

Ingredients for an Action Plan for Geospace Science at NSF 2017 – 2025

1.1 Background

Under the auspices of the Advisory Committee for NSF-GEO (AC-GEO), a comprehensive Portfolio Review (PR) of the activities in the Geospace Section of the Division of Atmospheric and Geospace Sciences (AGS) was conducted by an ad-hoc committee of community experts over a period of 14 months from Feb 2015 to Mar 2016. The resulting report titled *“Investments in Critical Capabilities for Geospace Science 2016 to 2025”* (hereafter referred to as: ICCGS) was formally submitted and accepted by the AC-GEO in April 2016. Subsequently, the NAS Space Studies board conducted an independent evaluation (a "Consensus Study") of the PR as reported in the document titled: *“Assessment of the National Science Foundation’s 2015 Geospace Portfolio Review”*, 2017 (Hereafter referred to as: NASAR). This document provides the response from the Geospace Section (GS) to the main findings and recommendations proposed in these reports.

1.2 Context

Overarching priorities for basic research in solar and space physics are provided in the National Research Council's Decadal Survey: Solar and Space Physics – A Science for a Technological Society, 2013 (hereafter, referred to as: the Decadal Survey). The decadal survey is the main source of guidance for research programs at NSF in this research area, of which the programs in the GS constitute the most significant part. Ensuring optimal alignment of GS investments in research and supporting ground-based facilities with the priorities in the Decadal Survey was a major motivation for the Portfolio Review, and doing so within the limitation of a flat budget outlook was a key charge to the Portfolio Review committee. The actions and activities highlighted here in response to these reports constitute a first step towards defining strategic objectives for the GS that will help us meet the science goals outlined in the Decadal Survey. We acknowledge the recommendation in the NASAR that strategic planning for the GS should be done as part of strategic planning for the division and with proper recognition and consideration of linkages to relevant activities both within the division and across NSF. **The recommendations offered both in the ICCGS and in the NASAR will be used to engage with the solar and space physics community on the formulation of a strategic vision for the GS programs and investments for the next several years.** We also appreciate the recommendation in the ICCGS (recommendations 9.8 and 9.15) that facility investments and research programs should be evaluated regularly through so-called senior reviews. However, we agree with the NASAR that reviews that jointly evaluate the entire GS portfolio will be more effective than separate reviews for facilities and grant programs. **It is anticipated that portfolio reviews for GS will be conducted every 3-4 years in accordance with NSF policy, either as stand-alone reviews or as part of the regular, mandated CoV reviews.**

1.3 Organization

In our response we will focus on the major recommendations emphasized in the ICCGS and NASAR reports. We organize our responses to individual findings and recommendations according to the five main themes identified in the NASAR. Each theme is addressed in a separate section below. For clarity, we will emphasize actions already taken or planned in response to the reports.

2.1 GS Facilities

Section 5.1 in the NASAR concerns the ICCGS recommendations for re-balancing of the GS Facilities program in support of innovative technologies, and to explore new avenues of research. The report calls out the need for specific details regarding the implementation of these recommendations.

The tight funding position that the GS is in is partly a result of a 65% increase in ISR funding that took place between 2006 (~\$8M/yr.) and now (~\$13M/yr.). In addition to this large increase, the GS undertook new spending associated with the introduction of CCMC (0.5M/yr.), SuperMAG (0.15M/yr.), SuperDARN (0.96M/yr.), AMPERE(1.02M/yr.), and CRRL (1.28M/yr.). Here we provide a status update and details on the planning for the implementation of the ICCGS recommendations in regards to GS Facilities.

