

Report
of the
Assessment Committee
for the
National Space Weather Program

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PREFACE

The space environment around Earth is becoming of ever-increasing importance for the successful operation of commercial, government, and national security infrastructure essential to the Nation. The U.S. National Space Weather Program (NSWP) is a Federal interagency (seven agencies) initiative whose overall objective to speed improvement of space weather services in order to prepare the country to deal with technological vulnerabilities to variable conditions in the Earth's space environment (space weather). Such vulnerabilities are well documented in numerous reports and research papers and were highlighted in the Space Weather Transition Architecture Plan section of the fiscal year (FY) 2000 National Security Space Architecture Report of the U.S. Department of Defense (DOD 2000).

This assessment report responds to actions in FY 2005 of the Federal Committee for Meteorological Services and Supporting Research (FCMSSR) and the Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR), which directed the Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCM) to conduct a comprehensive review of the NSWP. To perform this review and assessment, the Federal Coordinator for Meteorology convened a committee of six individuals with expertise encompassing the science and applications aspects of space weather. The Assessment Committee's findings and recommendations, stemming from its comprehensive review of the NSWP, are reported here.

The Assessment Committee thanks the personnel of the OFCM for outstanding support of its activities. Especially important has been the dedicated service of U.S. Air Force Lt. Col. Robert J. Rizza, who served as the Executive Secretary of the Committee and provided outstanding professional advice, assistance, and guidance throughout all of the Committee's activities and deliberations. The Committee thanks Jennifer Rumburg of the National Aeronautics and Space Administration for her leadership role in staging and processing the community and user electronic questionnaires. It thanks Science and Technology Corporation, the OFCM support contractor, for superb administrative and logistical support of the Committee's activities. The Assessment Committee also thanks the individuals in the numerous agencies that were visited (see Appendix C) for supporting its visits, for their informative briefings, and for timely responses to subsequent inquiries.


Louis J. Lanzerotti
Signature

Louis J. Lanzerotti
Chair

CRITICAL FINDINGS AND RECOMMENDATIONS

The National Space Weather Program (NSWP) Assessment Committee concluded that, since the program's inception in 1995, it has had a number of noteworthy achievements, most of which likely would not have been attained without the program's existence. The committee also found shortfalls in the program. Based upon the conclusions of the committee as contained in this report, continuation of the NSWP is strongly warranted because of the enormous potential to enhance the Nation's space weather mission over the next 10 years through improved operational capabilities, which capitalize on the transition of innovative research. Moving NOAA's operational space weather prediction center (i.e., the Space Environment Center) from its research organization to the National Weather Service was a positive step to improve operational focus within the NSWP. The committee made specific recommendations to further strengthen the NSWP in four key areas:

To centralize program management, set national funding priorities, and increase the effectiveness of the NSWP—

- Establish a space weather expert as the permanent Executive Secretary to the Committee for Space Weather under the National Space Weather Program Council
- Establish a focal point for the program in OSTP/OMB
- Create a joint, cross-agency, space weather organization, the "Center for Space Weather Research to Operations."

The Committee firmly believes that NSWP leadership and organization must be strengthened. The NSWP should have a permanent executive secretary with the ability to establish funding priorities between and among agencies. Focal points and expertise within the White House Office of Science and Technology Policy (OSTP) and the Office of Management and Budget (OMB) are also required.

For continuity of data sources critical to space weather forecasts and operations—

- Develop and execute strategy and funding for L1 sensor continuity
- Maintain critical ground-based assets such as USGS magnetic observatories.

The Federal government must ensure the continuity of critical data sources used in the NSWP. Particularly crucial are space-based sensors at the Earth-Sun L1 Lagrange point, now supported by NASA. The potential for use of new, lower-cost micro-satellite technologies must be examined. National attention must be given to continuity of essential ground-based data sources (including the magnetic observatories of the U.S. Geological Survey) and to arrangements with other countries for sharing of data from ground- and space-based observations.

To strengthen the science-to-user chain—

- Maintain and strengthen both targeted and strategic space weather research
- Enhance emphasis and resources for transition of models to operational users
- Increase the private sector role in supplying products and services.

The NSF has served as the leader in focusing applicable research results toward products for users. A strengthened NSWP leadership must enhance the process of transitioning research to DOD and NOAA operational users. Strategic research resources in the DOD and NOAA must be cultivated and maintained. The NSWP must strive to encourage the emerging private sector in providing products and services.

