Chapter 7: United States Case Study

Alan L. Porter, Search Technology, Inc., and Technology Policy & Assessment Center, Georgia Institute of Technology,

W. Bradford Ashton, Concurrent Technologies Corporation

1. BACKGROUND AND CONTEXT

National-level technology foresight studies have not been a prominent activity in the science and technology (S&T) landscape of the United States. In contrast to many other developed economies where foresighting is used to help determine national S&T priorities and set national technology investment strategies, the U.S. stands virtually alone in specifically avoiding centralized S&T planning. Some American technology foresight studies have been done, but they have been limited in their scope, application and impact. Federal government studies have been restricted to mission agencies with S&T budgets, such as the Departments of Energy (DOE) and Defense (DOD), and the Environmental Protection Agency (EPA) and they are rarely prominent above that level.

Many reasons for this state of affairs can be offered, but clearly one of the key drivers is a widespread skepticism of most forms of centralized, formal government planning among U.S. national leaders. The most prominent central planning at the national level is found in individual government agencies and administrations and even for these economic sector-oriented organizations, attempts to integrate programs of agencies with similar or overlapping missions are usually limited to inter-agency coordination groups. High level agenda-setting and budgeting in the federal government, even for work that is directed at national goals such as health, defense, energy, education, transportation and environmental protection, is carried out through the dynamic political interactions between the appropriate Executive Branch agency and the U.S. Congress. Drawing on a long tradition since the country was formed in the late 18^{th} century, Americans simply do not like strong central government and government planning.

Despite this experience, the U.S. has played two important roles in the evolution of technology foresight work. First, a variety of "foresight-like" efforts have been completed in both the public and private sectors. These efforts have some of the key process and method features found in more traditional studies as practiced in foresight-oriented countries such as Japan, the United Kingdom, Canada and Australia . But U.S. efforts do not have the comprehensive scope and central focus of the national government-sponsored work elsewhere. Government-sponsored foresight-like efforts have shown the following characteristics:

- A focus on anticipating the long range future, namely the period 20 – 30 years beyond the study date
- Participation by numerous stakeholders and subject matter experts, and
- Use of process and analytical tools found in non-U.S. foresight efforts.

Several firms in the U.S. private sector have also employed "foresight" methods for business strategic planning and to set directions for long term technology investments.

Second, U.S. planners, researchers, businessmen and other players have made significant contributions to development or improvement of the methods and tools used in foresight efforts around the globe. Computational, visualization, information gathering and planning tools along with process innovations to handle groups of experts have all enjoyed active development and application in many U.S. organizations. These three themes – no comprehensive national foresight studies, important narrowly focused foresight efforts in some federal agencies and a strong track record of methodology development – are described further in this chapter.

2. HISTORICAL HIGHLIGHTS OF FORESIGHT IN THE U.S.

We suspect that some of you turn here wondering if it might be a one-sentence chapter (and a short one at that):

The U.S. doesn't do foresight.

When you scan the major national foresight activities of other developed countries, this would not be totally off the mark. However, the U.S. does perform a range of related studies that have technology foresight features and that contribute to research & development planning. And, Americans also contribute extensively to pertinent tech foresight methodology. So, we will write a chapter.

We divide this section into four uneven parts: The Office of Technology Assessment (OTA), Critical Technologies, Federal Departments and Agencies and Other Foresight-like Activities. These cases describe organizations that have had an important role in the use and / or improvement of foresight tools and practices at strategic policy levels of U.S. public S&T organizations. Methods like scenarios, roadmapping and systematic gathering of expert judgments have been a central ingredient in strategic studies carried out by these groups.

The Congressional Office of Technology Assessment (OTA)

Did OTA conduct foresight studies? No. But it did devise a form and execute a rich set of technology assessments (TA's) to inform national policy deliberations. Each TA was called for by some Congressional client (e.g., a Committee), or by the bi-partisan Technology Advisory Board, or rarely at in-house initiative (distinctions were not always sharp). Over OTA's quarter-century lifetime, it generated some 500 publications, ranging from white papers to comprehensive TA's. Sample topics addressed include:

- Aging (e.g., *Life-Sustaining Technologies and the Elderly)*
- Defense technology (e.g., *Arms Control in Space*)
- Economic development (e.g., *The Technological Reshaping of Metropolitan America*)
- Health and health technology (e.g., *Cost Effectiveness of Influenza Vaccination*)
- Materials (e.g., *Advanced Materials by Design*)
- Transportation (e.g., *Advanced High-Speed Aircraft*)

The studies are highly varied, but they address future prospects and policy options at a strategic national level. Most studies employed systematic use of expert judgment and many included construction of technology-driven scenarios. For instance, a seminal study on U.S. options to address climate change (*Changing by degrees: Steps to reduce greenhouse gases*, 1991) employed forecasts of the potential to reduce greenhouse gas emissions for three basic scenarios - a Base case ("business as usual"), a Moderate (essentially "no-cost") case, and a Tough case ("forced reductions" in 2015 of 20-25 % from 1990 levels). To the extent possible, the report quantifies the potential for emissions reduction within each of six economic sectors from a variety of technology and policy changes—focusing on areas where gains in efficiency, product substitution, conservation, or other technical options can cut increases in CO2 and other greenhouse gases. The report presents a selection of policy options that appear to offer the most promise for achieving these reductions in the United States, which illustrates the role of OTA studies as a rich resource for public discourse as they were all publicly available[1].