Arecibo Observatory

The ICCGS recommends a reduction of AGS funding for the Arecibo Observatory (AO) from \$4.1M/yr. to \$1.1M/yr. (recommendation 9.11). AO is managed in partnership with the Astronomy Division (AST) in the Directorate for Math and Physical Sciences (MPS), but the management is formally the responsibility of AST. To examine all options for the future management of AO, a Draft Environmental Impact Statement (DEIS) was published in October 2016 with the final EIS (FEIS) expected in the summer of 2017. This DEIS, prepared in compliance with the National Environmental Policy Act of 1969 (NEPA), evaluates the impacts of five proposed action alternatives that address potential changes to operations at the Arecibo Observatory in Arecibo, Puerto Rico. NSF has indicated in the DEIS that collaboration with interested parties for continued science-focused operations is the Agency Preferred Alternative. A solicitation (17-538) calling for proposals aimed at developing such a partnership to manage the Arecibo Observatory was published in January, 2017 with a submission deadline of 25 April, 2017. The funding profile presented in this solicitation for possible NSF GS support indicates that the ICCGS recommended goal of \$1.1 M would be reached by the fifth year of the new award (nominally 2022/2023). Currently, no decisions have been made regarding the future of Arecibo Observatory. A record of decision on NSF's divestment plan for Arecibo Observatory will follow release of the final EIS. The record of decision will factor in important considerations beyond the EIS including any proposals that may have been submitted in response to the solicitation. **The GS will review the situation regarding the auxiliary aeronomy instruments at AO after the Arecibo Observatory RoD is issued and the future of the observatory is known.**

Sondrestrom ISR

The implementation of a total divestment from the Sondrestrom ISR radar facility as recommended by the ICCGS (recommendation 9.9) is complicated by the fact that the site in Greenland is not NSF property and no formal lease arrangement exists for its use. The ISR instrument and building structures on the site are owned by NSF and much of the auxiliary instrumentation at the facility are supported by GS funding. The Sondrestrom radar operations provide AC power and data transfer support for auxiliary instruments deployed at the site.

As a first step in the development of a plan for the future of the Sondrestrom facility, **the GS will conduct a site-visit panel review in July 2017 to establish the scientific value of continuing**

operations of the auxiliary instrument suite at the Sondrestrom site. Depending on the outcome of this review, a possible intermediate outcome might be a level of reduced logistical support combined with de-scoped Sondrestrom radar operations that continue to provide support for auxiliary instrumental science. This panel review would also consider the question of the long-term future viability of the Sondrestrom auxiliary instruments with or without Sondrestrom ISR operations and in comparison to a potential partnership with the EISCAT instrumental facility located in Svalbard. **In collaboration with OGC, OISE, and OPP, the GS also has initiated discussions with the Greenland Home-Rule government on establishing the legal status of the site as well as with the current manager of the facility, SRI International, on the potential for pursuing external partnership options for the facility.**

AMISR radar facility

The ICCGS recommended (recommendations 7.8 and 7.9) in accord with the long-standing NSF policy for large facilities for re-competition at ten years intervals that the AMISR award to SRI International be re-competed with separate awards for each of the two AMISR observatories at Poker Flat, AK, and at Resolute Bay, Canada. The purpose of this separation is to ensure that the AMISR site-specific science objectives could be readily discerned and highlighted in each site proposal. **The GS has adopted this path forward, and a solicitation (17-539) for the operations and management of the AMISR observatories has been posted inviting the submission of preliminary proposals for each site to be submitted May 1, 2017.** The preliminary proposals will be reviewed and the selected teams will be invited to submit full proposals by October 3. Also expressed in this solicitation is the idea that a relocation of the AMISR site to a new location of strong geophysical interest will be considered as a possible science objective.

Consortium of Resonance and Rayleigh Lidars (CRRL)

The ICCGS recommendation (7.18) to disintegrate the CRRL consortium into separate site science collaborations is currently being implemented with three separate proposals for the sodium resonance LIDAR systems located in Chile, Utah, and Alaska. These proposals have been submitted to the Aeronomy program and will be reviewed by a virtual panel in March, 2017.

2.2 Evolution of GS Facilities

Keeping the Geospace observational program at the cutting edge requires continuing adjustments of priorities and investments, support for development efforts, and actions to promote and take advantage of emerging opportunities. In recognition and support of these needs, the ICCGS recommends *significant new investments: in an international partnership (EISCAT) and in two new funding lines relevant to facility renewal, model development/upgrades, and instrument development.*

The GS has initiated discussions with the EISCAT project and will also engage with relevant community organizations, such as CEDAR, as soon as practicable, to determine the details of how US participation in the partnership (ICCGS recommendation 9.10) could be established. Assuming a feasible solution can be identified, it will be implemented when sufficient resources are freed up from a reduction in funding of the Sondrestrom ISR below its current level. This is expected to be possible by 2020 or earlier.

