SPACE WEATHER RESEARCH-TO-OPERATIONS AND OPERATIONS-TO-RESEARCH FRAMEWORK

Product of the

SPACE WEATHER OPERATIONS,

RESEARCH, & MITIGATION SUBCOMMITTEE

COMMITTEE ON HOMELAND & NATIONAL SECURITY

of the

NATIONAL SCIENCE & TECHNOLOGY COUNCIL

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About the Space Weather Operations, Research, and Subcommittee

The Space Weather Operations, Research, and Mitigation (SWORM) Subcommittee is organized under NSTC Committee on Homeland and National Security. The SWORM Subcommittee seeks to coordinate Federal Government departments and agencies to enhance national capabilities in promoting resilience to the effects of space weather.

About this Document

This document was developed by the SWORM Subcommittee in response to the National Space Weather Strategy and Action Plan, Action 2.7: Identify mechanisms for sustaining and transitioning models and observational capabilities from research to operations. This document was reviewed and published by OSTP. The National Space Weather Strategy and Action Plan was developed by the SWORM subcommittee with public input through Federal Register 83 FR 17526, the National Security Council, and the National Space Council, and published in March 2019.

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Response to Action 2.7 of the 2019 National Space Weather Strategy and Action Plan
National Science and Technology Council
Space Weather Operations, Research, and Mitigation Subcommittee

Action 2.7 Identify mechanisms for sustaining and transitioning models and observational capabilities from research to operations. Transitioning models from research to operations and leveraging operations to identify gaps in research is critical to improving operational space weather forecasts and services. Mechanisms for completing this action should include leveraging existing capabilities and centers, such as the DOC Space Weather Prediction Center, NASA Community Coordinated Modeling Center, or the Joint Center for Satellite Data Assimilation, or creating a more formal framework to enhance and accelerate the transition from research to operations, including academic, private sector, and international partnerships, where appropriate. [Ongoing; DOC, DOD, DOS, NASA, and NSF]

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1. INTRODUCTION

The absence of a formal interagency framework for space weather research-to-operations and operations-to-research (R2O2R) was identified by the Space Weather Operations, Research, and Mitigation (SWORM) Subcommittee, composed of 34 Federal agencies, as a critical gap in the Nation's ability to improve space weather forecasts and warnings. To close the gap, the Promoting Research and Observations of Space Weather to Improve the Forecasting of Tomorrow (PROSWIFT) Act (Public Law No: 116-181, Oct 2020) directs federal agencies to develop formal mechanisms to transition space weather research models and capabilities to operations. This Framework provides a formal interagency structure to ensure an effective space weather R2O2R process. The foundational components of a cross-organizational structure existed prior, but lacked the formality to fully incorporate the contributions from Federal departments and agencies (agencies), academic institutions, commercial enterprise, and international partners. This document describes the organizing Framework required to leverage talents and resources of the space weather enterprise to accelerate and enhance the research-to-operations (R2O) and enhance operations-to-research (O2R) processes. Furthermore, this Framework is in response, in part, to directives from Executive Order 13744; the FY2021 Administration Research and Development Budget Priorities memo; the 2019 National Space Weather Strategy and Action Plan (NSW-SAP) Action 2.7, and the PROSWIFT Act. Initially led by the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA), this effort connects and organizes existing R2O2R elements into a comprehensive Framework. The Framework leverages organizational strengths to form the Space Weather Proving Grounds. Entities comprising the Space Weather Proving Grounds conduct validation and demonstration of advanced operations, services, and science and technology capabilities that address user needs. Successful validation demonstrates readiness to implement these services and capabilities into operations. Though NOAA and NASA initially led this effort, the Framework will expand to include the National Science Foundation (NSF), Department of Defense (DOD), United States Geological Survey (USGS), and potentially other Federal agencies as partners; academic institutions, the commercial space weather enterprise, and end-users, as it evolves. Implementation of this framework is subject to the availability of appropriations. Any commitment of Federal resources to support the activities outlined in the Framework will be determined through the Federal department and agency budget process.

