mitigations documented and approved by NESDIS leadership (Appendix C).

As is standard practice as part of KDP-C, the SWFO Program, the Standing Review Board (SRB), and NASA HQ completed independent Joint Confidence Level (JCL) analysis for the SWFO Program LCC. As shown in Table 4 below, the analysis included estimates from three sources, the SWFO Program, an adjustment from the SRB, and a NASA HQ independent cost estimate performed by the Aerospace Corporation. The JCL analysis is a formal method to indicate the probability that simultaneously both a project's cost will be equal to or less than an estimated cost and that the project's schedule will meet the target finish date. NASA requires that a JCL analysis be completed and submitted at Key Decision Point C (KDP-C) for all projects above $250 million. By NASA policy, JCL are calculated at the 70-percent probability and 50-percent probability. Programs are planned according to the 70-percent probability. As shown in Table 4, the 70-percent probability LCC ranges from $654.7 million to $744.0 million indicating high confidence that the baseline budget of $692.8 million is achievable within the schedule constraint.

Table 4: Key Decision Point-C Independent Life Cycle Cost Estimates ($M)

	50 percent	70 percent
SWFO Program Joint Confidence Level	643.7	654.7
Standing Review Board Joint Confidence Level	646.2	657.2
NASA HQ (Aerospace Independent Cost Estimate)	652.4	744.0

IV. SCHEDULE FOR PROGRAM DEVELOPMENT

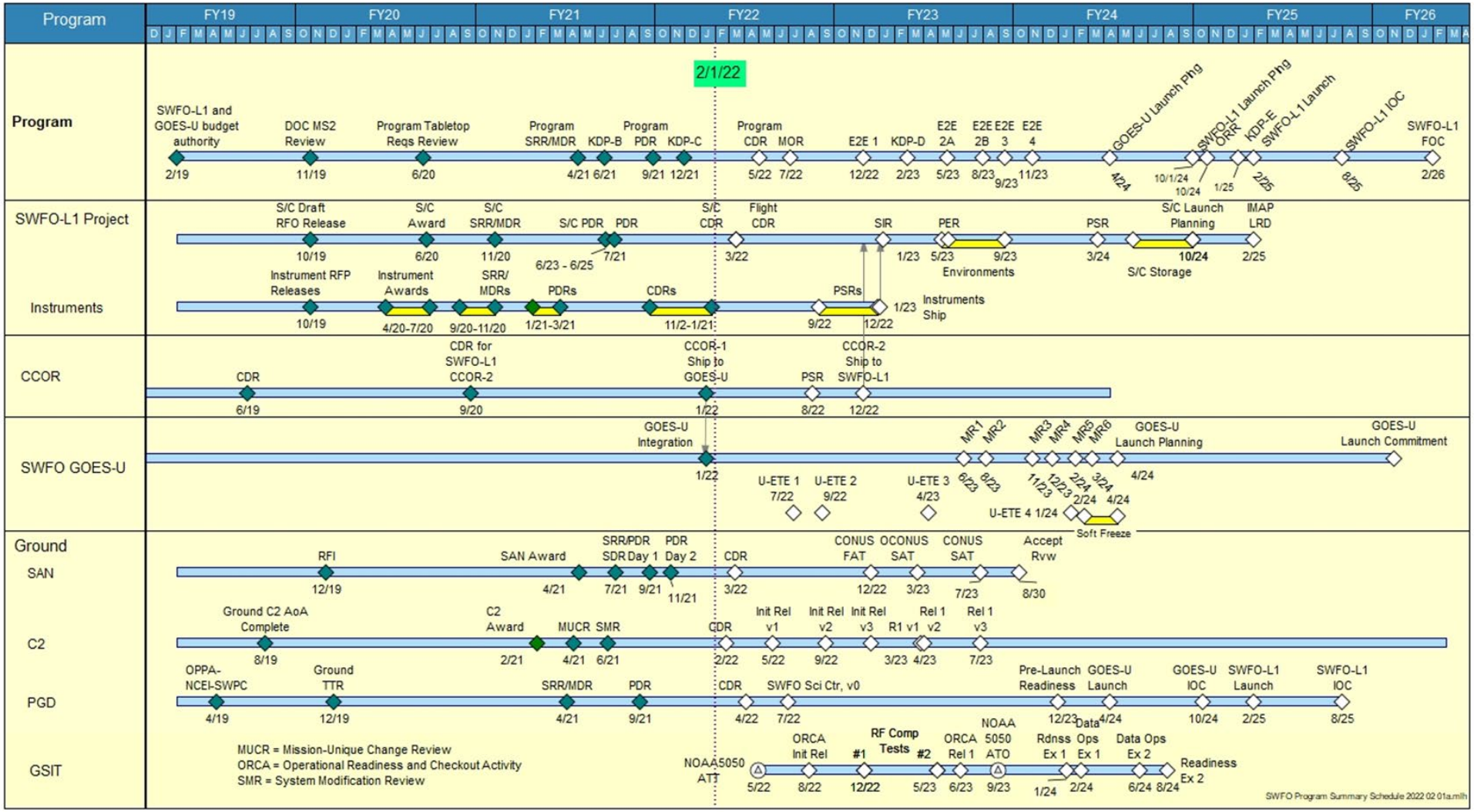
The SWFO Program is managed in partnership between NOAA and NASA and follows NASA standards for Lifecycle Reviews and Key Decision Points (KDP) beginning with NASA KDP B. The SWFO Program integrated master schedule is shown below in Figure 1 and Table 5, the major milestones including Lifecycle reviews and KDPs are as follows:

