Available online at www.sciencedirect.com
SCIENCE DIRECT
ELSEVIER
J. Eng. Technol. Manage. 21 (2004) 281–306
Journal of ENGINEERING AND TECHNOLOGY MANAGEMENT JET-M
www.elsevier.com/locate/jengtecman

Innovation through initiatives—a framework for building new capabilities in public sector research organizations

Charlette Geffen[a,*], Kathleen Judd[b,1]

[a]*Pacific Northwest National Laboratory,*[2] *P.O. Box 999, 902 Battelle Blvd, Richland, WA 99352, USA*
[b]*Battelle Seattle Research Center, 1100 Dexter Ave N, Seattle, WA 98109, USA*

Available online 11 November 2004

Abstract

The accelerating pace of change in science and technology has resulted in new attention to the process of identifying and developing ideas that ultimately lead to new scientific capabilities and business opportunities for an organization. The need to refresh research programs and capabilities is as important in federally funded research institutions as it is for industry. This paper explores the critical success factors for new initiatives at a federal laboratory, and building on lessons learned through this study and in private industry, identifies a more systematic process that could potentially improve the effectiveness of these initiatives in achieving results.

JEL classification: O31

Keywords: Innovation; Process management; Public R&D; Technology management; Idea generation

1. Introduction

New ideas in science and technology are the lifeblood of a research organization. The need to foster growth, innovation and diversification of products, technology platforms, and entire business units to maintain competitive advantage is increasingly important for

* Corresponding author. Tel.: +1 509 375 3646; fax: +1 509 372 6153.
E-mail addresses: ca.geffen@pnl.gov (C. Geffen), juddk@battelle.org (K. Judd).
[1] Tel.: +1 206 528 3330; fax: +1 206 528 3552.
[2] The Pacific Northwest National Laboratory is operated by Battelle for the U.S. Department of Energy.

0923-4748/$ – see front matter
doi:10.1016/j.jengtecman.2004.09.002

companies. It is equally important for publicly funded research institutions, with a responsibility to advance fundamental scientific discovery and to find ways to utilize those discoveries to address major national challenges. The accelerating pace of change in science and technology today and the emergence of breakthroughs at the interface of various disciplines have resulted in new attention to the process of identifying and developing ideas that ultimately lead to new scientific capabilities and business opportunities for an organization.

Much of the current research in technology innovation is focused on the efficiency of moving ideas from research to the commercial marketplace. Conceptualizing new products or technology platforms and linking them to potential markets are important aspects of successful innovation. An equally important element, however, and one that is not well understood, is how companies identify and foster the development of new focus areas for scientific research or technology development. This early stage of idea generation, before a product concept has evolved, has been called the ''fuzzy front end'' of innovation.[1]

Successful organizations are always generating new ideas—getting those ideas translated into program concepts that can be supported and funded by management, however, remains a challenge. The art of idea generation and development requires a supportive environment and a culture of discovery and innovation. Companies such as 3M are well known for their approach to encouraging research staff to explore new ideas. National laboratories in the U.S. also have a strong tradition of individual scientists developing new ideas for the next stage of their research or to explore a specific scientific question. Yet, the process of developing new organizational capabilities and major research programs that transcend individual interests remains a challenge. Understanding how best to evaluate and choose the directions for investment in new ideas, and then finding effective ways to accelerate the path to results is a challenge shared by public and private research organizations alike.

1.1. The importance of publicly funded science

The federal government has traditionally had a strong role in the U.S. research enterprise, providing at times as much as 67% of the total R&D funding for the nation (National Science Board, 2000).[2] As the nation's investment in R&D has grown over the last decades, however, industry has played an increasingly important role. According to the most recent publication from the National Science Board (2000), most of the R&D performed in the U.S. is currently paid for by private industry, which provided over 65% of the total R&D funding in 1998 (almost $150 billion). This support is provided during a time when the total level of R&D expenditures in the U.S. has been increasing since 1994 at a rate of almost 6% real growth per year. The role of industry in funding R&D is now greater than that of the U.S. government and is projected to remain so in the coming years. The federal government remains the major

[1] The term first appeared in an article by D.G. Reinersten, called ''Blitzkrieg product development: cut development time in half,'' *Electronic Business*, January 15, 1985.

[2] The government share of R&D funding was 67% in 1964—it has been on a slow decline, on a percentage basis, ever since according to the National Science Board.

contributor to fundamental or basic research, however, with over 50% of the total national investment (National Science Board, 2000).

Industry investments are primarily directed at the development of specific products and services to meet the needs of their existing and anticipated future markets. Their focus is principally on the ''D'' of R&D, taking basic science discoveries made in national laboratories and universities (although some companies still maintain a small, focused basic research enterprise) through the processes of development and commercialization. This major federal investment in basic science has been a significant factor in fueling many of the innovations and industries on which the growth of our economy in the last decades has been based (Crow and Bozeman, 1998).

1.2. Achieving results in a research environment

Both public and private research organizations are facing new pressures for productivity and performance. After years of being somewhat protected from financial measures, research organizations now feel the same need as business units to ensure that major investments in new research programs or exploratory ideas achieve significant returns. The terms ''return on investment'' and ''payback'' have reached both public and private research organizations and are increasingly used in making decisions on new program funding. The Government Performance Results Act of 1993 initiated a process whereby all agencies, including those engaged in fundamental scientific research, are required to define specific performance measures and outcomes on which to be measured. Work is actively underway to develop appropriate measures for science and technology activities (Jaffe, 1999).

Proactive management of the innovation process has demonstrated the ability to increase the effectiveness of the process for new product development, and improve the rate of successful product launch (Cooper and Kleinschmidt, 1986). Research organizations are now exploring new approaches to help them maximize the returns from investments in exploratory ideas at earlier stages of the idea generation and development process and related product development cycles. Understanding the process of translating early stage ideas into viable development concepts and the factors important to ultimate success is the focus of this paper.

Investments in major capabilities or program development that can significantly affect future directions of a research laboratory, but that are not yet fully formulated as specific product offerings or program concepts, are termed ''initiatives'' for the purpose of this analysis. Initiatives provide an important avenue for exploring innovative ideas that can strengthen a laboratory's scientific and technical capabilities and/or lead to new business opportunities. These internal investments provide support for new ideas and concepts that have scientific or technical merit, but may be ahead of the market, in terms of their ability to garner programmatic funding or external investment. This paper specifically explores the approaches used to develop initiatives within a federally funded research organization, and evaluates the critical factors for success. The results of this preliminary analysis lead to a recommended framework for use with future initiatives to improve the effectiveness of the process.

2. Understanding the front-end of the innovation process

The rich body of literature on the innovation process provided a useful context for this analysis. Much of this literature, however, is set within the context of industry, and focuses on more effectively managing the process of moving ideas from research to the commercial marketplace. Because there are fundamental differences in the missions of government R&D institutions and private R&D companies, the objectives, performance measures, and critical outcomes associated with innovation in the private sector do not always have direct applicability to the public sector. Yet, the notion of institutionalizing a more systematic approach to developing, assessing and managing new ideas, products, and processes does have important implications for both sectors.

