# Best Practices For Increasing the Impact of Research Investments


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## Foreword

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***OCEAN RESEARCH AND RESOURCES ADVISORY PANEL***

*The Ocean Research and Resources Advisory Panel is a congressionally established panel of experts, which provides independent advice and recommendations to the federal government on interagency efforts in the areas of ocean research, resource management, and education. The ORRAP is comprised of a diverse membership with representatives drawn from industry, academia, nonprofits, and government. The panel functions under the regulations of the Federal Advisory Committee Act and reports to the Interagency Committee on Ocean Science and Resource Management Integration.*

## Executive Summary

Successful implementation of the nation's ocean research agenda depends on the ability to transition research out of the laboratory and into applications that benefit the nation. To assist federal agencies with this research to applications endeavor, the Ocean Research and Resources Advisory Panel (ORRAP) convened a task force to identify practices that have been most useful in facilitating this type of transitioning.

The Research to Applications Task Force identified six foundational themes for enhancing the efficacy of the research to applications transition:

1. **Prioritize user involvement throughout the research to applications process.**
   The likelihood of new technology or knowledge being adopted is greatest when users—individuals who apply research knowledge or technology—are involved in the research process. If users participate "early and often," they are more likely to become invested in the effort and more likely to trust and adopt the results (i.e., they become "owners" of the process.)
2. **Engage and empower neutral third parties with the expertise to facilitate collaboration among researchers and the end-user community.**
   A skilled, trusted, neutral facilitator can greatly enhance interactions among people with varied interests who come to the table with different perspectives. Facilitators also help navigate the legal and economic landscape associated with bringing a new product to market.
3. **Conduct cross-agency state-of-the-science assessments that create consensus about the state of knowledge and identify gaps that define future research needs.**
   The user community is most likely to adopt new approaches and technologies when there is broad, documented consensus that solutions are mature.
4. **Encourage an agency culture that places high value on transitioning by creating incentives and accountability that stimulate program managers to integrate application into their research programs.**
   People respond to performance objectives that are measured and rewarded. Agencies should create reward structures that encourage program managers to sustain collaborations between knowledge producers and knowledge users, focused on application outcomes.
5. **Expand opportunities and incentives that motivate researchers to work with users and producers toward applications.**
   The present reward system for researchers is focused on publication and recognition by their scientific peers. It should be expanded to place greater emphasis on bringing their knowledge and insights to the *collaborative* research to applications process.
6. **Allocate the time, personnel, and funding necessary to support research and development through application.**
   Application/acceptance timelines are often much longer than a typical research grant funding cycle. Agencies should develop a staged process that minimizes funding gaps for technologies on the transition path.

A unifying principle among these themes is collaboration between knowledge producers and the community of knowledge users at every step of the process—from formulation of the problem, to selection of research proposals, to end-user application. Collaborative efforts are most effective when launched early in the process to synthesize existing information around a carefully and jointly crafted set of questions.

This report also provides a model of the research to applications process—illustrated in **Figure 1—** as a framework for discussing the research stages. The model identifies specific activities, illustrated

with case studies, which can be implemented during each stage to enhance transitioning. A more detailed version of Figure 1 is presented in Chapter 3.

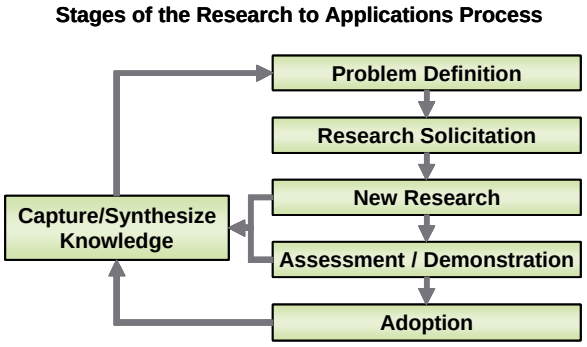



**Figure 1**. Collaboration between knowledge producers and users throughout the research process is necessary for successful application.

A second unifying principle is that the limiting factor in transitioning research to applications is not a lack of information about characteristics that enhance or impede transitioning. Rather, it is the need for an institutional culture that places high value on timely transitioning. Creating this culture requires leadership from the top. It also requires appropriate reward structures and sustained collaborations between knowledge producers and the community of knowledge users. Ultimately, efforts by mission agencies for transitioning research to applications should receive a level of commitment, support, and scrutiny comparable to that afforded the research itself.

# Chapter 1
## Introduction

America's investment in science and technology has generated a steady stream of new knowledge and technologies, but has failed to develop a network of institutional mechanisms that transition these advances to applications addressing major social and environmental problems. Although society eventually benefits from most scientific advances, the magnitude and urgency of present social and environmental challenges indicate the need for an increase in the rate, efficiency, and effectiveness of transitioning research to applications. Existing processes, which might often be characterized as diffusion, need to be transformed into a process more characteristic of advection, with specific mechanisms for influencing forward motion toward measurable goals.

This report grew out of the Ocean Research and Resources Advisory Panel (ORRAP) review of the Ocean Research Priority Plan (ORPP) at ORRAP's meetings in June and October of 2006. ORRAP noted that the Plan focused predominantly on new research, without reference to enhanced usage of the knowledge resulting from decades of prior research activity. ORRAP observed that efforts to synthesize this information, transition existing research to applications, and identify critical information gaps in need of additional research could greatly improve the plan's effectiveness. The Interagency Committee on Ocean Science and Resource Management Integration (ICOSRMI) agreed, and the final ORRP includes a commitment to enhance the processes by which the nation's ocean research is applied by intended users.

To develop more specific suggestions for ways to facilitate the transitioning of research and technologies to applications ORRAP formed the Research to Applications Task Force (RATF), a panel of experts from academia, industry, and government. The RATF examined present transition activities, both within and outside of the federal agencies, to identify the practices employed in the most successful research to applications transitions. Several examples, including those from the private sector and state and federal agencies, have been cited in this report as models for emulation.

The RATF identified six foundational themes, presented in Chapter 2, that were consistently found to be central to success in the research to applications process. A model of the research process and an illustration of how these foundational themes can be incorporated at each stage of the research endeavor are presented in Chapter 3. A summary of the RATF's conclusions, as well as insights regarding the next steps to begin implementation of the foundational themes, are provided in Chapter 4.

The focus of this report is on transition of mission-driven research conducted either by federal agency researchers or external grantees funded by federal agencies. However, many of the principles identified also apply to maximizing the value of curiosity-driven research.