To emphasize public and user awareness of space weather for critical national needs—

- Quantify the national benefits that arise from the NSWP
- Enhance academic and professional education programs for new space weather professionals.

The NSWP must increase public, congressional, and administration awareness of its value by better quantifying the benefits of NSWP activities. An emphasis on maintaining an academic pipeline of first-rate space weather professionals, begun with the NSF's new faculty development program, must be continued; it can be enhanced by participation of NASA and other agencies.

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EXECUTIVE SUMMARY

National Space Weather Program

The United States National Space Weather Program (NSWP) is a Federal government interagency initiative with the overall objective of speeding improvement of space weather services in the United States in order to prepare the country to deal with technological vulnerabilities that can occur due to the space environment. Agencies currently involved in the NSWP (www.nswp.gov) are the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), the Department of Defense (DOD), the Department of Energy (DOE), the Department of the Interior (DOI), and the Department of Transportation (DOT).

The NSWP builds on existing governmental and civil capabilities in order to establish a coordinated process to set national priorities, focus agency efforts, and leverage national resources. The program encourages contributions from the user community, operational forecasters, researchers, modelers, and experts in instruments, communications, and data processing and analysis—across the government, in research universities, and from industry.

The program is implemented and managed by the National Space Weather Program Council (NSWPC), operating within the Office of the Federal Coordinator for Meteorological Services and Supporting Research (www.ofcm.gov) under guidance of the Federal Committee for Meteorological Services and Supporting Research (FCMSSR). The NSWPC consists of representatives from the seven agencies that participate in the NSWP. The Committee for Space Weather was established by the NSWPC as the principal agent for advancing the goals of the program.

The National Space Weather Program began in 1995; its latest implementation plan is more than 5 years old. In 2005, the FCMSSR and the Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR) directed the OFCM to undertake a comprehensive review of the program. The stated purpose of the review was “to quantify and document the progress toward meeting the NSWP stated goals in observations, research, modeling, transition of research to operations, and education and outreach; to see if the program is still on target and moving in the direction pointed to by the strategic plan; to determine whether the strategic goals should be adjusted at this time based on emerging/evolving requirements; and to suggest a way ahead which will form a basis for a new strategic plan covering the next 10 years.” The full charge to the Assessment Committee, which was formed to conduct the review of the NSWP, is contained in Appendix A.

Committee findings are numbered by the chapter in which they are developed, followed by a sequential number. Recommendations are numbered for the finding on which they are based, followed by a sequential number. For example, finding 3.2 is the second finding in chapter 3, and recommendation 3.2.1 is the first recommendation based on finding 3.2.

Finding 2.1. The First Decade. Since its inception in 1995, the National Space Weather Program (NSWP) has had a number of noteworthy achievements, most of

which likely would not have been attained without the program's existence. Significant strides have been made toward institutionalizing forecast and protection mechanisms for safeguarding against space weather events that may impact many of the significant technology systems on which the United States depends for security, commerce, and advances in science. Despite many notable advances, significant shortfalls in the program also exist and are outlined in this report.

Recommendation 2.1.1. The highly successful National Space Weather Program should continue as an interagency program; however, it should be updated and modified as detailed in the further recommendations of this report.

NSWP Assessment by Plan Activities

The NSWP was assessed against a set of program activities that were specified for it by the 1995 NSWP Strategic Plan (OFCM 1995). The Assessment Committee added an assessment category for private sector participation and international collaboration—issues that cut across the plan-specified set of activities.

Activities: Assess and Document the Impacts of Space Weather; Identify Customer Needs

The NSWP has supported significant efforts to investigate economic and industrial space weather impacts. Such impacts are now discussed in scholarly science journals and in the industrial and popular literature. The program has significantly increased overall awareness of space weather and assisted in the compilation of a variety of assessment documents.

Agencies participating in the NSWP have devoted considerable attention and resources to the identification of customer needs in the period since the 2000 Implementation Plan (OFCM 2000). These needs have continued to change and evolve with time as the technologies and systems that can be impacted by space weather have evolved and shifted in importance for commercial, governmental, and national security interests.

At the same time, the chain of causality for the forecast of a space weather event to its ultimate economic or social benefits remains complex. To date, few in-depth studies have been done of the benefits to society, both economic and social, of space weather forecasts.

