National Cooperative Highway Research Program

NCHRP Synthesis 280

Seven Keys to Building a Robust Research Program

A Synthesis of Highway Practice

Transportation Research Board
National Research Council

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Synthesis of Highway Practice 280

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Transportation Research Board
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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

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The members of the technical committee selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and, while they have been accepted as appropriate by the technical committee, they are not necessarily those of the Transportation Research Board, the National Research Council, the American Association of State Highway and Transportation Officials, or the Federal Highway Administration of the U.S. Department of Transportation.

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PREFACE

A vast storehouse of information exists on nearly every subject of concern to highway administrators and engineers. Much of this information has resulted from both research and the successful application of solutions to the problems faced by practitioners in their daily work. Because previously there has been no systematic means for compiling such useful information and making it available to the entire community, the American Association of State Highway and Transportation Officials has, through the mechanism of the National Cooperative Highway Research Program, authorized the Transportation Research Board to undertake a continuing project to search out and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in the subject areas of concern.

This synthesis series reports on various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems. The extent to which these reports are useful will be tempered by the user's knowledge and experience in the particular problem area.

FOREWORD

By Staff
Transportation
Research Board

This synthesis report describes the current viewpoints of selected DOT research managers, transportation agency and industry administrators, and academics regarding characteristics of robust research programs. Based on these results and an extensive literature review, the authors identified attributes necessary to build and maintain a robust research program. This synthesis report will be of interest to researchers, research managers, administrators, and others concerned with the management of highway research programs. It is particularly applicable to state DOT research programs, but its findings are also relevant to research programs managed in other institutional settings. More specifically, the synthesis focuses on seven key attributes that contribute to the achievement of a robust research program, i.e., programs that flourish and thrive, are vital and enduring, and that support the overall performance of parent organizations. Information for the synthesis was collected by means of a focus group of state DOT research managers, state DOT research program peer exchange activities, an extensive search of business and management, research technology, and engineering literature, and selected indepth interviews with senior executives.

This report provides information to research managers and others who wish to encourage robust research programs. Defining the characteristics that help distinguish such superior research programs is necessarily subjective. The authors have drawn upon the information gathered, as well as their own experience in research management, to identify key elements in developing robust research programs. Their rationale and description of these keys draws heavily on anecdotal information. This is an unconventional style for an NCHRP synthesis. The Topic Panel, which provided guidance to the project, encouraged and supported this alternative approach with the expectation that it would more clearly illustrate the key attributes and the roles they play. Incorporation of some or all of these attributes can enhance the relevance, effectiveness, and reputation of highway research programs.

Administrators, engineers, and researchers are continually faced with highway problems on which much information exists, either in the form of reports or in terms of undocumented experience and practice. Unfortunately, this information often is scattered and unevaluated and, as a consequence, in seeking solutions, full information on what has been learned about a problem frequently is not assembled. Costly research findings may go unused, valuable experience may be overlooked, and full consideration may not be given to available practices for solving or alleviating the problem. In an effort to correct this situation, a continuing NCHRP project has the objective of reporting on common highway problems and synthesizing available information. The synthesis reports from this endeavor constitute an NCHRP publication series in which various forms of relevant information are assembled into single, concise documents pertaining to specific highway problems or sets of closely related problems.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, the available information was assembled from numerous sources, including a large number of state highway and transportation departments. A topic panel of experts in the subject area was established to guide the author's research in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now at hand.

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SEVEN KEYS TO BUILDING A ROBUST RESEARCH PROGRAM

SUMMARY

Robust research programs are those most often held up as the models others desire to emulate; they flourish and thrive, are vital and enduring, contribute to the achievement of organizational goals and, overall, add value to the parent organization. These programs must be effective, that is, they must produce a quantity of high-quality, well-targeted products capable of application to the real problems of their parent units. However, it is not enough that they do good technical work. To achieve a robust status, they must also be *perceived* as doing good work. Some research programs remain robust over long periods, whereas others struggle for respect and support.

Managers concerned about building robust research programs should seek ways to achieve these ends. This report focuses on those key attributes that contribute to the achievement of robustness.

In-depth interviews with public and private sector senior managers, both domestic and international; academics; a focus group of state Department of Transportation (DOT) research managers; peer exchange activities (extensive peer-to-peer meetings conducted by state DOT research units); and business and technology literature provide the basis for the conclusions found in this report. Analysis of these sources reveal that there is something more to creating and maintaining vital and enduring research programs than delivering timely, high-quality products—though this is essential. Seven key attributes (the "seven keys") were identified that seem to distinguish robust programs from others. What's more, these key attributes are universal, that is, they are applicable to research programs whether found in commercial enterprises, national or international organizations, or state DOTs. They are the keys to building robust research programs.

Although all research programs must be vigilant to assure their relevance and connectedness to their sponsors, state transportation research programs operate in especially difficult institutional settings. There are no explicit and compelling imperatives for DOTs to invest in research. Top managers may have short tenure and are increasingly drawn from nontechnical disciplines with a lack of understanding of how to manage research. In addition, there is the temptation to be a follower, that is, to use the results of research from other states, rather than committing to one's own program. These factors combine to encourage a tendency to neglect research.

However, state DOTs are in need of solutions for their particular technical, policy, environmental, financial, or other problems, some of which can be found through research. Although federal legislation generally requires each state to invest in research, the required program may be inadequate to address the needs of the parent department or to achieve a scale that warrants top management attention. These conditions present a major challenge for research managers.

One of the most positive factors in the achievement of robust programs is the presence of a chief administrative officer (CAO) who is predisposed towards research, understands the

contribution research can make to achieving organizational goals, provides sufficient resources, and requires accountability from the research program. Such leadership, combined with top-notch research management, virtually assures a robust program. Conversely, there are some CAOs who are predisposed against research, believing that research is at best an unavoidable overhead cost, and at worst a waste of taxpayer funds. Even the most capable research management will experience difficulties under such circumstances, and in such instances a robust program may prove impossible.

However, most CAOs do come to office more or less indifferent to research and left alone may finish their term with little understanding or appreciation for it. It is in these situations where the seven keys can make a difference. The incorporation of these attributes into a research program will, over time, establish its reputation as an important and vital part of the organization. This reputation will prevail among most top and middle department management, as well as legislators, academics, and the private sector. These individuals will form a constituency who will become advocates for the program at critical milestones as, for example, when new top management arrives on the scene or in times of department downsizing and budget cutting.

Most of this report describes the seven keys and illustrates these descriptions with anecdotes that demonstrate how successful managers have applied them in a wide variety of situations. In some cases names and places have been used; in others, specifics have been omitted or disguised to avoid individual or organizational embarrassment.

The seven keys to building and maintaining a robust program are as follows:

- *Found it on Trust*—The most important of the seven keys is the establishment of a trust relationship between the research unit and its parent organization. When trust exists, there is a feeling of confidence, of connectedness, an assurance of shared goals, of being on the same team. Developing trust takes time, and can be fostered through a variety of attitudes and activities. The feeling extends in both directions, from upper management down to research, and from the research program up to management. It can be injured by the careless or inattentive action of either party.

  Some of the other keys, for example, marketing, deal making, and accountability, although useful in their own right, can also be seen as methods for encouraging trust. With trust a program will likely prosper; without it, a program will become marginalized and ineffective, notwithstanding its other strengths.

- *Market Boldly*—Marketing is an essential component of a robust research program. It is not an activity that comes naturally to many researchers, nor is it readily understood or always embraced as an appropriate part of the job. However, considering the lack of incentives for DOT research, including a risk adverse climate, the lack of technical experience and short tenure of top management, and the nationally decentralized structure of surface transportation, it is not surprising that marketing is seen as a top priority for research managers. Without it, there are just too many forces pushing toward the neglect of this activity. The research manager must step forward and become an effective research advocate.

  Marketing is needed at every stage of the process; in the solicitation of problems, in anticipating research needs, in justifying the time and budget required, in persuading others to test the product, in arguing for deployment, in advertising successful products, and in selling the overall need for research. Successful research managers

use a variety of methods to accomplish this, for example, printed materials, networking, and alliances; however, a strong focus on the customer and customer needs are at the heart of the process. Marketing needs to be seen by both top management and research management as a vital part of the research function.

- *Root It in Economics*—Robust research programs look to economic justification for their activities. Top DOT managers, as public officials, are necessarily concerned with the economic use of taxpayer resources. In contrast, researchers are frequently selected primarily for their technical expertise. However, technical interest and enthusiasm, although laudable, are usually secondary to economic considerations when making research program decisions, or justifying the funding needed for implementation. Top management, having little understanding of the research process, will sometimes provide a research budget, but demand little in the way of accountability. In such circumstances, research managers are left free to form their programs. However, managers of robust programs are sensitive to the need to use economic rationale to ensure appropriate programs and their justification.

- *Make Deals Unabashedly*—Directors of robust programs are bold in their cultivation of alliances of all types. In the commercial research sector, opportunities to leverage resources, access to a wider variety of expertise, and rapidly changing technology, are forcing a growing use of joint ventures, partnerships, and other alliances. For many of the same reasons, robust state transportation research programs also have a need to promote partnerships. Such alliances add scale to programs struggling with insufficient resources and expand the program's constituency. The decentralized institutional setting within which transportation exists often requires consensus decisions on the adoption or deployment of research products. Joint research among affected agencies can sometimes enhance the credibility of the outcome. There are numerous examples where alliances with in-state universities have contributed to robust programs. In addition, many state research organizations have committed a substantial effort toward creating and expanding a variety of beneficial arrangements. All of these examples show that programs can often be enhanced by actively working to establish relationships with appropriate and compatible research entities.

- *Insist on Accountability*—Robust research organizations are accountable for their use of resources and their output. Research is especially vulnerable to a lack of accountability. Since World War II, American industry has perceived a close connection between research and long-term profitability. Top management was willing to provide the funds, but considered it the researcher's job to formulate the work program. However, international competitiveness is demanding a new accountability from research and is requiring a closer agreement between organizational goals and the research agenda.

  Although some top managers may be intimidated by the uncertainties associated with research, they nevertheless have a responsibility to fulfill their roles as agency leaders, setting the strategic direction for research to ensure alignment with departmental goals, communicating this strategy to stakeholders, providing resources to accomplish the research required, and giving their personal influence and support for appropriate research. Accountability is a two-way street—top managers perform their duties while research managers deliver programs that contribute to achieving agency goals.

  In addition, top managers should be accountable as well. Failure to do so gradually erodes trust in the program, and it becomes irrelevant to the parent unit. Robust programs do not permit such erosion.

- *Embrace Policy Research*—Robust transportation research programs include policy research in addition to technical research in their portfolios. Policy research provides a communications channel between research and top management. This channel is important because of the window it provides to the research manager to better understand the challenges facing the parent organization and thus to steer the research program in relevant directions. Policy issues are at the center of top management concerns and constitute the major challenges to the accomplishment of the state transportation function. Policy research can have a positive impact by better informing management decisions. Policy research also provides the opportunity for the research manager to sell the benefits of more traditional technical research to top management and to strategically access the research role and long-term program within the parent department.

  Traditional technical research on pavements, bridges, and operations are of major importance when considering the scale of departmental resources going to these functions. However, top management often does not comprehend this relationship. Accordingly, a research unit that does not include policy research will have a more difficult task in marketing its usefulness to a top management concerned primarily with policy issues.

- *Empower the Staff*—A robust research program must deliver quality products in a timely manner. Research tasks by their nature require a climate that fosters the generation of a flow of novel ideas. Idea generation is enhanced by interaction with other individuals working on similar problems in a variety of settings. Accordingly, researchers need to feel free to interact with others across organizational lines, either indirectly or face to face; have the opportunity to travel when required to interact with researchers working on similar problems in other organizations; and become familiar with potentially researchable problems of parent units.

All robust research programs may not necessarily employ all seven keys, and the emphasis placed on each key will vary depending on circumstance. However, this study suggests that more is better in the sense that all seven lead to the enhancement of trust, which is the most important factor, or to an improved output, which is essential. Research programs desiring to enhance their potential for robustness should seek ways to employ these keys in their programs.

Finally, this report suggests action on a number of additional items to assist organizations and individuals desiring to encourage these key attributes. They include:

- Research and preparation of materials for use in the training of the research manager, including:

  √ development of program marketing skills, methods, and tools;
  √ formation of alliances;
  √ economic and financial analyses;
  √ appropriate and noncumbersome accountability methods; and
  √ performance of policy research.

- Training opportunities to enhance skills required for accomplishing the preceding items.

- Training opportunities for senior managers to better acquaint them with the various elements of robust research programs and effective oversight of research.

- Methods to decrease the "cycle time" of research projects, i.e., reducing the time between idea generation and results application.

CHAPTER ONE

INTRODUCTION AND DISCUSSION OF THE PROBLEM

INTRODUCTION

State transportation research managers and others have a natural interest in fostering strong, enduring, vital, and effective research programs, because such programs can effectively address many of the problems facing state departments of transportation (DOTs). Two words can be used to describe desired programs; "effective," meaning they should target important topics and produce useful findings and products, and "robust," which Webster defines as "possessed of great strength, or health; strong or enduring; vigorous" (*1*). Although the terms have some similarity, they are different. For example, it might be possible, for a time, to be effective in the sense of targeting important topics and producing useful findings, but still not be robust, that is, never really becoming strong, enduring, and secure. Effective relates mostly to doing good, whereas robust primarily describes that perceived as doing good. Although it may be possible to be effective in the short run without being robust, in the long run the two factors must run in parallel if an effective program is to be achieved.

This study identifies the key attributes associated with robust programs in the belief that once identified managers can incorporate these attributes into existing research programs, strengthening and improving their prospects of becoming robust.