2. PURPOSE

Initially, NOAA and NASA will lead the Framework initiative to foster the collaborative transition of new and/or updated space weather capabilities from a variety of sources to include academia and commercial enterprises, into operations such that:

- Capabilities are efficiently transitioned from research-to-operations (R2O);
- Forecasters and other operators engage in capability evaluation and testing, and share data and knowledge with researchers, providing feedback from operations-to-research (O2R); and
- Specific, controlled, operational experiments determine the efficacy and impact of new or updated capabilities and potential future capabilities.

3. BACKGROUND

In July 2014, the Office of Management and Budget (OMB), the Office of Science and Technology Policy (OSTP), the National Security Council (NSC), NOAA, NASA, NSF, DOD, and USGS held a meeting to address space weather R2O2R at the Eisenhower Executive Office Building in Washington D.C. This meeting was the first of several important activities at the Executive Office of the President (EOP) to address gaps in space weather R2O2R. Additional EOP-led efforts included:

- **October 2015**: Actions 5.6.1 and 5.6.2 in the 2015 *National Space Weather Action Plan* are specifically directed at R2O and O2R. Action 5.6.2 states: “The DOC and DOD, in collaboration with NASA and NSF, will develop a plan (which may include a center) that will ensure the improvement, testing, and maintenance of operational forecasting models.
- **October 2016**: Executive Order 13744 - *Coordinating Efforts To Prepare the Nation for Space Weather Events*, directed the Department of Commerce to ensure continuous improvement of operational space weather services, utilizing partnerships, as appropriate, with the research community, including academia and the private sector, and relevant agencies to develop, validate, test, and transition space weather observation platforms and models from research to operations and from operations to research.”
- **January 2017**: Draft document - “*Improving the Space Weather Forecasting Research to Operations – Operations to Research Capability*” by the Space Weather Operations, Research, and Mitigation (SWORM) Subcommittee of the National Science and Technology Council (NSTC), was entered on the Federal Register for public comment. A final document was never released publicly.
- **March 2019**: Action 2.7 in the 2019 *National Space Weather Strategy and Action Plan* directs DOC, DOD, DOS, NASA, and NSF to identify “mechanisms for sustaining and transitioning models and observational capabilities from research to operations.”
- **May 2019**: NASA Headquarters’s Heliophysics Division (HPD) developed a top level R2O strategy for the new applied sciences-focused Space Weather Science Application (SWxSA) initiative. NOAA and the Air Force Research Laboratory (AFRL) participated in

NASA's development of the strategy titled, "*Recommendation for the NASA Space Weather Science and Applications (SWxSA) Research-to-Operations Strategy*."

- **August 2019:** A meeting was held at NASA Goddard Space Flight Center between NOAA, NASA, and representatives from OMB, OSTP, NSC, and the Federal Aviation Administration (FAA) to initiate a focused effort to define a NOAA-NASA led R2O2R Framework.
- **October 2020:** The President signed the Promoting Research and Observations of Space Weather to Improve the Forecasting of Tomorrow (PROSWIFT) Act into law (PL: 116-181). The PROSWIFT Act calls for the SWORM to develop formal mechanisms for R2O2R.

Tenets for Success

The following tenets for improving R2O-O2R capabilities were identified during an August 2016 O2R workshop held in Boulder, Colorado to explore options and gather input from academia, private enterprise, and space weather customers:

- **Keep R2O and O2R coupled:** The R2O and O2R tasks and activities are highly coupled and should be managed as two components of a continuous process that has the primary goal of improving space weather forecasts and services. NOAA hosts an annual R2O-O2R workshop, in coordination with the United States Air Force (USAF), NASA, and NSF, to provide progress updates and receive feedback from the broader space weather community.
- **Engage end-users, agencies, and collaborators:** Communication and collaboration between Federal departments and agencies, academia, commercial enterprise, customers, and international organizations are critical to ensure continued progress.
- **Encourage open source:** Open-source and community-developed models are necessary to provide the flexibility required for operational model development and maintenance. These types of models allow the operational space weather forecasting community to tap into the intellectual power of the broader space physics research community to improve space weather forecasting capabilities.
- **Identify and address opportunities for applied research:** Opportunities exist to strengthen the connection between fundamental research and the needs and requirements of the operational space weather community. Applying the results from fundamental research to address operational needs and requirements could improve hazard assessments and space weather forecasting that enhance national preparedness. Federal departments and agencies should identify and develop such applied opportunities.