2.1. The innovation process

Research and development activity, whether internal to a company or accessed through the work of others, is critical to the process of innovation. It is the engine through which companies develop new generation products and technologies. Inventions and resultant innovations can focus on products or processes. They can be incremental improvements of existing technology or radical breakthroughs that change the very nature of a product or process. The experience and resource base of a company (in terms of its existing technology platforms, product sets, technical knowledge and management approach) play an important role in innovation (Cohen and Levinthal, 1990). Companies develop innovations through experience with a particular technology and through learning by doing. Thus, the experience base and technical knowledge built up by a business are important factors in successful innovation (Rosenberg, 1994). Research by Henderson and Clark (1990) and Christensen (1992), among others, has shown that these same elements, however, can limit a company's ability to see and pursue radical or revolutionary innovations that are built on new principles or competencies, and may require new organizational approaches to product design and/or marketing.

Initiatives in the context of a non-profit or federally funded institution may be directed toward either incremental improvement to existing capabilities, where the team is building on a strong experience base and reputation, or to revolutionary changes in the capabilities of the laboratory. The latter case is often observed when dramatic changes in science and technology open up entire new fields of research. Nanoscience and technology and the emerging fields of bioinformatics and bioengineering are examples of areas that may demand revolutionary change. Emerging research in the early stages of the innovation process was reviewed to obtain insight into the factors that may be important to understanding the context of the initiative process for a publicly funded research laboratory.

2.2. Early stage discovery and exploration

The innovation process is neither linear nor highly structured, particularly in the early stages of discovery and exploration. It is true that highly structured management approaches supporting the development and commercialization process have been found to accelerate product development and launch when applied to specific projects (see

Wheelwright and Clark, 2001). Techniques, such as the stage-gate process as described in Cooper (2000) force management to quickly screen ideas for those that appear to have near-term commercial merit, and then support the development of those projects with the resources and staff they need to be successful.

These approaches are not as appropriate, however, for the early stages of innovation or for determining research agendas to address specific scientific and technical challenges in a selected application area. Organizational processes and structures oriented to new product development are not the same as those needed to foster and facilitate new emerging ideas and technologies. The front end of the innovation process, while conducted differently across organizations, generally includes the initial generation of an idea, followed by a period of explorative evaluation. To enhance the development and growth of new ideas, organizations must have effective and efficient processes for the following activities:

- Monitoring and understanding trends in science and technology.
- Monitoring and understanding market trends and customer needs, including changes in the external environment (sociopolitical trends, regulatory pressures, etc.).
- Identifying, sorting and screening new ideas.
- Refining concepts, based on an integrated evaluation of potential.
- Managing the innovation stream—the number of ideas being pursued at a given time and their developmental stages.

Recent research by the Industrial Research Institute on the early stages of innovation (see Koen et al., 2001) suggests that activities that lead to a clear understanding or evaluation of the market opportunities and the science and technology capabilities required to address them, as well as alternative paths to achieve success, are likely to enhance the probability of results.

In addition to processes for understanding market and technology trends, and the external environment, organizations need an internal culture and set of processes that encourage the creative process of idea generation and development. Significant research has been done to date on creativity and organizational culture, and their roles in encouraging the development of new ideas (see Khurana and Rosenthal, 1998 and Amabile, 1998 for representative discussions of this issue). Bower and Christensen (1995) have further shown that organizations with more flexible, decentralized structures and a focus on developing new product offerings are more likely to develop and adopt radical innovations. This body of work, and additional research focused on science and discovery processes (Koen et al., 2001) suggests that significant structure at the earliest stages of innovation is not necessarily conducive to the creative process or to the continued exploration of potentially revolutionary ideas.

3. Methodology

A review of the literature on innovation and factors important to the front end of the innovation process was used to help determine the elements of primary interest in this case study. The results of emerging research on the early stages of the innovation process suggest that for private research enterprises directed at commercializing new products,

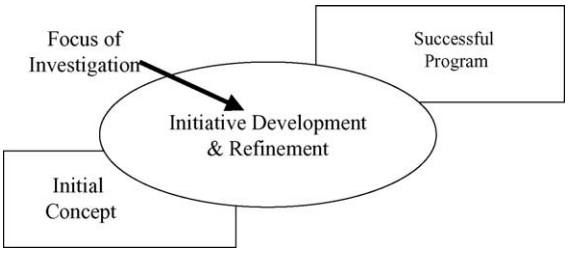

Fig. 1. The bridge between concept and program.

there are four major factors that are important to successfully moving ideas from early stage concepts to the point where they can be transitioned effectively into new product development processes. These factors are: (1) an understanding of science and technology trends; (2) clearly identifying market trends and customer needs; (3) strategic alignment and consistency of purpose in moving the ideas forward; and (4) leadership and organizational culture. In this study, experience with four early stage initiatives in a publicly funded research laboratory[3] was evaluated to understand the applicability of these factors in the context of a non-industrial research laboratory setting, and the extent to which they impacted the successful development of early stage ideas. A particular focus of the study, shown in Fig. 1, was to understand the success factors for crossing the bridge from initial concept to the development of a successful, large-scale research program (analogous to the process stages in industry required to go from idea to product development).

The exploratory nature of this study, and the importance of understanding the context for idea generation and initiative development led to the selection of the case study approach for this study (see Fig. 2).[4] The case studies captured key outcomes and lessons learned from those participating in the initiative development process.

Four initiatives were selected for analysis in this exploratory study, representing different sources of ideas, approaches to initiative management, and strategic objectives. These elements were considered in selecting the initiatives to understand how the contextual situation might influence the process of successfully moving from an initial idea to a fully supported research program, and how lessons learned from industrial experience might be applied to the initiative development process. Each initiative was evaluated with respect to three of the four major factors for success identified as relevant in industrial settings (science and technology trends; market knowledge; and leadership/culture). The fourth factor, strategic alignment, proved not to be a differentiator in this case study, since all initiatives had been approved by a senior management decision-making group for strategic fit and relevance to the institution. The initiatives and their characteristics are represented in Table 1, and were selected to provide the basis for a fundamental understanding of the elements and challenges of the initiative development process.

The process of conducting the case studies began with a review of historical data from business plans, investment proposals, and management reviews. One-on-one focused

[3] We will refer to this research organization as the "Laboratory" in this study.

[4] The methodology for this study is based on that presented in Yin, 1994.

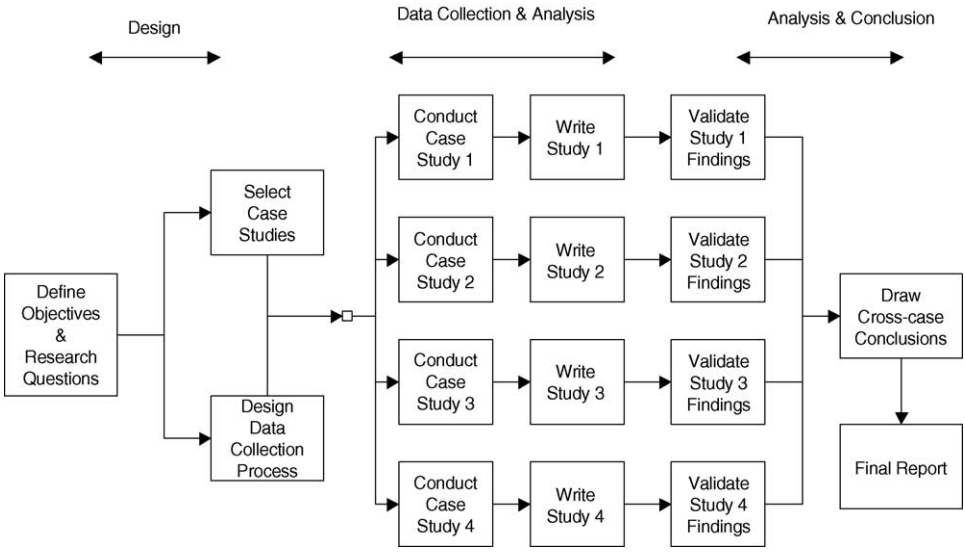

Fig. 2. Case study methodology.