Table 5: Schedule and Status of Key Program Milestones

Schedule	Status of Key Program Milestones
FY 2020	Department of Commerce Milestones 1 and 2 (completed)
FY 2021	KDP-B (completed)
FY 2022	KDP-C (completed) CCOR-1 Integration onto GOES-U (completed) SWFO Program Critical Design Review (CDR)
FY 2023	Instruments ship to SWFO-L1 KDP-D
FY 2024	GOES-U Launch SWFO-L1 Spacecraft Complete and placed in storage
FY 2025	KDP-E SWFO-L1 Spacecraft Launch SWFO-L1 Initial Operational Capability

SWFO-L1 is a rideshare with the NASA IMAP mission. As a result, the SWFO-L1 Launch Readiness Date (LRD), of February 1, 2025, is defined by the NASA IMAP mission LRD. The SWFO Program continues to mitigate schedule risk to ensure readiness for the IMAP LRD.

Figure 1: SWFO Program Integrated Master Schedule



V. PLAN FOR MITIGATING IDENTIFIED TECHNICAL, COST, AND SCHEDULE RISKS

The SWFO Program manages risk through its comprehensive risk management program documented in the SWFO Risk Management Plan. The plan details the process for managing risks at both the project and program levels. The SWFO Program uses a risk-informed decision-making approach with risks managed by the constituent project elements and the SWFO Program and with a risk management board structure. This is consistent with NASA and NOAA/NESDIS procedural requirements and policies. Risk management is applied to all activities performed by both civil servants and contractors at all levels across all elements of the program. The SWFO Program Manager chairs the program risk management board.

Risks are assessed for their likelihood and their technical, cost, and schedule impacts if realized. These assessments are vetted monthly by the program risk management board. The SWFO Program Manager briefs the identified highest risks, the anticipated impacts, and status of relevant mitigation efforts on a monthly cadence to several venues, including the OPPA Monthly Risk Meeting, the GSFC Flight Project Directorate Monthly Status Meeting, the GSFC Monthly Status Review, and the monthly NOAA/NASA Agency Program Management Council. In addition, risks are reviewed at all program, project, and element lifecycle reviews. Flight and ground project risks and lower-level element risks are reviewed by NASA Goddard Systems Review Teams at project and element reviews. Program risks are reviewed by the SRB at program reviews.