OTA began operations in 1972. It was created during the same era in which the U.S. instituted the environmental impact assessment (EIA) procedures under the National Environmental Policy Act of 1969 (NEPA). Concern for the "unintended, indirect, and delayed" impacts (Coates, 1976) of technological and other developments stirred national political action. Another motivation for the creation of OTA was to provide Congress with technical savvy to counterbalance that of the Federal Agencies. These U.S. innovations in future-oriented analyses, TA and EIA, have spread widely. Over 100 countries mandate some form of environmental impact statements. The U.S. has not actively implemented the NEPA mandate to assess "proposals for legislation" as well as discrete projects[2]. Other nations, especially throughout Europe, have advanced Strategic Environmental Assessment (SEA). Likewise, Europe continues to use nationally adapted TA offices to inform policy.

OTA's influence on Congressional deliberations has been deemed modest. The extensive formulation and review processes resulted in most major TA's taking a couple of years to deliver. One of the reasons given for doing away with OTA was this poor timing fit with the annual and biannual Congressional legislative cycles. A strong suspicion holds that the right wing, conservative Members who took control of Congress in the mid-1990's felt that OTA was slanted against their interests. OTA also served as a handy scapegoat to show that Congress was cutting its own budget in a time of Federal budget-cutting (1995). Sufficiently few Representatives and Senators had become so engaged with OTA that they would favor saving it at the expense of cutting some personal or committee staff instead.

Critical Technologies

Through the 1990's, the U.S. undertook a series of exercises to identify critical technologies. Definitions of critical technologies evolved toward specifying those "essential for the long-term national security and economic prosperity of the United States" (Wagner and Popper, 2003). While military critical technology lists had been used in U.S. defense strategic planning for national security reasons, development of a commercial sector list was prompted by concerns in the early 1990s with overall economic competitiveness of the U.S. in the face of increasing technological and commercial prowess from a number of countries, most notably, Japan. As U.S. technological leadership and economic competitiveness strengthened in some key areas, the assessment process shifted in the mid-1990s to focus on gathering views on the critical technologies from private industry. Although the NCT assessment is conducted within and by the government, it became recognized that the prime mover in technology development and use was (and is) private industry.

The most prominent efforts resulted in a sequence of four reports in response to Congress' direction that the President's Office of Science and Technology Policy (OSTP) should generate a critical technologies list

---

1 The "OTA Legacy" [available at http://www.wws.princeton.edu/~ota/] tells about OTA and provides the collection of OTA publications in searchable form.

2 The vision of NEPA is remarkable –see http://ceq.eh.doe.gov/nepa/regs/nepa/nepaeqia.htm.

biennially. The process varied for each such report, involving a National Critical Technologies Panel whose 13 (or so) experts included heads of major Federal agencies and industrial and academic leaders. Staffing moved with the second report to RAND's Critical Technologies Institute, later renamed as RAND's Science & Technology Policy Institute (STPI) (presently STPI is operated by the Institute for Defense Analysis).

In addition at least two Federal agencies (Defense and Commerce) issued their own critical technologies lists, as did two industry associations (Aerospace Industries Association and the Computer Systems Policy Project). Comparing the various lists entertained a number of researchers and students – there was much in common among the technologies identified. However, comparison was not trivial as the number, level, and details of the technologies varied greatly.

In contrast to most foresight practices, the American critical technologies processes tended to rely almost exclusively on expertise. The Congressionally mandated efforts strove for breadth in terms of including leaders from government, university, and industry; broad stakeholder or public involvement was not pursued. Moreover, tech foresight (forecasting, assessment) methods were not used much at all.

The critical technologies reports were discontinued after 1999, largely because the influence of the reports was diffuse. The effort stimulated significant "buzz" in the early 1990's, drawing attention to emerging technologies and the relationship between research and economic competitiveness. However, the reports did not directly lead to the many cross-agency technology initiatives that ebb and flow (Wagner and Popper estimate that there tend to be about a dozen such ongoing at a given time through this period). The critical technologies lists tended to be used for justification in support of stakeholders' interests. They seem also to have served as signposts influencing agency, state, and university initiatives.