Analysis of Effective Research to Applications Success **CASE STUDY**

**National Research Council (NRC): Linking Knowledge with Action for Sustainable Development**

The Roundtable on Science and Technology for Sustainability was created by the National Academies in 2002 to study and share information on the challenges of harnessing science and technology for sustainability. Input from workshops indicated that strong leadership at the program manager position was a consistent component of successful case studies. In 2004, the Roundtable gathered 20 program managers to integrate information on other common elements of success. Specifically, managers were asked to comment on six proposed requirements for research to transition to intended audiences. These requirements included user-driven problem definition and identification of the end-to-end system into which a new piece of knowledge or technology is to be integrated. The recommendations put forth in the present document were developed independently by examining successes in the ocean community, but align with recommendations in the NRC report.

For more information, visit
http://www.nap.edu/catalog.php?record_id=11652

# Chapter 2

## Foundational Themes for Successfully Managing and Funding High-Impact Research

Understanding successful transition of research to applications involves considering the full spectrum of the research process: problem definition, proposal solicitation, selection and funding, and knowledge transfer and/or commercialization, as well as the range of potential contributions from participating organizations. Participants may be divided into the following functional categories:

- Producers – researchers, research organizations, small businesses, and other commercial entities conducting research and creating systems and products for users. This group includes the scientific community and organizations doing research.
- Users – individuals, or stakeholders, who apply research knowledge or technology, such as policy makers, environmental managers, the public and commercial partners.
- Facilitators – translators who help link users with producers and help minimize barriers to knowledge use or technology adoption. This can include individuals within an agency, an outreach section of an organization, or external support contractors.

The required relationships among these entities can be represented as an integrated end-to-end system. **Figure 2** is a representation of a generic end-to-end system (built from Figure 2-1 in the aforementioned NRC report) illustrating the various functions that facilitators might perform to help transition solutions to various applications. **Figure 3** provides a specific oceanographic example of an end-to-end system, illustrating the chain of actions/ institutions that link research endeavors to decision makers.

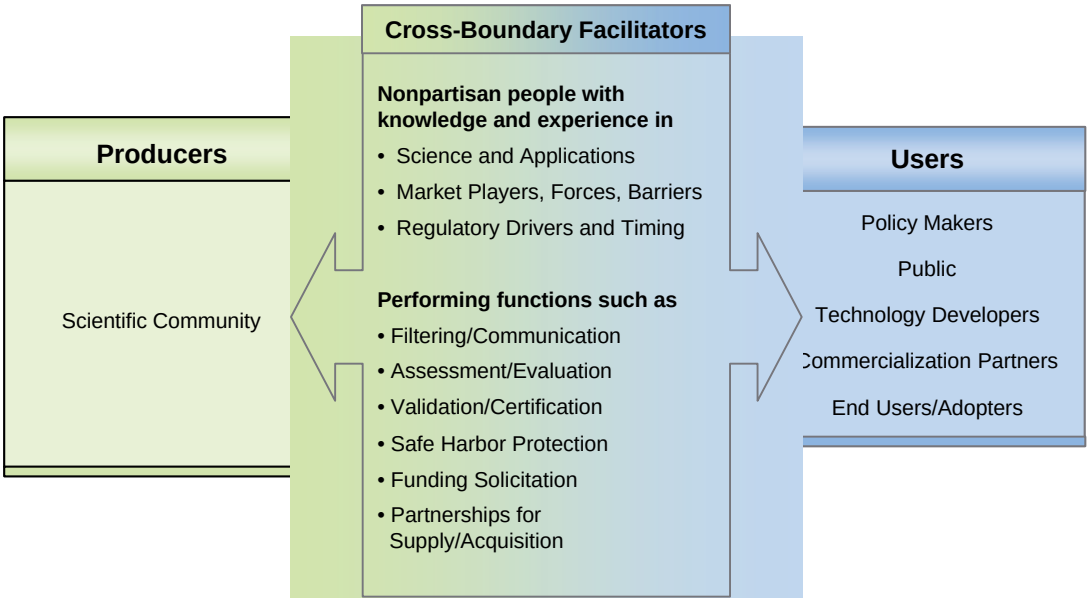



**Figure 2**: An end-to-end system illustrating the role of facilitators in transitioning research to applications.

In assessing the best approaches for using federal resources to foster effective collaborations between scientists and end-users, the RATF identified six foundational themes that fundamentally support transitioning success. This chapter describes these themes and the critical aspects to be considered when incorporating them into a transitioning process.

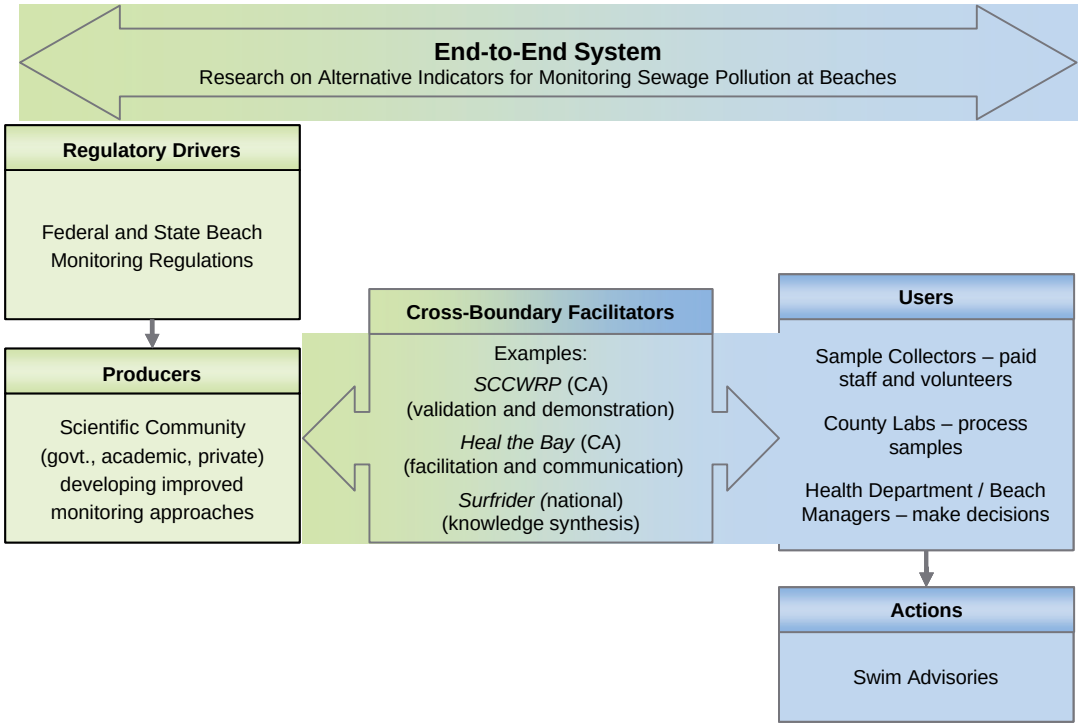



**Figure 3**: An oceanographic example of an end-to-end system for detecting sewage pollution of beaches

## 2.1 Foster Relationships with Users

*The likelihood of adopting new technology or knowledge is greatest when users are involved in the research process. If users participate "early and often," they naturally become invested in the effort and are more likely to trust and adopt the results.*