A. Technical Risk

As described in the SWFO Readiness report, the approach for SWFO has emphasized technologies with high TRL and low technical risk. All elements and components of the program are specified and procured with a minimum TRL 6, indicating that they have already shown to have been built and operated in a relevant environment, and that engineering feasibility has been fully demonstrated in operations under critical environmental conditions. Subsequent program reviews have confirmed that technical risk remains low.

The SWFO Program Preliminary Design Review (PDR) was completed September 27-29, 2021, and the SRB verified that the program met all requirements with acceptable risk and within the cost and schedule constraints. The current program status, along with the findings of the SRB, was presented on November 9, 2021, to both the NASA Goddard Space Flight Center Management Council and the Joint NOAA/NESDIS and NASA Science Mission Directorate Program Management Council. Each council was unanimous in recommending that the program be approved to enter the detailed design phase (Phase C) with the cost and schedule summarized above. They agreed that the proposed mission/system architecture is credible and responsive to program requirements, and the maturity of the program's mission/system definition and associated plans is sufficient to begin Phase C. The KDP-C decision briefing was made on November 17, 2021, to the NASA/NOAA APMC. The resultant approval memo is attached as Appendix C.

B. Cost Risk

The SWFO Program budget includes reserve funds consistent with NASA Goddard Space Flight Center guidelines, which requires a budget margin level of 25 percent or higher on cost-to-go through Phase D (Development). The SWFO Program assigns reserve funds according to the expected cost impact of risk mitigations and issues as they are identified. The reserve funds are expended to avoid or mitigate identified risks and to cover costs to recover from occurrence of issues. As presented at KDP-C, the program had 25.4-percent available reserves through development.

The following are liens and threats against reserve funds.

- CCOR-1 Mechanism: CCOR-1 (to be integrated on GOES-U) experienced cost growth due to seven months of schedule delay caused by challenges in the instrument door mechanism design and integration, instrument vibration testing and instrument thermal model predictions, and thermal vacuum testing. Challenges incurred were exacerbated by the COVID-19 work environment restrictions and staff shortages. Lessons learned from CCOR-1 are being applied to CCOR-2 to reduce CCOR-2 schedule and cost risk.

- Launch Duration: A longer than expected duration from launch to SWFO-L1 separation caused predicted spacecraft temperatures to drop below survival temperature limits. Modifying the design to launch powered-on and increasing the battery size provides power to heaters to keep the spacecraft within temperature constraints. Additionally, launching powered-on presents a do no harm risk to the primary IMAP spacecraft. Modifications to avionics are required to meet the IMAP do no harm requirements.

- Integrated Flight and Ground Interfaces and Testing: A detailed integrated master schedule review and technical review of the contractual "giver and receiver" documents and data revealed that the spacecraft, command and control, and antenna network contracts deliverables and schedules needed adjustments to ensure the necessary integrated testing and interfaces. Contract modifications are required to rectify the detailed deliverables and the integrated schedules.

- Radiation Susceptibility: As a space weather observatory, SWFO-L1 is required to actively observe events that other spacecraft are simply designed to survive. Operation of a key electronic component called a Field Programmable Gate Arrays (FPGA) through radiation storms is a particular concern. Potential modification to ProASIC FPGA design, FPGA testing, and the addition of spacecraft responses are being evaluated to mitigate risk to data availability during radiation storms.

- Staffing impacts due to COVID-19 are a current threat to the element delivery schedules across flight and ground. SWFO has placed procurement orders earlier than usual to help mitigate schedule and corresponding cost impacts.

- Because SWFO is a rideshare on the IMAP mission, any additional delays in IMAP LRD (beyond the 4 months already discussed due to COVID-19) will further impact the SWFO launch date and LCC.

- Schedule and technical risks related to the ESA XFM are not considered to be programmatic risks to the SWFO Program because ESA and NOAA agree that, while XFM would be a SWFO-L1 mission enhancement, its inclusion is not a criterion for launch. If the X-ray flux monitor schedule does not match the SWFO-L1 need date, the instrument will not be included.

