WORKSHOP REPORT

APRIL 1, 2016

Enhancing the Usefulness of

Science of Science and Innovation Policy (SciSIP) Research

An Agenda-Setting Workshop

Held at: George Mason University – Arlington, Virginia

On: December 7, 2015

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Executive Summary

Workshop Overview

On December 7, 2015, a group of practitioners of science and innovation policy drawn from the U.S. Federal government and select non-governmental organizations met for a workshop titled *Enhancing the Usefulness of Science of Science and Innovation Policy (SciSIP) Research: An Agenda-Setting Workshop.* The workshop was held at the George Mason University (GMU) campus in Arlington, Virginia, and organized jointly by the School of Policy, Government, and International Affairs at GMU and the Center for Science, Technology and Economic Development (CSTED) of SRI International. The workshop was sponsored by the SciSIP Program at the National Science Foundation.

This workshop was designed specifically to elicit input from practitioners in the field of science and innovation policy about important policy questions that they have faced in their careers that might be addressed by future SciSIP researchers. A second purpose was to learn more about how these professionals learned about the results of academic research relevant to their jobs, and ways by which the SciSIP program could facilitate knowledge transfer from the research community to the practitioner community. As a result, participants were drawn principally from the Federal government or from organizations involved in advising Federal and state governments on science and technology policy issues.

This report presents the results of the day-long set of interactive discussions and presentations with the hope that they provide helpful insights into the areas of research most likely to be read and used by practitioners in science and innovation policy. We also seek to strengthen the SciSIP community of practice, as envisioned by former Presidential Science Adviser Dr. John Marburger III, by presenting comments on potential mechanisms for improving the connection between researchers in this field and those who are charged with providing advice and recommendations to the policymakers formulating science and innovation policy. Although we summarize the inputs gathered from discussions among the participants, the workshop organizers are solely responsible for its content, and any statements contained herein should not be taken as representative of the views of the participants, their affiliated organizations, or the National Science Foundation.

Acknowledgements

The organizers would like to thank the current Program Director for SciSIP, Dr. Maryann Feldman, for formulating the call to organize this and similar workshops, and for her sponsorship and guidance of the workshop itself. We also thank the speakers who addressed the plenary sessions of the workshop: Dr. Faye Lomax Cook, Assistant Director for Social, Behavioral, and Economic Science at the National Science Foundation; Mr. Kei Koizumi, Assistant Director for Federal R&D at the Office of Science & Technology Policy in the Executive Office of the President; and Dr. Lisa Simpson, President and CEO of AcademyHealth.

Dr. Christina Freyman and Mr. Steven Deitz of SRI and Prof. Connie McNeely of GMU contributed substantially through their able facilitation of discussions during the workshop, and

their views and inputs before and after the workshop itself. We owe special thanks to Mr. Alfred Sarkissian, a doctoral student at GMU, for his research contributing to the workshop framing paper and design. We also acknowledge the efforts of Mr. Sarkissian and his fellow graduate students in SPGIA—Lisardo Bolanos Fletes, Joel Hicks, Yong-Bee Lim, Lauren McCarthy, David Morar, and Camilo Pardo—who served as rapporteurs during the workshop and recorded comments and contributions from the participants. Thanks also go to the staff of the GMU Office of Events Management who helped with the logistics and preparations for the workshop.

Finally, we owe a tremendous debt of gratitude to more than 30 professionals and experts in Federal science and innovation policy who contributed a day of their time and their substantial expertise and thoughtful observations during the course of this workshop. We hope that this report reflects the quality and depth of their commitment to making more informed and scientific decisions on issues of science and innovation policy.

Key Findings

The workshop relied primarily on the World Café format to elicit the perspectives of the participants. This format centers on 30-minute, facilitated small group discussions. Each participant joined six of these discussions over the course of the day.

The morning sessions, which aimed at building a practitioner-driven agenda for NSF's SciSIP research, identified more than thirty specific questions, answers to which would help practitioners in a variety of settings. The organizers distilled these questions from notes taken during the discussions by the rapporteurs or the facilitators, or from written notes taken by the participants themselves. We grouped the thirty questions under ten broad themes that reflect the types of problems and challenges faced by practitioners.

1. *Making R&D Funding Decisions*

- How are R&D funding decisions actually made in practice?
- What heuristics do senior decision makers use when determining R&D funding levels and distributions? How frequently are formal models or evaluations used as inputs to funding decisions?
- What are the different types of decisions that policymakers in Congress, the White House and Federal agencies make and how can SciSIP research inform each of them?
- How well do different functional approaches (e.g., peer review, strong program manager, formula funding) to allocating and managing Federal R&D funding work under different conditions and circumstances? What are best practices?
- Can we build empirically-based, theoretically sound models of R&D priority setting and decision making that account for such realities as incremental budgeting; option preservation; international competition; and differing levels of uncertainty across R&D domains regarding technical success, subsequent commitments of complementary resources, and goal accomplishment?

2. *Managing Agency and Multi-Agency R&D Portfolios*

   - Can we develop better databases and better data management tools for managing R&D portfolios within and across agencies?
   - Are there effective ways to access and incorporate information about non-Federal R&D investments to aid decision makers in deciding whether and how to reinforce and/or take advantage of such investments?

3. *Evaluating Federal R&D Programs*

   - What is the return on Federal investments in R&D and how does it depend on the context and objectives of the investments?
   - How might ROI approaches be augmented to incorporate both non-economic returns and returns received outside of the U.S. (so-called "international spillovers")?
   - Have Federal R&D agency strategic plans, performance plans, and performance reports under GPRA led to measurable improvements in agency performance and R&D outcomes?
   - Can retrospective analysis of more than two decades of experience with GPRA reporting help improve their basic parameters, including assessment of R&D outputs and particularly R&D outcomes?

4. *Designing and Implementing Public-Private Partnerships (PPP) for R&D*

   - How well do various models of public-private partnerships for science, technology, and innovation work?
   - Are different models better in difference circumstances?
   - How might their structure and operations be improved?

5. *Optimizing the Performance of the Federal Laboratories*

   - What is the nature and structure of the Federal government science and engineering enterprise?
   - What approaches would improve valuation and management of R&D activities conducted by government laboratories?
   - In what ways should Federally-employed and Federally-contracted scientists and engineers be managed and rewarded differently from those in academia and industry?

6. *Enhancing Regional Contributions of Federal R&D Investments*

   - What contributions do Federal laboratories make to regional innovation systems and to regional economic development in general?
   - How important is active participation in open innovation to the performance of the laboratories in achieving their missions?
   - For laboratories with primary missions other than economic development, to what extent can regional and national economic development be achieved as a side effect or co-benefit of achieving their primary mission?

7. *Tailoring Industrial Innovation Policy to Sectoral Variation in Innovation Processes*

    - How do industries, including service industries, vary with regard to innovation and commercialization processes?
    - How do appropriability mechanisms, such as patenting, trade secrecy, and use of complementary assets, differ by sector and over time?
    - How can Federal technology transfer policy as embedded in the Bayh-Dole Act be made more flexible and be adapted to industry-specific requirements?
    - How should policies aimed at accelerating industrial innovation be tailored to achieve better results across Federal missions, such as energy, transportation, and environmental protection, that impact "legacy" sectors?

8. *Lessening the Burden of Regulation on Academic R&D Performers*

    - How have regulations on the conduct of research affected R&D performers and outputs?
    - Would it be possible and useful to conduct regulatory impact analyses before issuing such regulations?

9. *Enhancing the Contributions of Scientific and Technical Understanding to Regulatory Policy Making and Implementation*

    - What is the relationship between information offered by the public and by scientific advisors and regulatory outcomes?
    - Do the institutional mechanisms through which such advice is offered make a difference?

10. *Helping Education and Training Institutions Respond More Effectively to Changing STEM Labor Market Needs*

    - Through what channels, how effectively, and how quickly does labor market demand for STEM skills get translated into education and training programs?
    - How can Federal research and education programs be better designed to facilitate adjustment by education providers to changing labor demand, where appropriate?

The afternoon sessions, which sought to identify mechanisms that would strengthen the contributions of SciSIP research to practice, led to the following strategies for SciSIP research activities (items 1-5) and for SciSIP program management (items 6-10) to consider:

1. *Commission meta-analyses or research syntheses on topics known to be of interest to practitioners and on which a well-established literature exists:* Syntheses of specific literatures targeted to particular groups within the community of practice would likely provide a high return on a modest investment.
2. *Solicit proposals and cluster awards around specific practitioner-identified themes:* The workshop participants expressed a firm consensus that the community of practice is likely to be better served if researchers and practitioners together define some topics of shared interest, balancing those defined solely by principal investigators.
3. *Support research in order to identify research themes of interest to practitioners:* The SciSIP community of practice is not well-defined, and it is likely that many of its 'members'

are unaware that they belong to it. Themes identified through relatively unstructured approaches that draw on self-identified members of the community may not represent fully the potential demand for SciSIP research.

4. *Create a "SciSIP Fellows" program in which researchers would serve temporarily in Federal agencies:* Active researchers may have knowledge that would be useful to Federal agencies. Experience in the Federal government would provide valuable input into the definition of research problems when the Fellows return to academia.
5. *Establish a pilot version of I-Corps for SciSIP:* I-Corps was devised to encourage NSF's natural science and engineering grantees to translate their findings into commercial use. The I-Corps template might be modified to reflect the differences between outreach to businesses by scientists and engineers and outreach to policy-makers by social scientists.
6. *Articulate more specifically to proposers that the program will interpret NSF's "broader impacts" criterion to include the anticipated value of the research results to the community of practice*: Clearer guidance as to the meaning of this criterion could encourage proposers to invest energy in engaging with the community of practice during proposal preparation and in communicating research results.
7. *Create a program advisory board that includes both practitioners and researchers:* This approach may provide a mechanism for identifying themes of mutual interest to both practitioners and researchers and for building awareness and trust that supplements a rechartered and reactivated Interagency Working Group.
8. *Develop stronger relationships with communication intermediaries:* Workshop participants generally agreed that the SciSIP research community should seek to leverage existing platforms that already reach the community of practice, such as think tanks and media organizations as well as government-wide websites like data.gov and research.gov. Projects carried out by such intermediaries or in partnership with SciSIP researchers are more likely to reach practitioners than efforts to build new platforms, such as the SciSIP website.
9. *Encourage SciSIP staff to intermediate actively between researchers and potential users of their research in the community of practice:* A targeted approach in which SciSIP staff members broker connections might be effective in reaching potential users and gaining their trust. However, this "trusted broker" responsibility could put a strain on the program staff and should be designed and implemented carefully in order to avoid the perception of favoritism and bias.
10. *Expand the use of practitioners as proposal reviewers:* This action would provide another mechanism to align SciSIP research projects more closely with practitioner demand, but would have to be handled judiciously, because there will be aspects of proposals that such reviewers may not be well-qualified to assess.

1. Introduction

1.1 Background on the Science of Science and Innovation Policy

From the earliest days of Federal support for R&D on a large scale after World War II, researchers have sought to strengthen the evidentiary basis on which decision-making regarding this support rests. The scope of such research expanded over time along with the goals of national policy, to encompass technology and innovation as well as science. The science, technology, and innovation policy research effort was diffuse, however, spanning diverse disciplines and settings and did not reflect a shared set of goals, much less shared methods and data.

Beginning in the late 1960s, NSF supported research on topics in science, technology and innovation policy and management, but by the mid-1980s this funding had largely ended.[1] In 2005, President George W. Bush's science adviser, Dr. John H. Marburger III, sought to reenergize the field. He called for the creation of a "specialist scholarly community" that could "offer more compelling guidance for policy decisions and for more credible advocacy" (Marburger, 2005). He established an Interagency Task Group on the Science of Science and Innovation Policy, which reviewed the wide range of methods used by agencies for making investments in science and technology and produced a *Federal Research Roadmap* in 2008 (OSTP, 2008).

Dr. Marburger's call for a "science of science policy" also sparked the establishment of a new program within NSF's Directorate for Social, Behavioral, and Economic Sciences, which began making grants to researchers, primarily from universities, in fiscal 2007. The NSF Science of Science and Innovation Policy (SciSIP) program has now participated in funding more than 300 awards worth about $80 million.[2]

Reflecting the structure of the workshop, this report consists of the following primary components.