Finding 3.1. The NSWP lacks a coordinated effort to identify and quantify, where possible, the benefits to society of providing space weather forecasts.

Recommendation 3.1.1. The NSWP should institute a coordinated effort to fund a series of space weather benefit studies that would cover the primary topics of concern to operators of space weather–vulnerable systems.

Activity: Determine Agency Roles

The NSWP has been a loose confederation of agencies in which participants coordinate their space weather activities as individual agency funding and statutory directives permit. The seven

NSWP member agencies, of which four (NSF, NASA, NOAA, DOD) act as cochairs of the Committee for Space Weather, cannot always speak and act with one voice. Although each agency has demonstrated considerable interest in, and commitment to, the NSWP, each agency must adhere to its own mission statement and authorizing legislation.

Activities: Coordinate Interagency Efforts and Resources; Set Priorities; Ensure Exchange of Information and Plans

The NSWP has numerous important responsibilities in the areas of agency coordination, priority setting, and information exchange. These are discussed in depth in section 3.4 of the report.

Space weather issues for civil aviation are related to all three areas. When the NSWP began in 1995, space weather needs for civil aviation were rarely noted, although such needs were widely recognized for DOD missions, especially high-altitude reconnaissance missions or those in polar regions. Significant changes have occurred in civilian requirements since the end of the cold war.

Finding 3.2. The FAA Air Traffic Organization's advisory *User Needs Analysis* identifies biological radiation exposure as a specification and prediction issue. The FAA Civil Aeromedical Institute has a rudimentary interface for public use available on the internet.

Recommendation 3.2.1. The NSWP should encourage and facilitate collection and analysis of real-time background radiation levels at space and aircraft altitudes. As a body, the NSWP should devote interagency resources to incorporate estimated dosage from energetic particle events into cosmic radiation exposure estimates and to make the specifications and results easily accessible, usable, and interpretable by the public via the Internet.

The Assessment Committee received little data comparing performance to the metrics outlined in the NSWP 2000 Implementation Plan. This information was not proffered by individual agencies or in the Committee for Space Weather briefings.

Finding 3.3. Little information was available on program performance as related to the metrics given in the latest (2000) NSWP Implementation Plan.

In terms of coordination, the confederation nature of the agency participation in the NSWP often appears to hinder effective assignments of responsibilities and priorities.

Finding 3.4. The National Space Weather Program Council does not have the authority to mandate roles, responsibilities, or priorities for space weather infrastructure needs. Nor can it allocate resources.

Activity: Encourage and Focus Research

The agencies in the NSWP have successfully seeded a number of research initiatives that have contributed to the national efforts in space weather. These have taken the form of both targeted research and strategic research.

Many of the targeted research initiatives have been science missions that have finite lifetimes and cannot be expected to contribute to space weather applications into the far future. Two important space missions that fall into this category are the ACE and the SOHO missions, which are located near the L1 Lagrange point.

Finding 3.5. Many data sets that are critical for both civilian and national security elements of the NSWP are obtained from science programs of often limited duration (some of these sources are already beyond their design lifetimes) or from sources originally designed for other objectives. Relatively little discussion and contingency planning are underway as to how the NSWP will incorporate possible foreign sources of critical space weather data if some national data sources become unavailable.

Many instruments designed as data sources for operational space weather applications—on the ground or in space—need not have the high precision of measurements usually required for scientific research objectives.

Recommendation 3.5.1. The cooperating agencies in the NSWP should investigate immediately the feasibility of using micro-satellites with miniaturized sensors to provide cost-effective science and operational data sources for space weather applications.

Measurements of solar and interplanetary phenomena at L1 are essential for many important space weather operational objectives. Arrangements for the continuation of such key measurements are uncertain at the present.

Finding 3.6. It is particularly critical to ensure continuity of space weather observations at L1 and continuity in delivery of that data in near real time. Planning for continuity is necessary prior to the failure of current scientific instruments at L1.

Recommendation 3.6.1. Micro-satellites and other small missions should be seriously pursued as an option for providing continuity of critical space weather data from observations at L1.

The DOD, NSF, and NASA each have strategic research components in support of their individual agency's goals. Strategic research is closely related to the level of space situational awareness that may—or may not—exist in the relevant agencies at a given time and over major planning cycles.

Finding 3.7. The benefits of having space weather strategic research and space situational awareness must be more meaningfully assessed and promulgated.