As funding becomes available through the further planned reductions in funding for ISRs, or through budget increases, **the GS will establish a new Facilities Innovation and Vitality program as proposed (ICCGS recommendation 9.14)**. The goal of the program will be to provide, as the ICCGS recommends, *a source of funds for driving innovation across the GS facilities and modeling portfolio, as well as instrument development and technology integration*. The program is envisioned as a core program component of the Facilities program, through which unsolicited proposals and supplemental requests can be supported. A detailed formulation of the program scope and objectives will be drafted with consideration for how it relates to the activities in the other programs in the GS and across NSF, such as the MRI and MREFC programs. The draft program description will be vetted with the community (through a DCL and other means) before final implementation. The new Facilities I&V Program will be created by 2020 at the latest, albeit possibly at a lower resource level initially than proposed in the ICCGS.

A number of current observational projects supported by the GS's core programs as well as several of the current Class 2 facilities in the GS qualify as Distributed Arrays of Small Instruments (DASIs). Their existence is a testament to the increased recognition of the value of this type of measurement concept for addressing current high-priority Geospace science problems related to large-scale dynamics. Distributed sensor networks also were a key topic for the recent GS-supported community workshop: *Exploring the Geospace Frontier: Quo Vadis?* As funding becomes available through the anticipated reductions in funding for ISRs, or through budget increases, **the GS will establish additional Class 2 facilities based on the DASI concept as proposed (ICCGS recommendation 9.12)**. It is expected that the first of these will be realized by 2020. To guide the definition and prioritization of future DASI-type projects, **the GS will continue to organize and support community workshops** aimed at identifying the *experimental infrastructure required for discovery research in Geospace science for the 21st century*.

The need for resources for mid-scale projects is well recognized across NSF. **The GS will continue to support the development of potential concepts and ideas for new mid-scale infrastructure for Geospace science (ICCGS recommendations 9.16 and 9.17)**. Such efforts will not only serve to document and highlight the importance of these projects but will also ensure that feasible, well-researched projects are ready for implementation should funds become available. The new Facilities I&V program will provide a valuable resource in pursuit of this goal.

2.3 GS Grants Programs

The disciplinary programs in GS (AER, MAG, and STR) together with the Space Weather Research Program (SWR) address a dual mandate. One goal is to enable curiosity-driven, frontier discoveries of fundamental physical processes, including those enabling systems science. The other goal is to advance integrative and cross-disciplinary science, including the development of coupled Sun-Earth models that can address space weather needs.

The ICCGS recommended (recommendations 9.3, 9.4, and 9.5) that the GS addresses the second mandate by *proposing specific portfolio adjustments to advance integrative science and predictive science that underlie space weather applications and cross-disciplinary science*. **In FY**

2017, the GS has begun the process of implementing adjustments to the GS Grants Programs in order to initiate the Grand Challenge Projects (GCP) program (annual budget of \$1.5M/yr.) by FY 2020, in addition to the current Space Weather Modeling (SWM) program. This new strategic program would reside under Integrative Geospace Science, or IGS, alongside the existing Targeted Grants programs (CEDAR, GEM, and SHINE).