This chapter provides background information on SciSIP and the purpose of this workshop as an input into setting the future agenda for the SciSIP program and community. It also presents an overview of the workshop structure and mechanics, particularly the "World Café" format of interactive discussions.

Chapter 2 presents the context-setting comments and deliberations of the morning workshop session and World Café discussions. Based on those deliberations, the chapter presents some proposed research questions that would be worthy of investigation by future SciSIP researchers while also answering high-priority needs and interests of the policy community.

[1] Among the NSF activities that funded such research were Interdisciplinary Research Relevant to Problems of Our
[2] The SciSIP program often co-funds awards with other units at NSF. The figure in the text includes the total project costs, whether funded by SciSIP or other NSF units. However, projects over $1 million, which are mainly large data collection programs in which SciSIP has played a small role, have been excluded from the total. SciSIP's FY15 budget was $6.1 million for research and $4.95 million for research infrastructure.

Chapter 3 presents the workshop organizer's framework for developing potential mechanisms that bridge the perceived gap between researchers and practitioners in SciSIP. It then summarizes the resulting discussions from the World Café sessions. It concludes with an overview of the participants' comments and assessments of various proposed mechanisms.

Chapter 4 provides closing observations in the form of broad perspectives derived from the participants in the closing plenary session, and summative findings for future discussions.

1.2 Workshop Motivation

On February 23, 2015, the Assistant Director for Social, Behavioral, and Economic Sciences at the NSF issued a Dear Colleague Letter, inviting proposals to organize agenda-setting conferences for the SciSIP program. As stated in the letter, "The goal of these conferences is to facilitate the generation and execution of a new Roadmap for the Science of Science Policy community and a strategic plan for the SciSIP program."

This report captures the activities and findings from one workshop funded by SciSIP through that call for proposals. The workshop organizers started with the premise that SciSIP research has not influenced science, technology, and innovation policy-making as much as it should and could. At least in part (and as seen in other fields), this unfulfilled potential results from a lack of understanding among presumed "producers" of SciSIP research about the needs and priorities of the potential "consumers" of that research. Our workshop was intended to provide the program with insights into these needs and priorities. In doing so, we are framing the entire SciSIP community as composed of two (not mutually exclusive) groups. The *research community* is made up of scholars and researchers, primarily at academic institutions, who conduct investigative studies of SciSIP issues, often with funding from the NSF SciSIP program. The *practitioner community* encompasses those individuals who work in the Federal government, the Congress, and related institutions in positions where they recommend, influence, or formulate decisions on policies relevant to science and innovation. Thus, broadly speaking, the research community is responsible for producing results that add to the body of knowledge for SciSIP, and the practitioner community is expected to consume those results.

We discuss the nature and make-up of the practitioner community in Section 2 below, but in summary, that community could include:

- Executive branch R&D program managers;
- Executive branch (including regulatory agency) policy, planning, budgeting and evaluation staff members involved in R&D management;
- Congressional committee and support agency staff members; and
- Staff and advisors to a wide range of consulting firms, interest groups, and non-profit research organizations that provide analyses to public institutions.

The importance of user engagement for enabling and hastening the realization of value from research findings was widely recognized decades ago in critiques of the "linear model" of innovation (e.g. Kline 1985). Industry responded to this critique by strengthening collaboration with downstream customers, identifying "lead users" and, more recently, crowdsourcing user

demand by releasing and rapidly refining beta versions of products (Rothwell, 1994; von Hippel, 1985; Iyer and Davenport 2008). Government research organizations have also evolved in response to this weakness, as reflected, for instance, in the creation of the NIH's Council of Public Representatives and the development of open innovation mechanisms, such as Data.gov (Chopra 2014).

The SciSIP program has funded an impressive body of work, covering a wide range of topics in science and innovation policy. Prior to the workshop, interviews with selected practitioners in the science, technology, and innovation policy community indicated a general lack of awareness of the results of SciSIP-funded research. In some cases, individuals providing advice to decision-makers in government R&D agencies lacked any awareness of the SciSIP program itself. The interviews suggested that many members of the SciSIP research community do not have ongoing relationships with such consumers that might provide an informal way to gain insights into the daily demands and constraints of the policy-making process. Nor are there formal mechanisms for eliciting the types of findings from the research community that would help users in formulating appropriate science and innovation policies. And there are few pathways for communicating research findings developed in academic settings to such users in an efficacious manner. In short, the demand articulation function for SciSIP research is underdeveloped (Kodama, 1995).

1.3 Priority-Setting in the SciSIP Program: Prior Efforts

At its inception, the SciSIP program director formulated a program prospectus that drew from the thoughts of Dr. Marburger himself and from the 2008 publication, *The Science of Science Policy: A Federal Research Roadmap* (Lightfoot, 2006; Fealing, 2007). The *Research Roadmap* set out ten "key questions" organized under three themes that formed what the IWG called a potential "scientific framework" for future Science of Science Policy efforts: understanding science and innovation, investing in science and innovation, and using the Science of Science Policy to address national needs.

Starting in fiscal year 2007, the SciSIP program issued grants in response to published program guidelines, and to intermittent targeted program solicitations detailing the focus areas for the program. Each solicitation articulated particular research themes, which have evolved over time. For example:

- The 2007 program solicitation encouraged proposals focused on developing models for analyzing SciSIP-relevant problems or tools for better analysis and decision support in science and innovation policy issues.
- The 2008 solicitation added a focus on proposals to develop new datasets for use by the SciSIP research community. A revision to this solicitation mentioned the plan to fund demonstration projects of scalable dataset development and dissemination.

Note that the solicitations did not exclude researchers from submitting traditional, PI-driven proposals on topics of their own choosing. The SciSIP program solicitations only provide guidance by listing topics of interest to the program.

These regular solicitations have been supplemented by occasional "Dear Colleague Letters" that identify particular areas of focus or time-limited opportunities. The program regularly co-invests in projects with other units at NSF. An initial study of 162 grants awarded by SciSIP through December 2010 showed that 41 distinct NSF programs had co-funded at least one SciSIP-supported project (Zoss & Borner, 2012).

In keeping with its mandate to develop resources and tools to assist in policy decision-making, the program also funded larger efforts to develop new datasets and analytical resources relevant to science and innovation policy. These include the work by the Bureau of Economic Analysis to develop a satellite account on R&D for the U.S. national accounts system, and development of the STAR METRICS (*Science and Technology in the American Recovery: Measuring the Effect of Research on Innovation, Competitiveness and Science*) data system for tracking Federal R&D awards to extramural performers and linking them to data on downstream activities and outputs.

Workshop funding is another investment area for SciSIP, aimed at catalyzing and convening the nascent scholarly community focused on science policy and innovation topics. These workshops covered a number of methodological approaches and subject domains of common interest to SciSIP-funded researchers, including those focused on Ph.D. students and general conferences such as the Atlanta Conference on Science and Innovation Policy.

The SciSIP program has also supported a few workshops and conferences aimed at disseminating the findings of grantees' research to the broader science policy community. The American Association for the Advancement of Science held two formal workshops for SciSIP. The first, in 2009, was attended almost exclusively by SciSIP awardees, and focused on sharing results among those PIs (Teich & Feller, 2009). The second, in 2010, consisted primarily of a series of panels, where SciSIP-funded researchers presented the results of their projects, and representatives from Federal government agencies acted as discussants evaluating the implications of those results for policy (Teich & Feller, 2010). In 2012, the Committee on National Statistics of the National Research Council organized and hosted SciSIP "Principal Investigator Conferences" at the National Academies' facility in Washington, DC. That event also offered presentations by PIs on their funded projects to an audience drawn from academic, government, and non-profit policy organizations (National Research Council, 2014).

To connect prior work funded by SciSIP with topics likely to interest policy practitioners, we reviewed the public SciSIP grant award records and clustered the awards iteratively based on the similarity in topical focus. This process identified six broad themes that provide a high-level understanding of the program's historical and current grant portfolio.

1. *SciSIP Research Theme: Science, Technology, and Innovation Policy Design and Policy-Making.* These projects support research on the impact of deliberation, use of information, and structure of decision-making on policy outcomes. In addition, they look at the responses of firms to policies in such areas as intellectual property rights and energy innovation.

2. *SciSIP Research Theme: Cooperation in Science, Technology, and Innovation.* These projects examine cooperation across disciplinary, gender, corporate, sectoral, and national boundaries. Subjects include management of research teams, international partnerships,

university-industry relationships, and industrial consortia, and they consider virtual as well as face-to-face cooperation.

3. *SciSIP Research Theme: Science, Technology, and Innovation Policy Evaluation.* These projects study the measurement and impact of Federal R&D funding and related programs as well as ethical tradeoffs involved in these programs. One group of projects deals specifically with the impacts of the American Recovery and Reinvestment Act (ARRA). Another cluster of projects focuses on Federal life sciences R&D, including NIH's Public Access Policy, research materials use in human embryonic stem cell research, and the price deflator for clinical trials.

4. *SciSIP Research Theme: Technology Commercialization and Diffusion.* These projects deal with regional knowledge-sharing and innovation processes, patterns of adoption of innovations, and university-industry technology transfer. The roles of women and African-Americans in technology commercialization are also addressed within this research theme.

5. *SciSIP Research Theme: Science and Technology Workforce.* These projects investigate the impact of particular educational practices on career outcomes; career choice and mobility among groups such as female science and technology workers; and networking and knowledge transfer within the science and technology workforce. This theme also includes projects on the role and impact of foreign-born students and workers in the U.S. science, technology, and innovation system.

6. *SciSIP Research Theme: Energy, Environment, and Sustainability Policy*. These projects mainly explore the efficacy of demonstration and deployment policies for energy efficiency and clean energy supply technologies.

Additional efforts have attempted to bring SciSIP and similar research to the attention of policy professionals. The American Association for the Advancement of Science (AAAS) has organized additional panels and conference sessions on the Science of Science Policy, often in conjunction with its annual Science and Technology Policy Forum. The National Bureau of Economic Research, similarly, hosts occasional meetings in Washington, D.C. that are organized by its Innovation Policy and the Economy working group, many of whom have received SciSIP support. The 2015 spring conference of the Association for Public Policy and Management (APPAM) was devoted to "How Policymakers Use APPAM Member Research" and dealt with the same issues raised here in domains other than SciSIP (APPAM, 2015).

While such events are motivated by the best of intentions, it is our observation that the policy community has been underrepresented at them, and only rarely are its members active participants in discussions with the researchers. Rather, these events embody a "supply-driven" model where researchers select projects to pursue and present the projects' results, and then solicit reactions from potential consumers. These events have not served as reliable mechanisms for eliciting the views of policy professionals about what they would like to see on the research agenda for the SciSIP community. Other conferences, such as the Atlanta Conference on Science and Innovation Policy, focus directly on presenting the outputs of SciSIP research, but very few participants in those conferences come from the potential user community.

1.4 Workshop Participants and Mechanics

As this workshop was intended to facilitate demand articulation in the science and innovation policy domain, the structure of the workshop and the makeup of its participants differed from the more conventional "supply-driven" workshop.

The participants were invited to attend based on their status as members of the practitioner community rather than the research community. The aspiration of the workshop was to understand more deeply what practitioners valued and what they might want to see researched in the future, not their reaction to extant work. The organizers sought to avoid any constraints or bias from the specific interests of particular members of the research community. A number of participants were cognizant of the work funded by SciSIP; seven were current or former members of the Science of Science Policy IWG, for example. Most of the participants could be considered pure consumers of SciSIP research. They might read such research results, but they were not engaged in SciSIP research themselves.

While the participant pool was focused on science policy professionals in the U.S. Federal government (the audience that Dr. Marburger posited would benefit from this type of research), the pool reflected an expansive range of topics within science policy. Participants included representatives of agencies in biomedical research, national security and intelligence, energy, environmental policy, and education, among other subjects. A number of participants also came from legislative bodies or their advisory organizations, as those professionals often must address policy issues across a wide range of topics simultaneously. A few participants came from non-government organizations, including think tanks, consultancies and private companies. The participants were not selected based on their subject matter expertise in economics, social science, or any other particular discipline.