Federal Departments and Agencies

Martin and Irvine (1989), from the perspective of the 1980's, devote considerable attention to an activity known as "The Five-Year Outlook" and attendant efforts to do national research planning in the U.S.. The OSTP was given the responsibility for preparing an annual report; it passed this charge down to the National Science Foundation (NSF). The lack of enthusiasm for an analytical process -- by OSTP, by NSF, and by the candidate users -- to set R&D priorities led to revisions. The National Academies were then asked to prepare sets of "Research Briefings" which the Committee on Science, Engineering and Public Policy (COSEPUP) undertook. Prominent scientists resisted any cross-disciplinary prioritization efforts, and these also eventually disappeared.

Various successive efforts involved the National Academies and their National Research Council. These do not much reflect the broad purview and participatory processes associated with Foresight. Yet, the studies of science & technology (S&T) issues, often with significant policy issues, generated by the National Academies continue to provide a major resource for public discourse. Their website highlights a staggering range of S&T topical treatments [http://www.nationalacademies.org/]. The site notes (as of June, 2005), that the National Academies Press offers more than 2,800 reports online, free. Topical headings range from Agriculture to Urban Development.

The National Academies conduct a rich stream of Federally mandated studies. They also pursue topics that span disciplines and do not involve Federal support. For instance, the National Academies Keck Futures Initiative is a 15-year program to foster interdisciplinary research – c.f., Committee on Facilitating Interdisciplinary Research (2004). A "New Releases" and "Best Sellers" sampling shows that these studies can and do address national technology policy concerns:

- Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate
- The Geological Record of Ecological Dynamics: Understanding the Biotic Effects of Future Environmental Change
- Memory: The Key to Consciousness
- How Students Learn: History, Mathematics, and Science in the Classroom.

Martin and Irvine (1989) observed that the National Institutes of Health (NIH) and NSF favor bottom-up “peer pressure” to generate research priorities. This holds true today. The past couple years, however, have seen the initiation of an NIH Roadmap. This was developed through a broadly participatory process to “roadmap” medical research for the 21st century. The process is outlined in the Overview [http://nihroadmap.nih.gov/]. Notably it starts with discussions to prioritize research areas. The purpose was to identify major opportunities and gaps in biomedical research that no single institute at NIH could tackle alone but that the agency as a whole must address, to make the biggest impact on the progress of medical research. The Roadmap identifies the most compelling opportunities in three main areas: new pathways to discovery, research teams of the future, and re-engineering the clinical research enterprise. Nine working groups were then charged to devise implementation plans, including timelines, coordination mechanisms, and staffing requirements.

The Environmental Protection Agency (EPA) has had an active interest in foresight efforts for many years. Following a 1995 report from the EPA's Scientific Advisory Board (*Beyond the Horizon: Using Foresight to Protect the Environmental Future*) EPA has sought on a regular basis to foresee future environmental stressors and reasonably predict their potential impacts. This knowledge helps EPA work to prevent or avoid these impacts rather than just respond to them. Implemented by the Office of Research and Development (ORD), the systematic foresight effort is focused on potential issues 10 to 20 years into the future in contrast to current research planning and budgeting processes which use a time horizon of approximately three to eight years. The "foresight" approach has two parts in which ORD:

- Searches for detectable early warning signals and extrapolate them into the future; and
- Identifies new issues for which an early warning signal does not currently exist.

EPA uses a network approach of workshops involving the broader scientific community, its own programs, regions, futurists, stakeholders, and the public. The EPA goal is to identify and understand potential future risks to human health and the environment, recommend new directions for research and program management decisions, and identify innovative, cost-effective solutions and alternatives through an ongoing futures program.

The US Department of Energy (DOE) conducts a foresight-like activity through the DOE Office of Industrial Technologies (OIT), Office of Energy Efficiency and Renewable Energy. In the late 1990s, OIT initiated a program called Industries of the Future to begin joint government-industry goal-setting and program planning for its research and development (R&D) activities. As part of this initiative, OIT established partnerships with representatives of the eight main energy-intensive industries[3] to identify and prioritize the major long-term industry needs for advanced energy-efficient technology. Industry needs represented technical barriers that no single firm could afford to address alone and thus were used to establish broad technology goals for all industry firms out to the year 2020 and interim

---

[3] The OIT Industries of the Future are: Aluminum, Chemicals, Forest products (pulp and paper, wood manufacturing), Glass, Metal Casting, Mining, Petroleum Refining, Steel

development milestones that OIT would support. These roadmaps and the OIT-industry teams associated with them became the foundation for resource-allocation and project selection for OIT's R&D program to ensure that the public investment supports realistic industry needs.