The first step in the IGS accommodation process is to reduce the current mortgage rates of 60-65% across the various GS Grants Programs down to 30%, as recommended by the NSF's *Proposal and Award Manual (PAM)*, by FY 2020. By having a lower mortgage rate, the GS Grants Programs will make available approximately \$4.5M annually to implement the IGS, as well as to possibly consider funding Heliophysics Science Centers jointly with NASA. This will be accomplished by issuing more standard, 3-year awards out of the core-program funds, while reducing the number of continuing awards. Due to the high proposal pressure to the GS Grants Programs in recent years, the common practice across the GS Grants Programs has been to issue mostly continuing awards in an effort to fund as many projects as possible and keep the funding rate above 15%. Furthermore, in order to create flexibility in the GS Grants Programs and address the issue of high proposal pressure, two specific actions will be taken. First, GS will remove the deadlines for the Targeted Grants programs (CEDAR, GEM, and SHINE) starting in FY 2018. Past experience has shown that program solicitations without deadlines receive fewer proposals annually than those with set deadlines. Second, GS will rewrite the CEDAR, GEM, and SHINE solicitations to ensure a stronger, more narrow focus for each of the Targeted Grants programs. This will be done in consultation with the community steering committees for the CEDAR, GEM, and SHINE programs, and will be implemented in a way that allows for the focus in each program to change on a continual basis to best serve the needs of the program at any given time. For example, in FY2018, the CEDAR solicitation will concentrate on studies combining ground-based measurements with and observations from the upcoming NASA missions ICON and GOLD. **In FY 2016, GS began using proposal pressure, together with consideration of portfolio balance and other programmatic concerns, in determining the budget allocations between the various grants programs in GS (ICGS recommendations 9.1 and 9.2).** The proposed change to the Facility Program, including termination of the Sondrestrom ISR and reduction of support for Arecibo, is expected to increase the proposal pressure to these programs.

During FYs 2017-2020, the GS will work diligently towards securing additional funds for running the CubeSat program (ICGS recommendation 9.6). **Until these augmentations to the program are finalized by FY 2020, the GS will maintain funding for the CubeSat program at the current level of \$1.5M annually.** Cubesats have been championed by NSF and the Geospace Section specifically. They are now widely recognized as a disruptive technology. **The GS is actively searching for partnerships across NSF (e.g., Directorate for Education and Human Resources (EHR), Directorate for Engineering (ENG), etc.) and outside of the agency for cofunding support of Cubesats.**

Going forward, the Faculty Development in the Space Sciences (FDSS) and CAREER programs will be continued as GS funding resources allow (ICGS recommendation 9.7).

2.4 GS Workforce Development and Diversity

Chapter 4 of the ICCGS pertains to workforce development and diversity. The report recommends continuation of current GS efforts to engage undergraduate students, fund graduate students, offer professional development, and promote workforce diversity. **The GS will continue to explore partnerships across NSF for investments in teaching research, citizen science, and public information in geospace and solar science as suggested in the reports.**

A recurring comment is the need for all the NSF-funded development programs to maintain metrics on the diversity of the participants, and report them annually. The ICCGS recommends and the NASAR concurs, that Ph.D. employment be tracked and entered in a data-information box in the final grant report. It is also recommended that a “Solar and Space Physics” category should be implemented in the “Survey of Earned Doctorates” that is administered by NSF. These recommendations are outside the purview of GS and may incur policy implications. **The GS will engage with the appropriate offices at NSF to explore ways to strengthen the data gathering on diversity and human development outcomes from our investments, to better recognize and promote the impact of geospace science.**

The assessment report acknowledges the challenge of implementing the recommendation that the GS should be *in the vanguard of NSF initiatives to promote engagement of women and underserved populations in all aspects of geospace science*. Suggested ways to implement specific ICCGS suggestions are listed below.

1. Section 5.4 of the NASAR recommended creating a clearinghouse of AGS and GS diversity related programs and activities by featuring them prominently on the NSF, AGS, and GS websites. **The AGS website was redone recently and includes this information. In addition, the GS section will publicize relevant selections from these programs in the community newsletters (AGU SPA, CEDAR, GEM, and SHINE).**
2. The new Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (NSF-INCLUDES) supports innovative models, networks, partnerships, technical capabilities and research enabling traditionally underrepresented and underserved groups in the U.S. science and engineering workforce to participate, at percentages comparable to their representation in the U.S. population. **GS will publicize and promote this program at the annual CEDAR, GEM and SHINE meetings.**
3. Section 4 of the NASAR recommended outreach of the GEM, CEDAR, and SHINE communities to national societies focused on diversity in STEM in general and physics in particular. **GS program managers will encourage CEDAR, GEM, SHINE, and core program PIs to recruit prospective graduate students at meetings of the National Society of Black Physicists, the National Society of Hispanic Physicists, the American Physical Society Conferences for Undergraduate Women in Physics, and other relevant national programs.**

2.5 Partnerships and Opportunities

The ICCGS was directed to “take into consideration the national and international Geospace Sciences landscape and the consequences of its recommendations for domestic and international partnerships. The recommendations and finding in the ICCGS (Chapter 8) largely encourage the Geospace Section to continue with the current course of actions. Here, GS provides updates on a few key partnerships and programs.