Engaging busy professionals employed in policy organizations can be challenging, given the tendency of such people to focus on very immediate concerns and requests. Interviews with workshop participants conducted before the workshop date confirmed the suspicion that these individuals are not commonly focused on academic research—even research relevant to their professional interests. Therefore, the workshop was designed to ensure that the participants were engaged in an active dialogue about the workshop topics. The World Café approach was used based on its past success as a mechanism for eliciting collective insights about broad and complex questions. As stated by the developers of this approach,

> The World Café is designed on the assumption that people already have within them the wisdom and creativity to confront even the most difficult challenges. Given the appropriate context and focus, it is possible for members to access this deeper knowledge about what's important. (Brown et al., 2002).

In the World Café approach, participants self-select into small groups at separate round tables to address topics crafted by the organizers. The discussion is kept purposefully informal and collegial. Facilitators pose specific questions to each group, and invite their reactions and opinions. Each group discussion is guided by a facilitator who strives to make the conversation

participatory, and welcomes broad and diverse input from all participants. As the discussion unfolds, a rapporteur records the discussion to capture key ideas.

Rather than having the small groups work on the same topic for a prolonged interval, the World Café approach entails multiple simultaneous conversations on different aspects of the workshop theme. Each table in the World Café setting has a particular focus. A group of participants talk about that focus for a specific period (typically 20 to 30 minutes), and then the participants get up and move to any other table. This discussion format is conducted multiple times in succession, so that different configurations of participants are discussing different topics during each interval. Since each participant is engaged in a discussion with a different set of participants on a different topic, these conversations tend to encompass diverse perspectives and novel interplay between the parties.

Another unique feature of the World Café is that for each succeeding discussion at a particular table, the facilitator provides the new table participants with a summary of the previous discussion(s). Also, participants can draw or write notes on large sheets of paper covering the table, and leave those notes behind when they change to a new table. This gives each cohort the ability to build on the previous conversations and perspectives, leading to even greater collective insight.

Prior to the workshop date, the workshop organizers circulated an initial "framing paper" to introduce the SciSIP program and the proposed themes of the workshop discussions to the participants. This included the topics for two sets of World Café discussions: a set of six topics for the morning session on research themes (described in Section 2 of this report), and a set of three topics for the afternoon session on enhancing the impact of SciSIP-funded research (described in Section 3 of this report). At the start of the workshop, a set of keynote speakers provided additional context for the day's topics.

Two separate World Café sessions were conducted. The morning World Café addressed potential topics for a future SciSIP research agenda based on the participants' priorities and interests. The afternoon World Café entailed discussions on various potential strategies for better connecting SciSIP research "suppliers" and "consumers." Between the two sessions, a speaker from an outside organization, AcademyHealth, provided the perspective of another policy domain attempting to improve the communication and application of academic research to that domain. The workshop ended with a plenary session for general discussion and synthesis.

2. A Practitioner-Driven Agenda for NSF's SciSIP Research

2.1 Introduction

The first objective of the workshop was to provide the SciSIP Program with views from the community of science and innovation policy practitioners on major policy questions that could be informed by NSF-funded research. To provide context for the overall workshop and for the morning sessions, participants gathered in an initial plenary session to hear comments from three speakers.

Leading off the morning was a short address by Dr. Fay Lomax Cook, Assistant Director of the National Science Foundation for Social, Behavioral, and Economic Sciences (SBE). The SciSIP Program is housed in SBE as a special multidisciplinary activity. Dr. Cook pointed out how the SciSIP Program exemplifies the application of interdisciplinary perspectives to address critical social questions.

Following Dr. Cook, Dr. Maryann Feldman, Program Director for SciSIP at NSF, greeted the participants. Dr. Feldman provided an overview of the SciSIP Program and its activities, as well as its relationship to the Interagency Working Group on the Science of Science Policy.

The final plenary speaker was Mr. Kei Koizumi, Assistant Director for Federal R&D at the Office of Science and Technology Policy. Mr. Koizumi provided a history of the "Science of Science Policy" concept proposed in 2005 by Dr. Marburger. He then recounted subsequent efforts to help in building the community and research base of the Science of Science and Innovation Policy, including:

- Creation and release of the Science of Science Policy *Federal Research Roadmap* in 2008
- The launch of the STAR METRICS data infrastructure, managed by the NIH and the NSF
- Development of the SciENCV registry for principal investigators, to assist in tracking the work of Federally-funded researchers and in disambiguating research records
- Promulgation of the public-access policy for scientific literature resulting from Federal funding, to disseminate more broadly those research results and provide additional data on research outputs and impacts

Mr. Koizumi asserted that "Now more than ever the Federal government needs to be able to document the results of Federal support of science and the science, knowledge, economic, workforce, and mission impacts Federal investments in science have." He noted funding for scientific research tends to be justified through "stories," and that "Our canonical examples are getting old and overused." He called for the development of better data and better models for tracking the impact of science on society and the economy, in hopes of making decisions about science policy using data-driven, empirical arguments.

Invoking Dr. Marburger's vision for a new "community of practice" focused on the science of science policy, Mr. Koizumi mentioned that the extension of the *Federal Research Roadmap*

needs to be a collaborative effort that encompasses both Federal and non-Federal experts. He closed by asking the participants to use the workshop to help in setting both a research agenda and an action agenda for the community, as "other, more mature science and engineering disciplines do."

Following Mr. Koizumi's comments, the participants were instructed on the mechanisms of the morning session of the workshop. To elicit an expansive set of inputs from the participants, the morning workshop session was structured in the World Café format, with six simultaneous roundtables. As common in the World Café format, each table focused on one of six topics and on an associated set of initial questions for discussion, as detailed below. The six topics were inspired by the six topical clusters derived from our review of prior SciSIP-funded projects. These six topics were:

1. Prioritization of Federal R&D investments
2. Management of the Federal R&D enterprise
3. Science, technology and innovation policy evaluation
4. Commercialization and regional innovation
5. Science, technology, and innovation and Federal environmental, health, and safety regulations
6. National education and human resources policy for science, technology, and innovation

The World Café was conducted in three 30-minute discussion sessions. Participants were asked to move to a different table for each session, so that each participant engaged in discussions on three different topics among the six available. In response to a pre-workshop survey, participants indicated that topics 1, 2, 3 and 4 were of particular interest to them. Therefore, during the third of the 30-minute sessions, topics 5 and 6 were dropped, and instead those two tables conducted an additional session on topics 1 and 2. As a result, topics 1 and 2 were each the focus of four discussion sessions, topics 3 and 4 were each the focus of three discussion sessions, and topics 5 and 6 were discussed in two sessions each.

2.2 Synopsis of the World Café Discussions

In this section we present the main findings from the morning World Café discussions. These discussions sought out practitioner views of their needs for data, information, models, and research results to help them make and advise senior policymakers on decisions regarding science, technology and innovation matters. The findings presented here are drawn entirely from the written records of the discussions maintained by each table's moderator and rapporteur, as well as from notes left behind on the table covers by participants. The findings are not augmented by the views of the workshop organizers and staff, except insofar as they may have influenced the conduct of the discussions, interpreted the remarks of the participants making brief notes, and combined remarks of several participants from more than one table to arrive at a single statement on each matter. A number of the discussions were quite lively, so it is possible that not all ideas were captured in the notes or carried forward into the summaries that follow.

2.2.1 Prioritization of Federal R&D Investments

Workshop Key Questions

- What analytic methods and models and what kinds of evidence do practitioners (e.g., policymakers and program managers) draw upon in deciding among competing research objectives, programs, projects, and investigators?
- What are the most important gaps in knowledge, methods, and models that constrain practitioners' abilities to make and/or recommend wise decisions on research investments?

Workshop Supplementary Questions (In each case, "how?" means "what methods, models and evidence do you use?"):

- How do you judge whether a proposed project will result in important but incremental progress or in a transformative outcome?
- How do you determine whether the proposed budget for a program or project is at a reasonable level?
- In setting priorities among programs, projects or investigators, how do you take into account the uncertainty inherent in funding activities that explore the unknown?
- How do you decide whether a particular research objective is best supported via individual PI grants, interdisciplinary or inter-institutional multi-investigator grants, cooperative agreements, or contracts?
- How do you select proposal reviewers for grant awards or contracts?

Synopsis of Workshop Discussion

The World Café discussion of prioritization was the most heavily subscribed of any topic. The participants in these vigorous conversations focused on the following themes:

- retrospective impacts of Federal R&D funding on outcomes,
- theoretical models of the impact of R&D funding,
- R&D decision-making heuristics in practice,
- management of risk and reward,
- public-private partnerships, and
- tools for tracking R&D projects within agencies.

The participants expressed a strong demand for empirical retrospective studies of the contribution of Federal R&D funding to outcomes. Evaluation studies of this type are important not only to determine the outcomes on their own merits, but as a tool for learning about how to manage future decision-making. Such retrospective studies should be structured around theoretical models to the extent possible to provide a sound foundation for making future projections.

Unfortunately, existing models of the impact of R&D funding, such as cost/benefit analysis, do not meet the practitioners' needs. For instance, R&D investments are not typically one-time decisions, although they are often modeled as such. Rather, ongoing reviews and evaluations may inform and lead to revisions of investment levels and priorities. Thus, there is a demand for structured evaluations throughout the life cycle of major R&D activities, built around reliable data that can feasibly be collected during the course of such activities.

While valuing theoretical models of R&D priority setting, the practitioners gathered at the workshop emphasized that R&D encompasses a heterogeneous set of activities across diverse Federal agencies and programs at varied levels of decision and directed toward a wide range of goals. It is unlikely that any one model or approach will be optimal or appropriate to their different circumstances. SciSIP research therefore should be explicit about context and its limitations in that regard.

An additional, important consideration is that senior R&D decision-makers often rely mainly on their own implicit heuristics based on experience and judgment, rather than formal analyses. They may prefer not to employ any analytic tools at all. The participants suggested that it would be valuable to conduct an empirical inquiry into the nature of those heuristics, that is, to make a systematic study of what decision makers on R&D priorities actually do. For example, R&D decision-making is actually incremental, reflecting Federal budget dynamics, political expectations, shifting national priorities, and other forces that extend far beyond R&D *per se*. Inertia and vested interests play large roles. Knowing what heuristics are actually used, as well as how and under what conditions, could improve more formal analytical tools and methods as well as, perhaps, the heuristics themselves.

The workshop participants expressed a strong interest as well in the management of risk and reward in R&D investments. Strategic considerations sometimes make it prudent to set aside portions of R&D budgets to fund high-risk projects, to fund projects that simply "follow" the evolution of a line of research, or that are devoted to communication, interpretation, translation or verification of prior results. Models or strong heuristics are needed to help make sensible decisions among these specialized priorities and others. Portfolio models can be useful, but need additional development and empirical grounding.

Public-private partnerships of various kinds have become popular in the Federal government. Needed are guidelines based on empirical research for when and how to use various approaches to forming and operating such partnerships. Similarly, the Federal government has experimented with an array of new funding and management vehicles for R&D in the past few decades. There is little empirical understanding of which vehicles work, and under what conditions, to inform decision making about such investments in the future.

Finally, in larger agencies, it can be very challenging for decision makers at all levels to be informed about R&D investments the agency has already made and is contemplating. R&D project databases are weak at best and very difficult to keep current. In practical terms, this means that for large agencies, decision makers are operating in a climate of considerable uncertainty, not only about possible outcomes of alternative investments, but even about what is already being supported. The workshop participants argued that improved tools are needed to help with this management problem.

2.2.2 Management of the Federal R&D Enterprise

Workshop Key Questions

- How well does the Federal R&D enterprise (the system of R&D funding agencies, Federal laboratories, and organizations for managing R&D policy and performance) recruit and retain talent, attract high-quality partners, and provide expertise to the rest of the Federal system?
- What role might scholars in management and related fields play in assessing key policies and practices that affect the performance of Federal R&D programs, personnel and organizations?

Workshop Supplementary Question (In each case, "how?" means "what methods, models and evidence do you use?"):

- How do we detect and measure the contributions of the Federal R&D enterprise to economic and social changes?
- How could the components of the Federal science & technology enterprise be organized and managed more efficiently and effectively?
- What are the relative strengths and weaknesses of different R&D program management and funding structures (e.g., the "strong program manager" model at DARPA or the PI-driven model at NSF and NIH) for addressing particular R&D challenges?
- How do we ensure that we are getting the most qualified S&T workforce for government R&D agencies?
- Can we determine the optimal way to structure and phrase a program solicitation or RFP to encourage the appropriate performers to apply for funding?
- What can Federal R&D organizations do to improve their coordination and collaborations with universities, firms, foundations, and other parts of the national S&T system?

