

Draft Space Weather Prediction Testbed Concept of Operations

1. Overview

The Space Weather Prediction Center (SWPC) has formed the Space Weather Prediction Testbed (SWPT) to transfer new research and technology into operational space weather products and services. The SWPT will serve as a link between the operational, research, and commercial communities, both to facilitate the use of new developments in operations and to focus research effort on operational needs. This facility will initially be located at SWPC in NOAA's David Skaggs Research Center in Boulder, Colorado, but could later move to another partner facility. This location will facilitate close interaction with: 1. the SWPC operational space weather forecasters; 2. the Air Force Weather Agency and Air Force Research Laboratory through the Air Force liaison at SWPC; 3. and our academic, commercial, research, interagency, and international partners through the activities of the SWPC research staff and the Space Weather Prediction Testbed Interest Group.

2. Background

In 2008, SWPC announced to the operational, research, and commercial communities its intention to form a testbed to transfer new research and technology into operational space weather forecasting. To investigate the possible organizational structures and external interactions of a space weather testbed, the Air Force Weather Agency funded a study by the National Center for Atmospheric Research (NCAR). This study resulted in a draft Concept of Operations, a sample Model Test Plan, and a demonstration project involving the installation and testing of a research model on NOAA supercomputers.

The strong interest among the research and commercial communities also led to extensive discussions and open meetings to explore issues and concerns regarding the formation and functioning of a space weather testbed. Through these discussions, community recommendations were documented that capture important aspects of how a testbed should function, both internally and externally. The identified issues include: intellectual property rights, support for external model developers, public access to assessment metrics, and ensuring adequate scientific advice. The Concept of Operations for the SWPT described in this document has benefited greatly from the recommendations provided by the research and commercial communities.

3. Mission Statement

The mission of the Space Weather Prediction Testbed is to identify, investigate, and shepherd new modeling capabilities, research results, and observational advances to improve SWPC forecasts, products, and services.

4. Implementation Functions

The SWPT mission will be accomplished by performing the following functions:

- maintain awareness of scientific advances and new techniques being developed to identify improved, real-time, data-analysis techniques, forecast models, and observational systems that have potential for significantly improving the forecast guidance provided to space weather forecasters;
- conduct focused research and develop improved, real-time, data-analysis techniques, forecast models, and observational systems that have potential for significantly improving the forecast guidance provided to space weather forecasters;
- implement promising codes emerging from the research community by performing the early steps of testing to demonstrate the potential of new science and technologies for possible use in operations;
- complete tests of the codes, products, and observations in a quasi-operational information-technology environment subject to metrics that mandate good scientific performance while meeting ease-of use criteria and time constraints;
- prepare documentation, training materials, and evaluations of performance characteristics of successful products to facilitate their deployment on operational systems and their use by the Forecast Office;
- communicate internally and externally to maintain fair and open interactions with all stakeholders (operational, research, and commercial) and to stimulate improvements in space weather analysis and forecasting applications;

Final testing, validation, and deployment on operational systems will be the responsibility of the Development and Transition Section. Acceptance of the new product will be the responsibility of, and at the discretion of, the Forecast Office. Long-term maintenance of the new product will then become the responsibility of the Development and Transition Section, with scientific and technical support provided as needed by the SWPT.

A successful project will consist of: 1) a converted research code that, running with an operational data stream on forecast center computers and display systems, is effectively utilized by the operational forecasters to improve products and services; 2) a new observational system with documented evidence of positive diagnostic or forecast impact; or 3) a prediction product leading to better space weather forecasts.

Upon availability of funding for external grants, an annual Announcement of Opportunity (AO) will be used to invite external proposals for SWPT transition projects. The AO will be prepared by the SWPT Director with help from the SWPT Steering Committee. The AO will be open to the U.S. scientific community, including the NOAA Line Offices, federal laboratories, universities, and the private sector. Proposals will be reviewed by the SWPT Steering Committee. The final selection of proposals to be funded will be made by the Space Weather Prediction Center (SWPC) Director. Salaries and expenses to support researcher participation in the transition will then be negotiated. Funded projects then become a SWPT activity.

5. Organization

A. SWPT Director

The SWPT Director shall be a civil servant selected by the SWPC Director. The responsibilities of the SWPT Director are to:

- Identify needed data, forecast applications, and models in conjunction with the SWPC Forecast Office and the SWPT Steering Committee;
- Recommend activities that facilitate the transition of research results and observational systems into improved products and services for operational space weather forecasting;
- Manage and administer the SWPT staff in a manner consistent with agency policies and guidelines;
- Prepare the Annual Operating Plan for transition activities;
- Prepare the Annual Report summarizing yearly activities.

When funding for external support is available:

- Work with the SWPT Steering Committee to prepare an annual AO;
- Conduct a review of the submitted proposals with the Steering Committee and provide recommendations to the SWPC Director for decision;
- Negotiate the needs, milestones, and timelines with the funded principal investigators;
- Coordinate the SWPT staff and external activities to achieve transition schedules.