C. Schedule Risk

The SWFO Program schedule includes margin consistent with NASA Goddard Space Flight Center guidelines. The JCL analyses, which considers the potential range of cost and schedule outcomes for SWFO development activities, indicated that there was greater than 70-percent probability that SWFO-L1 will be ready for the rideshare launch with IMAP on the IMAP LRD of February 1, 2025. Independent schedule estimates from the SRB and the NASA HQ (Aerospace) indicate greater than 70-percent and 63-percent, respectively, probability of SWFO-L1 readiness for the rideshare launch date of February 1, 2025.

SWFO has procured hardware earlier than usual to minimize supply chain risk due to COVID-19 schedule impacts.

VI. RESPONSIBLE AUTHORITY

The responsible reporting official as required by 33 U.S.C 878a(c)(2)(E) is: Dr. Elsayed Talaat; Director; Office of Projects, Planning, and Analysis; NESDIS; NOAA.

APPENDIX A: ACRONYM LIST

ACE	Advanced Composition Explorer
APMC	Agency-level Program Management Council
CCOR	Compact Coronagraph
CDR	Critical Design Review
CME	Coronal Mass Ejection
DOC	Department of Commerce
DSCOVR	Deep Space Climate Observatory
ESA	European Space Agency
FPGA	Field Programmable Gate Array
GOES	Geostationary Operational Environmental Satellite
HQ	Headquarters
IAA	Interagency Agreement
IMAP	Interstellar Mapping and Acceleration Probe
JCL	Joint Confidence Level
KDP	Key Decision Point
L1	Lagrange Point 1
LCC	Life Cycle Cost
LRD	Launch Readiness Date
MAG	Magnetometer
MCP	Management Control Plan
MS	Milestone
NASA	National Aeronautics and Space Administration
NCEI	National Centers for Environmental Information
NESDIS	National Environmental Satellite, Data, and Information Service
NOAA	National Oceanic and Atmospheric Administration
NPR	NASA Procedural Requirements
NRL	Naval Research Laboratory
NWS	National Weather Service
OPPA	Office of Projects, Planning, and Analysis
PDR	Preliminary Design Review
PPBE	Planning, Programming, Budget, and Execution

SMD	Science Mission Directorate
SOHO	Solar and Heliospheric Observatory
SRB	Standing Review Board
STIS	Suprathermal Ion Sensor
SWFO	Space Weather Follow-On
SWFO-L1	Space Weather Follow-On – Lagrange 1
SWPC	Space Weather Prediction Center
SWiPS	Solar Wind Plasma Sensor
SWIS	Solar Wind Instrument Suite
TRL	Technology Readiness Level
U.S.C.	United States Code

APPENDIX B: LEGISLATIVE MANDATE

Title 33. Navigation and Navigable Waters

Chapter 17, National Oceanic and Atmospheric Administration

Subchapter 1. General Provisions

§ 878a.Contract for development of a major program; costs; Major Program Annual Report for satellite development program

(a) For purposes of this section—

(1) the term 'Under Secretary' means Under Secretary of Commerce for Oceans and Atmosphere;

(2) the term 'appropriate congressional committees' means—

(A) the Committee on Appropriations and the Committee on Commerce, Science, and Transportation of the Senate; and

(B) the Committee on Appropriations and the Committee on Science, Space and Technology of the House of Representatives;

(3) the term 'satellite' means the satellites proposed to be acquired for the National Oceanic and Atmospheric Administration (NOAA);

(4) the term 'development' means the phase of a program following the formulation phase and beginning with the approval to proceed to implementation, as defined in NOAA Administrative Order 216-108, Department of Commerce Administrative Order 208-3, and NASA's Procedural Requirements 7120.5c, dated March 22, 2005;

(5) the term 'development cost' means the total of all costs, including construction of facilities and civil servant costs, from the period beginning with the approval to proceed to implementation through the achievement of operational readiness, without regard to funding source or management control, for the life of the program;

(6) the term 'life-cycle cost' means the total of the direct, indirect, recurring, and nonrecurring costs, including the construction of facilities and civil servant costs, and other related expenses incurred or estimated to be incurred in the design, development, verification, production, operation, maintenance, support, and retirement of a program over its planned lifespan, without regard to funding source or management control;

(7) the term 'major program' means an activity approved to proceed to implementation that has an estimated life-cycle cost of more than $250 million; and

(8) the term 'baseline' means the program as set following contract award and preliminary design review of the space and ground systems.