Recommendation 3.7.1. The NSWP must enhance its efforts to educate the U.S. Government, wider technical communities, and the public on the importance of strategic research and space situation awareness to national interests, particularly about the possible consequences of space weather events for national interests.

Activity: Facilitate Transition of Research into Operations

Significant advances have occurred in both empirical and physics-based modeling since the inception of the NSWP. The 2000 Implementation Plan identified three primary transition-to-operations objectives: the Community Coordinated Modeling Center (CCMC) and Rapid Prototyping Centers (RPC) at the NOAA SEC and within the DOD, and the radiation belt modeling in the DOE. The CCMC exists and is interacting strongly with the research community. The NOAA RPC is currently understaffed. Because the Air Force Space Weather Center of Excellence is scheduled for realignment and reorganization within the DOD, its future ability to provide prototyping support is unclear.

Finding 3.8. There is an absence of suitable connection for “academia-to-operations” knowledge transfer and for the transition of research to operations in general.

Recommendation 3.8.1. The agencies involved in the NSWP should continue to support basic research modeling efforts and, if possible, provide increased resources for modeling that has space weather operational potential. New resources should be made available within NSWP agencies for transition of research models to an operational environment, including validation and revision of existing models. Present resources and human capital should be carefully evaluated, strategically invested, and wisely managed.

Improving the transition process will require quantitative assessments of the accuracy of data, models, and products, with overall progress to be measured in terms of improvements in these metrics. Although many models and many data streams exist, still lacking are quantitative estimates of the accuracy of this information that can be effectively communicated to users of space weather services.

Finding 3.9. There currently are few overall verification and validation methodologies that can be used to assess the reliability of space weather models and operational products.

Recommendation 3.9.1. The NSWP should establish standards for data and model archives and for access to them. The NSWP should establish standards for modeling frameworks in order to facilitate model coupling, flexible execution, and data assimilation.

Recommendation 3.9.2. The NSWP should work towards the establishment (and application) of metrics for space weather capabilities.

Activity: Foster Education of Customers and the Public

The NSWP has had success in many aspects of education: (a) professional education, (b) formal advanced education, (c) formal undergraduate education, and (d) informal public education.

Some of the NSWP agencies show awareness of the need for workforce education and development in support of the national space weather effort. Other agencies are less clearly

committed to workforce development. The NSW agencies will need to work with the academic community to encourage it to develop new approaches to attract science and engineering students who can become space weather professionals.

Finding 3.10. There is a lack of a systematic approach to ‘grow’ new space weather professionals.

Recommendation 3.10.1. The NSW agencies should make a more unified and concerted effort to educate a new generation of professionals who have the systems view of space weather.

Private Sector Activities

The private sector has demonstrated interest in supplying tailored and unique space weather products and services as supplements to and enhancements of (added value to) the public products available from Government sources such as the NOAA Space Environment Center and the Air Force Weather Agency. Companies are interested in supplying tailored products to both governmental and private-sector entities.

Finding 3.11. The role of the private sector in providing space weather products, including potential for investment, is still being defined.

Recommendation 3.11.1. The NSW should work with the growing commercial sector for space weather services and products to enable this sector to flourish as a vital part of the national space weather program.

Recommendation 3.11.2. The NSW should work with the private sector to understand better the economic and social values of space weather knowledge and of products and services based on that knowledge.

International Activities

Individual agencies within the NSW have pursued international collaboration for specific projects. International cooperative efforts could assist in gathering and distributing space weather data if there were coordinated plans for encouraging other countries to participate in these collection and distribution efforts.

Finding 3.12. The NSW has made relatively little effort to consider international partnering opportunities for collecting space weather data and distributing space weather information products. The worldwide space weather community would benefit by much more aggressive collection of space weather data by other countries.

Recommendation 3.12.1. The NSW should consider the benefits (and possible drawbacks) of establishing a formal international coordination mechanism for the promotion, collection, and distribution of space weather data, including all forms of space weather data from satellites and ground-based sensors.

National Space Weather Program: Management Issues

The Assessment Committee identified a number of important management issues related to the program as a whole, as well as to individual agencies. Addressing these issues will enhance the effectiveness of the national effort.

National Space Weather Program Structure

The current arrangement of the NSWP as a loose confederation of agencies has made it difficult for the program to achieve the type of operational coordination that is essential to provide the national leadership needed for addressing the key space weather issues in the civil, governmental, and national security arenas.

