PROSPECTUS

Project Context and Issues

Since the late 1960s, Congress has required the National Science Board to prepare Annual Reports to the President, and through the President to the Congress. In a departure from previous versions, the Fifth Annual Report (entitled *Science Indicators 1972)* presented "first results from a newly initiated effort to develop indicators of the state of the science enterprise in the United States." The transmittal letter went on to state: "The ultimate goal of this effort is a set of indices which would reveal the strengths and weaknesses of U.S. science and technology, in terms of the capacity and performance of the enterprise in contributing to national objectives. If such indicators can be developed over the coming years, they should assist in improving the allocation and management of resources for science and technology, and in guiding the Nation's research and development along paths most rewarding for our society" (NSF, 1972).

Considerable progress in this enterprise notwithstanding, the key themes in this statement ring true today. Indicators are quantitative representations that together might reasonably be taken to provide summary information on the scope, quality, and vitality of the nation's science and technology enterprise. They are expected to function as guides to national resource allocation decisions. Science and technology are seen as linked, and both are viewed as contributing to national and social objectives.

The list of indicators that have been selected by NCSES to depict the status of mathematics, science, and engineering education, the scientific labor force, national and international trends in research and development expenditures, academic research and development, globalization, public attitudes about science and technology, and state indicators in the *Science and Engineering Indicators* (SEI) volumes and other publications are rich and varied. They consist of some tried and true, long-term indicators and some that have evolved over time. Some of the expenditure series go back many decades, other are more recent and experimental. For example, innovation ("new translations of knowledge into value") is implicitly included, even though it extends beyond S&T. The indicators in SEI 2010 are displayed in some 328 text figures and 180 text tables in the report, and are found in another 294 tables in the on-line appendices; many more are found in other publications and databases on the NCSES website.

Despite the significant depth and dynamic nature of the indicators, they are challenged to portray the substantial changes that have occurred in the global STI system, the conduct of R&D, the nature of innovation, and the role of technology in society and economy in recent times. These changes include changes in the composition and orientation of R&D (e.g., sectoral shifts and shortened time horizons), the organizational structure and sourcing of R&D and innovation (e.g., decentralization and collaborations), the location of innovative activity both domestic and international (e.g., clustering and globalization), and the growing complexity and inter-connectedness of global STI systems (e.g., international labor markets, migration, and knowledge flows; disaggregated and geographically distributed supply chains).

The challenge of identifying indicators that depict the changing global and U.S. economies is also being considered in the National Academies' Key National Indicator System (KNIS) program. This multifaceted program is identifying indicators that portray the status of several important domains that would define the state of the USA. Included in those domains is "Innovative Capacity." It is expected that the study proposed in this prospectus will feed into and, in turn, be informed by the work on innovation in the KNIS program.

The time is right to consider indicators that can better reflect trends and patterns in the rapidly changing international STI system; adapt indicators used elsewhere; consider the question of more detailed sectoral indicators; develop more detailed sectoral indicators; refine and add detail to existing indicators utilizing the newly available detailed breakdowns in the NSF Business R&D and Innovation Survey (BRDIS); devise direct indicators of technology-based economic development; and consider social and economic outcomes of science and technology investments. The results of reconsidering STI indicators should contribute to the work of an initiative by the National Academies and State of the USA to develop key national indicators to inform policy makers, opinion leaders, and the interested public.

Efforts to develop additional, more detailed, better, broader, and more policy relevant indicators of S&T, innovation, and their connections with social and economic outcomes raise questions such as:

- What is the priority order of developing the various proposed indicators?
- What is their development time frame, the feasibility of achieving them?
- How difficult will it be to develop broadly internationally comparable indicators? (A key consideration in an increasingly interconnected world.)
- From a policy use perspective, which of many proposed indicators should receive priority? An overly large number of indicators that presumably illuminate the same broad concept can confuse rather than illuminate policy discussions, while combining multiple indicators into an index can obscure rather than clarify. Also, highly disaggregated indicators, e.g., based on firm-level microdata, can easily lead to confusion between the role of indicators (to *indicate)* and special studies (to establish causal connections), something a 2010 OECD study does not entirely avoid.
- From a resource perspective, what is the net value added of proposed indicators?
- What existing measures, if any, can be scaled back or dropped in favor of new indicators?
- What actions should be taken in the near- and mid-range term with regard to indicator development activities?