(b)(1) NOAA shall not enter into a contract for development of a major program, unless the Under Secretary determines that—

(A) the technical, cost, and schedule risks of the program are clearly identified and the program has developed a plan to manage those risks;

(B) the technologies required for the program have been demonstrated in a relevant laboratory or test environment;

(C) the program complies with all relevant policies, regulations, and directives of NOAA and the Department of Commerce;

(D) the program has demonstrated a high likelihood of accomplishing its intended goals; and

(E) the acquisition of satellites for use in the program represents a good value to accomplishing NOAA's mission.

(2) The Under Secretary shall transmit a report describing the basis for the determination required under paragraph (1) to the appropriate congressional committees at least 30 days before entering into a contract for development under a major program.

(3) The Under Secretary may not delegate the determination requirement under this subsection, except in cases in which the Under Secretary has a conflict of interest.

(c)(1) Annually, at the same time as the President's annual budget submission to the Congress, the Under Secretary shall transmit to the appropriate congressional committees a report that includes the information required by this section for the satellite development program for which NOAA proposes to expend funds in the subsequent fiscal year. The report under this paragraph shall be known as the Major Program Annual Report.

(2) The first Major Program Annual Report for NOAA's satellite development program shall include a Baseline Report that shall, at a minimum, include—

(A) the purposes of the program and key technical characteristics necessary to fulfill those purposes;

(B) an estimate of the life-cycle cost for the program, with a detailed breakout of the development cost, program reserves, and an estimate of the annual costs until development is completed;

(C) the schedule for development, including key program milestones;

(D) the plan for mitigating technical, cost, and schedule risks identified in accordance with subsection (b)(1)(A); and

(E) the name of the person responsible for making notifications under subsection (d), who shall be an individual whose primary responsibility is overseeing the program.

(3) For the major program for which a Baseline Report has been submitted, subsequent Major Program Annual Reports shall describe any changes to the

information that had been provided in the Baseline Report, and the reasons for those changes.

(d)(1) The individual identified under subsection (c)(2)(E) shall immediately notify the Under Secretary any time that individual has reasonable cause to believe that, for the major program for which he or she is responsible, the development cost of the program has exceeded the estimate provided in the Baseline Report of the program by 20 percent or more.

(2) Not later than 30 days after the notification required under paragraph (1), the individual identified under subsection (c)(2)(E) shall transmit to the Under Secretary a written notification explaining the reasons for the change in the cost of the program for which notification was provided under paragraph (1).

(3) Not later than 15 days after the Under Secretary receives a written notification under paragraph (2), the Under Secretary shall transmit the notification to the appropriate congressional committees.

(e) Not later than 30 days after receiving a written notification under subsection (d)(2), the Under Secretary shall determine whether the development cost of the program has exceeded the estimate provided in the Baseline Report of the program by 20 percent or more. If the determination is affirmative, the Under Secretary shall—

(1) transmit to the appropriate congressional committees, not later than 15 days after making the determination, a report that includes—

(A) a description of the increase in cost and a detailed explanation for the increase;

(B) a description of actions taken or proposed to be taken in response to the cost increase; and

(C) a description of any impacts the cost increase, or the actions described under subparagraph (B), will have on any other program within NOAA; and

(2) if the Under Secretary intends to continue with the program, promptly initiate an analysis of the program, which shall include, at a minimum—

(A) the projected cost and schedule for completing the program if current requirements of the program are not modified;

(B) the projected cost and the schedule for completing the program after instituting the actions described under paragraph (1)(B); and

(C) a description of, and the projected cost and schedule for, a broad range of alternatives to the program.