4. GOVERNANCE

NOAA, NASA, DOD, and NSF are partners in the Framework and provide primary, long-term support, both financial and in-kind. Governance of interagency partnership activities is provided

by an Executive Board and an R2O2R Steering Committee. These activities will be agreed upon by the Executive Board and formalized in a Memorandum of Understanding (MOU).

The Executive Board is comprised of senior-level officials (Senior Executive Service, GS-15, or equivalent) from each of the participating agencies. The Executive Board provides strategic guidance to advance the SWORM implementation of R2O2R actions in the NSW-SAP, and ensures that R2O2R decisions are congruent to agency policies, rules, and guidelines for their respective agencies.

The Executive Board performs the following functions:

- Evaluates recommendations of the R2O2R Steering Committee and champions common strategic alignment among and within the agencies;
- Provides oversight for review and selection of incoming proposed tests and evaluations;
- Advises on the scope and priority of activities in view of strategic considerations, including funding availability, resource commitment, partnerships, and other factors that could affect viability; and
- Accounts for the execution of the R2O2R Framework.

The R2O2R Steering Committee will write a new MOU that encompasses the scope of the existing 2018 NASA-NSF-NOAA MOU for O2R Collaboration, includes the Department of the Air Force (DAF), and implements this R2O2R Framework.

The R2O2R Steering Committee supports the Executive Board and is comprised of personnel from each agency who serve as “Principal Representatives.” These Principal Representatives are federal employees who have program management and or oversight responsibilities within their agency. Under that agreement, the Principal Representatives develop the focus of solicitations for the O2R NASA Research Opportunities in Space and Earth Sciences (ROSES) on an annual or biannual basis. The Executive Secretary of the R2O2R Steering Committee will coordinate communication between this committee and the PROSWIFT-directed Space Weather Advisory Group (SWAG) as appropriate. As mandated by the PROSWIFT Act, the SWAG includes representatives from the academia, commercial space weather sector, and end-user community. NASA HPD manages the submission, review, and funding of solicited proposals. The R2O2R steering committee will coordinate with the NSW-SAP 2.3 and 2.5 activities as appropriate.

Within the R2O2R Framework, the R2O2R Steering Committee adds the following functions:

- Recommends capabilities for Proving Grounds validation and demonstration;
- Conducts annual reviews of accomplishments and plans for the Framework;
- Ensures that R2O and O2R are part of a single, continuous process
- Makes recommendations regarding R2O2R processes; and
- Consults with non-government advisors for the purpose of ensuring that the O2R ROSES solicitations are meeting the needs of the operations centers, and the Framework processes are effective in leveraging the research community capabilities.

5. FRAMEWORK COMPONENTS

Both NASA and NOAA Space Weather R2O2R processes are executed within the Framework. The new Space Weather Proving Grounds, which includes a new Space Weather Prediction Testbed (SWPT), enhances existing processes that govern R2O2R. The structure of the R2O2R Framework follows that of a funnel: Larger at the 'top' where basic and applied research are conducted and narrower at the 'bottom' where selected work with the most impact is transitioned into operations, see Figure 1 below.

The Framework funnel begins with the basic and applied space weather research contributions of institutions that include Federal agencies, academic institutions, and commercial enterprises. The Space Weather Proving Grounds umbrella provides an ensemble of well-aligned entities facilitating the path from research to operations. The Space Weather Prediction Center (SWPC) and the USAF 557th Weather Wing (557 WW) continue as the civilian and military operations centers, respectively, and provide critical O2R information back to the Proving Grounds and Research components. The roles of CCMC, SWPC, the 2018 NASA-NSF-NOAA MOU, and the Proving Grounds are described in further detail below.