Synopsis of Workshop Discussion

This topic attracted the second-strongest level of interest among the workshop participants (after the closely related topic of priority-setting) and provoked a vigorous discussion. The key themes that emerged from it were:

- "return on investment" (ROI) from the Federal R&D enterprise,
- variations in management challenges across the R&D portfolio,
- acquisition of R&D from non-governmental performers,
- how to ensure that a portfolio balances risk and reward adequately,
- the scale and appropriate use of the Federal laboratory system, and
- managing the Federal R&D workforce.

Participants expressed strong interest in understanding better how to calculate the "return on investment" (ROI) from the Federal R&D enterprise. They argued that it is important to perform such calculations across the portfolio as a whole as a means of justifying the entirety of the Federal investment of R&D. In addition, such calculations might be done in different ways across types of R&D and agencies. For instance, the National Science Foundation's calculation should differ from that of the Department of Defense, although there may be commonalities in such areas as basic research. Policy-makers may also want to know more about the ROI at the state level as well as the national level, and they may also want to understand the extent to which

the returns on the Federal investment spill over to other countries and are therefore not captured domestically. While the participants recognized that there is a diverse literature on this general topic, it may be ripe for synthesis or meta-analysis.

Closely related to the ROI theme is that of R&D portfolio management. Different elements of the portfolio raise different management challenges. For example, one participant argued that academic institutions and Federal laboratories have particular difficulty managing interdisciplinary and multidisciplinary research, which require different competencies than traditional disciplinary research. Similarly, older fields pose different challenges than newer ones, especially ensuring that they continue to tackle challenging and relevant problems. Alternatives to or hybrids of the conventional principal investigator-driven and program manager-driven management models for R&D might be explored more carefully. In addition, fragmentation of the decision-making structure for Federal R&D across executive agencies and Congressional committees poses unique management challenges at the highest level of aggregation.

The third theme that attracted significant attention from the workshop participants may best be characterized as the "make-or-buy" decision: what R&D should be done within the Federal enterprise, and what should be done elsewhere? In particular, when Federal agencies seek R&D performers via grants, contracts, or other funding instruments, there are difficulties in making sure that the most qualified and appropriate performers are aware of those opportunities and apply for them. Program managers would like more insight into how to evaluate the selection of performers at the start of a program. Highly attractive non-governmental performers may find funding from other sources to be easier to obtain, more compelling in terms of the problems presented, and more flexible than Federal funding. The participants expressed interest in tracking the progress of the Department of Defense's recent initiative to reach out to non-traditional performers in Silicon Valley and elsewhere.

An especially vigorous discussion focused on whether the Federal R&D enterprise devotes enough funding to and adequately manages "high-risk, high-reward," as exemplified by ARPA-E and DARPA. There was broad consensus that the acquisition process is "broken," because of an obsession about potential conflicts of interest and scandals and not enough focus on performance and risk-taking. The current political environment makes program managers risk-averse, which is presumed to suppress innovation. Current tools for oversight, such as Congressional hearings or GAO investigations, are blunt and crude. The participants expressed interest in understanding the opportunity cost of rejecting good proposals, including high-risk proposals. While the participants accepted that the Federal Acquisition Regulations are in place for good reasons, they suggested that research into alternatives and exceptions to these regulations for R&D acquisition would be appropriate.

On the "make" side of the "make-or-buy" question, several participants wanted more studies of the Federal laboratory system. Federal R&D data experts at the workshop lamented the poor quality of data on the scale, structure, and condition of Federal labs; we do not even have a consensus about how many exist and how they should be defined. Some participants expressed the view that Federally Funded Research and Development Centers (FFRDCs) are used excessively by agencies, primarily due to the ease of contracting with them, but they have no

way of validating that belief. A better understanding of this particular component of the Federal R&D enterprise would be very helpful.

Managing the Federal R&D workforce was the final major theme within this World Café topic. Most participants agreed that the Federal hiring process is an impediment to attracting high-quality talent for both performing and managing R&D. Research on the Federal hiring process might be valuable to fix that problem. For example, many agencies rely on rotators and Intergovernmental Personnel Agreements, but there is no evidence that these mechanisms are better than filling those positions with permanent government employees. Workshop participants speculated on the advantages of using rotators and IPAs, such as preventing burnout and bringing in new knowledge and networks, but those advantages have not been validated by any known study. Another mechanism for recruiting talent is the use of civil service exemptions, especially under Title 42 of the U.S. Code. Agency managers believe that such exemptions are very effective, but under-utilized. The evidence for this is purely anecdotal.

For the current Federal R&D workforce, participants feel that appropriate systems for performance assessment and improvement are lacking. Current systems generally rely on traditional academic performance metrics, like publications, and much discussion centered on whether alternative metrics used by innovative private firms would be appropriate for Federal agencies. Another common problem is that highly qualified scientists are moved into management roles, even though they have no skill or aptitude for management. Research might be conducted into how management training should be integrated into promotion and tenure decisions at Federal R&D agencies.

2.2.3 Science, Technology, and Innovation Policy Evaluation

Workshop Key Questions

- What are the major challenges facing the evaluation process in the R&D domain?
- What themes and tools can the research community investigate and develop to help meet these challenges?

Workshop Supplementary Questions (In each case, "how?" means "what methods, models and evidence do you use?"):

- How do you or your agency use R&D evaluation in decision-making? Do these activities focus on programs, policies, or both?
- What impacts are you asked for in relation to your programs or policies? Can you answer these questions?
- When is the most effective or most useful time to evaluate a program or policy?
- How do you estimate the societal benefits of your R&D programs or policies? What problems do you encounter in making such estimates?

Synopsis of Workshop Discussion

Along with priorities and management, policy evaluation was one of the workshop's most popular topics as indicated in the pre-workshop survey and participation at the event itself. The following themes emerged from these conversations:

- linkages between inputs, processes, outputs, and outcomes;
- credible attribution of outputs and outcomes to inputs;
- R&D program management techniques;
- the program or policy evaluation process; and
- data collection.

Perhaps the dominant theme of the workshop discussion of policy evaluation was the challenge of linking program inputs to processes, outputs and outcomes. Outcomes are particularly hard to measure, not only because they are often ill-defined, but also because any change in them usually lies outside the evaluation timeframe. Nonetheless, the participants were quite interested in further research that seeks to advance understanding and measurement of outcomes. For example, several participants expressed interest in outcome measures that go beyond economic payoffs to include scientific advancement or environmental benefit. Inputs, processes, and outputs are perhaps more realistic targets for SciSIP researchers. In addition to developing new concepts and metrics, researchers might be able to study what combinations of inputs and processes lead to particular outputs. They might also seek to measure cost savings and operational improvements as well as new companies and new revenues as economic outputs and outcomes of R&D programs. Understanding the linkages among these variables is also critical for high-quality science and innovation policy evaluation, bearing in mind that these linkages may not be linear. The workshop participants also seek points of leverage within this framework; they want to know where as program managers or policy-makers they can most effectively shape outcomes. Many evaluations are not very useful, because they do not focus on opportunities to exert leverage.

Credible attribution emerged as a second major theme on this World Café topic. In addition to linking inputs to outcomes, workshop participants have difficult demonstrating program or policy effectiveness relative to the counterfactual world in which the program or policy is absent. Experimental data is very rare in the science and innovation policy domain. Even quasi-experimental data is rare; for example, few agencies survey (or even record) unsuccessful proposers. SciSIP research comparing projects that were almost funded with those that were actually funded might be helpful in this regard. A related issue is the time lag between program implementation and results. Some government organizations claim credit for work done by their awardees long after the research was funded, even though the relationship of that funding to the later work may not be very strong.

The workshop participants also called for research on R&D program management techniques. For example, there was a call for better understanding of the value of different types of proposal review, such as proposal-based peer review, white paper-based program manager review, and white paper-based peer review. One participant asked whether it is better to invest in people or projects. Another raised the challenge of understanding how to calibrate the level of funding to maximize effectiveness. A third participant recommended SciSIP research on the types of performers that the Federal government supports, such as large and small businesses. A fourth expressed interest in comparing active program management, in which projects may be stopped early, with more passive grant-based management. Finally, on this theme, several participants called for SciSIP research on how to evaluate and manage R&D portfolio risk, including justifying greater risk.

When discussing the evaluation process, participants reflected on the difficulty in many cases of identifying the goal of many evaluations and a lack of a large "body of work" to develop best practices for R&D program evaluation. Sometimes evaluators do not know who the customer is or how the results will be used. Some program managers have difficulty specifying the criteria to be evaluated. It is not always clear when in the lifecycle of the policy or program an evaluation should be done. If an evaluation is done in the middle of the program lifecycle, there should be mechanisms that allow the program or policy to be adjusted (or terminated) in response to it. More generally, the participants suggested that there is a dearth of research to inform investment decisions.

Many participants stated that data collection in support of evaluation was a major challenge. Some Federal agencies do not collect even those data that are easy to capture. On the other hand, sometimes agencies collect *only* those data that are easy to obtain, even though they are not very useful for carrying out evaluation. Other data that would be useful for evaluation may simply not be available, or may not collected because the performers prefer not to provide them. SciSIP could contribute by providing insights into the data that evaluations need (or credible proxies for unavailable data), which in turn links back to the initial theme of better understanding and measuring inputs, process, outputs, and outcomes.

2.2.4 Commercialization and Regional Innovation

Workshop Key Questions

- What do we not know, that we should know, about how public policies (at all levels) can effectively promote technology-based economic development (TBED) at the regional level?
- What do we know about the contributions made by Federally-funded institutions to regions, and the channels through which these contributions flow?

Workshop Supplementary Questions

- Do we have adequate data to make new policies and to assess existing policies in a timely fashion? What kinds of variables, beyond aggregate economic growth, are important in judging success (job creation, new business formation, sustainability, equity, etc.)?
- What tools are available for spotting new opportunities for policy to make a difference? Are there emerging challenges that the research community could help to define and clarify?
- How well do we understand the internal dynamics of Federally-funded institutions (incentive structure, culture, etc.) and their interactions with other institutions in regional innovation ecosystems?
- How well do we understand how policies and policy-making processes at different levels of government (local, regional, state, Federal) interact? What metrics and methods are used to evaluate proposals to TBED funding programs at each level?

Synopsis of Workshop Discussion

Workshop participants identified five potential research themes in their World Café discussions about commercialization and regional innovation. They included:

- measurement of commercialization and innovation,
- modeling of the impacts of regional-level policies,
- variations in the innovation process across industries,
- methods to streamline the interaction between Federal labs and other institutions within regional innovation systems, and
- capturing the non-economic value created by intramural and extramural Federally-funded R&D.

The practitioners who gathered to discuss this topic expressed general unhappiness with the quality of data to measure innovation, especially at the regional level. They have the sense that the U.S. is well behind Europe in measurement, as demonstrated by the Community Innovation Survey. As a result, it is difficult to evaluate existing policies and to develop an evidence base upon which to build future policies. There was skepticism that some commonly used measures, such as patents and start-ups, correlate to outcomes of interest, such as economic growth. Flows of people, on the other hand, were perceived to be under-studied. The participants also expressed an interest in breaking down the process of commercialization into stages that could then be measured, such as proof of concept and initial product introduction. The main locus for such data collection should be government statistical agencies, which deserve more support, but pilot efforts and concept development in the academic sector could be valuable. These pilot efforts might also seek methods to speed up data collection that might be adopted by agencies, so that measurement can be closer to real time.

A number of the practitioners also expressed concern about the quality of modeling done to evaluate regional development and commercialization policies. Perhaps it would be possible to do more rigorous analysis using experimental or quasi-experimental methods to assess the impact of policies. The participants would like to understand better what would have happened in a region if specific policies had not been in place. These policies might include efforts specifically intended to accelerate job creation and growth, but also those that might unintentionally have such consequences, including Federal funding of R&D at universities.