interviews were then conducted with a set of prepared questions. At least two participants from each of the four initiative teams were interviewed, and several participants from the pre-initiative, idea development phase were also interviewed. Overall, 21 first-round interviews were conducted with initiative leads and technical staff. Additional documentation was collected during the first round of interviews, including meeting agendas, relevant email correspondence, and market studies. Data collection focused on understanding the entire lifecycle of the initiative (from early idea generation through the development and implementation process) and was designed to draw from multiple sources, including review of documentation and interviews with various participants in the initiative development process. This data was used to create detailed process flow diagrams that captured specific activities (e.g. conducted market assessment) along each stage of initiative development. These activities were characterized in three areas: market strategy, science and technology, and program leadership.

Draft write-ups and process flow diagrams were then constructed for each initiative. These write-ups were validated with interviewees to verify the accuracy of the information presented in the case studies and diagrams. Participants were also asked to provide feedback on the integrated set of recommendations that came out of the crosscut analysis of the cases.

4. Case study analyses

The lifecycle of an initiative in the Laboratory begins with an idea that is developed and nurtured over time, and, if viable, ultimately transitions into a self-sustaining research program or operating business. The means by which ideas are explored, developed into initiatives, and transitioned into programs and operating businesses varied significantly

Table 1
Comparative overview of initiatives

Initiative	Agriculture	Environment and health	Natural resources management	Electronics
Strategic objectives	New markets	New S&T capabilities; extend existing and build new markets	New markets	Extend market
Source of idea	Idea generation unit	Senior Mgt	Senior Mgt and idea generation unit	Customer
Senior level champion?	No	Yes	No	Yes
Early science and tech. focus?	Yes	Yes	No	No
Early market understanding?	Yes/No	Yes	Yes/No	No
Expected long-term outcome	A significant, diverse, and sustainable portfolio of government and commercial technology development programs	Position as a nationally recognized leader in advanced biological research, focused on the health consequences of environmental agents	Become a pivotal provider of advanced and integrated management solutions for complex watershed-scale natural resource problems	Long-term strategic partnerships with electronics companies in contract research and IP commercialization

across initiatives. New ideas come from a variety of sources, including from senior management, technical staff, a team dedicated to generating ideas for new initiatives, or even from outside of the Laboratory. The manner and timeframe in which an initiative is developed and implemented (i.e. the transitional phase between an exploratory idea and an operating business) can also vary considerably. Organizational factors, the characteristics of the leadership and the initiative team, and the resources provided for development can all influence how an initiative moves through this phase of its lifecycle. If an initiative matures to the point of becoming an independent operating business, it may take the form of a new market sector, product line, spin-off, or new technology platform. Therefore, how an initiative moves through its lifecycle may depend on the nature of the idea, where it comes from, and how it is managed through its development and implementation. Industry experience also suggests that the extent to which an initiative is building on existing capacity (either in the market or science/technology dimensions) may influence its direction and development path. This evolutionary process and the elements important to initiative success are the focus of these case studies.

The four initiative case studies are described below and a comparative overview of these initiatives is provided in Table 1. In each case study, the focus was on understanding the major initiative development activities and their timing, the outcomes achieved, who was involved at different stages in the process, and what techniques or tools were used to support these activities. Each initiative was specifically evaluated relative to the three factors important to the success of ideas in industrial organizations (science and technology, market knowledge and leadership/culture. The key lessons learned are summarized in the findings section, with a particular focus on suggestions for improving the effectiveness of the process.

4.1. Case study 1: agriculture

The initiative on agriculture was established primarily to create new business opportunities for the Laboratory in the food and agriculture industries, and secondarily to develop new capabilities and products. Through the development and application of science and technology (S&T) the initiative aimed to increase the quantity, quality, and safety of the world's food supply, while enhancing stewardship of energy and environmental resources associated with agriculture and food processing. The team's strategy for linking this mission to the Laboratory's business objectives and market opportunities was to develop an integrated portfolio of both government and commercial technology development programs with a diverse customer base.

The agriculture initiative proceeded through six major phases, described in detail as follows.

4.1.1. Initial concept

The idea to pursue work in the agricultural sector materialized during a workshop specifically designed to generate ideas for new initiatives. Several staff participating in the workshop believed that food production was a major global issue and could be a long-term, strategic, mission-changing opportunity for the Laboratory, and proposed shaping the idea into a potential new initiative. An initiative steward was charged with the task of developing a framework for the initiative over a period of 4 months.

The process began by filling out the set of market hypotheses that were crafted in the workshop. A team of researchers then began scanning the literature and reports on the major issues, problems, and trends associated with food and agriculture, and validated the information in scan group sessions with internal personnel. The team also engaged in a visioning exercise to project future technology needs (e.g. biotechnology) and other major resource needs (e.g. water) for food production. Information captured through these scanning and visioning activities enabled the team to generate several value propositions.[5] Through a process of creating, refining, discarding, and merging value propositions, it became clear that the Laboratory could provide substantial technical contributions to the food and agriculture industry. A single value proposition was drafted, providing the framework for the initiative. The value proposition was then linked to a preliminary market strategy, and senior management granted funding to further define the opportunity. A new lead, with both relevant industry experience and internal management experience, was then appointed to move the concept forward.

4.1.2. Define system and vision of future

The next phase focused on developing a more detailed understanding of the entire food and agriculture system and future trends to help the team determine how best to move forward. As a first step toward understanding the system, a high-level market characterization described R&D spending and sources, and identified key issues related to the industry, such as food safety and environmental impact. This market characterization provided input to an effort to model the U.S. food system, from farm to table, which required a four-month commitment from one engineer. The model detailed the various elements of the industry, the inputs and outputs at different stages, and the technologies used. To the extent possible, each of the components of the model was quantified using a variety of statistics (e.g. financial data based on Standard Industry Codes, energy intensity, environmental impact, labor intensity.) This information was organized and presented using a computer modeling program and was used to help define the industries' existing technology needs.

Although some visioning had occurred during the initial conceptualization phase, the new initiative lead determined that a clearer vision of the future of food and agriculture was necessary to develop a more targeted market entry strategy. The lead conducted a scenario-planning workshop, which brought together about twenty individuals from various areas across the organization. Prior to the workshop, individuals were given background information, including an overview of the systems model, and each was assigned a specific stakeholder role for the purposes of the workshop. During the workshop, the various stakeholders shared their vision of a "model world" for food and agriculture in 10 years, and then projected what transformational technologies would be needed to achieve this model world. This exercise also served to raise internal awareness of and support for the initiative concept.

4.1.3. Refine strategy and focus

At this point, the team decided to get additional detail on the potential market opportunity, principally from sources external to the Laboratory. The market was further

[5] The value proposition is a statement that defines the specific value that will be offered to a target market, in light of the organization's capabilities, competitive gaps, and customer needs.

analyzed and segmented, using the services of an external consulting firm and some information from the preliminary market characterization. At the same time, internal S&T capability focus areas were being identified, primarily through meetings with technical staff from across the Laboratory. A high-level competitor assessment was conducted through conversations with key industry players and site visits. Together, this enabled the lead to define a refined strategy and focus, which was validated through meetings with potential clients.