NASA-NSF-NOAA MOU for Operations-to-Research Collaboration

The purpose of the 2018 MOU is to encourage and support interaction among NASA, NSF, and NOAA that will advance the Nation's space weather research and operations capabilities. For the purposes of this MOU, O2R includes the space weather community working to upgrade and enhance: (1) existing operational models and products, (2) the communication of operational priorities and capabilities to the research community, (3) the testing and evaluation of operational model performance by researchers for fundamental scientific discovery and for improved operational services, and (4) the identification of gaps in the fundamental understanding of the physical system that impede operational capabilities. This MOU is intended to provide a structure through which NASA, NSF, and NOAA can coordinate research activities in support of targeted space weather needs.

Space Weather Science Application (SWxSA) Initiative

To fulfill NASA's responsibility delineated by the SWORM NSW-SAP and in the PROSWIFT Act, NASA has established the Heliophysics SWxSA initiative and developed a NASA Space Weather Strategy. Included in SWxSA is the annual NASA ROSES Research to Operations to Research (SWR2O2R) solicitation in order to advance and coordinate the Nation's space weather research and operations capabilities. The primary goal of these solicitations is to support research by the grant recipient to improve numerical models and/or data utilization and observation techniques that could advance specification and/or now/forecasting capabilities and that could also lead to an improved scientific understanding of space weather. Effective utilization of the available data is encouraged. Representatives of NASA, NSF, DOD, and NOAA regularly meet to discuss research topics for upcoming NASA Research Announcements.

Space Weather Proving Grounds

Space Weather Proving Grounds is an umbrella term describing the activities by the various focal organizations in NOAA, NASA, DAF, NSF, and other entities that specialize in different domains of space weather and/or various aspects of the transition to operations and applied and use-inspired research. Encouraging engagement from multiple entities has the benefit of adding diversity to the transition process. The Framework provides guiding principles for the Proving Grounds such that their objectives and goals are highly aligned, even if the entities themselves are not closely coupled administratively.

The first of these Proving Grounds is the Architecture for Collaborative Evaluation (ACE) shared computing environment at CCMC and the SWPT at SWPC.

Community Coordinated Modeling Center (CCMC)

NASA's CCMC is a highly utilized component of the space science and space weather enterprise. CCMC hosts an ever-expanding repository of space weather models developed by the research community, including academia, the private sector, and international partners. Space weather models and applications hosted at the CCMC include deliverables from major space weather programs such as Living With a Star (LWS) and SwxSA R2O2R as well as research supported by the NSF.

The CCMC currently maintains accessibility to hosted models through web-based simulation services such as runs on request for time intervals of interest and continuous simulations. The CCMC performs unbiased testing and validation of hosted models, so their model utility can be evaluated for potential transition to operations. CCMC enables collaborative evaluation initiatives including defining metrics and benchmarks for space weather applications and developing a process to trace progress over time. The CCMC maintains interactive archives of model evaluation results to facilitate the selection of models for R2O transition. The CCMC also works with model developers on improving model performance, operational readiness, portability, and ease of upgrades. In partnership with model developers, the CCMC maintains a flexible computational infrastructure and facilitates collaborative development, model coupling and community-wide ensemble modeling. The CCMC provides a portal for ingesting state-of-the-art space-weather science and modeling into the Research to Operations pipeline.

Space Weather Prediction Center (SWPC)

NOAA's SWPC, located in Boulder, CO, provides impact-based decision support services through timely and accurate operational space weather forecasts, watches, warnings, alerts, and real-time space weather monitoring for the Federal government, civilian, and commercial sectors, exclusive of the responsibilities of the Secretary of Defense. SWPC ensures continuous improvement of operational space weather services, utilizing partnerships, as appropriate, with the research community, including academia and the private sector, and relevant agencies to develop, validate, test, and transition new technologies, observation platforms, and models from research-to-operations and from operations-to-research. SWPC provides the research

community with operational needs, including information on model and tool performance, observation gaps, and other areas for improvement.

NESDIS Space Weather Program

NOAA's National Environmental Satellite, Data, and Information Service (NESDIS) provides continuous and timely access to space weather data from satellites, critical to SWPC's suite of space weather warnings and alerts. NESDIS is developing the next generation of space-based observations to continue and improve space weather predictive capability. Synergy with the SWPT is critical in evaluating the impact of potential new measurements, developing new products from future observations and enhancing existing products from the collective space weather constellation. This includes the insight and feedback to the observational strategies that will be gained as models mature and increasingly incorporate data assimilation.