Finding 4.1. Organizational Matters. The NSWP is an outstanding example of a Federal government program in which a significant number of executive branch agencies have important national interests and where the individual agencies have natural areas of experience and expertise. However, the program management organization under the Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCM)—namely, the National Space Weather Program Council (NSWPC)—needs to be strengthened and needs to take a more active role in the execution of its overarching responsibility to ensure that the NSWP can move forward in achieving its goals. Without further strengthening of the NSWPC as an interagency integrated program, the chances of meeting the challenging national needs in space weather will be greatly diminished.

Recommendation 4.1.1. Oversight for the NSWP should be established in the Executive Office of the President, as is currently done for several other critical cross-agency activities of the Federal government. Policy and technical implementation aspects should be coordinated under the aegis of a space-knowledgeable staff member in the Office of Science and Technology Policy (OSTP). Budgetary coordination and review for the NSWP agencies should be carried out under a designated examiner in the Office of Management and Budget (OMB).

Recommendation 4.1.2. The NSWPC Chair should review the council's membership and consider additional membership to increase the visibility of the program's fiscal and other challenges and to increase support for overcoming those challenges. The NSWPC should review and update its now 10-year-old charter to describe clearly its oversight responsibilities. These should include, but not be limited to, the authority to: (1) address and resolve interagency issues, concerns, and questions; (2) reprioritize and leverage existing resources to meet changing needs and requirements; (3) approve priorities and new requirements as appropriate and take coordinated action to obtain the needed resources through each agency's budgetary process; (4) identify resources needed to achieve established objectives; and (5) coordinate and leverage individual organizational efforts and resources and ensure the effective exchange of information.

Recommendation 4.1.3. A joint working group should be established for all cooperating NSWP agencies similar to that described in the NASA/NOAA Congressional Directive (2006 NASA Reauthorization Bill H.R. 3070, Section 306) and with similar reporting requirements.

Recommendation 4.1.4. A full-time space weather expert should be appointed as Executive Secretary to the Committee for Space Weather under the NSWPC.

Recommendation 4.1.5. The NSWPC should direct that a new NSWP Strategic Plan be written that takes into account the successes and the limitations achieved under the current plan, changes that have occurred in technologies susceptible to space weather, and advances made in scientific understanding.

Recommendation 4.1.6. The NSWPC should direct that a new NSWP Implementation Plan be written following a new strategic plan.

Recommendation 4.1.7. The NSWPC should create a joint, cross-agency, space weather organization, the “Center for Space Weather Research to Operations.”

National Space Weather Program Agencies

Solar and solar-terrestrial programs in NASA have unified leadership within that agency, whereas the management of the corresponding programs within NSF is currently divided between two directorates.

Finding 4.2. The current management structure of the NSF solar and solar-terrestrial research programs does not always operate optimally to foster basic solar and solar-terrestrial research or the links from this research to space weather.

Recommendation 4.2.1. The solar and solar-terrestrial program elements of the NSF should be managed as one, possibly division-level, program so as to have a unified overview of both the basic research and space weather elements.

The 2002 Decadal Research Strategy in Solar and Space Physics, from the National Research Council, recommended that both NASA and NSF fund bridged faculty positions at universities to bring solar and space physics into the academic curriculum, commensurate with the national resources that are being devoted to these research endeavors (NRC 2002).

Finding 4.3. While the NSF has implemented a program to support bridged positions for academic faculty in solar and space physics, NASA has yet to address this recommendation of the National Research Council’s Decadal Research Strategy in Solar and Space Physics.

Recommendation 4.3.1. NASA should institute a bridged faculty program in solar and space physics.

At times in the past, some programs and offices under the DOD and NOAA sponsored extramural research (primarily academic research) in solar and solar-terrestrial research at funding levels considerably above those at present. That level of research support enabled close interactions between in-house laboratories and the outside community of researchers and helped to develop analysis tools and models in support of space weather applications.

Finding 4.4. The continuing decline in the resources available to the DOD and NOAA for contracting peer-reviewed research, both targeted and strategic, to the extramural community, especially the academic community, means that the interactions and interchanges between the government and nongovernmental sectors in space weather are far from optimized.

Recommendation 4.4.1. Resources should be restored to the operational agencies to allow greater extramural research inputs. NOAA and the DOD should thereby provide competitive peer-reviewed funding for contributions from the nongovernmental sector to space weather program research elements.