THE PROBLEM

State DOTs find themselves managing ever-larger enterprises that use increasingly sophisticated technology. They are called on to address transportation needs with the wisdom and prudence appropriate for agencies that spend large amounts of public funds, while at the same time contributing to a wide array of social and economic goals, including environmental improvement, social equity, and economic development. Doing this necessitates that state DOTs take advantage of new technologies as they are developed in other fields and generate technology on their own when appropriate. The state of knowledge and the inherent uncertainty of these interrelated tasks requires ongoing research to assess and apply new technology to their traditional mission of road design, construction, and maintenance, as well as to information technology suitable for the application of intelligent transportation systems, improved public transit systems, the study of environmental mitigation measures, and a host of other economic, social, and technology related issues.

There are 50 states, however, and no one state feels (or should feel) the sole responsibility to fill all knowledge gaps, and there is a tendency in such a decentralized environment, to "let the other states figure it out and learn from them." The collective effect of such reasoning is a tendency to neglect research as an instrument for the solution of pressing problems and to chronically underfund and undermanage this potentially valuable resource

Throughout this century, the federal government has assumed the primary role in transportation research and even now encourages research both as a funder, coordinator, and performer. The Federal Highway Administration (FHWA) has conducted a significant program of research through its own laboratories and as contract administrator overseeing research in universities and other research institutions. However, as a result of the Transportation Equity Act for the 21st Century (TEA-21), the FHWA now receives substantially reduced funds for its research activities. In addition, the great diversity among the states in matters of climate, soils, topography, traffic, culture, environment, and economy dictates that states should control significant research programs themselves. Accordingly, federal legislation requires that each state operate its own program, close to where problems occur and where results can be deployed (*2*).

The typical state research program is small when compared with other major units within the parent organization; whether measured in terms of dollars spent or people employed. As public sector units the imperatives of future viability and profitability do not demand innovation with the same intensity as found in the private sector and, organizationally, research is often located several levels from the top. Access to top management is impaired by the fact that top DOT administrators often come from nontechnical fields (e.g., law, business, or real estate) and serve relatively short terms (e.g., 2-4 years or less). Under such circumstances, the top departmental official, the Chief Administrative Officer (CAO), may have little initial appreciation for technology or its improvement and research may not be a priority. All of these factors tend toward a neglect of research and a lack of awareness of the potential for research to address departmental problems.

The CAO may know that there is a research program and may have an impression of its effectiveness, but such an impression will likely have been obtained the same way

the CAO gets many other impressions of the department and its people, that is, from their reputations with other senior managers, from occasional individual meetings with unit heads, from incidental exposure to a unit report or brochure, or from a chance viewing of a work program. Such fortuitous exposure will provide either a positive or a negative impression, and notwithstanding the thinness of its foundation, may well be the deciding factor in the CAO's opinion of the research program and thus the extent of their support. The findings of this study are not primarily aimed at improving the quality or quantity of useful research products (though some identified key attributes are believed to relate to better products), but rather are directed at improving the likelihood that management perceives that the research program is useful.

These realities might suggest that building a robust program is improbable if not impossible. No matter how effective a program might be in developing useful findings and products, the likelihood that this would come to the attention of the CAO during his or her brief tenure would be low, as would be the opportunity to build a robust program.

ROBUST PROGRAMS

The extent of this problem varies among states, however, and there are notable examples of individual states that have developed effective research programs that seem to prosper year after year. What makes these programs different? Do some states have a greater predisposition toward research? Is it chance or are there internal attributes that can explain these differences? Are there lessons that can be learned from the private sector, from other countries, or from experiences at the national level?

This study affirms that the differences between strong and fragile programs can usually be explained by the extent to which they incorporate a number of specific key attributes, which research managers can normally advance if they choose. Employing these keys will increase the likelihood of a program with a strong reputation with all levels of management, including the CAO, and this in turn improves the prospects of robustness. Although some of the key attributes appear to have little to do with ultimate output, this study does not suggest that useful output is not an attribute of robustness. However, because the study investigators could not gauge the quality or quantity of the output function, it is assumed that a program with little or no output could not long survive, and that both quality and quantity of output are important ingredients of a successful program. Output then was assumed to be a necessary but insufficient condition for robustness. It is the other attributes that are the focus of this project. The following are the seven key attributes to building a robust research program:

1. Found it on trust
2. Market boldly
3. Root it in economics
4. Make deals unabashedly
5. Insist on accountability
6. Embrace policy research
7. Empower the staff.

This report, however, goes beyond the identification of attributes in abstract terms. The purpose at the outset was to illustrate the findings with actual examples. Accordingly, the report abounds with real-life stories, both to further elaborate the nature of each attribute and to illustrate to researchers how experienced managers have implemented these attributes in a wide variety of situations.

CURRENT CONTEXT

This project builds on work previously performed on a variety of associated topics, yet it addresses the topic with a different focus. Earlier investigations dealt with the best practices of on-going units. These investigations present how-to, tactical information designed to improve operational functions, for example, program administration, targeting important topics, and facilitating implementation (*3*). On the other hand, this project approaches the issue from a more strategic perspective. It emerges from the notion that enhancing operational functions is important and necessary, but not sufficient to produce research programs that are well supported by their departments. The project demonstrates that there *are* overarching principles or strategies that can elevate some research programs from the ordinary to the unusual. This report is a discussion of those strategic elements (or key attributes) that are present in robust research programs. It describes why they are important not only to the research manager but to senior executives who manage the whole of the state's transportation activities.

This may be an opportune time for states desiring to strengthen their research activities to consider ways to encourage robustness. Funds for state research have been increasing in recent years. The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) mandated that no less than one-quarter of the federal-aid State Planning and Research (SP&R) funds be dedicated to research, development, and technology (RD&T) activities, and at the same time increased funding for SP&R. In 1995, these factors combined produced a 64 percent increase in funding for research programs (*4*). Furthermore, ISTEA provided significant funding for the Strategic Highway Research Program (SHRP) implementation, Intelligent Transportation Systems (ITS), university research, and other research activities.

Similarly, the more recent legislation, TEA-21, effectively increased state research funding levels, redistributed the funding for many federal research efforts, and committed significant funds to targeted topical areas or specific academic research programs. Notwithstanding the reprioritization of some of these nationally oriented efforts and the relatively low level of the funding base, state DOT research programs are in better financial condition than they have been in recent memory.

REPORT ORGANIZATION

Chapter 2 discusses the sources of information used in preparing this report. Four major areas of information are discussed in detail: in-depth interviews with senior executives, a focus group of research managers, state DOT research program peer exchange activities, and an extensive search of business and management, research, technology, and engineering literature. Chapter 3 discusses the influence of top management on the development of robust programs. Chapters 4 through 10 examine in detail the seven keys. Chapter 11 presents the findings of the project and includes the researchers suggestions concerning avenues for further study. Appendix materials include a list of the experienced individuals interviewed during the course of the project (Appendix A), the current and/or former affiliation of the interviewees (Appendix B), and the participants in the research managers focus group (Appendix C). Appendix D contains the protocols for the senior executive interviews and the research manager focus group, and Appendix E contains short synopses of relevant research on topics having a bearing on this synthesis.

CHAPTER TWO

REVIEW OF CURRENT PRACTICE

IN-DEPTH INTERVIEWS

The search for the key attributes of robust research programs was carried out in a variety of ways, including a thorough literature search and by harvesting the personal experiences of the investigators. However, the primary source was from a series of personal interviews of individuals who the investigators believed had the experience and knowledge to identify important attributes, explain why they believed them important, and illustrate their arguments with real life examples (see Appendix A for a list of the interviewees). Many of these individuals were either currently or formerly among the ranks of top management in state DOTs or from the private sector. Some were either currently or had been managers of research organizations. Interviews were conducted with individuals within the United States and abroad, from both the public and private sectors, and from commercial, government, and academic institutions (see Appendix B for a list of interviewees and their present and/or former affiliations).

The early interviews began with an explanation of the background of the project, and why state researchers wanted and needed to know more about the attributes of robust programs. Then the interviewees were asked to list such attributes based on their own knowledge and experience and to explain their answers. The resulting conversation would usually produce a list of two to four items. Explanations of their answers often took the form of one or more anecdotes from their own experience that demonstrated the veracity and appropriateness of their lists.

As the interviews proceeded, it became apparent that many of respondents were saying the same things, and a candidate list of key attributes began to emerge. In later interviews, this list was shown to the respondents who were then asked to select the most important items, identify those of lesser importance, and again to make arguments for their answers or provide examples that made their points. This approach was heartening, because responses often confirmed that the list was "a good one," or "I agree," or "you're on the right track."

From the beginning, a goal of the study was to elicit examples to illustrate the validity and the subtleties of the attributes. Descriptions of attributes can come across as so much abstraction unless accompanied by real life experience. Respondents were quick to provide such anecdotal evidence. However, after providing a particularly interesting story, they would sometimes pause reflectively, and suggest "maybe it would be better if you didn't use that one." The problem being that some of the best illustrative stories are of organizational or individual failures, and respondents were hesitant to embarrass former colleagues. Even success stories often involved efforts to overcome organizational resistance to change, and most of these organizations still exist and might be offended to find their shortcomings in print. Accordingly, although many of the examples have been attributed to specific individuals, organizations, and events, others have been deliberately disguised. Even attributing an example to a specific state (leaving out names of individuals) was often deemed inappropriate, because it would be easy to speculate about the identity of the individuals involved. In such cases, the incident was attributed to a section of the country, for example, a western state. However, the anecdotes are all stories of real experiences.

It should be apparent that the findings of this study are inherently subjective and consist largely of opinions of knowledgeable people. The study has no systematic surveys that can say that X percent of top management believes thus and so. Nor was any effort made to draw a random sample of individuals from any particular class for the interviews. Most, but not all, interviews took about 2 hours. The interviewer was armed with a specific list of questions, but rarely went through it systematically. What was asked was often a function of the experience of the interviewee and the direction the conversation took after initial introduction of the subject. Nevertheless, the findings are a reflection of the preponderant views of interviewees, many of whom have demonstrated success in building robust programs.

It should be noted that not all robust research programs will necessarily have all of the identified attributes in the same measure. Nor is it always possible to distinguish whether the attribute is related primarily to the unit, the program, or the unit manager. However, robust research programs will demonstrate, to some degree, each of the key attributes listed.

FOCUS GROUP

A principal vehicle to gain a research managers' perspectives for this synthesis was by means of a focus group. Focus groups efficiently gather qualitative data on a topic

using facilitated idea generation and group discussion. Focus groups have been proven to generate equivalent amounts of data compared with individual interviews and in this exercise provided substantial amounts of relevant information (*5*). Considering the high caliber of the participants, a single exercise more than met the expectations of generating required input.

Participants in the focus group were chosen because of their research management experience and many are considered by their peers as managing robust programs. The chairman of the Research Advisory Committee (RAC) of the American Association of State Highway and Transportation Officials (AASHTO), the four chairmen of the regional organizations of the RAC, and four members of this National Cooperative Highway Research Program (NCHRP) synthesis topic panel, as well as several other research managers participated in the focus group (see Appendix C for a complete list of focus group participants).

The goal of conducting the focus group was twofold. Foremost was to gather first-hand information regarding the research managers' understanding of robust research programs. Second, was to determine the degree of consensus existing with the information emerging from the indepth interviews.

The research managers identified research programs they considered exemplary and also identified factors that in their judgment made these programs meritorious. Discussion included public sector agencies, private industry, research institutions, and state research programs. The group identified and discussed the relative merits of program characteristics such as technical strength, longevity, credibility, stability, and the ability to be results oriented and have continued funding and organizational support. The discussion emphasized that there are attributes other than effectiveness that make a research program robust. Using a classic definition made popular by Peter Drucker in his book, *The Effective Executive*, they defined effective as "getting the right things done" (*6*). The research managers noted that effectiveness was necessary, but not sufficient, for robustness. Remarkably, when the seven key attributes identified by means of the in-depth interviews were presented to the research managers, it was immediately apparent that the research managers themselves used the same attributes to describe exemplary programs. Even the same descriptive verbiage was used by both the research managers and those participating in the interviews.

In addition to the identified attributes, items such as access to senior management, technical competence, challenges of managing a contract research program, and implementation (changing the state-of-practice, resources, and responsiveness to customers) were emphasized in the focus group discussion. Participants provided valuable information regarding what transportation research programs require to survive and thrive in today's environment.

STATE DOT RESEARCH PROGRAM PEER EXCHANGE ACTIVITIES

State DOTs are required by federal regulation to conduct a peer exchange of their research, development, and technology programs every 3 years (*2*). The exchange is a gathering of research managers and others in the research community who are invited by a host state to study specific aspects of its research program. The research managers also share the practices and methods they employ to accomplish the goals identified by the host state. The objective of the process is to enhance the research management capacity, as well as to improve the quality and effectiveness of research programs. Overall, the whole team's successes and best practices are transferred among peers. A report documenting the results of the exchange is required.

A number of the peer exchange reports were collected during this project and provided excellent background material. One of the synthesis investigators had participated in a number of exchanges, providing added insight regarding best practices and program attributes. Furthermore, one of the synthesis investigators also recently completed an NCHRP study documenting the administrative experiences of the first 12 peer exchanges conducted. Detailed interviews with host state research managers and with peer exchange team leaders from 12 exchanges were performed in the course of that study (*7*). Where applicable, data from those interviews are used in this synthesis.

LITERATURE SEARCH

Because of the diversity of topics included in robust research programs, a wide variety of literature was examined. A comprehensive review of business and management, research and development (R&D), engineering, and technology sources was undertaken in addition to the traditional review of transportation and engineering literature. The literature search encompassed the private and public sectors, as well as domestic and international sources.