In examining the range of currently used core indicators, including those used in *S&E Indicators* and other NCSES publications, in OECD and EU publications (e.g., OECD Main S&T Indicators, Scoreboard, and EU Key Figures reports), the following issues will be addressed:

- How well do current indicators embody the underlying concepts they are intended to reflect, and what are their strengths, weaknesses, coverage, utility, and timeliness in reflecting current STI dynamics and trends?
- Are indicators drawn from other publications (e.g., EU, OECD, UNESCO), but not currently used by NCSES, feasible for the United States and would they contribute to improved NCSES indicator scope, strength, or utility?
- What major gaps in indicators coverage (due to faulty concepts, lack of data, or missing or poorly specified models) affect or undermine the ability to track key trends in global STI?
- How well would alternative indicators (such as those in OECD's report on Measuring and Monitoring Innovation) address current insufficiencies?
- What would be the net value-added of proposed new or alternative indicators, in terms of policy relevance, utility, measurability, analytical soundness, and statistical quality?
- What is the appropriate balance between special studies and on-going indicators? Will special studies of organizational, inter-organizational, and system dynamics continue to be needed to provide insight into the development and appropriate connections of indicators systems?

Project Audiences and Impact

The current decade has seen an acceleration of the emergence of new markets, new STI players, and their global interconnections on many levels – trends that started in the 1990s. Science, technology, and now innovation have come to be widely viewed as associated with productivity improvement, international competitiveness, and long-term economic growth. Indicators of activities such as R&D performance have been supplemented with indicators of linkages among different sectors, institutions, and countries.

The need for measures of the outputs of STI activities has become more pressing, as has tracking their connections to larger social outcomes. Likewise, increasing awareness of the role of innovation in economic productivity has spurred calls for reliable innovation indicators. STI indicators development requires substantive knowledge and technical expertise, but the statistical underpinnings of such indicators must be sufficiently robust to make substantively meaningful statements about their behavior, and to provide caveats about data and indicator peculiarities and limitations.

These developments have stimulated a number of ongoing indicators development activities, the aim of which is the creation of an indicators-based system that will broadly guide STI resource allocations, allow policy experimentation and learning, permit the tracking of STI outputs, and permit assessment of their broader social and economic outcomes. There are a number of examples of such activities:

In the United States, former Presidential Science Advisor Marburger's call for better tools to guide investment decisions led to the National Science Foundation's Science of Science and Innovation Policy Program (SciSIP). It focuses broadly on the development of new or

improved knowledge and theories about the transformation of creative processes into social and economic outcomes; of models and tools to support science policy decision making; of new science indicators and datasets; and of a community of experts. A description of this program and awards made under it can be accessed at the NSF website at .http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=501084&org=SES&from=home Indicators development at the intergovernmental Organization for Economic Co-operation and Development (OECD) is a perennial activity, but in 2006 the OECD, Statistics Canada, Industry Canada, and NSF convened a "Blue Sky II" conference for a broad discussion and review of the need for indicators development that stressed a systems view of innovation, the connections among different actors, and the broader impacts of STI in terms of economic and social change. The conference papers are available in OECD 2007, "Science, Technology, and Innovation Indicators in a Changing World: Responding to Policy Needs" and also at: www.oecd.org/sti/blueskyconference.

In 2009, the OECD promulgated a formal Innovation Strategy that stresses the need for indicators to address the dynamics of innovation processes. The strategy requires more disaggregated measures than traditional national-level indicators. It encompasses outcomes beyond science, technology, and innovation and draws on "measures of education, of entrepreneurship, of economic, environmental and social outcomes and of the broader conditions for innovation, including [cultural, economic, and structural] framework conditions." A 2010 (not formally released) companion paper entitled "The OECD Innovation Strategy: Measuring and Monitoring Innovation" (SG/INNOV 5 March 2010) discussed existing and potential indicators, data sources, and gaps from the Innovation Strategy's systems perspective.

The European Union has an active set of innovation policies that aim at job creation and economic growth. It examines the results of such policies and modifies policies accordingly. The EU innovation strategy focuses on four future directions: understanding the specifics of service sector innovation; developing specific supports for innovative services with high growth potential; fostering trans-national cooperation in services; and support of non-technological innovations. EU policy is focused on standardization, development of "lead markets," sector-crossing joint technology initiatives, cluster development, and other approaches deemed innovation- and jobs-generating. EU indicators of these and other aspects of S&T and innovation are found in a range of European Commission reports (e.g., "A more research intensive and integrated European Research Area: Science, Technology, and Competitiveness key figures report 2008/2009," EUR 23608 EN); see: ec.europa.eu/research/era/pdf/key-figures-report2008-2009_en.pdf.
Attention is also called to work proposed under the auspices of the United Nations Economic Commission for Europe. UN/ECE/CES (Conference of European Statisticians) proposes to conduct an in-depth review in furtherance of the coordinated development of statistics to measure science, technology, innovation, and other aspects of the information society (ECE/CES/2010/46; pre-release version). Thus, this review comes at a time of heightened national and international interest and activity in the assessment and development STI indicators.

A common thread is the focus on “innovation.” However, the concept of innovation now encompasses the full range of "traditional" S&T input and output indicators, along with broader social and economic outcome indicators and their interconnections. Thus, “innovation indicators,” also an important component of the National Academies' Key National Indicators program, will be explicitly included in the study.