Agencies should begin their research process by involving users who can articulate needs, perceived level of effort, and critical variables associated with the potential adoption of outputs from the research endeavor (cost, ease of use, compatibility with other methods, etc.). This input from the user community helps provide a better understanding of the elements that should define the research agenda at its start. Ultimately, program managers need to provide a problem identification step that fosters collaborative discussions among users in the end-to-end system if application is an important goal. Listed below are various ways to create this dialog and ultimately to focus research on problems with immediate impact and likelihood of adoption:

- Host workshops or roundtable meetings that involve researchers, producers, users, regulators, facilitators, etc. Face-to-face meetings are beneficial, as long-term relationships are a positive element in many successes.
- Interview key stakeholders about user needs, previously failed solutions, and related efforts at other agencies. Create a document that functions as a gap analysis and highlights areas of opportunity for funding research or translation with likelihood of success and/or significant impact.
- Modify the research solicitation process to encourage greater user involvement. This could take the form of giving priority to proposals that actively involve users or have co-funding from the stakeholder community. Targeted users should be genuine partners and members of the team working alongside the scientists, not simply advisors.

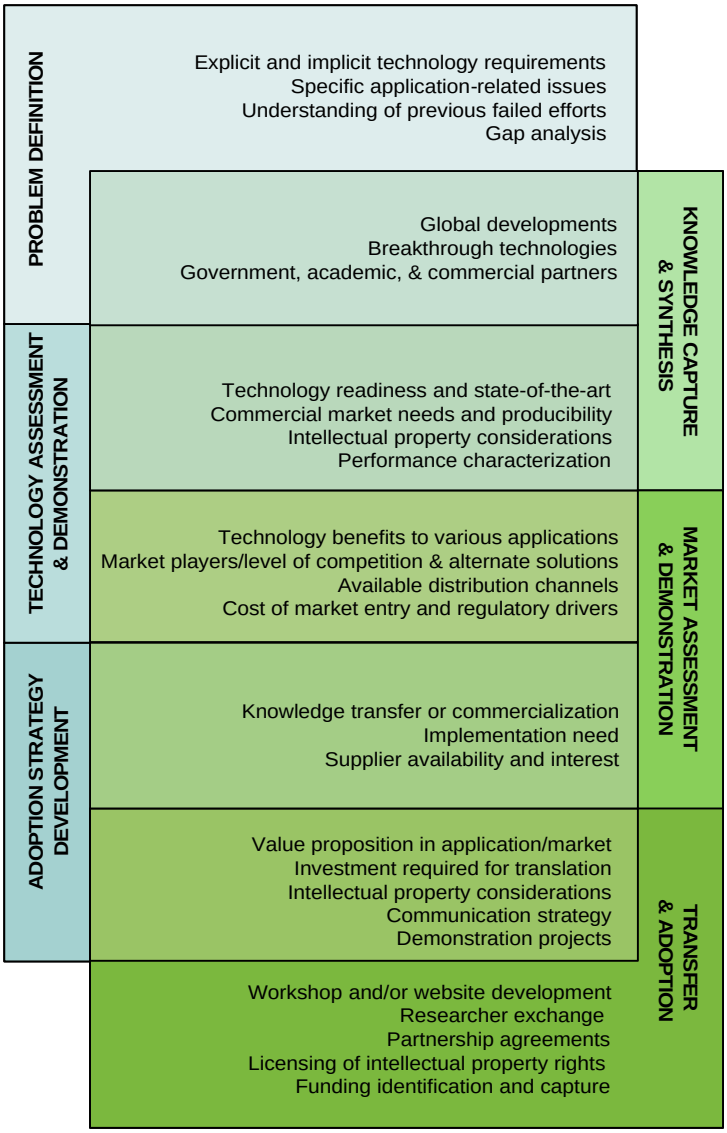
- Create a gated process whereby researchers can gain additional funding based on user involvement and endorsement of efforts/results.
- Involve users in technology evaluation, particularly beta-testing.
- Fund transition-based research when it is required to move a technology to application and there is no commercial incentive, a situation in which economics will not drive the application but the public benefit warrants the investment.

## 2.2 Engage and Empower Cross-Boundary Facilitators

*A skilled, trusted, neutral facilitator can enhance collaboration between various kinds of decision makers and scientists, who often come to the table with different perspectives and mandates.*

The facilitating entity is sometimes referred to as a "boundary organization" because it supports collaborations that cross organizational boundaries. The facilitator can be—and often is—a specialist within the program. Alternatively, it can be an outreach section of an organization (e.g., Sea Grant or Coastal Services Center) or an external support contractor (a successful model employed by NASA). Regardless of who performs the function, the facilitation role is important: researchers and decision makers often lack the experience, expertise or time to be fully aware of each other's needs or the barriers to adoption of new technology or knowledge. Skillful facilitators help frame the issues and problems in ways that make it easier for participants to see beyond individual program or agency missions.

Increased facilitation can be useful at virtually every stage of the research to applications process, as illustrated in **Figure 4**. At the problem definition stage, facilitators are useful in getting people with different viewpoints to agree on the challenges involved and how to address them. Later on, a small investment in transition planning at the time of the research funding award can




Created by: RTI International

**Figure 4**: Cross-boundary facilitators can add value at various research stages, as represented in the overlapping stages above.

help researchers better understand various barriers to success, partnership opportunities, and issues related to intellectual property.

Facilitators become particularly important in the later adoption stage. Facilitators are conversant in the legal and economic intricacies of bringing new technologies to market, which are typically unknown to technology developers. They often have relationships with, or are familiar with, the commercial sector that is frequently needed to bring a product to the user. Developers are typically not interested in providing supplies or training to users on an ongoing basis. Finally, facilitators are skilled and motivated to continue the transition process beyond the first successful users to a broader community of adopters, ultimately generating commercial interest whereby users have access to product support.