B. Product Scientists

The SWPT will be staffed by Product Scientists who will be responsible for leading the near-term and far-term evolution and improvement of SWPC's operational products. Product Scientists will manage portfolios containing the operational products in the major space weather domains: Solar/Interplanetary; Magnetosphere/Geomagnetic Activity; and Ionosphere/Atmosphere.

It will be the responsibility of the Product Scientist to:

- Provide scientific leadership to assess the needs and opportunities for product improvements;
- Work closely with the Forecast Office and its Product V&V and Customer Focus Teams to understand the strengths and weaknesses of the current product suite;
- Identify external and internal opportunities for product improvement;
- Test and evaluate new products and improvements to existing products;
- Facilitate the transfer to operations and have overall responsibility for the completion of the associated tasks.

Product Scientists may be permanent staff or long-term contractors. The Product Scientists may rely on off-site researchers from universities, laboratories, or other organizations who are temporarily assigned to the SWPT to work directly and/or remotely on SWPT systems. This group may also include long-term post-doctoral fellows associated with various projects interested in the technology transfer process. Given the nature of SWPT tasks, the successful Product Scientist must have a suitable combination of scientific background, computer coding and display creation skills, knowledge/experience in operations, and an ability to collaborate.

C. Product Specialists

The SWPT will also be staffed by Product Specialists who will assist with the technical aspects of software configuration and maintenance on the SWPT systems. Product Specialists will also have a scientific background in their product area and will be able to assist with product assessment, product design, and the transfer of the software to the operational systems. Product Specialists will have a key role in providing long-term product support after the successful transition to operations. For a given project, the Product Scientist and the Product Specialist will be the core team to insure the efficient transition to operations and long-term continuity for maintenance and on-going support.

It will be the responsibility of the Product Specialist to:

- Assist in the software development to implement the selected codes on quasi-operational and operational systems;
- Assist in the development of quality metrics;
- Assist in the testing of codes, products, and observations;
- Assist in the preparation of documentation, training materials, and evaluations of performance characteristics;
- Provide long-term support as needed after the successful transfer to operations.

Product Specialists may be permanent staff or long-term contractors. As with Project Scientists, the successful Project Specialist must have a suitable combination of scientific background, computer coding and display creation skills, knowledge/experience in operations, and an ability to collaborate.

D. Researchers and their Staff

These include the principal investigators with funded proposals and their support staff.

Responsibilities of external researchers and their staff include the following:

- Coordinate with SWPT staff;
- Complete applied research and transition activities on time, while alerting the SWPT Director of any problems;
- Provide regular (at least semi-annual) reports;
- Aid in setting up system and testing procedure;
- Monitor scientific integrity of tests; and
- Provide documentation and training materials for forecast and maintenance efforts.

E. Steering Committee

The Steering Committee is made up of internally and externally associated researchers, forecasters, and administrators. It advises the SWPT Director on all activities. Members will be individuals from throughout the spectrum of organizations concerned with space weather. The Steering Committee will report regularly to the Space Weather Prediction Testbed Interest Group (SWPTIG).

6. Process and Operations

A. Technology Transfer

Under the direction of the SWPT Director, the Product Scientists and Specialists (employees of the SWPT) serve as links between the internal and external researchers and the SWPC Forecast Office. For funded external projects, there may be a team of external researchers who work closely with the SWPT. External researchers may also be associated with other external locations (e.g., AFWA or the Community Coordinated Modeling Center) that are providing assistance in some specific SWPT task.

The test bed activity can consist of the full range of projects from new observations and empirical applications to new physics-based, data-assimilation models. The Product Scientist and Specialist may create links to new and/or existing data; configure new products from analyses, statistical methods, and numerical forecasts; and convert research code to testable quasi-operational applications. Functional tests of the new capabilities will provide quantitative evaluations of the proposed software for possible operational implementation.

When the functional test has successfully demonstrated a potential positive impact, a decision will be made for a pre-implementation operational test with real-time product generation. This latter testing activity will occur on equipment that closely mimics that in the Forecast Office. The SWPT Director will coordinate with the SWPC staff and Director on hardware requirements and test scheduling. The SWPC Director will determine whether the pre-implementation operational test is successful and whether the project is acceptable for full operational implementation. The researcher's role in preparation for the implementation is to provide case studies and documentation to the Project Scientist at SWPC for training of the forecasters and maintenance personnel. Where appropriate, some continued involvement and funding of external research staff should be anticipated through the completion of pre-implementation operational testing where tuning and adjustment may be required.

Given IT security issues and the unavailability of the operational computing, communication, and display systems for outside use, the SWPT must have a separate dedicated system for transition work that closely matches the characteristics of the operational system. Consequently, some SWPC support personnel are required for maintenance of the SWPT system. All codes must be kept current, and the SWPT staff must have a working knowledge of these codes for answering questions from the researchers and off-site participants. Every transition should attempt to move its code and displays to the target IT infrastructure. In cases where the advances require cutting-edge hardware or software not yet in place at the operational center, support for such enhancement from the SWPT will be considered.