CCMC-SWPC Architecture for Collaborative Evaluation (ACE)

The Architecture for Collaborative Evaluation refers to the information technology infrastructure, such as a cloud computing environment, local computing environments, data flow, and user interfaces, used to evaluate forecast capabilities. These computing environments are configured to be as similar to the NOAA operational systems as is reasonably possible. This similarity allows researchers and developers to modify codes for models, observational products, and applications to run quasi-operationally. When a capability is selected by the executives for inclusion into the Architecture Proving Ground, the Architecture staff will help facilitate the transition of the capability in the operations-like architecture and then perform validation and performance studies. A portion of the architecture is cloud-based and shared among NASA, NOAA, and other organizations participating in R2O2R activities. Having a cloud component makes access much easier by researchers and other Proving Grounds centers compared to a fixed hardware environment. Thus, the SWPT (below) can interface directly with the Architecture to support operational evaluation once initial performance and validation have been completed.

Space Weather Prediction Testbed (SWPT)

The SWPT provides a conceptual framework to foster collaboration between researchers, developers, forecasters, and customers to test and evaluate emerging technologies and science for operations. The SWPT has its heritage in a wide array of NOAA testbeds. As defined in NOAA Administrative Order 216-105B:

> *A NOAA testbed is a working relationship for developmental testing in a quasi--operational framework among researchers and operational scientists/experts (such as measurement specialists, forecasters, IT specialists) including partners in academia, the private sector, and government agencies aimed at solving operational problems or enhancing operations, in the context of user needs. A successful testbed involves physical assets as well as substantial commitments and partnerships.*

In the Testbed, stakeholders participate in collaborative exercises and experiments using new capabilities under quasi-operational conditions. Evaluations of the capabilities are conducted in either an on-going, real-time manner, and/or an event-based, retrospective manner. The impact on users will be evaluated during live exercises or experiments with participation by forecasters, end-users, and researchers. Providing a physical facility allows operators and researchers to communicate directly and in real-time while gaining experience with new capabilities. The SWPT is co-located with SWPC in Boulder, Colorado and uses both local computing and shared computing facilities to run applications for experiments.

For NOAA-funded research and development activities, NOAA Administrative Order 216-105B establishes the process for identifying, transitioning, and coordinating Research and Development (R&D) output to operations, applications, commercialization, and other uses. Within the National Weather Service (NWS), the policy for transition of research and development projects to operations is described in NWS Policy Directive 80-8. NOAA and NWS's processes for the transition of space weather R2O2R adhere to these policies and this Framework provides a supplement to more specifically describe the interagency relationships that support R2O2R.

Rotational Assignments

The success of the Framework depends on the ease with which ideas and information can be exchanged between participants. To that end, NASA and NOAA may establish an agreement that supports both short-term invitational travel and longer-term details between NOAA and NASA.

In the case of long-term details, an employee may be detailed to the Requesting Agency on a non-reimbursable basis. The duties of the detailee will primarily focus on strengthening ties between NOAA and NASA in the area of space weather technology transfer. Specific activities of each detail will be negotiated between NOAA and NASA executives and result in a signed task statement.

6. TRANSITION PROCESS

The Framework coordinates efforts among the following existing and planned elements of the R2O2R enterprise. The high-level depiction of the transition cycle steps is shown in Figure 1 and is consistent with NSW-SAP 2.7.