Finding a good facilitator can be challenging, as there are few training programs aimed at enhancing translational capacity. Although a few programs are starting to emerge, in general, technology transition is not a part of the present educational system. Education is needed to provide a foundation for future researchers to better manage their technology and knowledge along the spectrum to application. Training for this requires individuals who possess technical knowledge, an understanding of missions and applications, and the business and program management acumen to drive an effort from end to end.

## 2.3 Conduct Cross-Agency State-of-the Science Assessments

*The user community is most likely to adopt new approaches and technologies when there is broad cross-agency consensus that they are applicable and mature. Agencies should be active participants in developing cross-agency state-of-the science assessments to create consensus. Where agency mission and priority overlap exists, efforts of each individual agency can be augmented by participating in coordinated efforts—resulting in a leveraging effect on resources.*

Managers are motivated to act when their decisions are based on a broad acceptance that the path they have chosen is an appropriate one. Multi-agency consensus about readiness of research products gives managers and other end-users the confidence to adopt new approaches.

Cross-agency syntheses provide one means of communicating a consensus position to managers. One model for this kind of multi-agency effort might include the development of an interagency task force to develop assessments, which would determine the usefulness of what has been developed. In some cases, syntheses require evaluation studies to establish the state of science or the relative performance of competing technologies. The studies should encompass efforts by both the public and private sectors and assure broad participation. Federal agencies should encourage and utilize mechanisms to help foster this type of research. Oftentimes, these are conducted by nonfederal organizations that have built trust relationships with technology developers and the end-users. The evaluation studies conducted by the Alliance for Coastal Technologies (ACT) are a good example of the positive impact of this model.

Building Consensus—Objective Syntheses CASE STUDY

**National Research Council (NRC): Ocean Studies Board and Marine Board**

Timely and targeted syntheses play an important role in the proposed model. It can be especially beneficial to have objective, respected, and independent third parties conduct such syntheses, particularly when controversial or politically charged issues are involved. As part of the National Academies, NRC was established primarily to provide expert, balanced, and unbiased advice to the executive and legislative branches of the federal government. The NRC's Ocean Studies Board and the Marine Board have produced numerous reports over the years, many of which have been cited or used in developing or recommending national ocean policy, science programs, and objectives. The NRC and its ocean-related boards provide an invaluable service to the ocean community and nation as an important means for comprehensive and independent syntheses.

For more information visit http://dels.nas.edu/osb/http://nrc40.nas.edu/directory/comm_detail.asp?c=MB000

Cross-agency syntheses also provide the means for defining data gaps that need to be addressed through subsequent research efforts. The ocean research funding agencies should collaboratively conduct timely syntheses around carefully crafted sets of questions that relate to interagency ocean priorities. This collaboration is key to setting the research agenda and for assessing which solutions are ready for transition. Examples of positive cross-agency collaboration can be found in the National Ocean Partnership Program (NOPP), and the activities conducted by the Subcommittee on Integrated Ocean Management of Ocean Resources (SIMOR) and the Joint Subcommittee on Science and Technology (JSOST) as part of the President's Ocean Action Plan.

## 2.4 Create Incentives and Accountability

*The limiting factor in transitioning research to applications is the need for an institutional culture that places value on timely transitioning. Creating this culture requires appropriate reward structures and sustained collaborations between knowledge producers and users focused on application outcomes.*

People respond to performance objectives that are measured and rewarded. As such, it is important that agencies create incentives and accountability that motivate program managers. By creating metrics for program managers, measuring effectiveness with respect to those metrics, and rewarding individuals for exceptional performance in transitioning, agencies can enhance a culture that identifies and funds research that will have optimal impact.

Both process and progress metrics are important to consider in performance evaluations. The process of transitioning research to applications is often lengthy. Intermediary process-based metrics offer short-term objectives that increase the chances of achieving long-term goals. Overly general evaluation metrics may result in creating only a short-range focus that could be counter-productive to longer-range benefits and goals.

It is important to distinguish between the kinds of job-performance metrics referred to here and the programmatic metrics associated with the Government Performance Results Act (GPRA) and the Program Effectiveness Rating Tool (PART). Several program managers have noted that the incentive structures set up by GPRA and PART make managers failure-averse, rather than success-driven. As such, they channel their efforts into shorter-term, easily measured results that don't necessarily lead to the larger agency need for research transition. We recommend a more flexible approach, which stresses macro-management over micro-management, clear communication of expectations, and positive rewards for success.

It is also important to recognize that an accountability system should place emphasis on improving the agencies' core products and services and not simply on the quantity of transitions alone. Not all mature research will be transitioned into applications. While there should be metrics of transition success incorporated into many individual projects, the ultimate agency success should be defined by the cumulative impacts of their research on the operational environments and the organization's delivery of superior products and services to a larger client base.

## 2.5 Motivate Researchers

*The present reward system for researchers is focused on publication and peer recognition. The reward system should be augmented to place greater emphasis on bringing researchers' skills and insights to collaborative development. Motivation should include opportunities and rewards.*

U.S. ocean science agencies should develop mechanisms to reward and recognize scientists who work closely with potential users of the research outputs. Motivation of researchers can be generated by modifying the promotion and compensation criteria for federal scientists to increase recognition of the value placed on success in application of research results, including:

- Rewarding publications that are authored in partnership between researchers and users.
- Encouraging participation on management planning panels.

- Rewarding the publication of syntheses and scientific overviews in the popular press.
- Recognizing patents as public disclosure of an invention and also as an asset that can enable investment by a commercial entity.
- Creating special awards to acknowledge outstanding performance in integration and application. Awards should be available to scientists, translators, and users within and outside the federal agencies. Examples include the Walter B. Jones Memorial and NOAA Excellence Awards in Coastal and Ocean Resource Management, and Marine Stewardship Awards, which are bestowed annually by NOAA. To maximize the impact, awards should be given in a number of categories.
- Encouraging or cosponsoring awards by professional societies and institutional consortia for outstanding accomplishments in scientific integration and application.

Agencies should also create more opportunities for researchers to collaborate with the user community and see research results put to use in solving a problem. Opportunities could include:

- Encouraging researcher participation in workshops with users.
- Endowing visiting scientist programs to allow federal scientists to do research in corporate or university labs on a temporary basis, and in reverse, for researchers from user organizations or producer organizations to do research in federal labs as visiting scientists. Sabbatical programs are one example of how this could be managed.
- Training scientists on effective communication of scientific understanding to managers, policy makers, commercial interests, and the public at large through programs similar to the Aldo Leopold Leadership Program. Functionally, this training should enable researchers to frame information to make it appropriately relevant to different audiences.
- Supporting centers dedicated to integration and application related to the Ocean Research Priorities Plan.