B. SWPT Projects

The SWPT will regularly undertake space weather transition projects to support the goal of improved forecasts. Each project will have a well-defined metric for success and a time line for the transition, which will be coordinated with the SWPT Director prior to project initiation.

Upon acceptance and scheduling of the transition project, SWPT Product Scientists and Specialists will be assigned the task, and one or more point(s) of contact from the Forecast Office will be appointed. Progress toward a functional test will be monitored by the SWPT Director. In addition, if a funded

external researcher is involved, the researcher will be expected to submit regular written progress reports. When the transition has met the agreed-upon metric, the SWPC Director will make the decision for a pre-implementation operational test. When the operationally capable code is demonstrated to provide improved forecast guidance according to the agreed-upon metric and meets the operational constraints, the SWPC Director will make the decision for full operational implementation.

C. Proposal Process

Transitions involving external researchers may be initiated by a proposal and review process. The SWPT proposal process will be fair and unbiased and open to all interested researchers in the U.S. scientific community. The proposal cycle will begin with an informal review by the SWPC and SWPT staff to determine the needs and shortfalls in the Forecast Office. The Steering Committee and SWPC will identify new emerging research and coordinate these opportunities with the SWPT. From the resulting statement of need and opportunities, the SWPT Director and Steering Committee will draft an AO and coordinate it within SWPC. When all groups are satisfied, the AO will then be issued to the community with a specified submission deadline. Instructions for drafting project proposals will be given in the AO. The proposal candidate must provide evidence that research results have sufficient maturity and potential for a positive forecast impact under operational conditions within an agreed upon period (typically one to two years). The Steering Committee may choose to distribute some proposals to external reviewers familiar with research and operational needs. Once the reviews have been returned, the Steering Committee will provide comments on the proposals and rankings to the SWPT and SWPC Directors for their comments and endorsements. Final selection will be made by the SWPC Director.

A separate review procedure will be used for consideration of the second-year proposals prior to opening the new competition via the AO process. Given satisfactory progress on the first year milestones as reflected in the progress reports and the SWPT Director's assessment, the Steering Committee will provide an accelerated review of the second-year milestones, timelines, and budgets as updated by the researchers. Given the Steering Committee endorsement that the second-year proposals should be funded and continued endorsement of the project goals by the SWPT Director, the SWPT Director will submit the funding requests to the SWPC Director for final approval. Having then established the remaining funding for that fiscal year, a new AO is prepared via the process described above. The combined funding needs for the continuing and new projects will be defined in the SWPT operating plan and passed to the SWPC Director.

7. Relationship with External Researchers

A. Intellectual Property Issues

Model developers are concerned about threats to their intellectual property and their professional viability that might arise through model transitions. For example, results from SWPT validations could be published without modeler involvement, SWPT personnel could use their knowledge to compete against the contributing model developers, or conflicts of interest could arise if active or future model developers served in a SWPT role. These concerns can be resolved to a large degree by licensing a model to SWPC in a way that clearly identifies how the model and its results may or may not be used.

B. Concerns About Marginalization of Ongoing Research

There is a clear concern among researchers that selection of a particular model for operational status would effectively anoint it as the chosen model, giving it an advantage in future funding competitions and possibly undermining development of other models. This would be a negative

outcome, not only for the modeling community, but also for the ongoing advancements that are needed by the operational community. The mitigation of this problem will be to establish mechanisms to compare the performance of operational models with other models in the community, with the explicit goal of upgrading operational capability by bringing in more or different models.

C. Public Access to Operational Metrics

Metrics should be established by the SWPT that accurately reflect its needs. Metrics for operational forecasts, and those for forecast products in development, should be made publicly available, as should the data required for model input or to calculate the metrics. This allows model developers and others to compare against the current state-of-art, and will enable the development community to target model improvements to forecast capabilities of established importance.

8. Roles of Other Agencies

A. Community Coordinated Modeling Center (NASA/Goddard)

The Community Coordinated Modeling Center (CCMC) will be an important partner for SWPT, as it can identify numerical models that have potential to meet the needs of space weather forecasters. A close collaboration between the SWPT and the CCMC could facilitate the transfer of models into the pre-operational testing and evaluation phase.

B. Air Force Research Laboratory

As the primary Air Force facility for space weather research, AFRL will be an important source of research on models and techniques that meet DOD needs, complementing the activities of the CCMC. AFRL staff involved in SWPT related activities may spend extended periods of time physically located at SWPT in order to interact with SWPT personnel and visitors. The SWPT may also send personnel to AFRL to learn more about the needs and constraints of their activities.

C. International Partners

A significant number of opportunities are occurring via our international partners. Future space weather models will require data from around the globe, and real-time measurements are increasingly becoming available. In addition, a growing number of international space weather service providers are expanding their products suites, and they are looking to SWPC to partner in many of these efforts. The SWPT will work closely with our international partners through the International Space Environment Services organization, through emerging activities within the World Meteorological Organization, and through our bilateral agreements.