4.1.4. Develop business case

The initiative lead next focused on developing the business case for continued investment in the agriculture effort. For approximately 4 months, the team analyzed the potential value and costs associated with industrial solutions and the value of government program opportunities. This involved extensive interaction with government and industry representatives. They identified specific product offerings and clients to target. From this, an initiative vision, a business strategy with more targeted value propositions, and a growth scenario were outlined in an investment proposal, which was approved by senior management.

4.1.5. Integration and planning

Initiative integration involved defining the technical foundations and product platforms, and developing plans for specific R&D and business development investments. Technology roadmaps that had been designed to support other Laboratory efforts provided useful input to this activity. Key account managers were identified to move these capabilities into the marketplace.

4.1.6. Implementation

For the next 2 years, the initiative was provided investment support as it implemented the vision and plans designed over the previous year and a half. Cultivating relationships with strategic industrial and government organizations was the first step toward business development. A year's worth of aggressive marketing resulted in a few contracts and co-development efforts with other government agencies. While relationships were also being cultivated with industrial clients, these sales took much longer than expected due to the level of technology development required. At the end of a two-year implementation period, the initiative was transitioned to a business unit within the research Laboratory, where it operated successfully as an independent business.

4.2. Case study 2: environment and health

This initiative focused on integrating emerging capabilities in the biological, physical, and information sciences to strengthen and leverage existing capabilities and position the Laboratory to take advantage of anticipated research opportunities in postgenomic science. The long-term objective was to build fundamentally new biological sciences capabilities, including required research facilities and equipment, directing their application to identify, understand, and mitigate environmental health threats. While principally a capability building initiative, this investment also had a strong business development component. The initiative was commissioned as a long-term investment, projected to

receive internal funding for 8–10 years, although at the same time required to show progress toward developing new external business. The environment and health initiative was characterized by four major phases, each of which is described in more detail as follows.

4.2.1. Initial concept and scanning

The initial concept for this initiative came from the senior management team at the Laboratory, who established a small internal group to explore the concept. For 4 months, a multidisciplinary team of four individuals scanned the broad field of health with the objective of understanding the interface between the science and technology needs and trends, market opportunities and potential size, and Laboratory capabilities. At the same time, a parallel group was exploring the scientific directions and trends in the field of the biological sciences.

The preliminary market analysis conducted during this phase identified the drivers of change, emerging research needs, key agencies funding health-related S&T and their annual budgets, and opportunity areas for the Laboratory. Initially, the team attempted to create a systems model of the health system, based on the success experienced by the agriculture initiative with its systems model. That activity foundered when the team discovered that the health system was too complex to model quantitatively with its numerous feedback loops. Instead the team applied a more intuitive approach to the analysis, based on an extensive literature review of documents from sources, such as the National Academy of Sciences, the Institute of Medicine, scientific journals, and industry publications. External consultants were also used to help collect and validate market data. The product of this analysis was a high-level schematic of the health system – a qualitative model of the system.

A capabilities assessment was also conducted to identify the broad set of science and technology capabilities at the Laboratory that might be applicable to health-related research, from the perspective of the scientists at the Laboratory, and how these capabilities were being applied to serve existing clients and partners in the health arena. This information was gathered primarily through interviews with internal staff, an analysis of data in the financial system to identify related research programs (both current and past), and a review of various planning documents. Linking the capability data with information obtained by the group evaluating new directions in science led to a decision to utilize the initiative in environment and health as a major investment for developing new capabilities in biological sciences at the Laboratory.

4.2.2. Scoping

The scoping phase clarified and narrowed the focus of each of the groups that had evaluated the potential market opportunities in the health mission and the emerging scientific challenges in molecular biology. The scientific focus of the initiative was validated by outside experts, although initially limited discussion was held with existing clients. Leadership for this effort was assigned to two individuals – one focused on markets and program strategy, the other on leading the development of scientific capability. These leaders established an initiative team that included staff from a variety of scientific, engineering and management disciplines. This team took on the task of managing and coordinating activities within the initiative. Weekly staff meetings and regular workshops

were held to bring staff in the science, technology, policy, and health application fields together and build a cohesive team.

4.2.3. Integration and validation

Integrating the market strategy and the scientific direction of the two initial teams was the next major phase of the initiative development process. A long-term strategic business plan was developed along with a detailed process and timeline for defining and achieving initiative goals. The primary activities defined in this plan included the scientific research necessary for building capability, recruiting, partnership development, program leadership and strategy development, and communications. The development of an integrated research agenda, including an understanding of the market, relevant environmental policy, and scientific focus areas, was important to focus and validate the new direction of the investment. A market analysis focused specifically on environment and health was conducted to fill out the preliminary analysis conducted of the broader health field.

The scientific research agenda was defined in terms of specific thrust areas, mapped to strengths determined through a detailed assessment of existing capabilities. These areas were defined through a series of internal workshops and a literature review by the strategy team, and validated by an external advisory panel and a technical network established around the initiative. Communication throughout the Laboratory, at a variety of levels, was critical during this phase. Internal communication helped the initiative leadership generate broader awareness of the initiative among the scientific staff and ensure continued support of senior management. Communications with marketing staff and program managers helped extend the reach of the initiative, bringing additional insight on both market and science trends. Regular meetings to review progress with the initiative champions were highlighted by the initiative leads as critical to maintaining the interest and support of senior management. A web page, open forums, and occasional progress reports helped to keep staff informed. External communication activities, such as presentations, promotional materials, technical articles and news articles were a useful means of raising awareness with potential partners and clients, while the feedback from those communications also served to validate strategy and direction.

Program leadership and strategy development provided support in shaping and validating the initiative's proposed direction. A formal external advisory panel was established early in the life of the integrated initiative, and served as one important instrument for shaping and validating directions and priorities. The advisory group and other network contacts were also used to help recruit key staff and capabilities to support the initiative.

4.2.4. Implementation

The fourth phase of development focused on executing the plans laid out in the first year. While scientific progress and capability building continued to be primary objectives for this investment, business development became an increasingly important component in this phase. Partnerships were cultivated and formalized with other research institutions, including universities, potential funding agencies, and the private sector. Presentations and

site visits continued to be the predominant means of cultivating partnerships and collaborations. Multiple proposals were submitted and successfully won, based in large part on the new capabilities developed with targeted internal investment. Recruiting was a major activity in this phase, as were funding and building the necessary physical infrastructure, such as new equipment and facilities, to carry out the initiative's scientific and programmatic objectives.

4.3. Case study 3: natural resources management

The natural resources management initiative was developed to help diversify the Laboratory's client base and business portfolio in natural resources management. The intent was to establish the Laboratory as the regional provider of choice in natural science, engineering, and social science capabilities applied to complex regional natural resource and environmental challenges. While the initial investment in the initiative was driven by business development objectives, a shift in direction during the timeframe of the investment placed new emphasis on capability development. The natural resources initiative development process is characterized by three major phases, described as follows.