The National Reconnaissance Office (NRO) initiated an intriguing project in 1998 called "Proteus." It strove to develop truly fresh perspectives on intelligence needs and technologies to fulfill them. It did so using the scenario planning approach of a commercial facilitator, Deloitte Consulting. Focusing out to the year 2020, the project generated 9 insights – i.e., fresh lenses different from the Cold War themes. These metaphors could provide new ways to consider issues in a changing world, and subsequently, new ways to plan to address them. For instance, one insight keyed on "Herds" – people and ideas on the move (Loescher et al. 2000). Three workshops involving a range of intelligence professionals and outsiders helped compose 5 scenarios – characterizations of the world of 2020 to stimulate consideration of issues and solutions. For instance, one was named "Amazon.plague," wherein mutating viruses wrack the world, shrinking trade and the world's economy, with governments turning authoritarian or chaotic, and reliance on the global information grid in lieu of reduced physical interchanges. Follow-on stages aimed to transfer Proteus thinking, implement gaming environments, and assess the potential of emerging technologies to contribute to multiple future environments (Krause, 2002). In the wake of 9/11, the project and its approaches took on heightened significant to help in dealing with terrorism, including pick-up by other agencies (Waddell et al., 2004).

Nowadays, the Department of Defense (DOD) has a strategic planning process for development of defense S&T. Elements include[4]:

- Defense Science and Technology Strategy, including principles such as dual use (to facilitate a common base with commercial developments)
- Basic Research Plan, providing strategic basic research objectives and outlining planned investments in a dozen technical disciplines
- Joint Warfighting Science and Technology Plan, to plan for transitioning basic research findings through applied research and development toward joint (Army, Navy, Air Force) and coalition warfighting objectives.
- Defense Technology Area Plan, seeking to chart multi-agency investments relating to given technologies.
- Defense Technology Objectives, setting forth some 300 specific desired technology advances and their timing, along with funding requirements.

These involve the Secretary of Defense, the military services, and various defense agencies (e.g., the National Security S&T Council). The plans are shared with defense contractors and allies to help focus collective efforts.

Other foresight-like activities

Non-Governmental Organizations (NGOs): We note "The Foresight Institute," partly because of its name. This small NGO was founded in 1986 by Erik Drexler and colleagues to promote consideration of nanotechnology development, its potential impacts, and policy options. It continues to stimulate nano-related research, information exchange, and discussion but not to promote formal foresight studies[5].

The Millenium Project of the American Council for the United Nations University (ACUNU), an NGO that happens to be located in the U.S, is

[4] c.f., www.milnet.com/pentagon/dto/intro.htm

[5] www.foresight.org

conducting foresight activities internationally.. Jerry Glenn and Ted Gordon coordinate an array of activities, including global lookout studies that engage an international set of volunteers connecting through the web. Their website describes their participatory process to collect and assess judgments from several hundred participants to produce an annual "State of the Future" and various special studies[6]. They also compile a fine volume on Futures Research Methodology.

3. METHODOLOGICAL CONTRIBUTIONS

Foresight processes can involve widely varied use of methodology. For cases where methods and tools are important in the study, U.S. work in tool development has laid important foundations for foresighting. Tools such as scenario planning, Delphi methods, economic analysis, technology scouting and scanning, technology roadmapping and technology assessment and impact assessment are examples, In this section we spotlight some of the specific methods that can contribute and significant American contributions to their development.

Glenn and Gordon (2002) offer a great resource that provides a rich compilation of short papers covering the essentials of some 25 methods. Each addresses the method's history, description, how to do it, strengths & weaknesses, frontiers, and application examples. For instance, Delphi is covered by Ted Gordon. He notes its invention by RAND in the early 1960's – indeed, most of the tech forecasting and assessment tools were devised by Americans. *Futures Research Methods* also treats environmental scanning, trend impact analysis, scenarios, participatory methods, simulation, etc. It also compares suitability and integration, and treats "meta-issues," such as Hal Linstone's presentation of multiple perspectives.

Joe Coates, in particular, merits appreciation for efforts to enable technology assessment (TA). His diverse intellectual contributions abound. But additionally, he led the NSF Program Office of Technology Assessment through the early 1970's. They supported at least two dozen exploratory TA's that contributed greatly to methodological development – far more than did the ensuing work of OTA.

American texts have helped provide methodological foundations for tech foresight. Without pretense of comprehensive or unbiased coverage, we note:

- Ashton and Klavans (1997) provide the foundation for technical intelligence
- Martino (1993) and Porter et al. (1991) lay out tech forecasting methods, with express treatment of how these pertain to technology management
- Porter et al. (1980) cover technology assessment and other forms of impact assessment, while Porter and Fittipaldi (1998) edited a compilation of environmental methods

Comments on three important methods developed or improved in the U.S. are given below:

Scenarios: Scenario writing is a cornerstone methodology in virtually all major foresight efforts. Today, scenarios are a widely used strategic planning technique in government, private industry and other sectors throughout the world. One basic reason for their use is the ability of scenarios to deal with a variety of intersecting social, political, economic and technological forces that form the basis for what the future will bring. To deal with complex, uncertain, dynamic and risky matters facing strategic planners in the public or private sectors, scenarios have proven to be an enormously valuable tool.