Building on the idea noted above of breaking down and measuring the commercialization process, the participants suggested that deepening our understanding of variations in this process across industries would be extremely valuable. What works well in one sector may not work well in another. Policies should be attuned to such differences, as suggested by recent work on so-called "legacy sectors." A related theme was the comparison between start-ups and existing firms as the vehicles for commercialization. Is it possible to say whether one or the other does better in particular industries or fields of technology? It would also be helpful to have studies that look at the wide variety of programs conducted at multiple levels that seek to "fill the gap" between research and application.

On the question of the role of Federal labs in regional economic development, there were differences of opinion among the participants, which may reflect differences across agencies. For some agencies, this issue is peripheral or perhaps even a distraction from accomplishing their missions. Others need a deeper understanding of the regional innovation systems in which they might participate because they seek to leverage that system. From the perspective of the regions, there was a desire to streamline the interface between Federal labs on the one hand, and firms

and universities on the other. Legal, administrative, and cultural barriers impede their interactions and slow commercialization processes. For example, it may be difficult for graduate students to work at Federal labs, although it is believed that they are very important mechanisms for innovation and commercialization. In addition to studying such barriers, researchers might also provide international comparisons and best practices that would be useful to policy-makers in this domain.

The final theme that emerged from these sessions was how to capture, if not measure, non-economic value created by Federal agencies. For instance, the Pluto New Horizons mission, which received massive media coverage over the summer, may have educated the public about planetary science and possibly inspired students to pursue science careers. Numbers may be combined with narratives in fruitful ways in such cases.

2.2.5 Science, Technology, and Innovation and Federal Environmental, Health, and Safety Regulations

Workshop Key Questions

- How can academic researchers advance a constructive role for science and technology in the setting of environmental, health, and safety regulations?
- What specific gaps in knowledge might regulators encounter in their work that researchers could help address?

Workshop Supplementary Questions

- How can regulatory regimes and actions affect, promote, or delay the R&D and diffusion of new technologies?
- How might the timeline of regulatory enforcement in a technology's development (i.e., early standard setting vs. allowing room for experimentation, precautionary vs. reactive) influence innovation?
- Where do regulators "get their science"? How might regulatory and legal procedures affect what kinds of scientific information are considered in the setting of regulations?
- How well do expressions of certainty, consensus, and statistical significance used in the scientific community map onto the standards of evidence used in the legal context of regulatory rule-making?

Synopsis of Workshop Discussion

Workshop participants explored both the "science for policy" and "policy for science" dimensions of this topic. Key areas of demand for further research articulated by participants included:

- social dimensions of the implementation of regulations,
- structures of expert and public input into the regulatory process,
- modeling of the impacts of regulations on innovation, and
- standards of scientific evidence for regulatory action.

The first research theme emphasized by practitioners in this domain was the social impact of regulation. The focus of most research to date on regulatory impact has been economic activity.

However, new regulations are implemented in diverse social environments, which are often already subject to existing regulations that may have complementary or competing effects. The practitioners concluded that knowledge of the cumulative effects of regulations on individual and organizational behavior is limited. Moreover, local context shapes the implementation process, so it is important for researchers to study not only how regulations are issued at the Federal level, but also the variations in how they are put into practice across diverse localities.

Workshop participants also considered how expert and public input into regulatory processes may affect the outcomes of those processes. Regulators must determine who qualifies as an "expert" when regulations are being crafted, and how much input will be sought from experts and non-experts. This discussion led to the question of how the institutions and mechanisms through which that input is gathered may best be matched with the context in which the input will be used. The practitioners expressed strong interest in understanding how advisory boards should be composed and used (for instance, standing advisory boards with broad expertise vs. ad hoc boards with narrow but deep expertise). They also asked whether the rules that govern the use of committees in the Federal government, such as the Federal Advisory Committee Act (FACA), constrain the use of new and innovative platforms for soliciting public and expert input. Finally, the participants reflected on their own expertise, and whether practical experience was appropriately valued relative to technical expertise in the regulatory process.

The participants in these World Café sessions expressed a desire for new methods for testing and modeling regulations, including the capability to model the social impacts and synergies with existing regulations discussed above. They specifically seek to understand how regulations could be written so that they deliver positive social benefits as well as fulfill the agencies' missions. SciSIP-funded researchers might be able to provide predictive insights into the strategic interactions between implementing agencies and regulated parties in the private sector. The participants expressed the belief that the present state of theory and data on how regulation can hinder or help innovation is inadequate. They would like to know more about the inhibiting or encouraging effects on private sector innovation, particularly in emerging sectors such as commercial space launch.

The final area of opportunity that was discussed at these sessions concerned the scientific basis for environmental, health, and safety regulations. Participants reported that the following questions that could benefit from additional investigation: What level of evidence is required to justify a regulation? When do regulators have enough scientific information to act? What level of reproducibility should a study achieve to serve as a basis for environmental, health, or safety regulation? What level of evidence is necessary to *reverse* a regulation? Although research alone may not produce an answer to these questions, it could provide indications of the costs and benefits of employing different regulatory standards in different contexts.

2.2.6 National Education and Human Resources Policy for Science, Technology, and Innovation

Workshop Key Questions

- What decisions are on the medium-term policy agenda with regard to broadening participation in science, technology, and innovation education and occupations and for STI-related immigration policies?
- What kind of evidence and analysis might make an important difference in shaping these decisions?

Workshop Supplementary Questions:

- How do we enhance the diversity of the STEM workforce to ensure that we are gaining the full benefit of the talent of the entire population?
- How well do we understand the demand for science, technology, and innovation-related skills in the economy and how this demand is likely to evolve over time?
- Do we have a sufficient understanding of how the demand for skills is linked to the education and training system? To the immigration system?
- What do we need to understand better about the educational process at various levels (K-8, high school, undergraduate, etc.) to improve the attractiveness and sustainability of participation in STEM education?
- What key open issues remain with respect to workplaces that rely heavily on science, technology, and innovation skills – culture, promotion, retention, etc.?

Synopsis of Workshop Discussion

The World Café table conversations on the theme of education and human resources policy yielded the following major themes for consideration by the NSF SciSIP program:

- anticipating labor demand;
- balancing the Federal workforce between permanent employees and contractors;
- broad-based literacy in science, technology, and innovation; and
- broadening participation.

One major theme of these sessions was the challenge of anticipating labor demand related to science, technology, and innovation, with regard to the field and level of graduates and the skills they will need. STEM education is a very broad concept, covering everything from K-12 education to postdoctoral research, and from highly theoretical to applied fields. Participants expressed a desire to have better insight into setting priorities among fields and levels within STEM. They also expressed some concern about the possibility of a skills mismatch between the training that students receive in a particular field and at a particular level with what employers expect of such a student. While recognizing that learning on the job is necessary and desirable, the participants asked whether research can help educational institutions better anticipate the skills that will be in demand. Examples offered in this regard were team and leadership skills.

A second theme highlighted by participants in the human resources area was the balance within the Federal science and technology workforce between permanent employees and contractors. A certain degree of continuity is necessary in order to maintain institutional knowledge within the

Federal system, which may be as important as or more important than technical expertise. The requirements for specific types of technical expertise, on the other hand, change over time. Research in this area may be able to provide guidance that would help Federal agencies do a better job of managing their budgets and personnel, while continuing to target resources toward their missions.

Broad-based literacy in science, technology, and innovation was a third theme in these conversations. There was a general consensus that a basic level of education in these areas is valuable to citizens, but the nation has been falling short in achieving it. Some participants suggested that this issue warrants more emphasis than the training of experts in these fields, so that we can make better decisions as a nation. Science education seems to put more emphasis on weeding students out than bringing students in. The research community may be able to better inform policy-makers about what educational methods are effective, especially in instilling the ability to learn and adapt over time as science and technology change.

The final theme in this group was diversity and broadening participation in science, technology, and innovation. As with the issue of labor demand, participants expressed a concern that this issue has been dealt with at too high a level of abstraction. They want to know more about the representation of specific demographic groups, rather than diversity in general. The link between diversity and national goals is also not well understood, beyond diversity as a goal for its own sake.

2.3 Practitioner-Driven Research Questions and Challenges for SciSIP

This section draws upon the World Café discussions summarized above to propose an agenda of practitioner-driven research for consideration by NSF SciSIP. For purposes of clear reporting, we have reorganized and relabeled some of the clusters of research ideas that originally framed the workshop discussions. Also, we have prioritized and filtered the topics discussed to make them more clear and concise. In doing so, we have sought to be faithful to the views of science and innovation policy practitioners as expressed at the workshop. The brief presentations on the background for each cluster of research topics were drafted by the organizers to reflect the practitioners' views on the problems they face. We have tried to make this a report of the workshop, not a report about the organizers' own findings or preferences.

2.3.1 Making R&D Funding Decisions

Background
Decisions about how much money to invest in R&D and in what areas are made at many levels and in a variety of circumstances in the Federal government. Much effort has been expended by the research community to develop normatively driven models that can inform funding decisions, but these models do not seem to be used very much by practitioners. Furthermore, relatively little is known about the decision-making processes that are actually employed by those who allocate and manage R&D funding. Deeper understanding of actual decision processes could inform theoretical model building and may encourage practitioners to employ such models more frequently. Both simulations and empirically-based modeling could help provide deeper insights and perspectives for both practitioners and theory-builders.

Research Questions and Challenges

- How are R&D funding decisions actually made in practice?
- What heuristics do senior decision makers use? How frequently are formal models or evaluations used?
- What are the different types of decisions that policymakers in Congress, the White House and Federal agencies make and how can SciSIP research inform each of them?
- How well do different functional approaches (e.g., peer review, strong program manager, formula funding) to allocating and managing Federal R&D funding work under different conditions and circumstances? What are best practices?
- Can we build empirically-based, theoretically sound models of R&D priority setting and decision making that account for such realities as incremental budgeting; option preservation; international competition; and differing levels of uncertainty across R&D domains regarding technical success, subsequent commitments of complementary resources, and goal accomplishment?

2.3.2 Managing Agency and Multi-Agency R&D Portfolios

Background

Large R&D agencies face substantial management challenges in compiling information about the completed and on-going R&D projects for which they are responsible, which makes efficient and responsible management of their own portfolios difficult. Multi-agency and multi-sectoral data on R&D investments and results are even more limited as a foundation for coordination and decision making on R&D support. Past efforts at building such data bases at the agency and government-wide levels have been frustrated by a range of problems including inconsistent field and problem taxonomies, use of incompatible information management systems, inadequate resources, and limitations on public data access. Agencies would welcome, in principle, development of such databases and tools.

Research Questions and Challenges

- Can we develop better databases and better data management tools for managing R&D portfolios within and across agencies?
- Are there effective ways to access and incorporate information about non-Federal R&D investments to aid decision makers in deciding whether and how to reinforce and/or take advantage of such investments?

2.3.3 Evaluating Federal R&D Programs

Background

Policy makers have long been interested in understanding and measuring the outputs and outcomes of Federal R&D investments, both to assess whether current and past programs have accomplished their goals and as a guide to helping make future investments wisely. From an economic perspective, the key issue can be framed succinctly as one of determining the rate of return on Federal R&D investments (ROI). In addition, policymakers also want to know whether programs have or are likely to accomplish their goals and how well those programs are doing relative to expectations; that is, they examine such programs within a formal evaluation

framework that is codified and implemented via the mechanisms of the Government Performance and Results Act (GPRA) and subsequent amendments. Neither the ROI nor the GPRA approaches to evaluation have proven to be entirely satisfactory in practice. There is also indication that the large and diverse literatures on these topics are not well understood by practitioners and may be ripe for synthesis or meta-analysis.

Research Questions and Challenges

- What is the return on Federal investments in R&D and how does it depend on the context and objectives of the investments?
- How might ROI approaches be augmented to incorporate both non-economic returns and returns received outside of the U.S. (so-called "international spillovers")?
- Have Federal R&D agency strategic plans, performance plans, and performance reports under GPRA led to measurable improvements in agency performance and R&D outcomes?
- Can retrospective analysis of more than two decades of experience with GPRA reporting help improve their basic parameters, including assessment of R&D outputs and particularly R&D outcomes?

2.3.4 Designing and Implementing Public-Private Partnerships (PPP) for R&D

Background

The Federal government has undertaken many experiments in recent years that blur the sharp lines between sectors that traditional norms recommended. The advocates of these PPP experiments have called for expanding their use, but little research has been conducted to understand how well they have worked in various circumstances. Comparative research on the effectiveness of public-private R&D partnerships should provide principles for when PPPs should and should not be used, how they are best designed to meet various objectives, and what are best practices for establishing, funding, and operating them.