4.3.1. Concept development

The concept for this initiative developed from both management interest and a workshop specifically designed to generate ideas for new initiatives. Because the Laboratory was not well connected in most areas of regional natural resources management, it was determined that the support of a recognized leader in the natural resources field would greatly enhance the prospect for success. A strategic hire from outside of the Laboratory was brought in as the initiative lead to focus an effort around integrated natural resources management. This individual was instrumental in defining the strategy and potential direction for the initiative, summarizing the potential value of solving regional water and land resource problems, identifying possible impediments to success, listing potential clients, and suggesting a process for exploring the potential of a natural resources management initiative.

4.3.2. Understand the market and scope the initiative

For the next 12 months, the initiative lead and key technical staff focused on understanding the market and defining an appropriate scope for the initiative. A preliminary market assessment was conducted to better understand how the Laboratory might contribute to resolving regional natural resources problems, and whether this could be translated into a broader national and international business. The preliminary market assessment was completed after 10 weeks of outreach to representatives from government agencies, private industry, tribes, and non-profit organizations. The product of this effort was a summary of near-term regional opportunities for the Laboratory in forest and water resources management, and information on regional agency spending in natural resources management.

The initiative lead then began looking within the organization to identify the capabilities that could support the initiative. The institutional knowledge of a few key technical staff

provided the basis for capabilities identification, as the initiative lead was new to the organization. These individuals called on a variety of staff members whom they knew had done work relevant to integrated resources management to get a better sense for their capabilities and how they might support the initiative.

The next major activity in this phase helped to define an appropriate scope for the initiative and to validate the market opportunities and technical capabilities that had been identified over the past year. During a two-day workshop, entitled ''Issues and Opportunities in Natural Resources,'' over 30 individuals representing various sectors and divisions of the Laboratory came together to further define Laboratory capabilities, potential clients, and existing relationships between Laboratory staff and other organizations that might be leveraged to help the initiative move forward.

Collectively, the market assessment, capabilities assessment, and output from the workshop provided the lead with a preliminary vision for the initiative. This information was summarized in a business plan, submitted to the senior management for a decision, and approved for investment.

4.3.3. Engage the market and refine strategy

The next 2 years of the initiative's development focused on engaging the market and refining the strategy based on market feedback. The market engagement phase was marked by a shift from understanding and prioritizing opportunities to actively pursuing the opportunities. This involved raising awareness about the Laboratory's capabilities and cultivating relationships with key players in natural resources management in the region. The initiative management team set a goal of making at least one market contact per week with natural resource managers in these organizations to help build visibility, credibility, and new business for the Laboratory. Throughout this market engagement phase, key initiative supporters were also working to integrate the relevant science and technology capabilities across the Laboratory.

While the efforts to engage the market helped to increase the Laboratory's visibility in the region and close a few sales with early adopters of the integrated management approach, actual sales fell below projected sales in each year. As a result, a steering committee was formed to provide the initiative with direction in defining a new S&T focus, codified in a roadmap. Over a period of 6 months, a team of four process engineers worked with the natural resources initiative to determine what S&T investments would successfully impact high visibility natural resource problems in the region, while also successfully engaging the R&D capabilities of the Laboratory.

The roadmap process involved first identifying the drivers behind natural resource problems and defining issues that required S&T solutions. Subsequently, the group identified knowledge gaps and transformational products that would help put the Laboratory at the leading edge of regional natural resources management. Areas of expertise and S&T investment requirements were then defined to support the development of transformational products. Finally, a market capture strategy was outlined based on an assessment of the Laboratory's market penetration potential in different market segments.

The output of the roadmapping process provided the basis for a refined initiative strategy, to be implemented over the initiative's third year of investment. While business

development would continue to be the primary focus of the initiative, new investment would be targeted toward capability development in three strategic areas. The new plan for business and capability development was submitted to senior management and funded, although not at the level hoped for by the initiative team.

4.4. Case study 4: electronics

The initiative on electronics was established with the goal of creating a strong business for the Laboratory in this market sector through both contract R&D and strategic intellectual property development and commercialization. While business development was the primary driver behind the initiative, capability development became more important as the initiative matured. The electronics initiative development process is characterized by three major phases, described as follows.

4.4.1. Concept development

The concept development phase differentiates the electronics initiative from the other initiatives evaluated in this set of case studies. The idea for this initiative, unlike the others, was customer driven. A representative from a semiconductor products company expressed an interest in the Laboratory's core technical capabilities in process science and engineering. The company representative recognized the value that federally funded laboratories could offer, but expressed frustration with the pace at which their collaboration with such institutions had moved to date.

Staff members were commissioned to work with the company to determine potential areas of collaboration and craft an initial set of objectives for the partnership. The hope was that by working with the clients to anticipate their longer-term needs, the Laboratory could establish profitable long-term partnerships with this company and then expand to others in the industry. Several senior managers supported the idea of diversifying the Laboratory's business into this growing industrial segment. An internal funding proposal was submitted to demonstrate the potential value of this new business. The proposal was accepted and two managers were assigned co-leadership of the initiative. Overall, this process of developing the concept and securing early support for the initiative lasted about a year.

4.4.2. Understand the client and develop relationship

With the funding needed to move forward, the electronics team focused its efforts on understanding client needs and cultivating strategic relationships within the client organization. A client needs assessment and an assessment of relevant Laboratory capabilities helped the team develop a preliminary strategy for business development and near-term sales goals.

The initiative strategy was to enter the company at the grassroots level, then expand horizontally and vertically to build support across the client organization. Horizontal movement implied increasing the number of projects and therefore the magnitude of sales. Vertical movement meant gaining support at higher levels in the organization where the probability of making sales would be higher. The initiative leads believed that this process was essential to building trust and credibility with the client in order to capture bigger and

more visible business opportunities. Within a year the initiative team had initiated the first projects with the client.

The electronics team then began to establish contact with other key players in the electronics and associated industries. Face-to-face interaction with the staff of potential client firms was an important means of developing relationships in these organizations. Initiative leads made frequent site visits to the operating facilities of potential clients to help raise awareness and interest in the capabilities that the Laboratory had to offer.

While these relationships were being cultivated, the electronics team was also attempting to better understand the link between Laboratory capabilities and the demand of the broader electronics industry. A capabilities assessment was conducted through a series of meetings with technical staff. This information was assembled in a promotional brochure and distributed to approximately 50 contacts in the industry.

4.4.3. Understand the industry and business development

For the next 2 years, the initiative team continued its business development efforts with a focus on deepening and diversifying market penetration. The grassroots approach to business development with the first client was successful in giving the initiative team access to other customers and at higher levels of the organization. By the end of the fourth year of investment, the team had extended its business beyond contract research to commercialization of intellectual property. In addition, relationships being cultivated with the broader electronics industry through frequent site visits led to research programs with new clients during the third and fourth investment years.

Building internal support for the initiative with key business and technology managers, and technical staff was another important activity in this phase. The initiative leads funded technical staff members to write white papers and proposals, and to attend industry conferences. Technical staff were asked to assume responsibility for managing the new client accounts.

While the initiative achieved some of its objectives by the end of its third year, senior managers believed that the team needed to refine its strategy in order to better forecast and achieve the desired business targets. Accordingly, a major goal for the fourth year was delivering a more focused strategy and plan for business and capability development. Reviewing trade journals, major publications, manufacturing flow sheets, and industry roadmaps all contributed to their understanding of market trends, drivers of change, and needs. Working with industry members to link capabilities to industry roadmaps helped the initiative team focus their capabilities on areas where the initiative could make the highest value contribution. Three capability focus areas emerged from this effort and it is anticipated that there will be capability development investments in these areas in the future.