Business and management—The Transportation Research Board (TRB) Library provided substantial material from business and management literature. The researchers augmented these results with literature from Internet available on-line collections through reference providers such as Proquest Direct, including ABI/INFORM Global, EBSCO, and InfoTrack. On-line, full-text references permitted an in-depth review of the literature. In particular,

Harvard Business Review (Harvard University) and *Sloan Management Review* (Massachusetts Institute of Technology) provided insight into management issues in industries other than transportation.

Technology and R&D—The Industrial Research Institute (IRI) publishes a bi-monthly journal, *Rescarch-Technology Management.* This journal is one of the most useful sources of information from the private sector that relates to the experiences and critical issues found in the public sector transportation RD&T arena. The IRI is a nonprofit association of over 290 leading companies representing such industries as aerospace, automotive, chemical, computer, and electronics. These companies carry out greater than 80 percent of the industrial research in the United States. For technology-related sources, the computer and electronics industries provided a fertile area for relevant literature on research effectiveness and program management. Other industries, such as pharmaceuticals, contributed to the whole of the body of literature reviewed. The IRI world-wide-web site provided links to international organizations having similar goals to IRI, for example, the European Industrial Research Management Association and the Canadian Research Management Association. Other sources of technology management and research-oriented materials were the journal *Research Policy: A Journal Devoted to Research Policy, Research Management and Planning,* available through Elsevier Science B.V.; *Journal of Technology Transfer*, published by the Technology Transfer Society; and materials from the Society of Research Administrators.

Engineering—The primary source of comprehensive civil engineering literature is the American Society of Civil Engineers (ASCE). The Civil Engineering Database provides abstracts through its on-line Internet-based web site. Full text references are available from the Linda Hall Library of Science, Engineering and Technology. References were found in ASCE publications such as the *Journal of Professional Issues in Engineering Education and Practice* and the *Journal of Infrastructure Systems.*

Transportation—The Transportation Research Information Services (TRIS) database search provided transportation literature relating to technology and research program management. This database is a significant source for public sector transportation references. The TRIS search identified a number of studies performed within the transportation community that are predecessors to this study effort (see Appendix E for synopses of these related studies). In addition to the published documents from TRIS, transportation sources included unpublished reports or those with very limited distribution, such as the peer exchange reports, research program brochures, R&D program annual reports and program manuals, and other state research unit materials.

CHAPTER THREE

INFLUENCE OF TOP MANAGEMENT

TOP MANAGEMENT PREDISPOSED TOWARD RESEARCH

The interviews, the focus group, and the literature all underscore the importance of the support of top management in the development of robust research programs. In addition, intuition and common sense rank this as the single most important factor, at least in the short term. A top manager—a CEO or CAO—who articulates a vision, mission, and goals for the organization, and who views research as an important tool in achieving these goals, will ensure a strong research program. Research takes its place alongside capital investment, marketing, operations, customer orientation, and other tools as an essential instrument in improving the performance of the organization.

As an essential instrument for policy achievement, the top manager will ensure that the research activity functions properly and meets its goals. This individual will ensure that the research is adequately funded and provided with the proper facilities and leadership. He or she will also develop milestones and measure progress against them. There will be no ambiguity about the role of research, nor will there be any question as to what it is expected to produce.

Numerous examples of such programs can be found in the literature, and some were uncovered in the interviews conducted for this study. John McSherefferty, President of Gillette Research Institute (GRI), told of events initiated by the completion of a new strategic mission by the CEO at The Gillette Company, GRI's parent organization. Gillette is fundamentally a marketing company with a number of independent business lines including shavers, cosmetics, writing instruments, and dental products. GRI had been an independent division ever since it was acquired after World War II (WWII) when Gillette purchased Toni Home Permanents. GRI was separated from Toni and made to report directly to Gillette headquarters in the belief that it would be the source of new products. However, efforts were never made to articulate its role in the corporation and over time it became primarily a contract research organization, with most of its clients outside the organization.

In 1979, however, the new strategic mission articulated a vision of Gillette as a company of excellence based on innovation and saw GRI as an essential instrument for ensuring the achievement of that vision. He hired McSherefferty to take over GRI with the mission of making it an integral part of Gillette. Strategic plans were prepared with specific goals for the operating divisions and GRI's role in product innovation. McSherefferty described his efforts at making the "connection" with each operating division and establishing "trust" with division managers. Persistence and some early successes made GRI an essential part of Gillette's corporate strategy, but not before the CEO had the vision and made it happen.

Top management can be equally pivotal in energizing research in the public sector. Gene Ofstead, former Assistant Commissioner for Transportation Research and Investment Management for Minnesota DOT (Mn/DOT), described a similar situation in his state when James Denn was appointed CAO. Denn had been director of the Minnesota Trucking Association and came into the job with considerable background in transportation. He had a vision of Mn/DOT becoming even more customer-oriented and initiated a strategic planning process that reduced the department's mission to a few well-articulated goals, which were subdivided into quantified objectives for each division of the department.

This already good research program further benefited from this vision. Denn actively supported strategically important efforts such as the test road research project, Mn/Road, which addressed customer concerns about the frequency and duration of traffic interruptions related to road maintenance and reconstruction. Additionally, Denn encouraged the performance of research projects dealing with other parts of the department's strategic plan, such as alternative financing studies that prepared the agency for reduced gas tax revenues or metro growth studies that provided insight into future infrastructure needs. Denn's fostering of strategic research and demonstration of how its results applied to the broad mission of the department was a significant step leading to the continuing acceptance of research as a critical tool to be used in meeting Mn/DOT goals. Furthermore, to assure the relevancy of the research effort, Denn placed his department's research director on his staff to solidify the links between the strategic direction of the department and research. Not surprisingly, transportation research in Minnesota continues to flourish. Good research leadership was positioned to ensure that the programs could meet their objectives. Therefore, as long as research is seen as an essential instrument in achieving departmental goals, there will be robust research activity in Minnesota.

The following is another example of a successful program. Tom Larson, former Federal Highway Administrator,

former CAO of the Pennsylvania Department of Transportation (PennDOT), and former President of AASHTO, had earlier directed the Transportation Institute at the Pennsylvania State University. He believed in the effectiveness of research and that it could be an important instrument in the achievement of the department's mission. While CAO, his personal influence and dedication to innovation through research established a culture in the department that encouraged tackling long-standing problems, fostered a greater acceptance of the process required to produce quality results, and supported the efforts necessary to apply the research results to practice. Research flourished during his tenure.

WHEN TOP MANAGEMENT IS HOSTILE TOWARD RESEARCH

Conversely, if top management is strongly predisposed against research and believes that it has little or no role in the achievement of the organization's mission, then research is likely to be in jeopardy. Such a leader will see research as a benign overhead cost at best, and as a total waste of money at worst. In the case of a state DOT, the federal requirement for spending a portion of federal-aid funds on research may guard against total annihilation of the research activity, but even inspired research leadership will be unlikely to establish a robust research program against such odds. Such conditions may make robust research impossible.

In one state DOT, a CAO, with little interest in research, redistributed the bulk of the research function and resources to individual operating departments. The operating divisions tended to use these funds for technical assistance and routine problem solving rather than research. While such technical assistance and problem solving activities may fulfill important needs, this approach reduces the ability of the agency to concentrate resources for conventional research, particularly in smaller states. Even inspired efforts by research management would likely fail to develop a robust program in such circumstances.

Bill Carey, Executive Director of TRB from 1968 to 1980, stated that he would sometimes deliberately recommend CAOs known to be hostile to research as candidates for the TRB Executive Committee. Carey firmly believed that once they were exposed to the TRB annual meeting they would be more sympathetic. He understood that it would not necessarily make them avid supporters, but that their hostility usually diminished when they saw first hand the relationship between research activities and genuine problems faced by transportation departments. Although not all CAOs can be members of the Executive Committee, getting new CAOs to at least one TRB annual meeting is a good move for those concerned with support for research.

TOP MANAGEMENT WITHOUT A PREDISPOSITION

In reality, these extreme cases, at opposite ends of the spectrum, may also be rare. Although an increasing proportion of top management may be from finance or legal backgrounds, and thus have little knowledge or appreciation of how technology is developed, most recognize that the technological achievements of the United States are directly related to its financial prosperity and its international dominance during this period of history. Top leadership in the private sector continues to invest heavily in research (*8*,*9*). When they first take office, most new CAOs do not appear to harbor active hostility as much as indifference toward research. In their efforts to get their arms around the challenges of a demanding new job, research has low priority.

David Winstead, former CAO for Maryland DOT, may be typical (however, he may be unusual in openly acknowledging his initial difficulties with research and permitting his experience to be published in a research document). At the time of the interview, Winstead had been in office for almost 4 years, and his achievements and abilities had been recognized by his election as President of AASHTO and to a seat on the Executive Committee of TRB. Prior to his appointment as CAO, he had for several years practiced law for a firm that represented land developers in the Washington, D.C. suburbs of Maryland. This activity put him in close touch with transportation issues generally and with the Maryland DOT in particular.

Like most informed citizens, Winstead believed that U.S. prosperity was directly linked to its technological prowess, and that this advantage springs from the research activities of scientists and engineers. However, he was not aware that the DOT had a research function until after assuming his new position. He first became aware that his department included a research unit when he received modest complaints from a few University of Maryland professors, who believed that they could be more actively involved in DOT research. In the process of inquiry he discovered the research unit, learned something of its activities, and began to consider the possible advantages of having the research unit report directly to his office so it could be more involved in intermodal research and policy studies. He met with the research director and began discussions with other administrators about how his plan might work.

At some point he visited the materials testing labs and was confused and somewhat uncomfortable about why his state was engaged in what appeared to be pavement research. Why couldn't this be done by the FHWA, or if it was essential that Maryland do such work, at least they could contract the work to universities or other research contractors. He was having problems getting enough

authorized positions for other essential activities in the department; maybe some of these research positions could be used. He was supportive of the need for research related to the department's aggressive moves in ITS, and a number of policy questions had already surfaced that needed investigation, but it was not clear why such ordinary activities as pavement research were necessary for Maryland.

Subsequently, the research director left the department for another position, and for a variety of reasons (unrelated to research) the reorganization of research was never completed. Meanwhile, Winstead attended a session on NCHRP research at an AASHTO annual meeting, attended a TRB annual meeting, and was appointed to the TRB Executive Committee. These experiences were useful in giving him more insight into the scope and scale of transportation research, why what might appear to be commonplace investigations were an essential part of transportation improvement, and more understanding and support for research in his organization.

The experiences of DOT CAOs in Maryland and Minnesota may be instructive to those puzzled by what appears to be a general lack of support for research and confused about how to develop a robust research program. Both James Denn of Minnesota and David Winstead of Maryland clearly believe that attendance at a TRB annual meeting was an important part of their education with respect to research. In Denn's case, his first experience was an eye-opening occasion and he credits this with the beginnings of his vision for his department.

ROLE OF OTHER TOP MANAGEMENT

Although obtaining the support of the CAO is usually essential in the development of a robust program, it is useful to note that other top executives can also often play major roles. Depending on the particular state, deputy directors, chief engineers, heads of major divisions, district directors, etc., can play pivotal roles, both as advisors to the CAO and in decision making within their respective areas of responsibility. Often a new CAO will get a first (and sometimes the only) impression of the research unit from discussion with other top managers within the department. The establishment of a trust relationship with these managers is essential. Because top executives often have longer tenure and in many cases are technically oriented, the opportunity to establish a strong reputation through the sustained production of useful research products (output) is better than that with the CAO. A program with little or no useful output will be unable to maintain a quality reputation with these colleagues, and it is for this reason that in the long run output is an essential component of a robust program. However, it is possible to produce quality output and fail to achieve a robust program. This study is targeted toward identifying other attributes that can push a program into the realm of the robust.

The role of senior management in educating the CAO on the importance of research is often visible in peer exchange meetings. During these meetings, peer exchange team members (host and other state research mangers) frequently have the opportunity to meet with the host state's senior management and comment on program strengths and suggest areas for improvement. Senior managers who believe in research and trust that their program is important can be seen as openly advocating the program before the CAO, who may be viewing the research program for the first time. Robust programs will tend to have such support across a wide spectrum of senior management. Developing such relationships is essential to maintaining a strong program on a sustained basis. Successful research managers use a variety of methods to achieve this, many of which are described in this document.

USEFULNESS OF KEY ATTRIBUTES

Considering that most CAOs will likely begin their brief tenure in office with a predisposition best described as indifference with respect to research, the opportunities to develop a robust research program may well lie in the vigorous application of the keys identified in this report. The similarity of the interview responses, whether the respondent was from public or private enterprise, whether foreign or domestic, and whether academic or commerce, suggests some universality that lends weight to the findings. The report argues that establishing trust, marketing the unit and its products, using economic analysis in major decisions, looking for and making deals, including policy research in the portfolio, being accountable, and empowerment of the staff, will significantly improve the prospects of developing a robust research program.

CHAPTER FOUR

FOUND IT ON TRUST

The most important attribute of robust research programs is "trust": trust that the program is aligned with and a contributor to the achievement of the mission of the parent organization. This factor was the most frequently mentioned attribute in the interviews, was confirmed in the focus group, and is supported in the literature. The term "connectedness" or "linked" also came up in this context, either as substitute for, or as an elaboration of, what was meant by trust. Regardless of which term was used, the meaning was clear. A robust research unit or program is one that is connected and bonded with its parent organization, so that there is no ambiguity as to whether they are part of the same team. The parent unit feels confident that research is directed at the solution of problems that it believes are important, and the research unit is confident that because of its contributions it is a highly regarded part of the larger organization.