## 2.6 Plan for Continuity with Adequate Time, Personnel, and Funding

*Application/acceptance timelines are often longer than a typical research grant funding cycle. Agencies should develop a staged process that minimizes funding gaps during transition.*

Program managers need to think beyond simply funding good science and adopt a problem-solving approach. Time and financial resources often are insufficient in one funding cycle to complete the development process, resulting in partially developed concepts that are not sufficiently mature for users to implement the knowledge or technology. The reality of limited funding options and long application development timelines often translates into diminishing interest on the part of adopters, researchers, and developers, often resulting in a potential tool that doesn't reach fruition.

Funding should be planned to support stages beyond research, including: testing, verification, and market analysis—activities that encourage partnerships between users and commercial entities necessary for manufacture and product availability. The interaction with users requires constancy that leads to trust. Resources for such activities can be allocated using a gated process that requires demonstrated performance milestones before receiving additional investment for application.

It is also important to allocate the time for continuing support after the first transition success. The first success provides the opportunity to transfer the experience, through positive example, to users in other parts of the country, or related applications. In addition, a mechanism needs to be in place for ongoing assistance as a product is passed from initial to subsequent users within organizations. In many cases, particularly for those involving technology, that role may fall to a private sector entity that commercializes the product. However, for other research products, such as model development, there may be a need for continuing involvement by the original development team as subsequent users encounter new application issues.

## Summary

By engaging producers, facilitators, and users in an integrated end-to-end system, high-impact research can be successfully transitioned to relevant applications in a more efficient manner. Using an integrated end-to-end system and incorporating the previously presented foundational themes, such as cross-agency engagement and coordination, motivational incentives, accountability, and continuity plans, will support transitioning success.

# Chapter 3

## Endpoints and Activities to Facilitate the Transitioning Process

Successful research to applications transitioning can be enhanced significantly by integrating the foundational themes presented in Chapter 2 into specific activities at various stages in the research management process. In general, the research process follows a progression like that in Figure 5. This chapter describes desired endpoints and activities that can enhance research to applications success within each stage of the research process. While the steps involved can be conceptualized within a linear flow framework, the process is fundamentally iterative.

This report focuses primarily on enhancing the application of new research projects, but many of the activities within the framework are applicable to ongoing and completed work. In particular, it is important to mine earlier results to enhance the impact of current research. Several of the steps outlined in Figure 5, particularly those for "Problem Definition" and "Capture/Synthesize" Knowledge, focus on understanding how and why current or past tools and knowledge require augmentation. A byproduct of these activities is wider dissemination and usage of existing knowledge and tools, coupled with a better understanding of how future research can address technical and non-technical gaps.

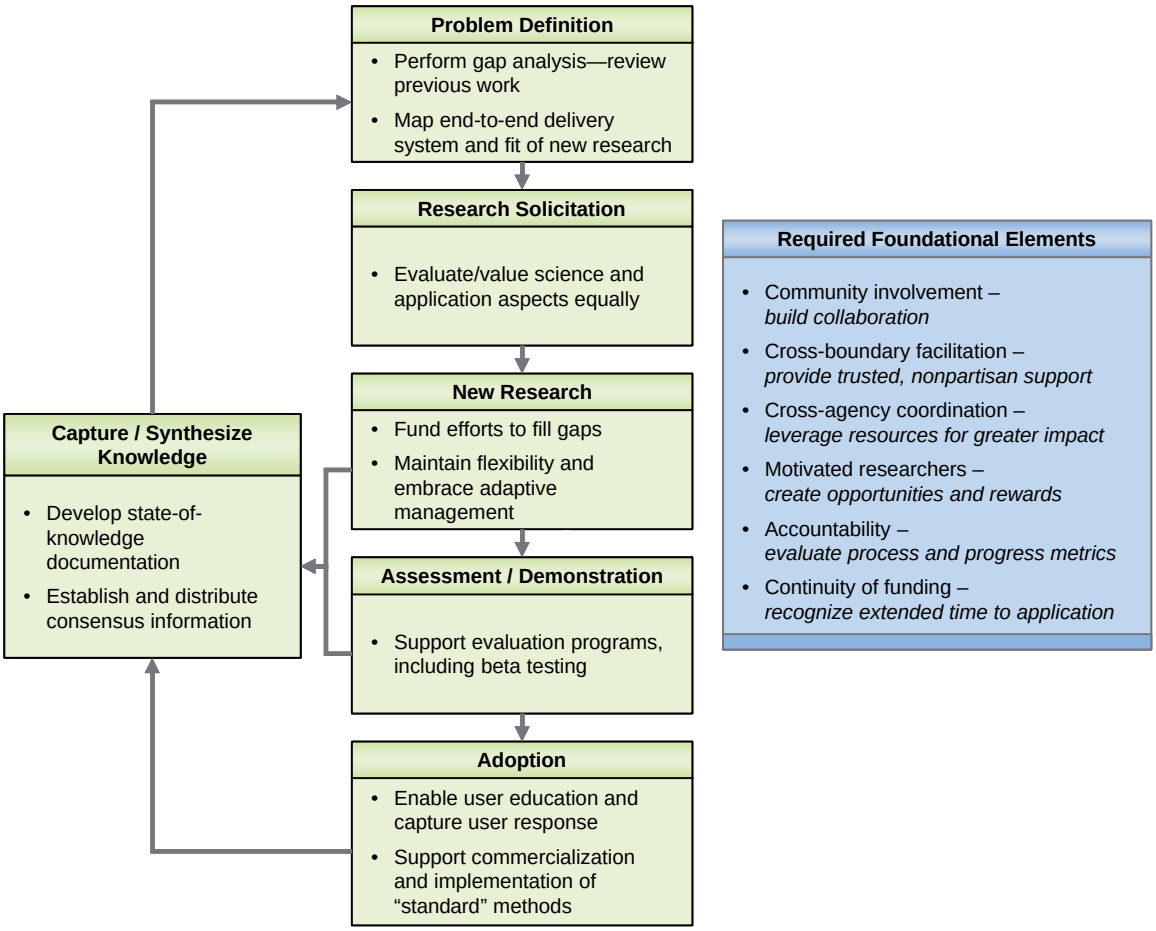



**Figure 5**: Model representing the stages of and flow associated with transitioning the research to applications

## 3.1 Problem Definition

Problem definition frames the terms by which researchers and users will work together. During this step, trust is built, assumptions are clarified, and goals are set. Too often, this occurs without user input or it occurs with only token input into a process traditionally controlled by scientists. This often leads to research products remaining within the research sector. On the other hand, defining the problem collaboratively with users creates a permanent infrastructure built on relationships by which information and technology are easily transported in both directions between researchers and decision makers.