Currently, the initiative is managed by a single initiative lead. Its primary focus is to continue analysis of the industry and to continue pursuing opportunities for new business development and technology commercialization. While it is not yet clear whether the initiative will result in a successful, independently operating business, it is likely to face a decision on transition from initiative to its next stage in the next 2 years.

5. Summary of initiative outcomes

Table 2 below highlights some of the key outcomes resulting from each initiative during its lifecycle. These outcomes are associated with the laboratory management's high-level expectations from initiatives, and also correspond to specific goals defined the initiative teams as part of an annual planning process.

Table 2
Summary of initiative outcomes

Initiative/objectives	Business/program development	Capability development
Agriculture		
Primary objective		
New markets	Successful business development with federal and state agencies Met or nearly met sales projections each year	Earned national recognition through Presidential award Formed several strategic partnerships, including a Cooperative R&D Agreement with an industrial client
	Developed new industrial business, but slower than expected	Multiple patent applications
	Launched commercial joint venture	Strong technical reviews
Environment and Health		
Primary objectives		
New S&T capabilities	Multi-year sales to target clients	Developed scientific reputation with multiple journal articles
Extend existing business and build new markets		Recruited new senior- and mid-level staff Multiple partnerships with written agreements High quality scientific development goals
Natural Resources Management		
Primary objective		
New markets	Some sales to target clients, but less than projected Increased visibility and partnership development on critical Northwest regional issues	Ultimately developed basic research component Some recognition from science and policy communities
		Recruited senior-level staff
Secondary objective		
Capability development		
Electronics		
Primary objective		
Extend existing markets	Some new sales to target clients, successfully diversifying client base, but sales less than projected Progress toward commercialization objectives	N/A

6. Key findings

The analysis of the case studies highlights several differences among the four initiatives, including the strategic intent of the initiative (e.g. business development and/or capability development), the extent to which the initiative was able to build on existing capabilities, the level of market understanding at the outset of the initiative and the speed with which market knowledge was obtained, and the leadership and management styles utilized in developing the initiatives. Yet, in spite of these differences, the key factors important to the success of idea development in industrial settings seemed to apply to all of the initiatives within the publicly funded laboratory context. Each initiative, at some point in its life cycle, had to ensure an adequate understanding of science and technology trends, markets, and develop a leadership style and culture relevant for their particular situation. While each initiative approached these elements in a different way, and at different points in their life cycle, they all at some point needed to develop this understanding to move them toward the next stages in their life cycle.

One significant variation observed across initiatives was the timing of obtaining external feedback on scientific trends and directions and the importance of linking this information in a timely way with evolving intelligence on market trends and customer needs. For example, the three initiatives focused primarily on building new research opportunities in new markets all relied at some point in their development on systematic roadmapping of the science and technology needs and gaps with the needs of specifically identified markets. The earlier this process was initiated, the more success the initiative had in focusing investment and achieving progress toward long-term goals. Agriculture, for instance, initiated a systematic evaluation of the science trends and the market and customer needs very early in their process, and maintained a consistency in updating that information and ensuring it was analyzed in an integrated way throughout the timeframe of their development activities. This ''roadmap'' helped the team understand the critical R&D needs for the target markets, and map these to the most likely potential sources of funding (market interest and needs). The natural resources management initiative was faced early on with the challenge of how to translate an anticipated market need (from a societal benefits perspective) to specific science and technology research programs that fit within the missions and needs of potential funding agencies. They belatedly engaged in an internal roadmapping process that helped focus the S&T, but continued to struggle with linking those capabilities to customers who might be willing to pay for the research. In this arena, these were not always the parties who owned the problem. The complexity of integrating science and technology opportunities with market needs within this network of actors remained a challenge for this initiative. The electronics initiative, with their close client relationships, relied primarily on meetings with clients and a review of the clients' roadmaps to shape that initiative's directions. Their challenge was making the appropriate connections with the advanced science and technology necessary to meet the identified market needs.

From a leadership and culture perspective, each initiative used a different approach for achieving its goals. In some situations, the team leadership approach worked effectively,

particularly at the formative stages of idea development. The ability to identify and engage a team of multidisciplinary researchers and business-oriented program managers seemed to be important in accelerating initiative progress. Each initiative, however, while faced with similar challenges, operated independently from the others. The teams lacked effective mechanisms and incentives for sharing information on their approaches, processes and tools across initiatives. There were no standard tools or codified approaches that dictated the necessity of gaining a systematic view of the science and technology landscape and the market trends. Further, understanding the importance of integrating these insights, and methods for accomplishing that integration, was something each initiative team essentially had to discover for itself. While initiative teams need to have flexibility to choose among different tools and techniques, it appears clear that an early and integrated understanding of the market and science landscape and trends, obtained in a systematic way, is important to eventual success.

There were also differences in the timing of several activities. As mentioned earlier, the agriculture and environment and health initiative teams focused on understanding the relevant system and the market at early stages in the initiative lifecycle. They used this knowledge to successively refine their strategies and focus their investment choices. They also used external advisory groups at early stages of the initiative to test and validate their strategies and scientific choices. This external knowledge proved invaluable in their ability to ultimately develop successful programs with external clients. The electronics initiative depended on the views of a particular customer base and their access to broader industry information. While they had market information early on, it was specific to a particular company, and was not sufficiently integrated with the science and technology capabilities of the laboratory or broader S&T trend data. The initial inability to strategically direct science and technology investments slowed progress in building the research programs originally specified in their strategic plans. They were, however, able to obtain some new research programs, given their proximity to the customer. The experience of the initiatives reviewed here suggests that the timing and sequence of key activities (particularly an integrated understanding of both market and scientific trends) can be important to accelerating the success of an initiative.

A number of common themes emerged from this study with respect to factors that both helped and hindered initiative development. The same factors that are important to the success of new ideas in industrial settings seem equally applicable to the public institution arena. The recommendations summarized below reflect the major strategic and organizational considerations important to the initiative development process, as reflected from our interviews and evaluation of the specifics of each initiative.

6.1. Define an S&T focus early and systematically

The importance of understanding science and technology trends early in the development process, and validating those insights with external data (whether literature or review groups) was strongly reflected in this case study. Initiatives lacking a strong S&T focus struggled more than those with a well-defined S&T focus or capability development component. Both the process of defining the S&T component and the internal investment in

capability building can also lend internal credibility to the initiative and provide a basis for cross-functional collaboration. Initiative teams need to define their S&T focus early in the initiative lifecycle using some structured approach, such as a roadmapping process or visioning workshop.

If an initiative requires new capabilities, it is recommended that the initiative team also define an S&T focus that initially leverages or incrementally extends existing capabilities. This can help to manage some of the technical risk associated with the development of new capabilities, while at the same time providing an opportunity to demonstrate success earlier in the lifecycle than would occur otherwise.

In this study, we found that even initiatives designed to meet an objective that on the surface did not seem to have a strong S&T component (such as the initial perspective of the natural resources management initiative with its focus on regional visibility) ultimately must address both the S&T elements and the market factors of interest in order to succeed in a research environment. Specific agreements with senior management on the goals to be achieved with the investment must still be reached, and the transition path to move from identification of new business opportunities (as a result of the investment) to the explicit pursuit of selected research program development directions.