Trust is equally important whether the research unit is imbedded in its parent organization or organized independently (e.g., university centers or independent contract research organizations). The parent or client needs to regard the research unit as an important, competent, and reliable extension of its own staff, and that its efforts are directed at the achievement of vital organizational goals. The relationship is much like the strategic alliances organized in recent years between commercial enterprises and logistics/transportation companies. These alliances allow the client firms to divest their internal transportation units and look to their strategic partners not only to perform the transportation function, but also to help them plan the locations of new plants, warehouses, and other facilities in order to minimize transportation and logistics costs. In other words, they look at their partner as an extension of themselves (*10*).

RESEARCH IN ISOLATION

One of the barriers to the establishment and maintenance of trust is the organizational isolation of research from the mainstream activity of parent units. A lack of access to top management fosters a tendency for the research program to move in directions of less relevance to corporate objectives, and for top management to see research as more of a burden to be sustained than a solution to problems. Research in state DOTs is a special problem because of its small size, the short tenure of top management, and other factors already cited. However, isolation can be a problem for research regardless of size or the nature of the business in which it is located.

In a recent book, *Third Generation R&D: Managing the Link to Corporate Strategy*, Roussel et al. describe how poor the connections between a research program and its parent business can become: "In the worst cases we found R&D treated as a line item in the budget, as a tax on the businesses. Its relevance and value were unclear, and its organization was physically and culturally isolated from the mainstream of the businesses. The analogy comes to mind of a family with an eccentric uncle who must be supported but who is best kept out of sight" (*11*).

According to the IRI, a survey performed by the Conference Board showed that there was a credibility gap between senior executives and R&D managers. The term "credibility" as used by IRI "means a complex of CEO attitudes toward R&D that are associated with trust, inclusion, and an assumption of shared objectives." IRI proceeded to find out if this was so within their organizational members as well. Surveying such companies as Air Products, Alcoa, Coors, Dow Corning, Eastman Kodak, General Electric, Hewlett-Packard, Lockheed, Mobil, and PPG brought out some revealing comments by CEOs and R&D leaders (*12*):

> It is important that you motivate the R&D folks not to live in their own cocoon, I have seen R&D executives try to detach themselves from the operations, ... Well, {operations} can make you or break you! You need an alliance.
>
> Another company's group vice-president ... said that relations with the Corporate Technical Center go bad because our guys feel that the people out there don't understand their business and just want to peddle their own technical ideas.
>
> Also, in my organization the R&D facilities are detached from the main headquarters. But I have an office at headquarters that I go to several times a week only to sense the climate, see what the issues are, and be able to translate them to my own people.

Overcoming this credibility gap between top management and research management is a major barrier to the establishment of the trust that is requisite for robust research programs.

THE DUPONT EXPERIENCE

Alex MacLachlan, former senior vice-president for DuPont Corporation and a member of its operating group,

related the story of how corporate research within his company was almost discontinued because of the loss of trust. Corporate research (corporate research that reported directly to corporate management is here distinguished from R&D units, which were part of individual product divisions) was originally organized in 1926 with the hope that it would attract talent, lead to something useful, and be good advertising. Within a few years the small corporate research unit had discovered synthetic rubber and nylon, products that became major profit generators. With these successes, corporate research became almost sacred and was supported by successive generations of company management as vital to the company's ongoing welfare, with hope for other breakthrough products. The activity grew in size and stature and made significant contributions to scientific knowledge. The company was praised by academics and others who saw these contributions as further examples of enlightened corporate management.

The problem was that this venerated status resulted in a loss of direction or demand for accountability from research, which in turn resulted in a loss of connection with the company's main business. Research worked on things that interested them and where their technical curiosity carried them, relatively unrestrained by a management whose attentions were focused elsewhere. The strong connections between the company's goals and those of research deteriorated and trust declined.

In the 1970s, oil price shocks and global competition began to erode DuPont's financial strength and cost cutting efforts were required. Initially, the sacred status of corporate research, which had grown to almost $100 million per year, protected it from downsizing. However, a number of efforts were made to refocus research on developing new products, including personnel transfers between research and corporate management and moving business managers into top positions in corporate research. Efforts were even made to have corporate research attempt the commercialization of some new products. Nothing worked, and the chorus of complaints about the costs of corporate research and its insularity and the lack of connection between research and the company continued. Trust had evaporated; something had to be done.

In the early 1980s, DuPont's top management called on MacLachlan, who had experience in business management as well as research, to do something about corporate research, that is, to better the linkage between corporate research and the needs of the company. He instituted a number of organizational and other changes that had the effect of linking research more closely with business units and that included regular transfers of personnel between business and research groups, insisting that corporate research personnel be included in product development teams, and the formation of a Corporate Technology Council (CTC) for the company. The CTC included the heads of all the business units and corporate research and agreed on a few "grand challenges" on which corporate research should focus that, if solved, would improve individual business unit performance. These usually were not breakthrough products, but often were less dramatic outcomes, such as reducing environmentally unfriendly byproducts of manufacturing processes or improving manufacturing efficiency. The effect has been to reconnect corporate research to the business of the company. It has permitted the company to retain many of its top scientists in its prestigious labs, while maintaining the trust required to continue a robust corporate research program.

STRATEGY OF HOPE

DuPont's experience is typical of many American companies. In the 1950s and 1960s, being part of the vaunted technical colossus that had won WWII, and having profited from the economic expansion that followed, many companies had a deep faith in the need for research and technology, but not much idea about how it should be managed. These companies generally believed that if they hired good people, gave them the best in equipment and facilities, and left them to themselves that they would produce commercially viable products.

Roussel et al. call this a "strategy of hope." They note, "Gary Hamel and C.K. Prahalad, in a *Harvard Business Review* article, described the Silicon Valley approach to innovation: 'Put a few bright people in a dark room, pour in money and hope.' The strategy of hope was a common R&D management method in large companies in the 1950s. The hope was that—given the right mix of brains, money, equipment, and time to pursue ideas—scientists and engineers, left alone, would concoct new products and processes that would translate into revenues, earnings, and market share" (*11*, p. 6-7). The book goes on to argue that competitive pressures have led many companies to find new ways to link their research units to strategic goals on a continuing basis. Without such linking, insularity of research increases and trust decreases.

TRUST AND TRANSPORTATION RESEARCH

If trust is a challenge in companies where the need to seek new products and improve existing ones is vital to longterm viability, it is much more difficult in state transportation agencies, where business imperatives often do not apply and where decentralization encourages the hope that others will solve the problem. Sometimes research programs become so disproportionately small that their very obscurity becomes a contributing cause of criticism.

An example of this occurred in the early 1980s. Bob Farris, the newly installed CAO of the Tennessee DOT, who later became Administrator of the FHWA, was most critical of research. Farris had been CEO of an apparel manufacturing concern prior to his transportation appointment. He later became a champion for research, served on TRB's Executive Committee, and on the SHRP Executive Committee. Early in his first term, however, Tennessee was experiencing some major and embarrassing asphalt pavement failures. If research was not providing answers to so basic a question, then he saw it as of little value. At the time, the scale of total asphalt pavement research did not match the seriousness of the problem Farris recognized, and resources tended to be spread thinly over many research projects. As a result, the perception was that research was unresponsive and trust was degraded.

At about the same time, the gap between top management and research became apparent in another state. The CAO of the New York DOT asked the TRB director to review his state's research program. When asked about the purpose of such a review, he exclaimed that he had large numbers of bridge decks failing around the state, many of them not more than 15 years old. But he did not see research, whether within his own department or nationally, taking the problem seriously. He believed that his unit as well as national programs were unresponsive and wanted to know how to improve the situation. Further discussion revealed that he had spent virtually no time with his research manager and thought about research mainly at budget time. He regarded research as largely an overhead activity and it had never occurred to him that it was an asset that required management and accountability.

Sometimes top management or research management can weaken trust by direct action, however unintended. For example, trust in one western state was threatened when researchers recommended a new type of asphalt mixture be used on a large section of new pavement. Management accepted the recommendation, but the mix failed and the media embarrassed the department. The CAOs confidence in the research program was shaken and trust was reduced.

One eastern state research manager reported on beginning a multi-year program on a research topic strongly urged by top management. However, when a decision was required on the second year's funding, management had focused on new problems and cut back necessary financial support, with little regard for the personnel and other issues associated with rapid start-ups and terminations of extended research projects. The researcher's trust in top management was damaged. Such incidents show that trust can be injured from imprudent decisions from either top management or research units.

Enlightened research managers, however, find ways to avoid such minefields and, over time, build the required trust. The methods they use are varied and tend to encompass every aspect of their program, from project selection to implementation of results. Some of these are revealed in subsequent chapters of this report. In fact, many of the other key attributes—for example, marketing and economic orientation—of robust programs are in the end designed to foster trust and confidence. One director of a midwestern university-based state research center, who felt trust (along with marketing) was paramount, cited that his state DOT moved their technical library to his center and had elected to have the center manage all DOT research grants and contracts, as a demonstration of trust. They had confidence in the center as a place that was competent to manage research and that had DOT interests at heart. In effect, they had arranged a "strategic alliance" in which the center was seen in some ways as an extension of themselves. Once established, trust tends to make customer and researcher mutually supportive, and trust is threatened when either side sees actions that suggest such mutual interests are not being protected.

TRUST AND NATIONAL TRANSPORTATION RESEARCH

Perhaps the low point for trust in national transportation research in recent times was experienced during the Reagan administration in the early 1980s. Political sentiment was running strong for reducing big government, and all programs were under intense budget pressure. The Office of Management and Budget directed that the FHWA make efforts to privatize the Turner-Fairbank Research Center and eliminate the research positions from the FHWA budget (*13*).

State CAOs tended to be supportive of research, although not necessarily supportive of transportation research institutions, whether found within their own organizations, universities, TRB, or FHWA. A lack of trust that research organizations were responsive to their needs was apparent. The CAO of Georgia, an engineer who had risen through the ranks, acknowledged that his state had major technical needs, but was critical of TRB and the NCHRP process, which he felt was out of touch with current needs. States were faced with a new set of problems, related to the aging of the highway system, including some of the early segments of the interstate itself. As highlighted by Choate's book, *America in Ruins*, the nations' "crumbling infrastructure" was the new focus, and states were feeling the pressure. But research products were not well matched to the priority needs as perceived by management. Whether management had doubts about the utility of research or research institutions, the effect was a decline in research funding. Sensing this decline, the TRB Executive Committee launched the Strategic

Transportation Research Study (STRS), under a committee largely composed of CAOs. The committee quickly identified the need for more research on pavements, paving materials, structures, and maintenance. It decided, however, to establish a new program and institution, the Strategic Highway Research Program (SHRP), to execute the program. There was a strong desire to have a new, highly focused organization to manage this program and be accountable for delivering results over a specific time frame.

The new SHRP program was presided over by a very active committee dominated by state transportation officials, but also including FHWA representatives. As the program proceeded, confidence and trust was gradually restored so that research could be targeted and managed to address issues of major importance to top management. As time approached for the 1991 reauthorization of federal surface transportation legislation, decisions were required about the nature and scale of research efforts in the postinterstate period. Charlie Miller, former Associate Administrator for Research at FHWA, remembers that some states lacked trust in FHWA's research program during this period. AASHTO had developed a program designed to elicit state views on potential legislation, and this process had revealed strong support for an expanded research effort. Public opinion polls had shown that the public supported efforts by transportation authorities to use improved technology, where appropriate, to enhance the efficiency and effectiveness of state transportation programs.

However, despite this general support for expanding research, it seemed that the states were reluctant to support an expanded research program administered by the FHWA unless mechanisms were provided that would institutionalize some state oversight and advice. Accordingly, when ISTEA provided major funding increases for FHWA administered research, AASHTO and FHWA organized within TRB the Research and Technology Coordinating Committee (RTCC). This committee is composed of a mix of state CAOs and research managers from major industries, related to, but outside transportation. The committee was also provided with adequate funding to permit independent staff support. The committee provides both written and verbal advice to FHWA top management about composition, administration, and direction of the federal program. It also reports back to AASHTO on its findings. The scale and decentralization that characterizes the nation's road programs are an inherent challenge to effective two-way communication between a dispersed client and effective research. Ways must be found, however, or trust evaporates and support for programs diminish.

To augment internal oversight of their research programs, the FHWA created internal Research and Technology Coordinating Groups to increase linkages between research and the major program offices. These groups are charged with developing coordinated research programs for major interest areas. They also provide coordination for technology transfer activities and those necessary for results implementation. The program offices chair the groups so that operational needs drive group agendas. Over time, membership of the groups expanded from the research center and headquarters operational personnel to include field people and those who provide liaison with state DOTs. The interaction among group members provides a more relevant research program that in turn results in a research program trusted by the senior management within the agency.

THE CHALLENGE FOR ACADEMIA

Perhaps there is no area where trust is more challenged than in the gulf separating the university and the users of applied research, as symbolized by the DOT and its employees and stakeholders. Research managers, CAOs, industry executives, and academics themselves see this as a major problem, the solution to which can make a major difference in continued support of robust programs.

The core of the problem lies in the different cultures, values, and incentives of DOTs and universities. DOTs are concerned with research because many of their efforts necessarily deal with technology. Improving this technology will enhance their ability to perform their missions, reduce their costs, or both. They want solutions to observed problems (e.g., premature pavement failures), new technology to better serve their customers (e.g., better traffic control or traveler information systems), or they want to better address adverse consequences of transport improvement (e.g., improved environmental mitigation methods). DOTs want practical solutions or tested devices that they can employ without fear of embarrassing failures. They are interested almost exclusively in funding *applied research.*

Conversely, universities are striving to be great research institutions, providing incentives for staff to obtain research grants, make scientific breakthroughs, and publish results in distinguished peer-reviewed journals. The culture tends to give more credit for fundamental research with its possibilities for conceptual breakthroughs than for practical products. An institution that prides itself on its freedom to pursue knowledge insulated from the vagaries of public opinion and political processes is hard to reconcile with the realities of applied research, with its preconceived prescriptions, contract-specified research processes, deadlines, funding limits, and reporting requirements.