PROBLEM DEFINITION CASE STUDY

**Climate Impacts Group (CIG): One of Six NOAA Regionally Integrated Science and Assessments (RISA) Teams**

CIG is part of the Center for Science in the Earth System at the University of Washington's Joint Institute for the Study of the Atmosphere and Ocean. An interdisciplinary research group studying the impacts of natural climate variability and global climate change on the U.S. Pacific Northwest, CIG works with users to increase resiliency to fluctuations in climate. The group integrates climate science into public policy by including planners and policy makers in fundamental research design and implementation. This occurs through regularly occurring workshops with users. In addition, the essential implementation concepts of the CIG require the following:

- All participants must have demonstrated interest in end-to-end integration, including human dimensions.
- At least two people on the investigator team must have as their primary responsibility "seeing the problem whole" and facilitating interconnections when and where needed.
- All participants must be involved in interactions with stakeholders to some extent.

For more information on CIG, visit http://www.cses.washington.edu/cig/

For more information on NOAA's RISA program, visit http://www.climate.noaa.gov/cpo_pa/risa/

### Desired Endpoints

- A team composed of a spectrum of stakeholders and researchers is formed; seeds of trusting relationships are sown.
- Team members have an increased understanding of what knowledge/technology currently exists as well as critical gaps hindering resource management and other applications.
- Team members understand the end-to-end system in which any new knowledge/technology must fit in order to be used efficiently.
- The team reaches consensus on how new knowledge/technology must be created to fill an existing gap.

### Actions for Success

- Work with a facilitator during the problem definition process.
  - Scientists and scientific programs have their own agendas, no matter how benevolent their intentions—these agendas are not always in alignment with those of the potential users. If the research is intended to produce products for the user community, a neutral facilitator should be used to broker the various perspectives.
- Include and support the participation of many users.
  - There are many types of users and perspectives can vary among them. Ultimately, research endeavors benefit from the integration of a variety of perspectives: state and local agencies, nonprofits, citizens' groups, industry representatives, etc. Some program managers also note that inviting new users to join the team throughout a program can be invigorating to the overall process. In some instances, key users may need to receive financial support in order to attend important meetings.

- Strive for consensus on the necessary time and budget to solve the problem at the selected scale (e.g., regional/local), and then seek the appropriate funding.
  - Too often, program managers let funding cycles dictate the parameters of research endeavors. However, research to applications often takes ten years, not two. Acknowledging this more realistic timeline promotes longer-range planning, which in turn fosters increased collaboration and leveraging among organizations to ensure continuity of funding.

## 3.2 Research Solicitation

Problem definition, when done well, results in the clear framing of a research question, and suggests an approach that optimizes potential for application. Whether the research is internal to a federal agency or involves competitive extramural grants, program managers need to continue "hardwiring" user involvement into the process. Optimally, program managers will create a situation in which users are vested, participating in decision-making processes as opposed to being relegated to passively observing the effort. Maintaining this infrastructure not only creates more usable research, it enables smoother, more automatic transitioning of research products upon conclusion of the research effort.

### Desired Endpoints

- Research proposals are designed, authored, and submitted with user participation.
- The perspectives of intended users are brought to bear on the review side as well as the application side.
- Applicants are given one or more chances to make substantive changes to their proposal in response to user (and scientific) feedback.

RESEARCH SOLICITATION CASE STUDY

**Strategic Environmental Research and Development Program (SERDP) Stakeholder Involvement & Adaptive Management in the Proposal Review Process**

SERDP is the Department of Defense (DoD) environmental science and technology program, planned and executed in partnership with a number of other organizations. SERDP pursues high-risk/high-payoff solutions to DoD's most intractable environmental problems. To maximize return on research investment, SERDP employs the following steps as part of its regular review process:

- Employs a standing review committee made up of both technical experts and end-users.
- Identifies the highest quality proposals and invites applicants to present to SERDP's scientific advisory board. If significant changes are suggested, SERDP staff serves as a bridge between applicants and reviewers to ensure that modifications address identified shortcomings.
- Partners with the Environmental Security Technology Certification Program (ESTCP), which is DoD's environmental demonstration and validation program, to promote adoption of new technologies through demonstration at DoD sites. ESTCP utilizes a competitive process similar to SERDP to ensure the highest quality, most relevant technologies are demonstrated in the field.

For more information, visit http://www.serdp.org/

### Actions for Success

- Use the influence of funding (including internal funding to agency scientists) to build teams comprised of researchers and intended audiences.
  - Successful case studies of research to applications typically involve a user representative on the project team, with the budget reflecting this critical role. For competitive grants programs, this can be achieved by requiring end-user inclusion on the investigator team, or making user participation a heavily weighted criterion in proposal evaluation. Even for internal research, greater resources can be supplied to investigators who make representatives of the intended user community part of the research team.

- Include users as part of the review team.
  - For many types of research proposals, particularly for research in the latter stages of development, it is desirable to integrate users into the proposal review process. Users add to the process because they understand the nontechnical barriers that can prevent an excellent scientific plan from being of use to decision makers. There are many options for integrating users into the review process, such as having them serve on technical review panels. An alternative is to use a two-part review process, in which scientists screen proposals to identify those possessing sufficient technical merit for further consideration, and then users select from that group the proposals that have the greatest likelihood of leading to products that will be adopted by the user community.
- Plan for one or more adaptive management opportunities where applicants can modify their projects to better address the intended use of the research products.
  - Many proposals poorly address user needs or a process for user involvement to ensure those needs are met. Program managers should take advantage of the application review process to allow applicants to modify their suggested approach in response to both technical and nontechnical feedback during the review process. This allows proposals strong on science, but weak on application, to compete. The result is better research and a program that continues to reward good science, as well as good research to application transitioning.

## 3.3 Research Efforts

This step generally encompasses the bulk of the time and expenditures for research development efforts. Researchers must have the flexibility to follow the research directions that the research creates. However, program managers must ensure that the researchers remain focused on the problem to be addressed and that commitments to user involvement in the research phase are being upheld.

### Desired Endpoints

- Research remains focused on the programmatic need.
- Program managers ensure dialogue with, and/or participation of, the user community in the research process.
- Researchers make appropriate modifications to the research plan based on user community feedback.
- Research activities capitalize on partnership opportunities (e.g., with commercial partners, etc.).