6.2. Understand and engage the market early

In order to formulate a credible value proposition, the initiative team must understand the market landscape, including the potential customers and their needs, the size and distribution of the market, the organizations that comprise the markets of interest, and the competitors. The means of acquiring this knowledge will depend on the nature of the endeavor. Initiatives with objectives of delivering existing technologies to new markets or incrementally extending capabilities into existing or new markets may be able to acquire an appropriate level of market understanding using traditional market and industry assessment methods. The level of detail in a market assessment will depend upon what is known about the market and the Laboratory capabilities at the outset. A systems model, such as that created under the agriculture initiative, is one potentially useful tool to support a thorough market assessment, although it may not be well suited for initiatives that involve exceedingly complex industries or markets.

Traditional market assessments may not provide the information needed to understand the potential for initiatives targeting emerging (or latent) markets and/or those requiring the creation of completely new capabilities. Such discontinuities may require a more rigorous investigation to assess the real potential of an opportunity. Miller and Morris (1999) point to the importance of using market research techniques that involve creating new, shared experiences with potential users of an idea to help them make informed assessments about its potential value. This is particularly important when needs have not yet been expressed or are not yet understood by potential users of a product, process, or platform. Working jointly to define application scenarios and explore the uses and implications of new technologies, capabilities, and markets can help to establish the understanding necessary to make informed ‘‘go/no go’’ and strategy decisions.

Whether the effort involves continuous or more discontinuous markets and technologies, initiative participants found it important to actively engage potential

customers, partners, and other important stakeholders in the *early stages* of the project. This serves to both validate and shape the initiative offering, and foster important relationships that may ultimately lead to new business development. It is recommended that initiative teams focus initially on strategic sales to early adopters and clients that may be important partners in the long run. Securing three or four customers early in the development process helps demonstrate to both Laboratory management and the initiative team that the concept they are developing is in fact viable.

6.3. Look outside the organization for direction and validation

Initiatives need to get external review early and often. In almost every instance, external input—whether a formal peer review or simply informally gathered ''insider information''—was of value to initiative teams by validating or modifying a proposed direction or approach. Unfortunately, external validation is too often dismissed when initiative teams are operating under tight schedules and budgets. In the end, this can compromise the quality of the initiative. It is necessary to plan ahead for external review by scheduling at the outset of the initiative multiple critical review points to occur during the initiative's lifecycle.

The need to obtain external information must be balanced by the potential risks of giving access to others to potentially valuable intellectual property and business strategies. While this is traditionally a risk in private research groups, it is increasingly a concern for publicly funded organizations as well. Finding ways to obtain external validation and insight and protecting internal strategic decisions is important for publicly funded research organizations. In general, it is recommended that emphasis be placed on collecting external information and validation prior to the formal review process. During the review process, the review group should take into consideration whether the initiative team has adequately drawn from external sources and answered the right questions before moving forward.

6.4. Create the right team for the task

Creating the right team for the task begins with the right leadership. Initiative leaders need to have both a good understanding of the market, and experience with the internal development process in the organization. Familiarity with Laboratory capabilities, decision processes and organizational structure helped leaders to bring the right capabilities together to address market needs. The experience of the agriculture and environment and health initiatives, where there were co-leads or a lead and a deputy, suggest that this segmenting of responsibility can be very effective in accelerating progress, as long as the individuals are working together as a team to achieve a defined set of strategic goals.

Understanding the existing scientific capabilities at the Laboratory and being able to integrate them to respond to emerging market opportunities proved to be an extremely important element for success. Initiative teams had to be able to understand what capabilities were relevant to the initiative and be able to bring staff together from diverse technical areas. Because the funding was generally not available to fully support initiative teams, much of this teambuilding required working with the internal organizational culture and finding synergies with related programs. Where the initiative team and management

created an environment that encouraged individuals to work in an integrated fashion, the team made greater progress. Also, having prior knowledge of the organization and where key capabilities resided accelerated the process of linking capabilities with market directions. Initiative leaders that were new to the Laboratory had a difficult time making these connections. Providing funding to explicitly support cross-functional teams is extremely important to managing this challenge. Holding regular meetings with the initiative team also helps to ensure continuous support and cross-functional collaboration. Finally, building an effective information-sharing platform for the team would facilitate integration of diverse capabilities and resources. We found that the time investment necessary to build and retain constituencies was generally underestimated across the initiatives.

6.5. Develop alliances within the organization for direction and internal support

Interviews with initiative participants suggested that they believed the support of a senior management champion and other strategically important individuals (e.g. lead scientists, product and line managers, and marketing staff) were critical to the initiative's success.

Several initiatives conducted specific activities that facilitated the development of a supportive internal network. Aggressive marketing and internal networking was used in the agriculture, environment and health and natural resource management initiatives to raise awareness and interest across the Laboratory. Periodic progress reports and regular meetings with champions were conducted by some initiatives to help ensure that the initiative was appropriately represented to the senior management. Ultimately, the senior management represents the initiative in investment decision meetings, so that link was critical for the initiative teams. All initiative leaders felt they needed more communication between the initiative team and senior management. One approach for this might be to assign a mentor to each initiative. This individual could help to translate any concerns and guidance and ensure a consistent message across the teams. Another suggestion is to form an initiative steering committee with key internal stakeholders to provide a source of strategic direction for the initiative team, while also generating senior management interest in and support for the initiative.

7. Conclusions and recommendations

The focus of this study was to evaluate the current process for the early stages of developing new capabilities and programs in a publicly funded R&D laboratory context to determine the potential importance of key success factors and the application for tools and processes developed in industrial settings. The results of this initial set of case studies suggest that the four primary success factors identified for industrial concept development processes (understanding trends in science and technology; clarity around market targets and needs; strategic alignment; and leadership/culture) have equal importance in a public R&D context. In addition, this study points out the importance of addressing these factors early in the life cycle of an initiative. This suggests that the conceptual framework of a

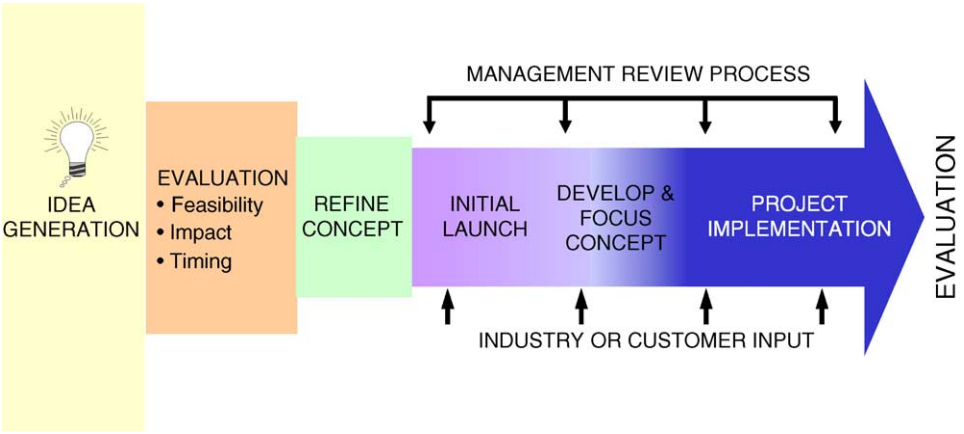

Fig. 3. Recommended approach to an initiative development.

stage-gate approach, which is primarily used in the new product development cycle in many industrial organizations, can also be effectively applied to the initiative process in publicly funded R&D organizations. As shown in Fig. 3 below, an initiative proceeds through several stages of development. Understanding this cycle and identifying at what stage key activities need to happen could significantly accelerate the progress of early stage idea development. Each initiative in this study conducted activities to evaluate an initial idea and refine the concept, with continued development and focusing throughout the timeline of the initiative. Initiatives that conducted these processes in a more disciplined way, with systematic tools and a clear understanding about their stage of development and the level of detail required, were able to more effectively meet their goals. Without a process framework and a consistent set of tools, however, initiative teams had to identify and select analysis techniques and engaged in some duplicate analysis. They often found themselves re-evaluating their initial concepts, which slowed the progress of the team, and in some cases hurt morale. In addition to being clear about the development process, the investments in an initiative should be more closely tied to the achievement of explicitly stated goals at each stage. For instance, investment in scientific capability development should only follow a clear definition of the appropriate direction, based on an understanding of S&T trends, defined gaps in existing capabilities and targeted to clearly identified market needs.