U.S. universities as a group have been extraordinarily successful in producing more technical breakthroughs than

any other nation (say as measured by the number of U.S. Nobel Laureates or patents). One can therefore observe the attributes of this culture without being critical of it. The United States may not be perfect, but it clearly has been doing something right. In any case, it exists, and it is unlikely that we can, or should, expect to change it (*14*).

State DOTs have implemented a variety of models for harnessing the research capabilities of universities to their needs for applied research, but the resulting partnerships can be frequently uneasy and, when so, trust is often the missing element. Some faculty are happy to take DOT research money, but prefer as few strings as possible. Some resist deadlines, accountability, or oversight and when they do, DOT personnel are frustrated and lose trust. In such cases, the university appears to deomonstrate that it has little concern for sponsor interests.

On the other hand, there are numerous examples of effective partnerships that develop trust and are able to maintain robust research efforts over extended periods. Such partnerships vary significantly in their organization details, but they have without exception established a culture of mutual trust. Ways have been found to bridge the culture gap, or at least to link it sufficiently so that both can benefit (*15*).

Because few universities demand a strong accountability from faculty as to their management of research, successful DOT-university alliances sometimes depend on organizational strategies. These strategies include the establishment of legislatively sanctioned or mandated independent research institutes located on campus, with their own staff, but able to harness the resources of faculty and graduate students for particular projects. These institutes can develop strategic alliances with DOTs in which they are assured continuity of funding and provide a responsive research organization in return. Both sides must continuously work at encouraging trust by understanding the motivations and culture of each other and ensuring that a win-win atmosphere is sustained.

Research institutes or university offices of research coordination give a point of administrative and management contact for the state DOT research unit. It is significantly easier for the research management in the state to develop trust in the DOT-university partnership when there are specified individuals from the university also having the role of fostering the alliance. Using institutional structures assures that both parties in the alliance know how to do business with each other. Moreover, by means of such structures, the culture and accountability differences between the DOT and the university can be addressed through an understanding of what is required from both organizations. The institutional structures developed by many universities for dealing with state DOTs and other research sponsors often result in a more robust research effort at the state level.

In addition, such a coordinated approach by a university when performing work for the state DOT reduces disagreements over administrative matters. Researchers seem to agree that administrative disputes may equal or exceed technical concerns when working with universities. One northeastern state has addressed these problems by developing appropriate research schedules compatible with academic calendars. The state positions these projects for a start date in August and provides multi-year commitments for securing graduate student researchers for the effort. Reducing the opportunity for schedule conflicts encouraged trust.

DOT-university collaboration has been particularly strong in Virginia where the Virginia Transportation Research Council (VTRC) has been successful in maintaining a robust program for many years. One truststrengthening by-product of that union has been the stream of engineering students who find employment in the VTRC, move to the DOT upon graduation, and over the years become executives in the DOT. Aside from its other benefits, such an arrangement ensures a predisposition towards the VTRC and its research programs by senior DOT executives, assisting in the maintenance of a robust program.

TRB finds itself frequently at the intersection of these cultural vectors. The nature of its work requires that TRB maintain close relationships with faculty at many major universities. Such experts work on TRB committees, participate as volunteers and consultants on TRB-managed research efforts, and are significant contributors to TRB's publications. In the early 1980s, several academics approached TRB concerned that publishing in TRB's peerreviewed journals was not recognized by some university deans and department heads as creditable in decisions related to promotions and tenure. In response, TRB participated in a study to determine the extent of the problem and what might be done. It was determined that most universities did recognize TRB's peer review process and did credit faculty members choosing to publish in TRB's journals; however, some universities, particularly those where transportation work was located in business schools, economics departments, etc., where TRB was relatively unknown, did not credit such publications. Academics located in those institutions wanted changes that might help their situations; some pressed hard for a new publication series that would be devoted to more theoretical and basic transportation themes. TRB resisted this, believing that it would degrade its regular publications dealing with applied research. However, it did work to increase its visibility and credibility to targeted universities in other ways, trying to maintain trust, both in academia and in DOTs and with other applied customers.

R&D LINKING: TRUST PERFECTED

Perfect trust is not likely to be found, but its direction can be easily perceived as a merging of R&D with other business strategies aimed at mission achievement. In *Third Generation R&D*, Roussel argues for such a merger, "... research and development management is a continuous interactive process. It demands active dialogue and a sense of partnership in technology among the leadership of R&D and other key managers focused on business strategy. This is possible only if all involved undertake to educate themselves about each other's concerns and perspectives. This style of R&D management requires regular review of the R&D project portfolio in relation to product and market strategy. It requires active participation of general management to ensure direction, provide guidance, and mobilize resources" (*11*, p. *xii*).

Such linking is a major challenge for business and even more so for surface transportation. One midwestern state has made a concerted effort to link DOT goals and research. A strategic plan was prepared that was rooted in market surveys of customer values and a small set of overarching goals was identified. Measures of effectiveness were developed and responsibilities assigned to major departmental units. Business plans for subunits were also prepared that included milestones and measures of effectiveness. Plans for achieving these targets were developed that evaluated alternative methods for cost effectiveness. R&D was found to be cost effective in some instances and was included as an integral part of the strategic plan with funds provided appropriate to the task. Measures of effectiveness for R&D were also developed.

This approach resulted in R&D becoming a part of the team dedicated to achieving departmental goals and incidentally to a significant increase in the R&D program. If research is able to meet its goals and makes its planned contribution to the achievement of departmental goals, it will likely have induced an environment of trust between general departmental management and R&D.

A new generation of DOT management could dismantle this idealized trust relationship, and there are no guarantees in life for us as individuals or as organizations. However, the longer this intimate relationship exists between research and its parent, and the more widespread it is throughout the department, the more likely robustness will be maintained.

Although synthesis interviewees agreed that trust was the preeminent characteristic of robust transportation programs and supplied considerable anecdotal evidence to support their contention, trust remains a two-way street. Top managers must give access and the opportunity for the cultivation of trust and research managers must conduct programs that encourage trust. It has been observed that several of the other key attributes cited in this report, for example, marketing, deal making, and accountability, can be seen as merely methods used to enhance trust; but trust is the ultimate goal. With trust a program will likely prosper; without trust, a program will likely become marginalized and ineffective, notwithstanding its other strengths.

CHAPTER FIVE

MARKET BOLDLY

WHY MARKETING?

Conventional wisdom holds that there is a marked dissimilarity between the stereotyped image of the researcher and the salesman. The researcher is seen as clad in a smock, alone in the lab with myriad instruments, possessed with a technical/analytical/introspective/problemsolving mindset. The salesman is seen as dressed more flamboyantly, loudmouthed, and inherently extroverted/unfocussed/breezy and less substantive. The researcher's work contributes to human welfare, whereas the salesman's efforts are motivated by self-interest. Although overblown, this image contributes to our understanding of the reluctance of some researchers to market their activities. This researcher probably believes that if an activity has value, it will sell itself. If the research program produces useful products that assist the parent organization in accomplishing its mission, then that will become apparent soon enough, and no additional effort is required, or appropriate, to ensure that others see these benefits.

Top managers agree, however, that reality is more complicated, and that it is not enough just to "do good." What is also required is to be "perceived as doing good." This means that as part of the job a manager of any activity must ensure that the unit is perceived as dedicated, competent, and more than adequately fulfilling its mission.

Although successful research managers agree, some researchers apparently do not. Alex MacLachlan, former Senior Vice-President at DuPont, noted that as soon as the researcher gets "off the bench" and begins to supervise projects, the researcher becomes a salesman if he or she wants success, and even "when on the bench" needs to be able to sell the project. Charlie Miller, Dick Braun, Calvin Grayson, and Ivar Schacke all noted marketing as an essential element of research management.

Some individuals may be concerned about a distinction between marketing and selling. The use of market research that places emphasis on the preferences and habits of buyers has somehow made marketing acceptable, whereas selling may not be. Webster makes less of such distinctions, however, defining marketing as "the entire process of storing, shipping, advertising and selling which promotes and actualizes a sales transaction." Selling on the other hand is defined as "to cause through salesmanship to accept, approve, desire, adopt, or purchase something; as to sell the public on a new trend." Our impression is that the successful research manager will use the best of selling and/or marketing as required.

The transportation research manager has a special need to market his or her enterprise because no one is quite sure what to expect from research. The output of the departments of design, planning, or construction are fairly well understood because these products look more or less the same from year to year, and although conditions and requirements change, the techniques employed are fairly stable. There is a recognizable basis for evaluating the effectiveness of such activities.

Conversely, research must move into unfamiliar territory and find untried solutions with results inherently uncertain. Research rarely moves linearly from problem identification, to research concept, to program execution, to results, and finally to implementation. Frequently, research is trying to test the feasibility of a technology or process developed elsewhere, which may require testing by some other department before it is ready for deployment. Improvements flowing from research are usually not dramatic, but are more likely incremental, and the value of the improvement is hard to gauge. It is difficult to measure the effectiveness of such an untidy and uncertain activity, even for those with technical skills. Considering the modest level of technical literacy of many CAOs, evaluating effectiveness is especially problematic. Research managers must be prepared to step into this vacuum and make a case for what they do, how they do it, and why it is necessary.

Marketing is needed at every stage of the process; in the solicitation of problems, in anticipating research needs not otherwise identified, in justifying the time and budget resources required, in persuading others to test the product, in arguing for deployment, and in selling the overall need for research. Considering the lack of incentives for DOT research including, a risk adverse climate, nontechnical backgrounds, and short tenure of top management, and the nationally decentralized structure of surface transportation, it is not surprising that marketing is seen as a top priority for research managers.

MARKETING FOCUS OF INDEPENDENT RESEARCH ORGANIZATIONS

It is instructive to contrast the emphasis that independent research organizations put on marketing compared with those that are organized internally. Southwest Research

Institute in San Antonio is a typical nonprofit research organization, one of several founded after WWII to serve the needs of industry in its region. Some of the initial seed money was provided by an individual who believed in the concept, but long-term success depended on obtaining contracts from those who believed they needed the results of applied research and were willing to pay for it. In such cultures, the essential role and need for "rainmakers," that is, those who can successfully market potential clients, is obvious and highly regarded. Norm Abramson, former Executive Vice-President of Southwest, an organization with contract revenues in excess of $250 million annually, stressed the essential nature of marketing for the success of their organization.

There are also many commercial consulting firms that conduct research where the ability to market is the most valuable and highly rewarded skill in the organization. As a senior officer in Planning Research Corporation, a major defense research and consulting firm, once said, "A young engineer begins his career 'doing the work,' and if he does well, is promoted to 'managing the work,' supervising others. If he is good at this, he will then be called on to 'get the work.' Getting the work is the highest skill of all, and those most successful will be made corporate officers." Organizations may do good work, given the opportunity; however, they must also be good at "getting the work" if they are to grow and enjoy a robust status. In this context, marketing is seen as an essential component of a successful research organization.

The clients of research conducted by independent organizations are using discretionary money, that is, funds that if not used for research could be used for other important purposes (e.g., profits, training, advertising, employee salaries, etc.). However, they believe that successful research is essential to their mission and, because scarce dollars are being used, they want results. Accordingly, they demand accountability of their researchers and will tend to manage the research efforts, that is, they want to know up front the approaches to be used, and will monitor progress as the project unfolds. They also will gain impressions of the research organization and use this information in making decisions about future research efforts. The researcher in this context understands the need for performance if future work is to be obtained. Incentives are used to solve the current problem if possible. The researcher, however, also wants to ensure that the client knows that the research manager and the organization are highly skilled and have extended their best efforts whatever the outcome. This requires marketing.

MARKETING MOTIVATION IN INTERNAL RESEARCH UNITS

Motivations are less pronounced when the research unit is organized within the client organization, as it frequently is in transportation. DOTs often regard research as an overhead activity, but one so small and so poorly understood by top management that they often do not demand accountability or manage the resource effectively. The research manager wants to do a good job, but sometimes views the task narrowly and focuses on the technical aspects of the activity. Marketing becomes a daunting task, given other responsibilities, when the research manager may not have the required skills or the staff resources to address it.

This tendency was demonstrated when, in the mid-1980s, TRB decided to begin a "Research Pays Off" feature in *TRNews*. It was believed that top managers and legislators would be more likely to support research if they better understood the nature and value of products generated by research and had some quantification of this value. It was decided that the best way to accomplish this was to provide anecdotes on individual research success stories. Each anecdote would be limited to two pages, include credits to the performing and funding organization, identify the problem that needed a solution, the costs of performing the research, the nature of the solution, and the benefits flowing from its application, quantified in dollars if possible.

Nearly everyone thought this was a good idea, certainly worthy of a 1-year trial, during which six success stories could be told. If this proved successful, the series could be continued. It was easy to identify a number of potential product candidates, along with the responsible research organizations. Problems arose, however, when the successful researcher was asked to report on the experience in the prescribed format. By this time, the researcher was engrossed in some new project and had little interest in revisiting an old project that by now had lost its technical challenge. The results had been successful and were being used, and that was enough. When arguments were presented as to why this was important (that top management needed to comprehend the value of research products in terms they could understand), the researcher might agree, but not why it was necessary to interrupt current work. Someone else could take care of the marketing.