Research Questions and Challenges

- How well do various models of public-private partnerships for science, technology, and innovation work?
- Are different models better in difference circumstances?
- How might their structure and operations be improved?

2.3.5 Optimizing the Performance of the Federal Laboratories

Background

There are robust sets of literature studying R&D management in firms, and some extent in universities (especially research centers). There are fewer studies of the management of government R&D organizations. Market forces, to some extent, enforce accountability and discipline on private sector R&D activities. Relatively less is known about dealing with "non-market failure" and with optimizing the performance of public sector R&D performers, especially the Federal laboratories. As an example, technology transfer and commercialization in the Federal sector is assumed to function much like the same activities in academia, but that assumption may not be accurate.

Research Questions and Challenges

- What is the nature and structure of the Federal government science and engineering enterprise?
- What approaches would improve valuation and management of R&D activities conducted by government laboratories?
- In what ways should Federally-employed and Federally-contracted scientists and engineers be managed and rewarded differently from those in academia and industry?

2.3.6 Enhancing Regional Contributions of Federal R&D Investments

Background

Numerous authors have studied the contributions of academic R&D performed in a region to the economic performance of that region using a variety of economic and case study methods. Even though the Federal laboratories and FFRDCs absorb nearly 40 percent of the Federal R&D budget, or some $50 billion per year, much less is known about how they affect regional innovation ecosystems and regional development in general. Policymakers would benefit from a better understanding of how inducements to the laboratories to participate in "open innovation" in their regions affect their contributions to regional development.

Research Questions and Challenges

- What contributions do Federal laboratories make to regional innovation systems and to regional economic development in general?
- How important is active participation in open innovation to the performance of the laboratories in achieving their missions?
- For laboratories with primary missions other than economic development, to what extent can regional and national economic development be achieved as a side effect or co-benefit of achieving their primary mission?

2.3.7 Tailoring Industrial Innovation Policy to Sectoral Variation in Innovation Processes

Background

Public policies are increasingly based on the expectation that industrial innovation will contribute to the resolution of policy issues in such areas as health care and public health, climate change, national security (including cybersecurity), regional economic development, and job creation, to name but a few. These policies are often designed by drawing on the experiences of a few high-tech sectors, such as information technology and pharmaceuticals. Yet, these high-tech sectors are not representative of all industries; there appear to be a diverse range of patterns across industries. In fact, drawing too heavily on the high-tech model may be counterproductive for policy-makers seeking to shape innovation in older industries.

Research Questions and Challenges

- How do industries, including service industries, vary with regard to innovation and commercialization processes?
- How do appropriability mechanisms, such as patenting, trade secrecy, and use of complementary assets, differ by sector and over time?

- How can Federal technology transfer policy as embedded in applicable legislation be made more flexible and be adapted to industry-specific requirements?
- How should policies aimed at accelerating industrial innovation be tailored to achieve better results across Federal missions, such as energy, transportation, and environmental protection, that impact "legacy" sectors?

2.3.8 Lessening the Burden of Regulation on Academic R&D Performers

Background

Many principal investigators and institutions complain that they are overburdened by regulations imposed on the conduct of academic research. It is unclear whether in each case these complaints reflect significant costs, or the degree to which regulations as implemented have yielded benefits. It has been suggested that regulatory impact analysis like that required for "major" rules (which have an expected annual cost greater than $100 million) in such areas as environmental and financial regulations be extended to cover rules governing academic research.

Research Questions and Challenges

- How have regulations on the conduct of research affected R&D performers and outputs?
- Would it be possible and useful to conduct regulatory impact analyses before issuing such regulations?

2.3.9 Enhancing the Contributions of Scientific and Technical Understanding to Regulatory Policy Making and Implementation

Background

Federal agencies are required to seek public input as they formulate new rules and must base those rules on scientific and technical understanding. They use diverse mechanisms to call upon scientific expertise as they make regulatory decisions, and they use a variety of methods for gathering public input to the regulatory process. These differences should provide a solid basis for comparative studies across agencies and domains of public policy that may inform and improve information gathering practices such as assembling advisory committees, organizing public participation, soliciting written commentary, and holding public hearings.

Research Questions and Challenges

- What is the relationship between information offered by the public and by scientific advisors and regulatory outcomes?
- Do the institutional mechanisms through which such advice is offered make a difference?

2.3.10 Helping Education and Training Institutions Respond More Effectively to Changing STEM Labor Market Needs

Background

Currently, STEM skill development is primarily a supply-push process. Skills in demand may change rapidly, and real-time labor market indicators are increasingly available to measure demand. With better understanding of these labor markets, education and training institutions

may become able to serve students and employers more effectively, especially if bottlenecks and gaps are identified and filled.

Research Questions and Challenges

- Through what channels, how effectively, and how quickly does labor market demand for STEM skills get translated into education and training programs?
- How can Federal research and education programs be better designed to facilitate adjustment by education providers to changing labor demand, where appropriate?

2.4 Closing Remarks

In the World Café morning workshops, Federal science, technology, and innovation policy practitioners articulated – often in graphic terms – a set of needs to which they hope the SciSIP research community will respond. While it is true that the research community has done more work that is relevant to these needs than practitioners are aware of (a gap that is the subject of Section 3 of this report), it is also true that key questions of interest to practitioners have been neglected or under-studied by researchers. The workshop revealed opportunities for mutual learning that could over time materially improve scholarly understanding of science, technology, and innovation policy issues and the quality of the policy-making process.

3. Mechanisms for Strengthening the Contributions of SciSIP Research to Practice

3.1 Introduction

Following a short break for lunch, the workshop resumed with a keynote address to the plenary session by Dr. Lisa Simpson, President and CEO of Academy Health. As the afternoon session of the workshop focused on strategies for better connecting the SciSIP research community to the community of practitioners, the workshop organizers felt it might be instructive to see how a different domain approaches this same challenge. AcademyHealth is an organization dedicated to improving "health and the performance of the health system by supporting the production and use of evidence to inform policy and practice." As Dr. Simpson noted, this mission centers on the role and use of evidence in health policies and programs.

Like the SciSIP community, the domain of health services research often faces impediments in maintaining the connections and flow of information between its community of researchers and its practitioner community. Dr. Simpson described how AcademyHealth is working to overcome those barriers, drawing parallels between that work and the three approaches presented in the workshop framing paper as approaches to enhancing the impact of SciSIP research.

Approach 1: Aligning the agenda for SciSIP research with the needs of the community of practice

One core function of AcademyHealth is to track the current state of health services research, and ensure that the agenda for the research community is responsive to the needs of patients, populations, and policymakers. Working with the National Library of Medicine at NIH and the University of North Carolina at Chapel Hill, AcademyHealth maintains a database of current "Health Services Research Projects in Progress." This searchable database logs key information and abstracts for health services research funded by the NIH and other sponsors, extracted from online databases or submitted by AcademyHealth's partner organizations. AcademyHealth and those partners conduct periodic meta-analyses of projects to summarize the key trends and current status of overall research efforts in this domain.

Using this database along with staff interviews of representatives of health care policy and provider organizations, AcademyHealth also produces periodic "listening reports." These reports identify topics that the practitioners interviewed feel would benefit from more evidence to guide decision-making. The group also experiments with online collaboration platforms and social media as mechanisms for better connecting the real-world needs of practitioners to the research community.

Approach 2: Engaging in translational research to connect fundamental SciSIP research to the community of practice

Like other domains, the health services community has found that research results may need further extension or modification to enhance their relevance for practitioners. For example,

AcademyHealth has organized the Electronic Data Method (EDM) Forum, an open group of researchers and other stakeholders that studies the use of electronic health records as data for health services research, and recommends best practices on how those records can be employed in patient-centered outcomes research (PCOR). Part of that effort involves identifying and disseminating best practices, but part also includes development of new systems and infrastructures to enable better research while protecting patient privacy and confidentiality.

Approach 3: Ensuring that SciSIP research is communicated more effectively to benefit the community of practice

AcademyHealth uses some of the practices suggested in the workshop framing paper to make health services research more accessible to a range of stakeholders. The organization commissions occasional "research syntheses" that summarize recent studies on a particular topic, and distills the implications of their common findings. The EDM Forum also established a special open access journal, eGEMs, as a venue for publishing new research using electronic health records. The journal specializes in works that might not be accepted in more traditional journals, including descriptions of new analytical methods, the use of multidisciplinary approaches to address research questions, and publications that make extensive use of visualizations and other digital media. One issue recently highlighted in eGEMs is the importance of good user interface design in developing electronic health record systems.

In closing, Dr. Simpson highlighted the importance of evaluation and impact measurement in health services research. AcademyHealth continues to work with partner organizations to develop appropriate impact metrics, drawn from bibliometrics, case study analysis, and other approaches. AcademyHealth itself is interested in showing that health services research can produce tangible outcomes, not just publications. The workshop participants responded enthusiastically to Dr. Simpson's presentation of AcademyHealth activities, and her comments spurred much of the discussions during the afternoon workshop session.

Following the presentation by Dr. Simpson, the six discussion leaders from the morning World Café sessions summarized a few key points from each of the six topics. The participants were then briefed on the framework and process for participating in the afternoon World Café discussions. The participants again broke into six different tables, but each of the three afternoon topics had two tables dedicated to it:

1. Aligning the research agenda to practitioner needs
2. Translating SciSIP research for use
3. Improving communication and dissemination of SciSIP research

Again, participants were encouraged to discuss a different topic during each of the three time intervals in the World Café session, so that each participant had the opportunity to discuss each of the three topics above.

3.2 Synopsis of the World Café Discussions

3.2.1 Aligning SciSIP Research with the Needs of Practitioners

Workshop Proposition
The *agenda* of SciSIP research should be *better aligned* with the needs of the community of practice.

Workshop Key Questions
- Is there a problem of misalignment of the SciSIP agenda with practitioner needs?
- If so, what might be done about it?

Proposals for Discussion
- Expanding use of practitioners as proposal reviewers
- Creating a program advisory board that includes practitioners
- Soliciting proposals and clustering awards around specific practitioner-identified themes
- Setting up a "solver" website where practitioners could post problems that the program might address
- Encouraging proposers to demonstrate practitioner demand
- Establishing a PI-practitioner dialogue
- Other ideas

Synopsis of Workshop Discussion
As in the other afternoon World Café discussions, the participants in the discussions of alignment noted that there is much ambiguity in the concept of "practitioner," and great diversity among the roles to which that term is applied. Researchers should be aware that different kinds of practitioners have different needs. That said, of the afternoon topics, alignment was generally agreed to be the most important of the challenges facing the SciSIP research community in making its work more useful to practitioners. Other themes of these discussions included building trust between agencies and researchers, soliciting proposals around specific practitioner-identified themes, creating a program advisory board, brokering research-practitioner relationships by program staff, establishing "SciSIP Fellows" within agencies, and setting up a principal investigator-practitioner dialogue.

Alignment should be a very high priority for program managers who seek to fulfill the original SciSIP mandate. Gaining some agreement on the problems that are worth studying and the kinds of results that would be taken up are preferable to trying to match users and producers of SciSIP research after the fact. Improving alignment would likely strengthen trust between the research community and the community of practice. Agencies are likely to use results only if they have confidence in them and believe they can trust their proponents based on experience over time. Timeliness is always an issue as well in bringing research results to bear on practical problems.

Of the several ideas for improving alignment offered by the workshop framing paper, soliciting proposals and clustering awards around specific practitioner-identified themes garnered the most enthusiastic and widespread support among the participants, with the proviso that not all SciSIP

projects should be practitioner-driven. The portfolio should balance investigator-initiated projects with those more closely aligned with explicit practitioner needs.

The participants discussed a variety of potential mechanisms for eliciting such themes. One mechanism would be funding further research that seeks to discover such themes. Potential projects in this vein could include (1) a survey of client requests made to STI policy R&D organizations, such as the Science and Technology Policy Institute and the Congressional Research Service; and (2) a systematic inventory of decisions made by Federal STI agencies, such as the one currently being developed by the Department of Homeland Security.