(f) NOAA shall complete an analysis initiated under paragraph (e)(2) not later than 6 months after the Under Secretary makes a determination under subsection (e). The Under Secretary shall transmit the analysis to the appropriate congressional committees not later than 30 days after its completion.

APPENDIX C: SIGNED KEY DECISION POINT C DOCUMENT

November 17, 2021

National Oceanic and Atmospheric Administration (NOAA) and National Aeronautics and Space Administration (NASA) Agency Program Management Council (APMC)
Space Weather Follow-On (SWFO) Key Decision Point C
Decision Memorandum

Summary: The joint National Oceanic and Atmospheric Administration (NOAA)/National Aeronautics and Space Administration (NASA) Agency Program Management Council (APMC) met on November 17, 2021 and evaluated the readiness of the Space Weather Follow-On (SWFO) Program to proceed to Phase C of its life cycle as defined in NASA Procedural Requirements (NPR) 7120.5: *Space Flight Program and Project Management Requirements* and the *NOAA-NASA Satellite Programs and Projects Management Control Plan* (MCP).

The APMC considered the recommendations of the Goddard Space Flight Center/ National Environmental Satellite, Data and Information Service (NESDIS) Center Management Council (CMC), and the Joint NOAA/NESDIS and NASA/SMD Program Management Council (DPMC). A joint CMC/DPMC KPD-C Review of the SWFO Mission was conducted on November 9, 2021. The APMC also considered the findings of the SWFO Standing Review Board (SRB) and the Aerospace Corporation Independent Assessment. This APMC determined the SWFO readiness to proceed with a recommendation of the baseline cost and schedule commitments to the Deputy Secretary of Commerce in accordance with the Department of Commerce milestone process.

Decision:
Based on this APMC review, the program readiness documents, and the recommendation of the CMC/ DPMC, the co-chairs and decision authority hereby recommend to the Deputy Secretary of Commerce that the program be approved to enter Phase C with the cost and schedule provided in Tables 1 and 2 below.

Table 1: KDP C Cost ($M) and Schedule Baseline Commitments

	KDP-C Management Agreement (MA)	KDP-C Agency Baseline Commitment (ABC)
Development Cost (Phases C&D)	388.8	388.8
Program Lifecycle Cost (Phases A-F)	692.8	692.8**
Key Schedule Milestone - LRD*	2/2025	2/2025
Years/Months of Prime Operation	60 Months	60 months
Joint Confidence Level Cost & Schedule	≥60%	≥60%**

November 17, 2021

National Oceanic and Atmospheric Administration (NOAA) and National Aeronautics and Space Administration (NASA) Agency Program Management Council (APMC)
Space Weather Follow-On (SWFO) Key Decision Point C
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Table 2: Estimated NOA Phasing through Phase E ($M)

	Prior Years	FY-21	FY-22	FY-23	FY-24	FY-25	FY-26	FY27	CTC	Total
KDP-C Management Agreement (MA)	105.7	108.1	146.9	136.2	97.2	41.2	22.3	21.8	13.4	692.8
Agency Baseline Commitment (ABC)	105.7	108.1	146.9	136.2	97.2	41.2	22.3	21.8	13.4	692.8**

*The SWFO-L1 Launch Commitment Date is linked to the launch date of the Interstellar Mapping and Acceleration Probe (IMAP) which is no earlier than 2/2025.
**SWFO has sufficient funding reserves, per NASA guidelines, to be ready for launch in February 2025. Funding risk is during Phase E, with risk mitigations documented and approved by NESDIS leadership via the Sponsor Commitment Letter signed September 26, 2021.