Even more surprising was the muted enthusiasm of research managers. Presented with the opportunity for their unit to get national publicity, they often waffled. They appreciated the chance for favorable notice, but not if it meant any delays in on-going work.

The Research Pays Off series has been successful despite these difficulties and remains a feature of *TRNews*. Within a year of the beginning of the series, the chairman of the powerful House Transportation and Infrastructure Committee was citing examples from the series in speeches justifying increased expenditures for transportation research. He cited specific problems needing solution

and the burdensome costs that would result if solutions were not found. Then he noted the solutions found by research and how much had been saved by a fairly modest investment. Examples he used were drawn directly from the series.

A critical analysis of the series would be required to acknowledge that these anecdotes do not prove anything; noting only the successes, while ignoring the failures, skews the outcome. However, efforts like the Research Pays Off series is pure marketing to officials who need some understandable concrete examples of the types of benefits that research can produce, and that such benefits are in fact being obtained. Successful research managers tend to use similar marketing approaches.

SHIFTING FROM AN INTERNAL TO AN EXTERNAL STRUCTURE (THE TRRL STORY)

The change in marketing emphasis when an organization has to make the shift from an internal research unit, with most of its funds provided by its parent organization, to an external unit, which must compete with others for its survival, is instructive. This transformation was required of the United Kingdom's Transport and Road Research Laboratory (TRRL) one of the largest transportation research institutions in the world devoted to surface transportation, during the 1990s. The shift was successful, and after an initial downsizing, the organization is now growing again.

John Wootton, former director of the TRRL, held this post during the period when Thatcher government policy dictated that the government was to become a purchaser of services instead of an operator of services. Accordingly, the TRRL was to be shifted to "executive status," and government funds assigned to it previously through the appropriations process were now to go directly to the Ministry of Transport (to which the TRRL had earlier belonged), requiring the TRRL to compete with other research organizations for its work. Because nearly 95 percent of TRRL's revenue came from the Road Research Vote (grant), it was clear that the organization was bound to lose revenue when faced with competition. The 632 members of the permanent staff were going to have to face a new and uncertain future.

As Wootton noted,

> The main issues came from the changed nature of the business-TRRL now had customers on whom its future depended-and a declining revenue. The solution was to explain the problem carefully to staff and provide a clear vision and targets for the future. At early staff meetings, he would explain the change that was occurring, tell of his concern for them as researchers and people, the need for good project management, sound finances and potential markets. He told them that his initial interest was to look at the image of the organization, its relationship with customers and future markets. He found that customers considered TRRL as introverted while the staff considered themselves as extroverts. Happily customers regarded the quality of the research as high.

Wootton then set about to shift the organization's thrust to marketing while still maintaining the quality of its output. He went on,

> With this vision in place the issues then requiring attention were customers, markets, revenue streams, organization, the quality of research and the staff. With respect to customers. there was a need to remind them of the strength and depth of TRRL's expertise and at the same time 'cuddle them.' An early action was the production of "TRL NEWS" a quarterly news letter that would contain short articles on research activities. In specifying its terms of reference to the editor, he insisted that articles should be no longer than 500 words, that every article should include a quotation from a customer and at the end of each article there should be a TRL (another marketing move was the change of the name to Transport Research Laboratory, TRL) contact name and telephone number.
>
> Far more fundamental, and soul searching for many of the staff, was the change in the internal organization. It was very clear that TRL had to be customer focused and that this could only be achieved by changing the roles of individuals, relationships between groups and procedures within the Laboratory. After much discussion with senior staff, and with considerable trepidation, he replaced the existing seven level hierarchical structure, with a flat, matrix style structure comprising four units-Business Development, Resources, Research and Finance. In the new structure, the Business Development unit had the responsibility for all relationships with customers. Hence they were responsible for obtaining new business and ensuring existing projects were delivered on time. Project managers were drawn from an appropriate Resource Centre and reported to the relevant Business Development Manager.
>
> In retrospect, this organizational change was one of the most important and beneficial changes made, as it destroyed existing relationships and demanded the formation of new ones. It also gave new responsibilities to people and empowered them to take action.

The point here is not to argue that external organization for research is superior to internal, nor is it arguing for any particular change that was instituted at TRRL. Rather, it is to show the dramatic change in focus that an organization will assume when its very survival is at stake. Also, by underscoring that much of this new focus is on customer needs, it includes a very strong marketing emphasis that ensures that the customer knows of the good things that research is producing.

METHODS

Successful research managers intuitively understand the need for marketing and do not shrink from meeting the need by using any reasonable means at their disposal. Marketing of research takes many forms, and pointing out the benefits of successful research in a publication series is only the beginning. In a very real sense, some of the other

key attributes of robust research cited in this report, for example, policy research, deal making, economic orientation, are all components of marketing, of getting the research function to be seen in its most favorable light, of increasing confidence that it is needed and can produce results.

In talking with successful managers of robust programs, one gets the impression that marketing has a lot to do with the attitude and enthusiasm that is prevalent in most of what they do. These managers appear to be looking for opportunities to let others know of their activities. For example, many research managers are considering marketing impacts when they put together advisory committees or boards of directors for their research units, and when they organize steering committees for individual projects. With the regulatory requirement of a research program advisory committee each state has the opportunity to use these bodies for marketing its research. Annual reports are made more attractive with customers in mind. Joint venture research with other organizations may produce better products, but such ventures can also increase the visibility of the organization and of the research program. Subtle adjustments such as use of the word "teams" to describe project oversight committees made up of both inside and outside individuals reduce feelings of second class citizenship by the outsiders. The securing of special funding to permit some projects to move ahead on a fast track, thus improving the timeliness of research findings, makes the research more responsive and also happens to be good marketing. Participation in meetings with construction industry representatives, safety advocates, ITS groups, cities, counties, environmentalists, and other stakeholders can all increase awareness of research and its potential. Such opportunities are potentially limitless and require that targets must be carefully selected.

Some programs, recognizing the importance of marketing, have employed staff or contracted for special marketing services. Others have required that their research contractors prepare report summaries of completed research suitable for promotional purposes. These are useful devices that have been successfully employed by robust programs. It is important, however, that such approaches not be seen as the whole of the marketing effort, but as part of a larger set of marketing activities.

Given the essential nature of marketing, it would be useful to provide training for research managers and others in the techniques and methods useful in marketing their programs. Partial training was available in the early 1990s as part of a course presented by the National Highway Institute. This course is no longer available; however, consideration could be given to the preparation of a new course devoted exclusively to marketing. The FHWA is currently making efforts to fill this gap through the availability of a marketing specialist and marketing courses for state DOTs. However, more such opportunities, specifically for the unique needs of research managers, may be very beneficial.

Gary Allen, Director of the Virginia Research Council, a strong state research program for many decades, acknowledges the need for a conscious marketing posture at many points in his program. His agency now uses 13 advisory committees covering the full spectrum of research interests. He notes that they make efforts to ensure that they include all 27 division administrators, all 9 district engineers, and many of the resident engineers and assistant administrators on these committees. This not only ensures that their research programs are responsive to parent interests, but it also ensures that as these people are promoted to higher positions, they enter senior management ranks already familiar with the Council. He noted that currently every top official in their department had served on council advisory committees in the past.

Allen also takes pains to ensure that many of these committees include local government officials, some academics, and "corresponding members" from the private sector. He noted that the Council's offices, located at the geographic center of the state, were a good place for meetings, and they intentionally make their conference rooms and other facilities available for meetings of constituent organizations, even when the meetings do not concern research. This allows for more contact with their customers. Briefing of new CAOs and their deputies is high on his list of priorities. He emphasized their use of quality graphics to make favorable impressions. Busy new top executives might not be willing to take the time for a research briefing, except that they are surrounded in the front office by people well acquainted with the Council.

David Albright, Research Bureau Chief of the New Mexico State Highway and Transportation Department, describes in some detail how the research program in his state progressed from a very small program of less than $250,000 per year in 1986 to a multi-million dollar partnership [Alliance for Transportation Research (ATR)] less than a decade later (*16*). The process of building this robust model follows many of the precepts advocated in this report, including sensitivity to the financial interests of parent organizations (see chapter 6), deal making (see chapter 7), and accountability (see chapter 8). It is difficult to separate all the interwoven components of this success story, but Albright acknowledges that unabashed marketing was an important part. Some elements of the ATR program related to marketing were as follows:

- Working on research activities that resulted in a financial advantage to state transportation interests, and capitalizing on the resulting research interest by management to expand research funding;

- Establishment of an innovative research partnership that took advantage of resources unique to New Mexico, including the state transportation department, two New Mexico federal laboratories, and two state universities;

- Providing visibility for the ATR by the establishment of a high level oversight group that included top people in each of the partnering organizations and extending advisory participation to other organizations including the U.S. Department of Energy (DOE) (within which the two New Mexico federal labs were organized) and the FHWA;

- Providing technical direction by the establishment of an operations committee with appropriate mid-level representation from the partnering organizations;

- Reaching out to the commercial sector by forming an ATR Industry Advisory Board, both to increase ATR visibility in the private sector and to get valuable input from this sector in determining an appropriate research program;

- Reaching out to the public through use of a statewide conference on intermodal planning, with support in three languages (English, Spanish, and Navajo);

- Meetings with the governor to obtain his support for the ATR as a state resource with the demonstrated ability to obtain outside funds to conduct research useful to the state;

- Establishing an awards program recognizing national leaders in research. These awards not only encouraged researchers, but also increase the visibility of the ATR throughout the United States; and

- Reaching out to international research organizations and participating in international research. This activity expanded the horizons of ATR participants and also resulted in conducting funded research useful to international organizations.

The ATR experience is evidence of the effectiveness of innovative marketing in a DOT setting. The university setting provides no less opportunity for effective marketing. Some academic researchers are legendary in their ability to conceive and implement effective marketing, while simultaneously conducting credible research. The director of one research center at the University of West Virginia has established a credible presence in his chosen field; however, he also has mastered the art of effective marketing on behalf of his unit. He has developed professional relationships with one of West Virginia's U.S. senators, with the CAO of the West Virginia DOT, and with other state leaders. He successfully competes for research contracts with other institutions, but also uses his contacts with leadership to encourage special funding in federal and state legislation. He periodically invites state leaders to special briefings of his work in which he describes the status of selected research projects, the value of his findings, and its application to West Virginia's needs. It can be argued that such special pleading works against orderly peer review processes designed to select and oversee priority research programs. However, one does not have to agree with all aspects of his methods to respect the fact that he has developed a relatively robust research effort that has sustained itself over many years, and that bold, skillful, and innovative marketing has played an important role in achieving this record.

ANTICIPATION OF NEEDS AND OPPORTUNITIES

A keen sense of timing is important in the marketing of research. Frequently top managers identify current problems in genuine need of research, but are not enthusiastic about moving ahead because of the time (several years) realistically needed to obtain results. This is frustrating to the researcher who understands that research never begun is never completed, that the identified problem will continue to exist, and that work should begin as soon as possible if solutions are ever to be found. Nevertheless, for top managers who see their own tenure as from 2 to 3 years, initiating projects with outputs 4 or more years away somehow loses its appeal.

Many transportation research organizations have welldeveloped processes to facilitate identification of needed research projects, including user committees and/or conferences, in what might be characterized as a "bottom up" process. Such a process permits identification of pressing problems by operating units, and then comparing them to set priorities and ensure the best use of available funds. There is reason to believe that such systems are effective, but often insufficient, because they frequently emphasize current problems at the expense of more important ones that are on the horizon, but have not yet had visible impact. They also emphasize needs as perceived by units represented on the committees at the expense of more important needs being experienced by nonrepresentatives. Research managers in a marketing posture should always be trying to view the world through the eyes of the larger stakeholder community in order to increase the breadth of the program and its relevance to a larger constituency.

One northeastern research manager makes a particular effort to meet on a regular basis with key technical leaders within the department for the purpose of determining what is on the horizon in their respective technical areas. This research manager has had access to top management and

the strategic issues of concern within the agency. Augmenting this knowledge with a scanning of technical progress in relevant research areas allows the manager to encourage problem statement development for projects that will become issues of importance in the future.

Howard Newlon, the former director of the VTRC, considered it his mission, if possible, to have answers to problems before the department management realized they had the problem. This took an extraordinary effort in determining what issues would become important in the future. With careful planning and perhaps selecting parallel approaches to problems the research group was able to produce answers within a significantly reduced time.

Calvin Grayson, former director of the Kentucky Transportation Center, described how this worked in Kentucky. Although he felt the need to be sensitive to projects that had been identified and funded by the state transportation cabinet, he also was constantly looking for upcoming issues that the department would likely be required to address. At the same time he searched for upcoming problems of building contractors, materials suppliers, equipment manufacturers, and local public officials, especially the administrative judges who managed county activities. By working with such officials he was able on occasion to develop jointly funded projects, and when that was not possible, to use the political clout of such groups to obtain special public funding, either administratively or by legislation. This can rightfully be called deal making, but it is also marketing; identifying a need to be filled and promoting the project jointly with those who would benefit.

Part of the answer to this problem lies in anticipating opportunities while there is still time to prepare. When ISTEA legislation was first passed and included significant funds for ITS research and demonstrations, there was little clamor from DOT middle managers or practitioners for ITS research projects. Yet, only modest foresight was required to see that there were many opportunities for work in this field. Many of the demonstrations required a long lead time to develop the public and private participation and partnerships required. A number of states and local areas correctly perceived of this coming need well before it was apparent to all. When requests for proposals were issued, these localities were ready with well-thought-out projects.