Early use of scenarios as a strategic planning concept appeared after World War II where military planners used them to help strengthen strategic and

[6] www.acunu.org/millennium

contingency plans. In particular, the U.S. Air Force tried to anticipate how its enemies would behave in different situations, and then prepared alternative response strategies. Then, in the early 1950s, Herman Kahn, a participant in the earlier Air Force efforts, sharpened development and use of scenarios at the RAND Institute. Later in the 1960s, he refined scenarios as a tool for business applications, which lead to his role as a prominent futurist in the U.S at the Hudson Institute.

As a business planning tool, scenarios were popularized Pierre Wack at Royal Dutch Shell in the 1970s and 80s (Schoemaker and Corelius, 1992). At about the same time, some groups in the U.S began using scenarios for a wide variety of business and economic sector planning applications, including the Battelle Memorial Institute, the Futures Group and, later in 1987, the Global Business Network. Nowadays, strategic planners from the business and government sectors use some variation of scenario writing as standard practice.

Technology Intelligence (Scanning and Scouting): Although originally developed in the U.S. national security arena, forms of technology intelligence (TI) have been practiced in the private sector for many years (Ashton and Klavans, 1997). Technology intelligence in business refers to the process of gathering information from a variety of "open sources" to develop an understanding of current activities, emerging trends and future directions of key companies, technologies and other players of interest. Environmental and, more specifically, technology scanning is one form of TI that is important in foresight studies. Scanning involves systematic surveying of a broad landscape to identify activities, organizations and events that warrant further study, often as inputs to strategic planning processes.

In the U.S., scanning has been a component of some strategic planning process in a variety of companies for many years and its use is growing. The term "environmental scanning" was coined by strategic planners about forty years ago (Aguilar, 1967) and has grown in use with the advent of computer-based literature and web site sources and automated search tools. A review of relevant media covering the social, technological, economic, ecological, and political (STEEP) environments – sometimes called "360 scanning" -- is a foundation practice in futures research.

An emerging TI practice called technology scouting also has the potential to become a more prominent element of foresight studies. Scouting refers to the purposeful searching for specific technology-related entities of high interest such as products, companies or individuals. Both technology scanning and scouting provide essential foundation data into the foresight process for further analysis or consideration by the working teams evaluating potential directions for an entity.

Technology Roadmapping: Technology roadmapping has become a widely used technique during the past few decades, primarily in business but increasingly in government. The main purpose of a technology roadmap is to chart an overall direction for technology development or usage for a long planning horizon, typically 5-20 years. The concepts were initially popularized by Motorola, Inc., in the U.S. to help decrease development cycle time and time to market for new products (Willyard and McClees, 1987). This methodology later turned in to a process to tie strategic planning with technology roadmapping and even evolved into corporate vision management. Use of roadmapping has been a recent development in foresight studies compared with techniques like scenarios or Delphi surveys. But its use is expected to grow given the benefits that roadmaps provide. Once created, a technology roadmap serves as a tool to provide essential understanding, orientation, context, direction, and some degree of consensus in planning technology developments and implementations.

A variety of U.S. Federal agencies have used roadmapping and the practice is increasing. Examples include NASA, the National Science Foundation, and the Department of Energy. Private sector R&D

organizations, such as the Electric Power Research Institute (electricity technology roadmap) and The Santa Fe Institute (a Novel Computational Roadmap to synthesize and guide the research needed now to create the computing technologies), have both developed science roadmaps to help guide their research for the next 10-20 years.

The symposium on EU-U.S. Future-oriented Technology Analyses provides a nice perspective on recent methods development (IPTS - Institute for Prospective Technological Studies, 2004). Background papers reviewed the state of the art of technology forecasting, assessment, intelligence, and related methods vis-à-vis emerging societal foresight challenges (Coates et al., 2001; Technology Futures Analysis Methods Working Group, 2004). We note eight challenges of note to those involved with foresight (drawing heavily, but not exclusively on these sources):

1. Changes in the nature of “technological change” with increasingly science-based innovation
2. Shift in the prime drivers of technological innovation from the more narrowly technical concerns of Soviet-American Cold War military systems to industrial competitiveness concerns requiring inclusion of contextual influences
3. Renewed attention to societal outcomes (impact assessment and sustainability)
4. Opportunities to exploit electronic information resources to enrich tech intelligence and foresight
5. Better capabilities to address systems complexity in technological innovation
6. Gauging irreducible uncertainties to devise adaptive foresight and technology management processes
7. Interactive, participatory methods (scenario planning, multi-actor gaming, simulations)
8. Suitable approaches to anticipate potential discontinuous advances and radical innovation.