Concurrence:

Elsayed R. Talaat — Digitally signed by Elsayed R. Talaat Date: 2021.11.18 08:51:32 -05'00'

NOAA: Date
Director
Office of Projects, Planning, and Analysis

DENNIS ANDRUCYK — Digitally signed by DENNIS ANDRUCYK Date: 2021.12.01 13:30:47 -05'00'

NASA: Date
Director,
Goddard Space Flight Center

Stephen Volz 11/19/2021

NOAA: Date
Assistant Administrator,
National Environmental Satellite, Data and Information Service

Sandra Connelly — Digitally signed by Sandra Connelly Date: 2021.12.03 17:22:43 -05'00'

NASA: Date
Deputy Associate Administrator,
Science Mission Directorate

November 17, 2021

National Oceanic and Atmospheric Administration (NOAA) and National Aeronautics and Space Administration (NASA) Agency Program Management Council (APMC)
Space Weather Follow-On (SWFO) Key Decision Point C
Decision Memorandum

Approval:

NOAA: Date
Under Secretary of Commerce for Oceans and Atmosphere

APPENDIX D: MILESTONE 2/3 DECISION MEMORANDUM

THE DEPUTY SECRETARY OF COMMERCE
Washington, D.C. 20230

NOV 19 2019

MEMORANDUM FOR DR. NEIL JACOBS, ASSISTANT SECRETARY OF COMMERCE FOR ENVIRONMENTAL OBSERVATION AND PREDICTION, PERFORMING THE DUTIES OF UNDER SECRETARY OF COMMERCE FOR OCEANS AND ATMOSPHERE

FROM: Karen Dunn Kelley
Deputy Secretary of Commerce

SUBJECT: Milestone Decision Memorandum (MDM) Approval of Milestone 2/3 for the Space Weather Follow-On Program

The National Oceanographic and Atmospheric Administration (NOAA)/National Environmental Satellite, Data, and Information Service (NESDIS) presented the Space Weather Follow On (SWFO) Program to the Milestone Review Board (MRB) for Milestone 2/3 approval. The MRB Executive Secretary held an Integrated Product Team (IPT) review of the program. This Milestone Decision Memorandum (MDM) sets out my expectations for officials at NOAA for the SWFO Program.

The Program's presentation to the IPT highlights the criticality of the SWFO program schedule in order to maintain the continuity of space weather data. Existing space weather satellite programs – such as ACE, DSCOVR, and SOHO – are well past their mission design life and are projected to be completely operationally inactive by 2026. In order to meet the L1 rideshare opportunity with NASA's Interstellar Mapping and Acceleration Probe (IMAP), the completed SWFO-L1 Space Vehicle (SV) must be delivered for launch integration by April 1, 2024.

To meet this aggressive program schedule requires expedient contract actions, in particular for the L1 Spacecraft bus, as well as adequate funding to execute the program on a compressed schedule. Since Fiscal Year (FY) 2020 and FY 2021 budget appropriations are not yet enacted, this remains a risk. Therefore, prior to Spacecraft contract award, I direct NOAA to provide the MRB Secretariat an L1 schedule assessment that meets the program rideshare commitment, and a plan that demonstrates the assurance of funding availability necessary to meet this schedule. This plan should account for the possibility of a continuing resolution during the first quarter of FY 2021 and identify how NOAA and the program would respond to maintain the schedule.

In May 2019, the Acquisition Review Board (ARB) provided conditional approval for SWFO to release the SWFO-L1 instrument Request for Proposals. The IPT's review and findings support the previous ARB's approval. Successful MS 2/3 approval constitutes final ARB approval per the Department's combined review structure.

The MS2/3 approval establishes the Department's program baseline, summarized below in Table-1. The program shall report execution against the program baseline in the prescribed Office of Acquisition Management format on an annual basis each January, incorporating the cost, schedule and cost performance data from the previous fiscal year.

SWFO Program Resource Baseline

Prior Year	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	Total
$ 41.7	$ 38.6	$ 108.1	$ 146.9	$ 136.2	$ 97.2	$ 41.2	$ 22.3	$ 21.8	$ 19.7	$ 19.1	$ 692.8

Table-1

In my capacity as Milestone Decision Authority (MDA) for the Department, I approve Milestone 2/3 for the SWFO Program, subject to the above direction.

cc: SWFO MRB Members