One research manager tells of preparing a research program in the early 1980s that would include solutions to environmental problems that were just becoming issues of importance to highway officials. The research manager found an engineer within the agency's highway design group who was interested in and anxious to begin research on emerging environmental topics. Recognizing that here was an individual who understood trends and saw future issues of importance, it was not difficult to encourage the engineer to prepare reports on several issues for submission to the annual research problem solicitation process. The same process was repeated during the next several years so that as environmental issues became critical there were solutions already flowing out of the research pipeline.

The SHRP was established in response to recommendations of the STRS conducted by the TRB. When the STRS study was first proposed in the early 1980s research funding was low and declining in most areas of the country. One of TRB's goals was to "encourage research," but it was not succeeding at this. Tom Larson was CAO for PennDOT (and later to become FHWA Administrator) and chairman of the TRB Executive Committee. He had been a professor and researcher earlier in his career and was predictably sympathetic when the TRB Executive Director proposed a study to analyze national research needs and perhaps make a recommendation for new research totaling $100 million. It was believed that by forming a study committee made up primarily of CAOs research needs believed important to top management might be identified, and that simultaneously a constituency would be formed that could obtain the funds needed for its execution. First, however, funds had to be obtained to conduct the STRS study, but it was not feasible to openly suggest the conduct of a study whose purpose was to stimulate interest in a much larger research effort to follow. Rather, its purpose was ostensibly to "develop a national five-year research agenda." No one was quite sure what that meant, but some initial investigation had developed statistics that convincingly showed the paucity of current research efforts. Statistics from a variety of industries showed that transportation spent a much lower percentage of total revenues for research than even the most ordinary industries in the private sector. After discussion and acceptance by the TRB Executive Committee, Ray Barnhart, the new FHWA Administrator, approved funding for what came to be known as the STRS study, which later recommended the SHRP program (a fuller discussion of the SHRP program can be found in chapter 6). This is an example of how research can be marketed when appropriate efforts are made to respond to opportunities derived from otherwise unfavorable circumstances.

In summary, there is a consensus among top managers and successful research managers that marketing is an essential component of robust research programs. Neither the value of research nor how it is managed is well understood among many top transportation managers. Often, because the time from project inception to final results of research projects is longer than the tenure of many top managers, their interest in research tends to diminish. For these and other reasons marketing has an important role in improving the acceptance of research as a vital part of a

state transportation program. Successful research managers use a variety of methods to accomplish this, but a strong focus on the customer and customer needs are at the heart of these efforts. Successful marketing will also strengthen the bonds of trust between research and customer. Marketing needs to be seen by both top management and research managers as a vital part of the research manager's job.

CHAPTER SIX

ROOT IT IN ECONOMICS

At the core the research manager must be educated and trained in science and technology to the point of knowing the nature of the technical problems targeted for research. Researcher managers must have some notion of alternative solutions to such problems, the expertise needed to address them, and the equipment and financial resources required to solve them. In addition, they must have the technical knowledge to gain and maintain the respect of technical subordinates. Finally, such knowledge is essential to earn the respect and confidence of major line units in DOTs, the major customers of research.

BUDGET ORIENTATION

Scientific and technical knowledge, although essential, is frequently inadequate and sometimes irrelevant when dealing with top managers and budget officials, where expertise in finance, economics, and communications is more useful. As noted earlier, CAOs are frequently appointed from nontechnical fields, and have little knowledge of or interest in technology. When thought of at all, CAOs assume technology to be the product of scientific labs located in academia or high tech industry. Although it may be apparent that the DOT is a heavy user of technology, such technology is often viewed as unexceptional and largely outdated. After all, roads and bridges have been built for generations; certainly we know all that we need to know, and if more is needed, let the federal researchers worry about it. In such situations, requests for research support may fall on deaf ears.

CAOs realize that they may be in office for only a few years at most. They may have many objectives, but none can be accomplished if they cannot defend their budget requests in a highly competitive environment. Sometimes this requires increasing road taxes, proposing special bond issues, or other highly controversial initiatives. Setting aside the politics, advocating such measures is primarily an exercise of salesmanship where the relevant language is in terms of percentages, dollar signs, and decimal points. CAOs must show why the funds are needed and why taxpayers will have to bear even higher costs if the requested funds are not provided in a timely manner.

CAOs know that they must demonstrate that they are not wasting tax dollars within the department and that every measure has and is being taken to do the job with the least resources. Measures that promise reduced costs in the short term are the easiest to defend. More difficult are measures that cut costs in the longer term, especially if the savings are large, reasonably certain, and not too distant. Still more difficult, but not impossible, is defending measures that do not promise savings in tax dollars at all, but promise to save motorists or truckers travel time, and improved safety or convenience. Even here the task is easier if the savings can be quantified in dollar terms.

Tommy Hart, Deputy Commissioner, Tennessee DOT, demonstrated senior management's interest in the dollar foundations for research when he spoke at the AASHTO Research Advisory Committee meeting held in July 1998. He noted that research was a means to make his "business" more valuable to its stakeholders—an investment that generates productivity and return to the taxpayer. Furthermore, his response to the topic of getting increased resources for research was to "put together a business plan with specific projects and estimates of investment returns and sell it to the senior staff. With the proper checks and balances to make sure the money is invested well, it is surprising what can result." A full-blown business plan may not always be required, but the successful research manager will be alert for opportunities to show the benefits of research in economic terms.

PROSAIC TECHNOLOGY

In the early 1980s, a recently appointed CAO from North Dakota was quite verbal about his lack of support for research, not only within his own program, but he also saw little reason for state support of national research programs including the TRB or the NCHRP program. When questioned, he acknowledged that his staff had told him of state problems with early and unexplained pavement failures. However, he was confident that they would quickly find the solution to such problems by simply "observing those pavements that were holding up and those that were not, and insuring that in the future they only construct pavements like those that had endured." This disarmingly simplistic formulation seemed persuasive to him. He had enjoyed a successful career in real estate development prior to his appointment, and had never had to give much consideration to how technology was improved. Within a couple of years, however, he discovered that it was not so simple, and state and other officials convinced him to become a supporter of research, both at the state and national levels.

Although such naivete might generate knowing smiles, the tendency to oversimplify the technical challenges faced by transportation agencies is not restricted to the technically unsophisticated. During the period when the SHRP program was being organized within the National Research Council, the president of the National Academy of Sciences (NAS), a world class geophysicist, exclaimed his surprise that such a large effort would be required to understand how to build effective pavements. "Surely," he observed, "it should not be too difficult to measure the relevant independent variables (traffic loads, soils, pavement thickness, etc.) and correlate them with the dependent variable (pavement durability)." However, as the details of the Long Term Pavement Project (LTPP) within SHRP began to unfold, the complexities became more obvious. Pavement sections located throughout the world were to be monitored and measured for 20 years. Hundreds of such sections were required to cover the very large variety of initial conditions of pavement, substructure, and soils, and of the continuing changes in weather, traffic, and maintenance. The NAS president and others soon realized that the very number of relevant factors and measurement uncertainties made the project complex indeed, and with this understanding came increased project support.

That we have been studying pavements and bridges for generations is often seen as a demonstration that such research is of questionable value. Some would argue that if these studies were really doing any good, we surely would have found the answers by now. Why throw good money after bad. During the early 1980s this argument was raised against the SHRP proposal. During that same period, the U.S. auto industry was being criticized by some of these same people for having neglected research on more efficient gasoline engines, resulting in increased sales of Japanese fuel-efficient cars. Somehow, the fact that we had been studying gasoline engines for generations and "if it did any good, we surely would know all we need to know" never came up. Ultimately, both pavements and engines have been studied for almost a century and much has been learned about both, because better pavements and engines are being made than ever before. However, there is much more to be learned.

Pavement researchers need not be shamed by the seeming similarity between current studies and those of the past. Even if we had learned all there was to know about pavements by say 1960, or 1970, there are always new challenges. Heavier loads, scarcity of quality local building materials, changes in the composition of asphalt materials as new sources are found, availability of improved chemical additives, new analysis tools, and the arrival of new economic imperatives to build it cheaper and make it last longer all argue for more research.

Given all this, it should not be surprising that the world of the research director and the world of the CAO are sometimes incomprehensible to each other. The researcher is interested in solutions to problems that the CAO does not know exists. The CAO has a strong interest in saving dollars, but the researcher frequently does not consider the dollar implications of the work.

ECONOMIC AWARENESS IN STATE TRANSPORTATION RESEARCH

A few years ago a visiting official was interviewing a research director from a small state about his current research program. As it turned out, most of his limited budget had for several years been directed at the development of a technique for constructing laminated wooden beams, which promised much greater strength than conventional timber used in bridge construction. He was justifiably enthusiastic in pointing out the progress that had been made, which had required overcoming several interesting technical obstacles. However, when asked about how many locations there were where such bridges might be used in his state, how much they might cost, and how much might be saved, assuming the technology delivered on all its promises, the director knew only in the most general terms. Clearly, he had become so engrossed in the technical challenge that he had not considered that the technology might be irrelevant if its use did not result in immediate or life-cycle cost savings. It is not surprising that his program was small and not likely to grow, nor that his CAO did not see much connection between departmental objectives and research.

It was not possible from the interviews to determine how widespread was the problem of researchers losing sight of customer needs, but apparently it is not uncommon. Several times during interviews anecdotes were offered where research programs, absent from oversight and the demand for accountability from general management, steered themselves in directions of more interest to the researchers than to the customer. One new manager, on taking over an existing state research program, asked for a list of all ongoing projects. However, such a list was not available. The ongoing work was a collection of research activities the origins of which were not always known, and some of the projects even had no name. After receiving an activity inventory and a resulting project list, the new manager asked for a list of customers for each project. Not surprisingly, this list was also not available. Further investigation revealed that some of the customers had disappeared (more accurately, the customers' needs had changed), but research continued, with researchers unaware and apparently unconcerned that the change in circumstances meant that there was no use for the product,

even if the research was successful. Needless to say, such a program had little concern for the economic benefits of its work, nor was it likely to attract the favorable attention of senior management.

Successful research managers say they must become students of the way resources are granted within their respective departments, and then match that style. Gary Allen (Virginia DOT) and Bob Benke (Minnesota DOT), both directors of robust research programs, argue that economically and financially oriented material prepared for their programs is geared to the expectations of management, whether they be department officials or legislative or governor's staff. Another research manager noted that financially based performance measures for his program had been instrumental in saving his budget during a time of severe budget cutting.

Some research directors use anecdotal "winner" projects to show the economic benefits of their programs. Winners are projects with high return on investment, which are also sufficiently practical that financially oriented managers can understand the problems they address and how the research solved the problems. Sometimes, promotional materials are prepared for easy distribution and review by budget officials. The message is that not only was "this project worthwhile," but by inference "research itself is worthwhile."

The research program of the Pennsylvania DOT completed a research effort leading to computer-aided design and drafting for a type of bridge much used in that state. A review of the economics of the project indicated a benefitcost ratio of 20 or more. The director of research developed materials that demonstrated that this project alone had benefits that more than paid for the entire research program. Having such materials at the ready can pay big dividends when defending research budgets.

Successful managers are alert for opportunities to exploit the economic benefits of research to market their programs. David Albright, research director, New Mexico State Highway and Transportation Department, took advantage of such an opportunity to move his unit from a low visibility $250,000 per year activity to a robust $15 million per year program. "Prior to 1985, transportation research was not a priority in the state of New Mexico. Had research funds not been earmarked by legislation in providing federal-aid highway funds, it is unlikely there would have been a research program. The prevailing wisdom was to let larger states, California, New York, Texas, conduct the research and eventually the smaller states would implement the results" (*16*, p. 27).

The opportunity for change came when New Mexico was being threatened by the loss of some of its federal transportation funds, apparently due to being out of compliance with the national 55 mph speed limits. A research effort was launched that resulted in a new methodology for correcting raw speed data collected in the field, which in turn saved the state thousands of dollars. Shortly thereafter, the state was concerned about losing federal funds because of the way traffic data were being collected. A research effort resulted in the development of new traffic monitoring standards. Implementation of these standards resulted in a recalculation of the vehicle miles on state roads, which resulted, in turn, in more federal aid. These two successes demonstrated to state officials that research could provide <u>real</u> (i.e., financial) benefits to the department, and the decision was made to create a research bureau. Within 15 months, research expanded from a one-person function to a formal unit with a staff of nine. Albright notes "The progression was a result of involving research in measurement theory and practice about issues of direct financial importance to the Department."

Having gotten the attention of management and built a measure of trust, Albright went on to make deals with other appropriate research organizations within his state, form a partnership with them, market their special capabilities, and, step-by-step, build a robust program.

Albright used a well-accepted and successful method to gain an awareness of the value and contribution that research can have for a department. Because there are so many pressing issues commanding the attention of the department's decision makers, having one or several "winner project(s)"—projects that demonstrate all the best advantages of research—is often the only entree into the environment of those who manage and distribute department-wide resources—those who can provide the resources to enable robustness. Whether building trust or reputation in a research program or maintaining a good standing within the agency, exploiting the results of specific projects for the purposes of adding to or maintaining the robustness of a program is often effective.

ECONOMICS IN PRIVATE SECTOR RESEARCH

Problems stemming from a lack of financial and economic consideration in developing research programs are not limited to the public sector. For example, a research unit within a plastics manufacturing company developed a revolutionary new concept for making polyvinyl chloride (PVC), part of their existing product line. A phase one project to test the laboratory feasibility of the project was successfully completed at a cost of $2 million, and resulted in a recommendation to spend $10 million more on developing the commercial feasibility of the process. This also was successfully completed, with a recommendation to spend $300 million on a new plant to implement the new

process. When these results were presented to top management, there was a horrified reaction. Apparently, the size of the PVC market did not justify such an investment. Had an appropriate economic and financial analysis been conducted at the outset, the research projects, though technically successful, would never have been undertaken. Although this example may be extreme because of its size, smaller failures of this type are believed common in R&D throughout industry (*11*, p. 5-6).