Publicly funded R&D organizations can benefit from incorporating other elements of a stage-gate philosophy to the development of major S&T initiatives. One important premise behind a clearly defined, but flexible approach is that ideas and initiatives do not necessarily develop according to a fiscal calendar year but rather at a pace determined by the scope of the endeavor, the information and resources available to it, and a number of other internal and external factors. A systematic approach to planning requires allocating resources and defining objectives, outcomes, and performance measures in a way that reflect where the idea or initiative is in its lifecycle, as opposed to where it is at the end of the fiscal year. At the same time, each initiative will have opportunities to accelerate their

progress toward desired outcomes. The implementation of a modified initiative performance assessment system, tailored to fit the organization's culture and management expectations, is ultimately critical to the success of a new approach.

Financial resources need to be allocated in a way that is consistent with the initiative lifecycle. This requires valuing and financing initiatives in stages. Investments would be ramped up in each subsequent stage at a level commensurate with the value of activities that need to be accomplished. This can be challenging for public organizations that receive budgets on an annual basis, resulting in a more periodic than phased approach to resource allocation. Implementing a phased approach will require a significant shift in the mindset of those who allocate and request financial resources for initiatives.

Performance evaluation should be based on a staged approach. ''Go,'' ''no go,'' ''hold,'' and ''recycle'' decision points are built into the process between initiative stages (e.g. idea selection, proof of concept) and at other points deemed appropriate. These critical decisions should involve both senior-level decision makers and initiative representatives. They should ideally be evaluated for both the individual merits of the initiative and their fit within the context of the Laboratory's broader initiative portfolio. To facilitate evaluation, both expected outcomes and performance measures should be clearly defined for each stage.

Performance measures need to include both leading and lagging indicators and draw from a mix of investment/input, financial, commercial/business, bibliometric, patent, peer review, and organizational/managerial/strategy metrics. As pointed out by Miller and Morris (1999), financial metrics and outcomes in the early stages of initiatives, particularly with initiatives that target new markets and new capabilities or discontinuous technologies, may not be helpful. Instead, early performance measures might be procedural in nature. Procedural or intermediate outputs (e.g. established relationship with potential client) are often a necessary and time-consuming precursor to achieving more tangible, longer-term outcomes (e.g. met $5 million sales target). Emphasizing procedural metrics and outputs early on and longer-term metrics and outcomes later in the lifecycle, along with clearly defined decision points, helps to manage expectations both of those performing the work and those evaluating the initiative's investment potential.

Measurement of return on investment and expectations of results on accelerated timelines are no longer the sole province of industrial research organizations. Publicly funded research organizations are increasingly required to think about how to build new capabilities and programs in a more cost-effective way, and on shorter timelines. Our evaluation of the initiative process in this study suggests that applying elements of lessons learned from industry to the process for generating ideas, exploring concepts and managing longer-term, Laboratory-level initiatives can help future initiative leaders and teams to more effectively achieve results that support strategic objectives. Ultimately, each team must be able to accommodate the specific needs of their particular market and investment goals, but would have a ''roadmap'' for better understanding where they are in the development process and access to a related set of tools to support their activities. Ideally, a modified, more systematic approach will provide a smarter, more flexible framework that incorporates the best practices and critical success factors acknowledged by past initiative participants while building on the emerging experience from industrial research laboratories in developing early stage ideas to program or product concepts. We believe

a general framework for developing ideas and initiatives, along with a set of related processes and tools can significantly enhance the performance of initiative teams.

References

Amabile, T., 1998. How to Kill Creativity. Harvard Business Review, Sept–Oct, pp. 77–87.

Bower, J., Christensen, C., 1995. Disruptive Technologies: Catching the Wave. Harvard Business Review, Jan–Feb, pp. 43–53.

Christensen, C., 1992. Exploring the limits of the technology S curve. Part I: Component technologies. Production and Operations Management 1 (4), 334–357.

Cohen, W., Levinthal, D., 1990. Absorptive capacity: a new perspective on learning and innovation. Administrative Science Quarterly 35, 128–152.

Cooper, R., 2000. Product Leadership: Creating and Launching Superior New Products. Perseus Books, Cambridge, MA, p. 292.

Cooper, R.G., Kleinschmidt, E.J., 1986. An investigation into the new product process: steps, deficiencies, and impact. Journal of Product Innovation Management 3 (2), 71–85.

Crow, M., Bozeman, B., 1998. Limited by Design: R&D Laboratories in the U.S. National Innovation System. Columbia University Press, New York, p. 384.

Henderson, R., Clark, K., 1990. Architectural innovation: the reconfiguration of existing product technologies and the failure of established firms. Administrative Science Quarterly 35, 9–30.

Jaffe, A., 1999. Measurement Issues. In: Branscomb, L., Keller, J. (Eds.), Investing in Innovation: Creating a Research and Innovation Policy that Works. MIT Press, Cambridge, MA, p. 536.

Khurana, A., Rosenthal, S.R., 1998. Towards holistic 'Front Ends' in new product development. Journal of Product Innovation Management 15, 57–74.

Koen, P., Ajamian, G., Burkart, R., Clamen, A., Davidson, J., D'Amore, R., Elkins, C., Herald, K., Incorvia, M., Johnson, A., Karol, R., Seibert, R., Slavejkov, A., Wager, K., 2001. Providing Clarity and a Common Language to the Fuzzy Front End. Research-Technology Management. 46–55, March–April.

Miller, W., Morris, L., 1999. Fourth Generation R&D: Managing Knowledge, Technology and Innovation. Wiley, New York, NY, 313 pp.

National Science Board, 2000. Science and Engineering Indicators. National Science Foundation, NSB-00-1, Arlington, VA., p. 395.

Rosenberg, N., 1994. Path dependent aspects of technological change. In: Rosenberg, N. (Ed.), Exploring the Black Box: Technology, Economics and History. Cambridge University Press, New York, p. 263.

Wheelwright, S., Clark, K., 2001. Accelerating the design-build-test cycle for effective new product development. In: Burgelman, R., Maidique, M., Wheelwright, S. (Eds.), Strategic Management of Technology and Innovation. McGraw-Hill Irwin, New York, NY, pp. 900–910.

Yin, R.K., 1994. Case Study Research Design and Methods, second ed. Sage Publications, Thousand Oaks, CA, p. 49.