### Actions for Success

- Encourage a meeting of users and researchers at the project onset to

GATED RESEARCH CASE STUDY

**Small Business Administration Innovative Research (SBIR) and Technology Transfer Programs (STTR)**

The Small Business Administration administers two gated research programs intended to foster the transition from research to applications in which many of the federal agencies that sponsor research participate. The SBIR and the STTR programs provide funding whereby Phase I provides start-up (6-12 month) funds to support exploration of scientific, technical and commercial feasibility, and Phase II provides funding (up to 2 years) to prove the concept, frequently resulting in a prototype. Phase III of the SBIR and STTR programs is not funded, since at this stage it is expected that the applicant will have found a commercial partner to successfully complete the transition from research to application. As a result, only a small percentage complete the transition to Phase III. In an attempt to address this shortfall, the 2006 National Defense Authorization Act mandated creation of the SBIR Commercialization Pilot Program (CPP) to provide assistance and incentives to increase participation in the "technology transition stream." The US Navy's version of this provides selected Phase II recipients a consultant and an intensive 10 month program with training in protecting intellectual property, partnering, obtaining venture capital, licensing agreements, and developing a business plan and provides introductions to potential transition partners.

For more information: http://www.navysbir.com/navy_CPP.htm

establish a collaborative tone and to determine roles and milestones.

- Establish multiple project milestones or gates (e.g., at annual reporting) to ensure that the project remains on target and meets requirements for collaboration. Use the milestones and reporting thereon to once again engage users in process.
  - A phased approach to funding reflects the iterative nature of research. Formal decision points provide incentives for investigator teams to achieve program objectives and provide mechanisms for rewarding excellent implementation.
- Provide opportunities to exercise adaptive management.
  - Project engagement often leads to unforeseen results that require or otherwise point to a change in direction. Properly managed, these redirected efforts can sometimes lead to equal or greater success than the original intent. The manager will be placed in the role of evaluating and approving these changes. Having user participants engaged in the process will make this step more straightforward.
- Provide program managers the ability to dispense discretionary bridge funding and possible funding extensions to foster progress toward application.
  - Most program managers have the ability to reduce funding levels for underachieving efforts, but it is also important to provide positive incentives that maintain and extend efforts. This will also prove an important tool for managers in bridging funding cycles.

## 3.4 Assessment and Demonstration

Successful mission-driven research efforts ultimately arrive at a point in which new knowledge or technologies are ready for assessment and demonstration trials. This stage generally is another iterative process in which users communicate overall effectiveness and identify problems, while producers work to adapt and refine the product. This step marks a critical juncture in the overall research to applications process, the step in which users begin to "pull" the development process rather than rely on the programmatic "push" that typically drives the earlier stages.

The pull for technology often comes from the commercial sector, which has additional capabilities and motivation for research to applications success. The research community is unlikely to serve as a manufacturer or supplier of expendables, or to have the capability for assessing what attributes will make a product financially viable. The private sector should have been involved as a stakeholder in earlier stages of a project, but their enhanced role at this later stage becomes particularly important for technology-driven products.

THIRD-PARTY EVALUATOR CASE STUDY

**Southern California Coastal Water Research Project (SCCWRP)**

SCCWRP is a public agency established in 1969 to serve as the interface between science and water quality management in southern California. SCCWRP observed that managers were hesitant to adopt new microbial source identification methods because individual researchers were each advocating alternate approaches, with no consensus about method effectiveness. In partnership with the EPA, SCCWRP led an evaluation study in which 22 researchers using 12 different methods came to southern California and processed 54 blind samples. The study clearly differentiated which methods worked best. As a result of this third-party evaluation, managers began to incorporate these methods into key decision-making processes, and scientists used the results to refocus their research on those methods that proved most promising.

For more information, visit ftp://ftp.sccwrp.org/pub/download/PDFs/422_evaluation_of_micro.pdf

### Desired Endpoint

- Technologies and methods undergo independent verification by both the scientific and user communities.

### Actions for Success

- Seek out and empower third-party evaluators.
  - Third parties are better suited to conduct independent evaluations than the researchers themselves.
  - Third parties may also be better positioned to simultaneously evaluate multiple solutions developed by different agencies or different researchers.
- Engage users to attain application-based performance input.
  - End-users should serve as beta-testers in which they use the technology as part of their routine activities to assess its effectiveness. Users who have verified performance are the most effective people to convey confidence in the product to their peers.
- Program managers need to re-engage in the process to encourage evaluative testing.
  - Program managers typically maintain minimal contact with researchers for long periods while the research is ongoing, but they are often best suited to connect researchers with the evaluative testing community.
  - Program managers should be provided resources to supplement the research budgets to accommodate this stage.

## 3.5 Adoption

Adoption is the final step in the process that completes the transition from knowledge or technology to application. It can include marketing of the new information or technology, providing user training, and other activities to ensure that target audiences are actively engaged and ready to use the new product, whether it is new information or knowledge or a new technology. Although adoption is the last step in the research to applications process, successful adoption requires consideration of opportunities and obstacles to adoption from the time the research endeavor begins and throughout the entire process.

ADOPTION CASE STUDY

**Maine Sea Grant: Submersible Mussel Raft**

The transfer of solutions to applications often requires funding beyond the research itself. Development of the submersible mussel raft to reduce problems for boats is an example where Maine Sea Grant provided and assisted in obtaining funding for three phases of the project. The first phase used Sea Grant development funds to design the raft system. In the second phase, scale model testing took place in the University of Maine's tow facility with tests witnessed by engineers, fishermen, aquaculturists, and equipment suppliers. The third phase of the project used Maine Technology Institute funding (facilitated by Sea Grant) for a full-size prototype. These successive testing phases, conducted in partnership with the user community, provided the evidence necessary for adoption.

For more information, visit http://www.seagrant.umaine.edu/extension/aquaculture/submus.htm

### Desired Endpoint

- The target audience successfully adopts the new technology or knowledge.

### Actions for Success

- Consider issues related to adoption throughout the process, and especially immediately after grant/contract award.
  - The likelihood of adoption increases if end-user capacity and other obstacles to adoption are considered and understood prior to completion of the research.

- Allocate funding to assure that the adoption step can be successfully implemented.
  - Funding often is insufficient to complete the development process, resulting in partially developed concepts that are not sufficiently mature for users to implement the knowledge or technology.
  - Generally, a separate funding source is required to move past the research phase into production, marketing, and adoption. The NOPP grants have been good examples of funding for these types of late-stage activities.
- Engage experts or managers experienced in supporting successful adoption.
  - The skills required to identify potential markets, manage intellectual property issues, and develop training programs and other means to ensure a 'pull' for the new knowledge or technology are not usually found in the research community.
  - Initial product offerings are sometimes released to market prior to being fully productized (in reality beta-level products), and problems with performance can impede broader adoption. Experts can assist in developing a well-formed business case and investment strategy for potential products.
  - In many cases, adoption expertise may come through creation of private-public partnerships. Most researchers do not have the inherent or institutional capabilities to drive their technology fully to application and would benefit from the business acumen present in a boundary entity or organization.