An interesting facet of this joint EU-US symposium was the limited American participation, even in this workshop devoted to methods. The Synthesis paper (IPTS, 2004) offers challenges in terms of foresight utilization, credibility, intellectual interchange (academics, practitioners, users; public and private sectors), and how best to address such challenges.

4. PROCESS CONTRIBUTIONS FROM THE U.S.

A variety of group processes are essential ingredients of foresighting studies and many of these techniques were developed or improved in the U.S. Techniques for generating ideas such as brainstorming, for prioritizing ideas such as the nominal group technique and for reaching consensus on issues where viewpoints can vary, such as the Delphi technique, have all proven valuable in foresight exercises in one form or another.

Brainstorming is widely applied as a creativity and idea generation technique in foresight studies and other efforts where structured group interaction is important. A group of participants with a facilitator systematically generate and discuss ideas in a round-robin process where all participants have an equal chance to participate. The term was coined and documented by Alex Osborne shortly after World War II (Osborne, 1948).

Originally developed as an organizational planning technique by Delbecq, Van de Ven and Gustafson in 1971, the nominal group technique is a consensus planning tool that helps clarify and prioritize issues. With help of a moderator, group participants are brought together for discussion of a topic, written evaluation comments and ranking of responses. Newer versions of NGT have been developed, including electronic formats, and the technique is now widely used for group processes in government and industry.

The purpose of the Delphi Technique is to elicit information and judgments from participants to facilitate consensus based problem-solving, planning, and decision-making without physically assembling the contributors. Instead, information is exchanged via physical or electronic communication systems. This technique is designed to take advantage of participants' expertise and creativity through structured facilitation of group involvement and interaction. Delphi was designed at the RAND Institute in the U.S. in the 1960s and, with several modifications, has been widely used since then for technology forecasting and impact analysis by many organizations.

5. CONCLUSIONS

The Foreword of an OECD report (1999) asserts:

There is a growing interest in technology foresight in the OECD Member countries because of the need to set priority in research and development in the context of the increasing cost of research and the tightening public budget for research. R&D efforts also need to be directed towards fulfilling social needs at the same time as providing sources of innovations that contribute to sustainable growth.

These premises do not hold for the U.S. There is no growing interest in foresight. There is no momentum, still less consensus, that R&D prioritization should be set by spelling out goals and ascertaining relative priorities for various research domains. Indeed, the U.S. seeks to be a predominant player in all R&D domains (National Academy of Sciences, 1993). And there are no strong indications of commitment to link R&D priorities to societal goals.

What are the consequences of this "anti-foresight" situation? Can a nation fare well scientifically and economically trusting to a marketplace of ideas and pressures to establish priorities and allocate resources? If so, why are other nations investing in extensive foresight activities?

The American political process essentially treats science & technology via pluralistic processes. Voices cry out (for resources) from scientists, industrial interests, and activists (pro- and anti-science). Multiple agencies support and sometimes conduct R&D in somewhat overlapping spheres of interest. Multiple Congressional committees exert power over legislative, budgetary, and regulatory aspects. Two political parties strive to effect agendas. The Executive Branch balances against the Congressional Branch, where the House and the Senate jockey between themselves. Annual Federal budget cycles predominate. In recent years, pork-barreling has arrived in R&D, with earmarking of pet projects for institutions in particular political constituencies. However, most R&D funding continues to rely on some variation of scientific peer review to assure quality. This is not a milieu conducive to far-reaching national foresight. But it lends a multi-voice robustness to science and technology development.

Wagner and Popper (2003), reflecting particularly on the decade of U.S. critical technologies activities, identify the poor fit between foresight-like processes and the American S&T system. While some of us lament this in whole or in part, Americans and others should also reflect on its strengths. The lack of an established priority-informing process allows, and may facilitate, adaptive response to changing concerns. The lack of clear agency R&D responsibilities enables alternative routes to pursue new initiatives. Examples abound, but consider how many U.S. Federal agencies have a hand in "nano" R&D. This risks redundancy and waste of precious resources. However, the increasing availability of accessible S&T information resources on research programs, projects, and outputs (papers, patents) offer the potential to coordinate (not that this is well done now).

To the extent that tech foresight is able to foresee emerging technologies and shifting needs, those who use foresight may gain a significant advantage over those who do not. Wagner and Popper (2003) assert that "Foresight cannot provide predictions or even leading indicators." We disagree, yet must admit that it is not easy to present clear evidence of foresight providing effective "early warning" that made a difference.