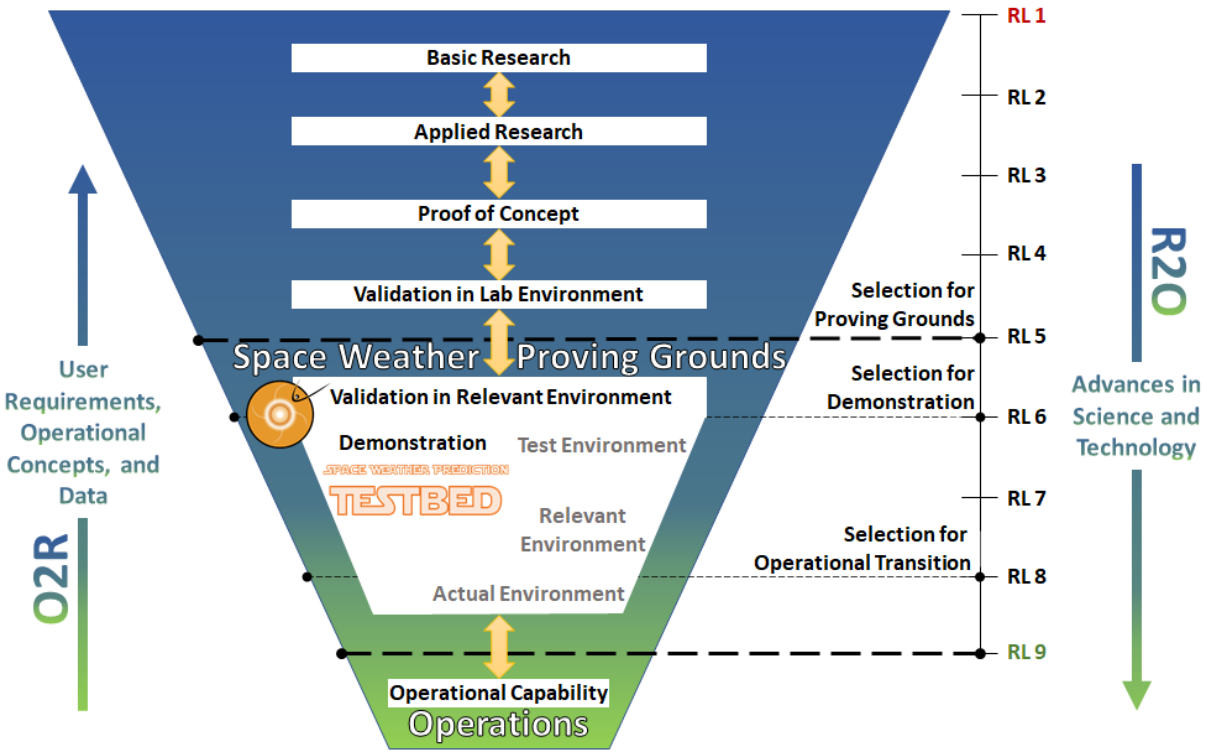

Figure 1: Research to Operations to Research Process (NOAA Example)

RL	NAO 216-105A Definition (Dec 2015)	Simple Definition
1	Basic research: experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view. Basic research can be oriented or directed towards some broad fields of general interest, with the explicit goal of a range of future applications.	Basic principles have been observed and reported.
2	Applied research: original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective. Applied research is undertaken either to determine possible uses for the findings of basic research or to determine new methods or ways of achieving specific and predetermined objectives.	Technology concept and/or application have been identified and formulated.
3	Proof-of-concept for system, process, product, service or tool; this can be considered an early phase of experimental development; feasibility studies may be included.	Analytical and experimental critical function and/or characteristic proof of concept.
4	Successful evaluation of system, subsystem, process, product, service or tool in laboratory or other experimental environment; this can be considered an intermediate phase of development.	Component/subsystem **validation** in laboratory environment.
5	Successful evaluation of system, subsystem process, product, service or tool in relevant environment through testing and prototyping; this can be considered the final stage of development before demonstration begins.	System/subsystem/component **validation** in relevant environment.
6	Demonstration of prototype system, subsystem, process, product, service or tool in relevant or test environment (potential demonstrated).	System/subsystem model or prototyping **demonstration** in a relevant end-to-end environment
7	Prototype system, process, product, service or tool demonstrated in an operational or other relevant environment (functionality demonstrated in near-real world environment; subsystem components fully integrated into system).	System prototyping **demonstration** in an operational environment
8	Finalized system, process, product, service or tool tested, and shown to operate or function as expected within the user's environment; user training and documentation completed; operator or user approval given.	Actual system completed and "mission qualified" through test and **demonstration** in operational environment
9	System, process, product, service or tool deployed and used routinely.	Actual system "mission proven" through successful mission operations.