## 3.6 Capture and Synthesize Knowledge

Timely state-of-the-science synthesis efforts are important at both the front end of the research process as well as at the end. Functionally, knowledge synthesis has value in two ways:

- Communicating the state of the science to decision makers
- Framing opportunities in the research to applications process and for building consensus regarding next steps based on gaps/needs assessment

The goal is to determine what is known, what gaps exist, and what the foundation is for the collaboration necessary to move forward with the critical users.

"There is an overwhelming sense that a vast amount of useful data and information exists, but is not readily accessible." (Summary Report of the Southeast Coastal Managers Focus Group on Ocean Observations Needs, Coastal States Organization, November 29–30, 2004.) This statement reflects the perception of many decision makers and end-users of research.

Syntheses are improved when conducted through interagency collaboration and with

CAPTURE AND SYNTHESIZE KNOWLEDGE CASE STUDY

**Alliance for Coastal Technologies**

The Alliance for Coastal Technologies (ACT) is a NOAA-funded partnership of research institutions, resource managers, and private sector companies dedicated to fostering the development and adoption of effective and reliable sensors and platforms. A signature component of these efforts are the ACT workshops, in which representatives from all of these sectors are brought together in equal numbers to explore existing needs, assess the current state-of-the-art in the science, and delineate current commercial solutions. Brought together to participate in intensive two-day workshops, the parties interact to develop consensus on current status and steps required to move these technologies forward. These workshops serve to create solid foundations for determining "next steps" in transition and adoption of new capabilities. Thus far, ACT efforts have led to assessments and recommendations for nearly 40 technology themes and have moved to in-depth technology performance evaluations of in-situ dissolved oxygen, chlorophyll fluorescence, turbidity, and nutrient sensors. ACT is an excellent example of disparate community factions developing a consensus synthesis, but their workshops have focused on technologies. Such workshops can be even more valuable when focused on problems the technology might ultimately serve.

For more information, visit http://www.act-us.info/

partners, customers, and/or end-users, and when done around a carefully crafted architecture of questions that are developed jointly. Additionally, the process of conducting syntheses has other benefits. It not only provides a firm technical foundation, but also builds trust among program managers, users, and researchers that leads to collaborations important to the success of the longer-term research to applications process.

### Desired Endpoints

- Information from a broad array of sources is synthesized and distributed in a manner that allows users to understand the current state of the science.
- Inter-agency and inter-program collaboration is established.
- Consensus is reached regarding existing knowledge and gaps.

### Actions for Success

- Integrate information both within and across disciplines to include cross-agency collaboration.
  - Multi-disciplinary, multi-agency, and multi-sector knowledge should be synthesized to ensure comprehensive understanding of the state of knowledge and to highlight gaps. In addition, the accuracy and availability of data, information, and knowledge at local, regional, and national scales must be assessed to ensure a complete understanding.
- Facilitate consensus among stakeholders
  - As a precursor to the Problem Definition stage, a range of stakeholders should be consulted to ensure that all relevant knowledge, and not just the information found in peer-reviewed articles, is considered in the preparation of a concise synthesis of knowledge. Stakeholders should represent diverse sectors (i.e., researchers, end-users, producers) and possess multi-disciplinary expertise. Ideally, the stakeholders have the opportunity at a facilitated meeting to share information, identify gaps, and reach consensus on the state of knowledge.

### Summary

Beyond the foundational themes presented in Chapter 2, actions and success criteria were identified in this chapter for managing the research to applications process. Ultimately, a team must be developed to define needs—with insight as to users' adoption criteria and limitations of existing solutions—and inform the research solicitation. The solicitation and research processes should include stakeholder participation with flexibility in management and funding to optimize the likelihood of successful application. Programs should then plan for and enable technologies and methods to undergo independent verification in lab and user environments. Throughout the process, both barriers to adoption and information transfer should be considered and planned for.

# Chapter 4
## Conclusions

The nation's mission agencies make huge contributions to scientific understanding both through the extramural research they support and through research done by agency scientists. Federal agencies count within their ranks some of world's best scientists—providing invaluable resources, information, and knowledge to the nation's scientific enterprise. Often these agencies are the only source of long-term observational programs that are important to understanding environmental processes and human impacts upon them.

The importance of the research conducted and sponsored by federal agencies should not be underestimated. However, with relatively modest changes in agency research policies and practices, the nation could benefit more quickly and more effectively from the federal investment in agency and agency-sponsored research by enhancing the process for transitioning research to applications. Ultimately, this would also provide some level of security for long-range programs during periods of budgetary constraint.

This report provided guiding principles in the form of foundational elements and a model of the research to applications process, to assist agencies in successfully transitioning research to applications. The model emphasizes communication, cooperation, and collaboration among and within agencies, and between scientists and the intended community of end-users for the knowledge being developed. It is equally applicable to the extramural research supported by agencies.

The successful models described in this document do not come free. They require resources in order to be implemented effectively. There will be those who are threatened by these models of success, who see in the changes a diversion of money away from research. In the short-term, this is probably correct, but we suggest that increasing the positive impact of research will contribute in the long-term to augmented budgets, not depleted ones, as tighter relationships with the user community lead to greater demand for the research products.

The proposed model will require cultural changes for some federal mission agencies and the challenge of changing strong, deeply-embedded institutional cultures should not be underestimated. It has been demonstrated clearly in the management and organizational behavior literature that effecting cultural change requires champions in leadership positions up and down the organization, and that without a clear mandate from the top, cultural changes rarely stick. In addition to leadership, making a cultural change requires constancy of commitment and implementation of a reward system that reinforces the desired values.

Program managers play particularly important roles in the success of the proposed venture. If the present mode of operation is to change, program managers need to be assured that their leadership is committed to these changes. To enhance their research to application capabilities, agencies might begin by collaboratively selecting a project that is a shared priority of two or more agencies, make that shared priority unambiguously clear, and then begin to incorporate some of the elements of the research to applications model presented here. Inclusion of key end-users as full partners in the process, combined with a commitment from upper management to support the program managers, will lead to success.

Finally, the RATF will dissolve upon submittal of this report, but the members remain available and eager to help if requested.