Another argument in favor of the U.S. non-foresight stance is that foresight is usually open information. Hence, American agencies, companies, and researchers can, in principle, make use of foresight knowledge generated by others. Albeit, we do not have evidence that much attention is being paid to such knowledge in any explicit way.

To what extent does a "tri-helix" innovation system involving academic, industry, and government contributors to and users of R&D attend to foresight? In countries that strive to do so, national governmental roles take a strong leadership position – i.e., set national priorities. But, for some technology and economic situations, the pluralistic American innovation system may make up for such focused effort through fostering more multi-path explorations – or as Wagner and Popper (2003) call it, "self-assembly." The more the innovation system is subject to unpredictable, rapid changes, the more advantage to the pluralistic approach. Good technological intelligence to pick up quickly on emergent opportunities may outweigh careful foresight. Such a messy, opportunistic system may especially do better at "Radical Innovation" (Dismukes et al., 2005).

That said, how about the value in spelling out R&D fit to societal goals? As we write the U.S. is fighting about stem-cell research but has opted in to genetically engineered foods without much of a murmur. The American scientific community does not seem overly anxious to engage a broad public in deliberating about research agendas. While agenda-setting ought to be inclusive in a democratic society, do we want a populace whose majority (+/-) disbelieves evolution directly involved? As foresight proponents, we might well counter that well-orchestrated processes have a strong educational component preceding judgmental elements. Were foresight able to widen popular interest in science, this might yield significant impetus to fixing an educational system that fares badly in teaching science, math, and engineering compared to other nations.

6. FUTURE DIRECTIONS FOR U.S FORESIGHT EFFORTS

The information regarding U.S. foresight activities presented in this paper suggests that "the future of US foresight efforts will probably be very much like the past". This means that decentralized foresight studies will continue to be undertaken. Agencies such as the EPA, DOE and DoD, will probably continue foresight work, but it is not likely that national level efforts encompassing a broad slate of national goals with national leadership will occur. The pluralistic nature of the US R&D system, the diverse, dynamic nature of US national political bodies and the limitations of US foresight history makes centralized goal-setting across many national issues in the U.S. very unlikely.

However, in line with other past foresight contributions, the strong interest in methods, techniques and tools exhibited by US researchers and practitioners is also very likely to continue. This means that new methods and tools that can be applied to foresight studies around the world will probably emerge from U.S. developers. Tool development will also probably be diffuse and diverse with inputs coming from a wide range of strategic planners, policy analysts, business leaders, the academic community and other political players.

Three themes surrounding tool development seem likely as we move into the future. First, the increasingly widespread availability of data of all sorts is not likely to abate, making advanced tools that help process, search, mine, organize, display and interpret the many forms of data we expect to become available a probable U.S. contribution. Second, the need for better methods of extracting, organizing, comparing and combining a wide variety of human judgments will also continue to prompt method development in the U.S. Taking a vast array of expressed interests and opinions into account seems to be a continuing driver to improve foresight studies. Third, the increasing proliferation of rapid and comprehensive communication tools, such as those building on progress with the internet and other electronic networks, will permit vast numbers of individuals around the world to participate in decision making situations like foresight studies. For instance, it is not difficult to imagine that future foresight and other large scale analysis efforts will one day incorporate inputs from experts and stakeholders using some form of election-style electronic voting processes. Networking and collaboration tools seem to be attractive solutions to dealing with large diverse contributors and stakeholders and these tools will undoubtedly improve over time.

In short, it appears that contributions to foresighting from U.S. players are likely to continue as they have in the past. While not fully embracing centralized national-level foresight studies, the U.S. does place a high value on development and use of advanced strategic planning and decision making methods and tools.

REFERENCES

Aguilar, F. J. *Scanning the Business Environment*. New York, NY: McMillan (1967).

Ashton, W.B., and Klavens, R.A. (eds) (1997), *Keeping Abreast of Science and Technology*, Columbus, OH: Battelle Press.

Coates, J.F. (1976), 'Technology Assessment: A Tool Kit', *Chemtech*, 6, 372-383.

Coates, V., Faroque, M., Klavins, R., Lapid, K., Linstone, H.A., Pistorius, C., and Porter, A.L (2001). 'On the future of technological forecasting', *Technological Forecasting and Social Change*, 67 (1), 1-17.

Committee on Facilitating Interdisciplinary Research, National Academy of Sciences, National Academy of Engineering, Institute of Medicine (2004), *Facilitating Interdisciplinary Research*, Washington, DC: National Academies Press.