Another mechanism that could define topics of interest to both researchers and practitioners would be a program advisory board that included representatives of both groups. The workshop participants generally supported this approach. There was little clarity among the participants about the activities of the Interagency Working Group on the Science of Science Policy, which might also provide some insights into practitioner needs. Some participants also enthusiastically supported the expanded use of practitioners as proposal reviewers, while others expressed concern about the competence of such reviewers on critical aspects of proposals, such as the theoretical context and prior work in a field. The workshop participants expressed skepticism about a related approach, in which proposers would demonstrate practitioner demand as part of the proposal. This requirement would be easy to game and might open up the proposal process to political interference.

The idea of setting up a "solver" website on which practitioners could post problems that the program might address received some support. Such a website, however, would likely face a significant level of mistrust; agencies might not want to expose important problems in a public forum. An individualized "brokerage" scheme received a better reception. In such a scheme, the SciSIP program staff could connect practitioners who face particular issues with researchers whose work might help them. One person suggested that the SciSIP community organize a "quick response" team to be available to help agencies as needed. Another idea that won support was the creation of co-funded "SciSIP Fellows." The Fellows would be active researchers selected competitively to spend a period of time serving as temporary staff members of agencies to provide technical advice on S&T policy issues.

The idea of establishing a principal investigator-practitioner dialogue received a mixed response. It could serve as a mutually educational device that would strengthen the odds of alignment. On the other hand, it might be seen as leading to the perception of favoritism or conflict of interest on the part of the SciSIP program. An alternative would be to support informal mechanisms for unstructured interactions, such as seminars or open fora in the DC area to which practitioners and researchers would both be invited, without discriminating among the researchers who are invited.

3.2.2 Translating SciSIP Research for the Community of Practice

Workshop Proposition
Translational research is required to connect more fundamental SciSIP research to the community of practice.

Workshop Key Questions
- Has SciSIP research been translated effectively, so that it is understood properly by the SciSIP community of practice?
- If not, what might be done to encourage translational research?

Proposals for Discussion
- Requiring proposers to include a translational research plan.
- Making translational research an area of emphasis.
- Establishing translational research partnerships with intermediary institutions.
- Other ideas

Synopsis of Workshop Discussion
The World Café sessions on translational research turned out to be rather contentious. They were marked by debate about whether the lack of "translation" as defined by the workshop organizers is in fact a problem for the SciSIP community of practice, or whether the topic of alignment more aptly captured the key barriers separating producers of research from potential users. Remedies for possible misalignment between the SciSIP researcher agenda and practitioner needs were thus a major focus of these sessions. Other themes included the definition of the SciSIP community of practice and trusted third party intermediaries that might serve as effective "translators" of SciSIP research.

Many participants took the view that the uptake of SciSIP research by practitioners was primarily a failure by researchers to pay attention to practitioners' needs and concerns when designing their projects. (In the language of the workshop organizers, the problem is primarily one of alignment, rather than translation.) In the view of this group, if practitioners' views are ignored in the design phase, efforts at translation after the research has been completed are not likely to be effective. There were a few strong dissents to this view, however; this minority argued that SciSIP researchers should be much more forceful in promoting their work to potential users.

Many of the ideas that were discussed focused on procedures that would ensure that users are consulted early in the research process, such as:

- Providing a point-of-contact at each agency in the R&D community to serve as a gateway for researchers who seek the input of practitioners
- Requiring proposers to describe how they have tried to approach and engage with practitioners
- Using a two-stage proposal process, in which principal investigators develop white papers that are reviewed by practitioners, followed by full proposals that are reviewed by more traditional peer reviewers
- Including training on "translational" research and writing in Ph.D. programs

- Creating a crowdsourcing platform to solicit research questions from practitioners that may generate responses from SciSIP scholars

Many of these proposals overlapped with those considered in the sessions on alignment and are discussed in more detail in section 3.2.1.

If these procedures are to be implemented, one challenge for researchers is that they may not know who the potential users of their research might be. The NSF SciSIP program could fund research on policy decision-making systems and mechanisms in order to inform researchers about how to design projects that are more likely to produce usable findings. As a preliminary step, it would be helpful to have a clearer definition of SciSIP practitioner. Workshop participants noted that projects to carry out translational research of this type might have difficulty competing with traditional principal investigator-initiated projects, since they lack a dedicated source of funding.

Another major theme of these World Café sessions was whether a trusted third party might serve as a "translator" for SciSIP research. The use of a third party may be especially important in reaching policy-makers in the intelligence and national security domains. These policy-makers they depend on intermediaries like the Institute for Defense Analyses and RAND to translate research into policy-ready proposals. Intermediaries in other fields, such as the National Academies and AcademyHealth, were also discussed. There is an opportunity for the SciSIP community to learn from researchers in other policy fields in this regard.

3.2.3 Communicating SciSIP Research to Practitioners

Workshop Proposition
SciSIP research must be *communicated more effectively* so that it becomes more accessible to the community of practice.

Workshop Key Questions
- Does the SciSIP research community do an adequate job of communicating its findings to practitioners?
- How might the communication between the two communities be improved?

Proposals for Discussion
- Commissioning research syntheses targeted to practitioners.
- Brokering researcher-practitioner communication networks.
- Expanding the investment in the Science of Science Policy website and listserv.
- Enhancing communication intermediaries.
- Establishing an I-Corps for SciSIP.
- Establishing a communication training program for principal investigators.
- Other ideas

Synopsis of Workshop Discussion
All of these six World Café discussions began with a consensus that many practitioners who should know about SciSIP and its associated research community are not in fact aware of them;

in other words, an alignment/translation/communication problem of some sort certainly exists. Participants noted that it was important to not only communicate the results of the program, but also the reasoning behind the program's activities, and what it hopes to achieve. However, many workshop participants had difficult distinguishing among the challenges of alignment, translation, and communication; at a minimum, they are closely interconnected. There was agreement that if alignment and translation were addressed, communication would be substantially improved. The main themes discussed beyond these two broad points included: understanding the intended user community, identifying the platforms that reach users, the role of personal relationships, information intermediaries, research fellowships and sabbaticals with Federal agencies, "perennial" research topics in demand, and testbeds for policy-making innovations.

Workshop participants argued strongly that SciSIP researchers must understand their intended audiences better in order for their communication to be effective. The content of this communication should reflect the capabilities and interests of the audience. An executive branch audience is constrained to work within existing legislation, for instance, so seeking to inform them about legislative options would not be very effective. Similarly, the media and formats through which researchers communicate should vary according to the audience they seek to reach. The work conveying research findings will generally need to be shorter and more accessible than researchers' usual outputs. In some instances, it may make sense to work through social media platforms, while in others, more conventional outlets, such as *Science*, will be more effective. What matters is what the audience will pay attention to.

In that vein, the participants generally discouraged the idea of focusing resources on the Science of Science Policy website.[3] They believe it will be expensive to try to build a dedicated platform for this community, and it is unlikely to succeed much beyond the existing group of "true believers." Leveraging other platforms and linking to other communities is more likely to succeed. There was some support among the various groups for requiring proposers who seek to shape policy to include a detailed communication plan for broader impact in their proposals, including digital engagement that would shape public discourse, when appropriate. Involving practitioners in reviewing at least these aspects of SciSIP proposals might be valuable to improve the quality of the plans. The SciSIP community should also engage in continual learning about emerging media platforms that would reach new or different audiences.

The participants noted that, even in the digital age, much policy-related communication is interpersonal and depends on trust. Personal visits and calls are the most important way that ideas get communicated, especially in Congress and the White House. These personal relationships have to be continually refreshed because of staff turnover in these decision-making bodies. The NSF SciSIP program could take on the role of connecting researchers with potential users of research, so that these personal relationships can be developed.

An alternative or complementary strategy would be to leverage relationships of trust that already exist. Rather than seeking to plug directly into decision-making networks, researchers could target their communication to think tanks, consulting firms, support agencies, and other intermediaries, who would in turn digest, interpret, and synthesize research findings and carry

[3] http://www.scienceofsciencepolicy.net

them into the policy community. This approach suggests the importance of expanding the SciSIP community to include such intermediary organizations.

For those scholars who have the inclination to build personal relationships, the community might explore encouraging sabbaticals or fellowships with agencies and Congressional offices, whether for a summer or semester. Such visiting experiences provide an inside understanding of the challenges facing the policy community as well as "face time" with potential users of research. A modified version of the NSF I-Corps program, in which Federally funded innovators go into the field to meet one hundred potential customers for their inventions, might also be explored, This program would substitute policy-makers in place of customers, and limit the number of required meetings to a more reasonable number.

The participants noted that while policy decisions are often made up against deadlines and give the appearance of being rushed, there are many perennial subjects that form the bulk of these decisions, including funding, procurement, and hiring. Sustained research on such perennial issues would be continually in demand if communicated properly and would help to build the SciSIP community's brand among policy-makers. Indeed, the participants expressed great enthusiasm for the commissioning of research syntheses along these lines. Such syntheses might be tailored separately for each of the various user audiences mentioned above.

Finally, some participants suggested that it would be valuable to have a mechanism that would prototype and test science, technology, and innovation policy innovations. This mechanism would be expected to assess these experiments and to communicate the results. One proposal was for NSF itself to be the testing ground, since it is taking the lead with the SciSIP program already. Another would be a more distributed function that might be called ARPA-M (for Management) that would support experiments across a variety of Federal sites.

3.3 Strengthening the SciSIP Community of Practice: Recommended Strategies

As the summaries in section 3.2 show, the practitioners who participated in the workshop had a wealth of suggestions for strengthening the contributions of the SciSIP research community to the community of practice. In this section, we cull and prioritize these suggestions, based on our understanding of their feasibility and likely impact. The first group of five strategies would reorient a portion of the SciSIP research budget. The second group of five strategies would require changes in the proposal review process and program staff activities.

3.3.1 Strategies for SciSIP Research Activities

1. Commission meta-analyses or research syntheses on topics known to be of interest to practitioners and on which a well-established literature exists. Some workshop participants were unaware that a research literature exists on topics of great interest to them, such as the return on R&D investments. These literatures tend to be diffuse and technically complex, creating access barriers even for practitioners who are aware of them. Syntheses of specific literatures targeted to particular groups within the community of practice would likely provide a high return on a modest investment, as long as they are well written and communicated effectively.

2. Solicit proposals and cluster awards around specific practitioner-identified themes. The program's original objectives included producing results useful to practitioners. We discovered that few of the workshop participants were familiar with the program's outputs, so it was difficult for them to ascribe utility to those outputs. The workshop participants expressed a firm consensus that the community of practice is likely to be better served if researchers and practitioners define some topics of shared interest up front, rather than only communicating the results of investigations of researcher-defined topics after completion. At the same time, the workshop participants agreed that a significant portion of the SciSIP program portfolio should respond to principal investigator interests. Thus, this recommendation for clustering projects is meant to balance the portfolio in this regard, rather than to replace it.

3. Support research in order to identify research themes of interest to practitioners. The SciSIP community of practice is not well-defined, and it is likely that many of its 'members' are unaware that they belong to it. Themes identified through relatively unstructured approaches that draw on self-identified members of the community may not represent fully the potential demand for SciSIP research. Potential projects to uncover new research themes could include (1) a survey of client requests made to STI policy R&D organizations, such as the Science and Technology Policy Institute and the Congressional Research Service; and (2) a systematic inventory of decisions made by Federal STI agencies, such as one currently being developed at the Department of Homeland Security.

4. Create a "SciSIP Fellows" program in which researchers would serve temporarily in Federal agencies. Active researchers may have knowledge that would be useful to STI policy agencies. Experience in the Federal government would provide valuable input into the definition of research problems when the Fellows return to academia. Fellows could be selected competitively with the host agency's participation, and the host agency would be expected to co-fund the fellowship. The Presidential Innovation Fellows program may provide a model.

5. Establish a pilot version of I-Corps for SciSIP. I-Corps was devised to encourage NSF's natural science and engineering grantees to translate their findings into commercial use. The analogy with the uptake of social science findings by Federal STI agencies is imperfect, but the I-Corps template might be modified to reflect the differences. For example, rather than calling on 100 potential commercial customers to identify uses as I-Corps grantees do, SciSIP I-Corps grantees might be required to call on practitioners in a smaller number of potential user organizations. An experimental approach with a small number of grantees could complement the SciSIP fellows program contemplated above.