Several programs that the GS utilizes for cofunding are being or have been phased out. This includes Integrated NSF Support Promoting Interdisciplinary Research and Education (INSPIRE), and Hazard SEES. The Section will seek cofunding from the follow on programs as they become available. The current EarthCube solicitation is set to expire in FY17 and does not yet have a replacement program, however, new initiatives are expected. The Research Advanced by Interdisciplinary Science and Engineering (RAISE) Program is the follow on to INSPIRE. The RAISE program is expected to have 25% cofunding from the Office of Integrative Activities this year, but next year no cofunding is expected. Geospace has been active in seeking cofunding from the Prediction and Resilience against Extreme EVENTS (PREEVENTS) program, and is active on the working group. There are also two tracks in the solicitation. Track 1 is for workshop funding. So far, Geospace has had one workshop funded through this mechanism. Track 2 is for large scale modeling projects. A competition is currently underway with strong participation from the Geospace community and the next competition is expected in 2018.

Recent changes to the MREFC program included dropping the lower budget limit to \$70M. This provides the Geospace community with a better opportunity to compete for funds as the projects being developed at the moment have smaller budgetary requirements. The Section works actively with the community, in part through the sponsoring of workshops such as Quo Vadis (<https://www2.hao.ucar.edu/events/GeospaceFrontier2016>), to help develop these ideas in line with funding opportunities. **We are urging the community as they develop them to consider the management, operating, and maintenance costs and to take steps to streamline and minimize these as much as possible.** These costs are part of the prioritization of actions for the Section. The section is in close contact with PIs and the community regarding projects such as the solar radar and midscale infrastructure projects such as COSMO, so as to be prepared when opportunities arise.

The ICCGS noted a concern with the historical trend of GS to pick up the O&M costs for legacy DOD instrumentation. They find that that doing so can be a benefit to the sections science goals, but recommend using a review process to determine overall value before assuming these responsibilities. **The GS intends to follow this advice in the next such instance.**

There are several recommendations regarding NASA/NSF Collaborations. The recommendations to continue the Space Weather Modeling and to explore a joint program for the Heliophysics Science Centers (HSC) create a budgetary challenge for the section. **The Section is currently pursuing a pilot program on space weather modeling with NASA, which heavily leverages internal NSF partnerships and would dovetail into a full HSC program.**

The ICCGS recommends that “The AGS Director and GS Head should continue to coordinate with the Director of HAO to facilitate alignment of HAO science goals with GS science goals.” We

agree completely. **NCAR is an NSF FFRDC and the GS is an integral part of its scientific management through SVTs, annual budget guidance, and regular communications with the NCAR and HAO directors.** In addition to high level communications the HAO director and many of the scientists communicate regularly with program managers regarding science direction and the development of instrumentation and community models. The science goals of HAO are also well coordinated with those of the GS section, in part through community documents such as Decadal Surveys. We also review and approve the NCAR Strategic Plan.

The Geospace Section has also been active in the National Science and Technology Council's subcommittee on Space Weather Operations, Research, and Mitigation and is participating on 4 of the 6 Goals. The most critical of these has been the benchmarks of Goal 1, which will guide research priorities for the nation over the next 5 years. NSF has taken the lead role in Goal 5.5.1, which is *"an annual effort to prioritize and identify opportunities for research and development (R&D)"*. Additionally, NSF has been an active contributor to the goals pertaining to the establishing of the research to operations and operations to research linkages. **Basic research plays a critical role in fulfilling the goal of a space weather ready nation and the Geospace Section will continue to support NSF's participation in this important subcommittee.**