Table 1: NOAA Readiness Levels

The technical maturity of the capability under consideration is central to the initiation of the transition process as well as the social, behavioral, decision and user experience research which will be integrated into development and evaluation activities to better understand the information needs of decision-makers, as well as the information needs of operational forecasters. The Space Weather R2O2R Framework defines maturity in terms of NOAA Readiness Levels (RLs) defined in NOAA Administrative Order 216-105B (See Table 1). This establishes a common language and definitions that are essential to success.

The steps to mature a capability from RL1 to RL9 within the Space Weather R2O2R Framework are:

1. The R2O2R Steering Committee coordinates with the SWORM's biennial prioritization of research and development as outlined in NSW-SAP 2.3.1. The key goal of this step is to identify operational capability gaps by connecting end-users and researchers. Connections can be established in dedicated workshops, conferences or via direct individual contacts and site visits. Communications can also be facilitated by dedicated application area-focused working groups that have representatives. These activities apply primarily to Readiness Levels 1-3 and are consistent with NSW-SAP 2.3.1:

   > *NSF and NASA, in collaboration with DOC, DOI, and DOD, will lead a biennial effort to prioritize and identify opportunities for research and development (R&D) to enhance the understanding of space weather and its sources.*

2. The R2O2R Steering Committee identifies research opportunities to be offered through the NASA ROSES process. The priorities from step 1 are considered and refined by continuous engagement with end-users and researchers. The ROSES opportunities apply to RLs between 2 and 5 and are carried out by NASA under the SWxSA program. This effort is covered by the NOAA, NASA, and NSF tri-agency MOU and is consistent with NSW-SAP 2.5.5:

   > *NSF and NASA, in coordination with DOC, DOD, and DOI, will identify and support targeted basic and applied research opportunities that seek to advance solar and geospace models with the goal of improving space weather predictions.*

3. The R2O2R Steering Committee provides recommendations regarding capabilities at RL 5 that should proceed into evaluation within the Proving Grounds based on functional, performance, and readiness level characterization. In most cases capabilities will proceed first to validation at the CCMC. Capabilities under consideration may result from the NASA R2O2R ROSES awards, Small Business Innovation Research awards, NSF research awards which support work at RL1-3, or independent research from academia, commercial interests, or government research centers. CCMC evaluation efforts will be supported through the SWxSA program.

4. The R2O2R Steering Committee provides recommendations regarding capabilities at RL 6 that should proceed to further evaluation within the Space Weather Prediction

Testbed. These more mature capabilities may result from CCMC evaluation or may be other observational or application capabilities. At the Testbed, these capabilities will undergo real-time, event-driven, and/or demonstration ("experiment") activities with the full participation of the capability providers, forecasters, and operational users.

5. The R2O2R Steering Committee provides recommendations regarding capabilities at RL 8 that proceed to transition to operations at NOAA and/or the DAF.

6. The R2O2R Steering Committee compiles information at all stages of the R2O2R cycle. Information on operational needs is gathered from stakeholders during Testbed trials and experiments, conferences, or targeted workshops.

New capabilities are hosted by the Testbed only for a prescribed period of time to enable the aforementioned activities – not indefinitely. At the end of the hosting period, the Executive Board will conduct an impact review meeting and recommend whether or not the capability will transition into operations.

The endpoint of the R2O2R process (Figure 1) is a new or improved operational capability. However, once a new or improved product is in operations, it will require: continuous validation; minor improvements; changes to adapt to operational computer hardware updates; forecaster and user training; new ways to display and present the model or service results to make them more effective; continuous support of model developers; and analysis and identification needs for future model or service improvement. A successful R2O2R process requires support for all of these activities, in addition to those that bring the new or improved operational capability into operations.

Participation of partners and stakeholders with a vested interest in successful outcomes from the Testbed and Proving Grounds is critical to the success of this process. The planning, preparing, conducting, and follow-up activities in the Testbed and Proving Grounds require personnel and resources through "core" funding (e.g., NOAA operations and maintenance support for Testbed; NASA support for CCMC), and acquired for "project" funding as appropriate. The core funding establishes a long-term foundation and capability, while project funding leverages this foundation and delivers on specific tasks for the project sponsors, enabling improvements to models, observations, and other resources particular to the sponsor, to the various industry sectors, and to the Federal government.