3.3.2 Strategies for SciSIP Program Management

1. Articulate more specifically to proposers that the program will interpret NSF's "broader impacts" criterion to include the anticipated value of the research results to the community of practice. This criterion is employed to evaluate all proposals, and the program manager has significant discretion as to how it is interpreted. Clearer guidance as to its meaning for SciSIP proposals through the SciSIP program guidelines could encourage proposers to invest energy in

engaging with the community of practice during proposal preparation and in communicating research results.

2. Create a program advisory board that includes both practitioners and researchers. This approach may provide a mechanism for identifying themes of mutual interest to both practitioners and researchers that could be implemented rapidly. The Interagency Working Group on the Science of Science Policy has served as a mechanism for gathering input from the community of practice, but it does not bring together researchers with practitioners. The Working Group's charter has expired, and the level of participation in it has waned in recent years. Rechartering and reactivating the Working Group would complement the proposed program advisory board. Such a board might also be a mechanism for building awareness of the program among the broader community of practice and for building trust in the program among those who are members of the board and the agencies they represent.

3. Develop stronger relationships with communication intermediaries. Workshop participants generally agreed that the SciSIP research community should seek to leverage existing platforms that already reach the community of practice. There are a number of potential intermediaries, such as think tanks and media organizations, that share the interests of the SciSIP community but have not been engaged in it. Government-wide websites like data.gov and research.gov are also well-established destinations for many in the SciSIP research and practitioner communities. Projects carried out by such intermediaries or in partnership with SciSIP researchers are more likely to reach practitioners than efforts to build new platforms, such as the SciSIP website.

4. Encourage SciSIP staff to intermediate actively between researchers and potential users of their research in the community of practice. Workshop participants expressed skepticism that "wholesale" vehicles, such as the SciSIP website or a proposed "solver" website, for sharing research results and products would be effective in reaching potential users and, especially, in gaining their trust. The participants suggested that a "retail" approach in which SciSIP staff members broker connections would be more effective in both respects. They also recognized that such a responsibility could put a strain on the program staff, and that program directors who are rotating from academic positions might not be well-positioned to perform this function. Furthermore, the participants recognized that such activities could lead to the perception of favoritism or bias, and that the program staff would need to design and carry them out with sensitivity to this concern.

5. Expand the use of practitioners as proposal reviewers. This action would provide another mechanism to align SciSIP research projects more closely with practitioner demand. The program manager has significant discretion with regard to how proposal reviewers are selected and how their reviews are considered as she or he makes funding recommendations to senior NSF officials. Practitioner involvement in the review process could provide insights into the likely uptake by the community of practice of the results of completed projects. However, there will be aspects of proposals that such reviewers may not be well-qualified to assess, such as the theoretical context and prior work in a field, so practitioner reviews would have to be handled judiciously.

4. Concluding Observations

The workshop summarized in this report validated its organizing premise. The workshop discussions indicated in general that there is a lack of understanding within the SciSIP research community about the needs and priorities of potential "consumers" of that research, and that the practitioner community had relatively little awareness or appreciation of prior SciSIP research. The workshop engaged a diverse sample of practitioners from Federal agencies, Congressional offices, and non-governmental organizations with substantive interests across a wide range of science, technology, and innovation policy fields, including defense, economic development, energy, health, intelligence, transportation, and others. The participants put forward many questions into which the SciSIP research community could provide insights. In some cases, research has been carried out, but often the participants were not aware of it or were unable to apply the findings. In other cases, little work has been done that the organizers are aware of to study questions of interest to these practitioners.

This report lays out a substantive, practitioner-driven research agenda that might usefully complement the topics that principal investigators have put forth over the years of the SciSIP program's existence. Its intention is to supplement, rather than to supplant, the historic PI-driven approach. Perhaps more important, the report offers a variety of ways to build and make more systematic the interaction between the research and practitioner communities, so that topics of mutual interest can be identified on an ongoing basis and findings communicated in ways that may reach the "consumers" more effectively.

In conclusion, it may be useful to consider the "engineering of science and innovation policy" along with the "science of science and innovation policy." Policy-makers operate in a world of risk and constraint as well as one of opportunity. Like engineers, they face tradeoffs among key variables and must allow for unexpected contingencies. They are often highly pragmatic and rely on rules of thumb gained through operational experience. The SciSIP research community would benefit from putting its theories and models into closer proximity with these practices, strengthening the external validity of the former and improving the odds of broader impact with regard to the latter.

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Appendix I: Workshop Agenda

Enhancing the Usefulness of Science of Science and Innovation Policy (SciSIP) Research: An Agenda-Setting Workshop
December 7, 2015
Founders Hall 126, George Mason University - Arlington

0800-0900	Check-in and networking
0900-1000	Plenary Moderator: David Hart, GMU Welcoming Remarks: Fay Lomax Cook, NSF Maryann Feldman, NSF Keynote: "Science of Science Policy, Ten Years Later and the Next Ten Years," Kei Koizumi, White House OSTP Workshop Objectives: Chris Hill, SRI and GMU Introduction to World Café I sessions: Jeff Alexander, SRI
1000-1015	Break
1015-1145	World Café I
1015-1045	Session 1
1045-1115	Session 2
1115-1145	Session 3
1145-1300	Lunch Keynote: Lisa Simpson, AcademyHealth
1300-1315	Plenary Highlights of World Café I: Facilitators Introduction to World Café II: Jeff Alexander, SRI
1315-1330	Break
1330-1500	World Café II
1330-1400	Session 1
1400-1430	Session 2
1430-1500	Session 3
1500-1600	Plenary: Highlights of World Café II General discussion Closing comments & thanks

Appendix II: Letter of Invitation

October __, 2015

Name
Title
Affiliation
Address

Dear Dr. ___ :

Are the findings and results of academic research on science, technology and innovation policy useful for informing decisions facing your organization? What questions do you wish such research could answer? How could such research be presented in ways that are more accessible to policy professionals?

We are writing to invite you to participate in a workshop aimed at eliciting responses to these questions from key members of the national science, technology, and innovation policy community. The workshop, organized by GMU with assistance from SRI International, is supported by a grant from the Science of Science and Innovation Policy (SciSIP) program of the National Science Foundation, as described in the attached abstract. The workshop's findings will help shape SciSIP's future grant-making agenda, and influence the community of scholars focused on policy issues related to science and technology.

The workshop will be held on December 7, 2015, from 9 am to 4 pm at George Mason University's Arlington campus. Approximately 40 participants from Executive agencies, Congressional offices, and non-governmental organizations, will be engaged in highly interactive, facilitated small group conversations among practitioners. Illustrative topics for these conversations include:

- Allocating Federal funds among competing S&T objectives, programs and projects
- Tracking and assessing the impacts of Federal R&D investments
- The consequences of evaluation and reporting requirements for R&D programs
- Management of the Federal science and technology workforce
- The impact of Federal regulations on commercial innovation

Kei Koizumi, Assistant Director for Federal R&D at the Office of Science and Technology Policy, has agreed to contribute by providing framing remarks to kick off the workshop. We will be developing the workshop agenda in more detail through brief interviews with confirmed workshop participants in the coming month. Your comments would be incorporated into a written report of the workshop for SciSIP that will be widely circulated in both professional and academic venues.

Participation in this workshop is by invitation only. Please let us know whether you will be able to attend by email to scisip@gmu.edu. If you are unable to attend and would like to recommend a substitute, please contact us with your recommendation. Feel free to contact any of us if you have questions or suggestions.

Jeffrey Alexander
Associate Director, SRI
Jeffrey.alexander@sri.com

Christopher T. Hill
Senior Fellow, SRI
Emeritus Professor, GMU
Christopher.hill@sri.com

David M. Hart
Professor, GMU
Director, Ctr. for S&T Policy
dhart@gmu.edu

Appendix III: List of Participants

Name	Affiliation
Charlotte Kirk Baer	Department of Agriculture (USDA)
Wenda Bauchspies	National Science Foundation (NSF)
Peter Blair	National Research Council
Stephen Campbell	National Institute of Standards and Technology (NIST)
Bill Carrigg	Government Accountability Office (GAO)
Fay Lomax Cook	National Science Foundation (NSF)
Bill Duval	National Institutes of Health (NIH)
Ivy Estabrooke	Utah Science Technology and Research initiative (USTAR)
Maryann Feldman	National Science Foundation (NSF)
Ryan Glenn	Ben Franklin Technology Partners
Richard Hencke	Department of Defense (DoD)
Rich Hung	Government Accountability Office (GAO)
John Jankowski	National Science Foundation (NSF)
Kathleen Kingscott	IBM
Kei Koizumi	Office of Science and Technology Policy (OSTP)
Bhavya Lal	Institute for Defense Analyses (IDA)
Alan Marco	United States Patent and Trademark Office (USPTO)
Jeff Marqusee	Nobilis
Jerry Miller	National Research Council
Dewey Murdick	Department of Homeland Security (DHS)
Irena Pala	Department of State (DOS)
Adam Rosenberg	House Committee on Science, Space & Technology
John Sargent	Congressional Research Service (CRS)
Avery Sen	National Oceanic and Atmospheric Administration (NOAA)
Arun Seraphin	Senate Armed Services Committee
Robbin Shoemaker	Department of Agriculture (USDA)
Lisa Simpson	AcademyHealth
Tobin Smith	American Association of Universities
Michael Telson	University of California System
Steven D. Thompson	National Intelligence Council
Marina Volkov	National Institutes of Health (NIH)
Anne Washington	George Mason University
Philip Webre	Congressional Budget Office (CBO)
Matt Wilson	National Science Foundation (NSF)
Jim Woodell	Association of Public and Land-grant Universities (APLU)
Ryan Zelnio	Office of Naval Research (ONR)

Appendix IV: Project Team

Workshop Organizers

Name	Affiliation
Jeffrey Alexander	SRI International
David M. Hart	George Mason University
Christopher T. Hill	SRI International

Workshop Facilitators

Name	Affiliation
Jeffrey Alexander	SRI International
Steven Deitz	SRI International
Christina Freyman	SRI International
David M. Hart	George Mason University
Christopher T. Hill	SRI International
Connie L. McNeely	George Mason University

Workshop Rapporteurs

Name	Affiliation
Lisardo A. Bolanos Fletes	George Mason University
Joel T. Hicks	George Mason University
Lauren N. Mccarthy	George Mason University
David Morar	George Mason University
Camilo Pardo	George Mason University
Alfred Sarkissian	George Mason University

Appendix V: Workshop Plenary Speakers

Kei Koizumi, Assistant Director, Federal Research and Development, White House Office of Science and Technology Policy (OSTP)

Kei Koizumi is a renowned expert on the federal budget, federal support for research and development, science policy issues, and R&D funding data. He also served as the Director of the R&D Budget and Policy Program at the American Association for the Advancement of Science (AAAS) for about ten years, where he was the principal budget analyst, editor, and writer for the annual AAAS reports on federal R&D. He is widely quoted in the general and trade press on federal science funding issues and speaks on R&D funding trends and federal budget policy toward R&D.

Fay Lomax Cook, Assistant Director for the Directorate for Social, Behavioral & Economic Sciences, National Science Foundation

Dr. Cook is a professor at the Northwestern University's School of Education and Social Policy as well as a Faculty Fellow at the Institute for Policy Research, where she was a director from 1996 to 2012. Her research revolves around the interrelationships between public opinion and public policy, the politics of public policy, how Americans come together to discuss policy issues, and the dynamics of public support for Social Security and other social programs. She has also served in other capacities such as the president of the Gerontological Society of America; a fellow at the Center for Advanced Study in the Behavioral Sciences; and a visiting scholar at the Russell Sage Foundation.

Lisa Simpson, President and CEO, Academy Health

Dr. Simpson is the president and CEO of AcademyHealth, an organization addressing the needs of the health system, informing health policy, and translating evidence into action. She is a pediatrician, a health policy researcher, and an advocate for the translation of research into policy and practice. She has served in many capacities such as the director of the Child Policy Research Center at Cincinnati Children's Hospital Medical Center; professor of pediatrics in the Division of Health Policy and Clinical Effectiveness, Department of Pediatrics, University of Cincinnati; and the Deputy Director of the Agency for Healthcare Research and Quality from 1996-2002.