Correia, Z. and T.D. Wilson, "Factors influencing environmental scanning in the organizational context" *Information Research*, 7(1) (2001) [Available at http://InformationR.net/ir/7-1/paper121.html]

Delbecq, A.L. and VandeVen, A.H., "A Group Process Model for Problem Identification and Program Planning," *Journal Of Applied Behavioral Science* VII (July/August, 1971), 466 -91 and A. L. Del becq, A. H. VandeVen, and D. H. Gustafson, *Group Techniques for Program Planners* (Glenview, Illinois: Scott Foresman and Company, 1975).

Dismukes, J.P., Miller, L.K., Bers, J.A., and McCreary, W.N. (2005), 'Technologies of Thinking" Seen Key to Accelerated Radical Innovation,' *Research Technology Management*, July-August, in press.

Glenn, J. and Gordon, T., 2002. *Futures Research Methods: Version 2.0*, AC/UNU Millenium Project, Washington , DC: http://www.acunu.org/millennium/FRM-v2.html.

IPTS - Institute for Prospective Technological Studies, [European Commission, Directorate-General], (2004), *New Horizons and Challenges. for Future-Oriented Technology Analysis. Proceedings of the EU-US Scientific. Seminar: New Technology Foresight, Forecasting & Assessment Methods* [EUR 21473 EN; www.jrc.es/projects/fta/].

Irvine, J. and Martin, B.R. (1984), *Foresight in Science: Picking the Winners*, London. Pinter Publishers.

Krause, P.H. (2002), 'The Proteus project – Scenario-based planning in a unique organization', *Technological Forecasting & Social Change*, 69 (5), 479-484.

Linstone, HA and Turoff, M., Eds, *The Delphi Method: Techniques and Applications*, (2002). (http://www.is.njit.edu/pubs/delphibook/)

Loescher, M.S., Schroeder, C. and Thomas, C.W. (authors); Krause, P.H. (compiler), *Proteus: Insights from 2020*, The Copernicus Institute Press.

Martin, B.R., and Irvine, J. (1989), *Research Foresight: Priority-Setting in Science*, London: Pinter Publishers.

Martino, J. P. (1993), *Technological Forecasting for Decision Making*, third edition. New York: McGraw-Hill.

National Academy of Sciences (1993), *Science, Technology and the Federal Government: National Goals for a New Era*, Washington, DC: National Academy Press.

OECD – Organization for Economic Co-operation and Development, Working Group on Innovation and Technology Policy, Directorate for Science, Technology and Industry, Committee for Scientific and Technological Policy (1999), *Technology Foresight and Sustainable Development: Proceedings of the Budapest Workshop (11 December 1998).*

Osborn, A.F. (1948) *Your Creative Power*. New York, Charles Scribner's Sons.

Porter, A.L., and Fittipaldi, J.J. (Eds) (1998), *Environmental Methods Review: Retooling Impact Assessment for the New Century*, Atlanta, GA: Army Environmental Policy Institute.

Porter, A.L., Roper, A.T., Mason, T.W., Rossini, F.A., and Banks, J. (1991), *Forecasting and Management of Technology*, New York, John Wiley.

Porter, A.L., Rossini, F.A., Carpenter, S.R., and Roper, A.T. (1980), *A Guidebook for Technology Assessment and Impact Analysis*, North-Holland, New York.

Schoemaker, Paul J.H., and Corelius A.J.M. van der Heijden. 1992. "Integrating Scenarios into Strategic Planning at Royal Dutch/Shell." Case Study. *Planning Review*, pp. 41-46.

Skumanich, L and K. Silbernagel (1997), *Foresighting Around the World*, Battelle Memorial Institute. Seattle, WA.

Technology Futures Analysis Methods Working Group (2004), [Alan L. Porter, W. Bradford Ashton, Guenter Clare, Joseph F. Coates, Kerstin Cuhls, Scott W. Cunningham, Ken Ducatel, Patrick van der Duin, Luke Georghiou, Ted Gordon, Hal Linstone, Vincent Marchau, Gilda Massari, Ian Miles, Mary Mogee, Ahti Salo, Fabiana Scapolo, Ruud Smits, and Wil Thissen], 'Technology Futures Analysis: Toward Integration of the Field and New Methods', *Technological Forecasting and Social Change*, 71, 287-303.

Waddell, W., Kim, J., and Smith, J. (2004), 'Proteus, New Insights for a New Age', *2004 Command and Control Research and Technology Symposium: The Power of Information Age Concepts and Technologies* [www.dodccrp.org/events/2004/CCRTS_San_Diego/CD/papers/011.pdf].

Wagner, C.S., and Popper, S.W. (2003), 'Identifying critical technologies in the United States: a review of the federal effort', *Journal of Forecasting*, 22 (2/3), 113-128.

Willyard, C. H. and McClees, C.W., "Motorola's Technology Roadmap Process," *Research Management*, pp. 13-19. (Sept.-Oct. 1987).