According to the authors of *Third Generation R&D*, these unhappy experiences tend to occur more often in companies that manage research in the "first generation mode: they hire good people, provide them with the best facilities money can buy, have them work in a creative—possibly remote—setting, leave them alone, and hope they produce commercially viable results." Unfortunately, this description accurately portrays the situation in many states, where research is regarded as an overhead function only remotely connected to strategic departmental aims. In such situations, the research manager must ensure that the research program is focused on economically sensible objectives.

In an effort to address such problems, research directors in commercial enterprises sometimes employ economically based performance measures. No one format for such measures has gained favor across all private sector research programs, and it is generally agreed that the approach must be customized for the particular organization's culture and practice.

NATIONAL TRANSPORTATION RESEARCH: THE SHRP EXAMPLE

The origins of the SHRP were rooted in the concept of designing a research program to directly respond to the financial and economic concerns of management. This is in contrast to the way many transportation research programs are prepared, for example, by the submission and evaluation of problem statements from practitioners in the field. SHRP was a $150 million 5-year intensive research effort aimed primarily at finding better ways of building and preserving highway infrastructure. Although it may be too early to judge how effective SHRP was as a generator of useful transportation technology, there is little doubt that it captured the interest and imagination of highway leadership at both state and federal levels, as well as the private sector. It is viewed by many top managers as a model of effective research and has improved the climate for other research initiatives, many of which found their way into ISTEA.

Such a success could not have been forecast in the early 1980s when the STRS, the precursor of SHRP, was conceived at the TRB. The Reagan Administration had just come into office with the aim of downsizing the federal government, and promptly began cutting government spending. The administration was skeptical about the value of many federal programs, including research. Highway research expenditures, already low by historical standards, were scrutinized for further cuts. TRIS, a database of completed and ongoing transportation research, normally used by researchers to avoid duplicate efforts and build on the works of others, was used by political appointees to seek out projects for elimination. A formal proposal by the Office of Management and Budget was made to sell the Turner-Fairbank Highway Research Center labs to the private sector and cancel all FHWA research efforts. Many state leaders often cited embarrassing technical failures—for example, bridge deck failures, concrete reinforcing bar corrosion, or pavement failures—but could not see the connection between these problems and anemic research efforts. Even highway executives with predilections toward increased research were disinclined to simply "throw money" at the problem through existing research programs.

Despite the lack of interest in public sector research, the private sector, bogged down in economic recession and frightened of expanding Japanese competition in markets long dominated by the United States, was expanding research efforts. Interviews with research managers of some of the largest U.S. corporations confirmed that top corporate executives saw a clear connection between long-term survival and the effectiveness of their internal research efforts and were willing to sacrifice short-term profits to ensure effective research.

Noting these sharp contrasts between public and private attitudes became the basis for the STRS effort. Private management saw a clear relationship between corporate missions and research, whereas public management saw technical problems needing solution, but did not see a relationship between the solution to these problems and research. A committee composed primarily of top state and federal highway managers was appointed to oversee a TRB policy study whose avowed purpose was to develop a 5-year research program seen as important by management. Study staff analyzed spending patterns of research programs and compared them with spending patterns for the highway industry, generally looking for neglected areas and for areas where timely solutions might result in big payoffs. For example, it was found that "about $10 billion annually was spent on asphalt pavements, representing about 20% of all highway expenditures. It was further shown that this was ten times the money spent for AMTRAK, six times the size of the intercity bus industry, half the size of the air carrier industry and more than one-third the size of the entire railroad industry" (*17*, p. 64). Moreover, the national research effort to improve asphalt pavements was a relative pittance of less than $2 million per year and declining. There was little chance that the oil companies that produced asphalt could be encouraged to

spend more on improving their product, given that asphalt represented only about 1 percent of their total revenues and was purchased largely on a low first cost basis. There was also little chance that paving contractors would find ways to produce a more enduring pavement, because state procurements were always on a low first cost basis. The only incentive for contractors was not to produce better pavement, but to meet specifications at a minimum cost. Thus, if improved asphalt technology was to be developed, state DOTs would have to take a leadership role, and they were spending almost nothing on the subject, despite a rising number of embarrassing pavement failures.

When these issues were quantified and reported to the managers on the STRS committee, there was immediate and strong support for a research effort where asphalt problems were a major priority. There was a clear and unambiguous link between problems they understood and the proposed research. If pavements could be built to last 11 years instead of 10, a 10 percent savings would be achieved, or $1 billion annually. It was also clear that the low-bid procurement process meant that no one else was going to make the effort if they did not. When it was suggested that one-quarter percent of federal highway aid would produce about $30 million per year that might be dedicated to research this problem, it seemed a reasonable and proportional response to a major problem. What's more, they now understood the dimensions of the problem, not so much from a technical perspective, but in the financial terms with which they were familiar. Note the term "proportional." Once the group knew the scale of the problem and of the benefits flowing from a better technology, it was necessary to propose a response that could succeed. At that point, it was much easier to sell a $150 million research program than a $10 million program, which would have been seen as insufficient in terms of the scale of the problem. Management saw the relationship between research and their own missions, wanted the problem solved, and was prepared to support a program on an appropriate scale.

Note that none of these factors have anything to do with the technical aspects of the proposed research, exactly what the project would consist of, how it would be carried out, or who would be responsible. Those important considerations followed comparatively easily once a conclusion had been reached that the work was needed.

The STRS study was roundly criticized by many academics and researchers who justifiably felt that there were areas of highway research that deserved attention other than the pavement and bridges, the primary emphasis of SHRP. Many were concerned that the concentrated funding of SHRP would result in reduced support for existing research programs. The plight of "America's crumbling infrastructure," however, had captured the attention of the media and the growing problems associated with maintaining roads and bridges was well known to highway management (*18*). They were willing to support major new funding to address these problems. They were unwilling to support research as a concept or an unfocussed effort addressing all potential needs. As SHRP began work and generated favorable attention, the willingness to support research became more broadly evident, other STRS studies were proposed and carried out, and a number of new research programs were begun during the years following SHRP. Although it would be inaccurate to attribute this success entirely to SHRP, many observers believe SHRP made a major contribution to the favorable environment for research experienced during this period.

It is easy and probably accurate to criticize the SHRP program as being too limited, even at the time it was launched. However, it is better to have a less than perfect program, addressing genuine problems, than no program at all. It was important to engage management such that they could clearly see the critical alignment between effective research and issues they believed important and do this in the dollar terms they could readily understand.

Research managers at all levels would do well to heed the lesson of SHRP and when dealing with management, selling the benefits of their work, or proposing new research, put themselves in the boss's shoes and think dollars. Finance and economics may not be the field of their original training, or an area in which they feel comfortable or one that they enjoy, however, it is one that is necessary if they are to understand top management and be able to convince their bosses that research is an investment worth making.

CHAPTER SEVEN

MAKE DEALS UNABASHEDLY

STRENGTH FROM ALLIANCES

The connection between research and deal making seems counterintuitive. Frequently, research conjures up visions of quiet, unhurried individuals, working in remote laboratories in venerable and unchanging institutions located on ivy-covered campuses. Such circumstances may exist, but organizational and competitive pressures more often force a different reality: ad hoc teams from a variety of organizations pursuing short-term goals necessitated by reduced product development cycles and rapidly changing technology.

Chuck Larson, Executive Director of the IRI, says that rapid change is forcing more alliances and partnerships in research:

> Partnerships and alliances between two or more organizations can be highly effective in developing major new products or processes, or in combining different levels of expertise in research, development, manufacturing, or marketing. Sharing cost and thus reducing risk for pre-competitive R&D can be particularly advantageous in helping to accelerate the innovation process. Intercompany arrangements between DuPont and Merck, Human Genome Sciences and SmithKline Beecham, and GM, Ford and Chrysler (in the Partnership for a New Generation of Vehicles) are examples. Alliances are also growing between industry and universities and industry and federal laboratories (*19*).

Alex MacLachlan, former Senior Vice-President for DuPont, in a recent speech before other researchers, noted the changes in recent years in the way large companies search for needed technology. In the decades following WWII it was expected that within large companies the technology for new and improved products would come from internal R&D efforts, and that R&D management would know which technologies to pursue. External oversight from general management was unnecessary. However, the scope, scale, and speed of new technological development, along with internal budget pressures, have radically changed the old model. Now, large companies look to their R&D units to monitor relevant technology development in universities, federal laboratories, other countries, small companies, and competitors, and by being well integrated into the company's market strategies, to decide the fastest and least expensive way to obtain needed technology. This may mean strategic partnerships with particular universities. MacLachlan says.

> Many research programs between universities and companies around the world are now being set-up to augment companies research organizations. Russian, Chinese and Indian research institutes and universities have benefited from this new approach. The reasons are many, but include access to outstanding research personnel and facilities, lower cost to do research, faster response for research results, knowledge of new markets and many others. Company R&D budgets are today moving more and more to university partnerships (*20*).

University partnerships, however, are the smaller part of these arrangements. Most of the technology alliances are with other companies.

> Often, large powerful companies with global marketing organizations will partner with smaller more entrepreneurial companies to gain or develop new technology and then act as the principle marketing arm for themselves and the partner. In other cases they partner with the smaller specialized company to get some of the technology development completed and then license the results for use in their product lines. There are many variations within this type of partnering but the results have been very good for all involved, including fostering rapid growth of whole new industries based on biological and electronics technologies (*20*).

MacLachlan goes on to describe a variety of partnerships with other organizations, such as federal laboratories, and with competitors in precompetitive research (e.g., Semitech and the U.S. Advanced Battery Consortium). However, all are just more illustrations of the fact that today U.S. industrial R&D is more and more an array of ad hoc arrangements and deals wherein technology is shared both to increase the speed of development and to reduce costs.

The primary objective of realizing such development or cost improvement is to enable the organization to be more effective in its marketplace. Rosabeth Moss Kanter, a leading researcher and author on business topics, notes that, "Alliances that both partners ultimately deem successful involve *collaboration* (creating new value together) rather than a mere *exchange* (getting something back for what you put in)." Such alliances "yield benefits for the partners, but they are more than just the deal. They require managing the relationship, much like developing relationships among people." Alliances that provide what Kanter calls "collaborative advantage" for their partners are "living systems that evolve progressively in their possibilities ... offering parties an option on the future, opening new doors and unforeseen opportunities" (*21*). Kanter also points out that alliances are most often generated by officials who have the vision for the partnership's advantage and have access to others of similar position and influence within their respective organizations. Additionally, these partnerships take time to develop and

mature, particularly as individuals within the organization learn to collaborate with their counterparts in the parent organizations.

The maturing process for alliances, in large part, centers on building trust among the partners. Like the key attribute for robust research programs, many corporate managers consider trust the most important ingredient in making alliances work. Some guidance from IRI companies shows that there are practical steps organizations may foster to allow trust building opportunities and the eventual formation of enduring partnerships. These steps include: (1) encourage friendships—a certain continuity and familiarity of faces is useful, and organizations do not devote enough time to this; (2) facilitate communication—provide the means to develop relationships though personal, voice, and electronic contact; (3) have limitations on management—the real progress is made with the R&D staff, not in the executive suite; and (4) select the size and complexity of an alliance that can be managed (*22*).

PARTNERSHIPS AND ALLIANCES IN TRANSPORTATION RESEARCH

If partnerships and alliances are a major part of technology development among large industrial R&D organizations with their extensive resources, it is not surprising that successful transportation research organizations are also looking for such opportunities. Joint work permits the pooling of funds, intellectual assets, equipment, and other resources, and thus provides the basis for a more intensive, detailed, and complete project than might otherwise have been possible. The limited resources available to transportation research make the need for joint work even more compelling than with industrial organizations.

The advantages of joint work in surface transportation, however, extend beyond these obvious direct benefits. Indeed, indirect benefits may exceed the direct. The decentralized institutional setting within which transportation exists often requires consensus decisions on the adoption or deployment of research products. These joint decisions may be between states, between public and private organizations, or between state and federal agencies. Joint research between effected agencies can sometimes enhance the credibility of the outcome, especially on controversial projects where contending parties agree to work together. It also can assist in getting the attention of a larger multiagency audience, which is important where study recommendations may apply to several organizations. Enough joint work, successfully executed, can enhance the reputation of the originating unit, increase its ability to gain support, and increase the size of its program and its utility to the parent organization; in effect, enhance its prospects of becoming robust.

Nationwide, the ITS program has made unusual demands on the deal making capacity of transportation institutions. Many ITS operational tests, funded generously under the ISTEA and TEA-21 programs, have necessarily required the participation of state and local government transportation agencies, automobile manufacturers, communications companies, police agencies, towing companies, advertising, and computer and information interests. Such diverse organizations are unfamiliar partners, and ITS applications are frequently new and poorly understood. However, in recent years, a number of successful operational tests have been conducted by innovative public-private partnerships organized for the purpose of testing and evaluating untried systems, well within the definition of applied research.

European experience is also moving toward more cooperative arrangements in research, as the European Community seeks economies and consolidation of activities. Ivar Schacke, international director for the Danish Road Directorate, has a job that requires the encouragement of deals among countries, to cost share on major research, and to gain economies of scale. He is also Chairman of the Forum for European Highway Research Laboratories, an organization set up to facilitate cooperative research. They have recently established a web site in which transportation research organizations throughout Europe post their annual programs. The purpose is to permit other organizations with similar problems to join forces early through cooperative deals. There is also a trend toward privatizing research organizations in moves that require the labs to make deals with a wide variety of clients and partner with other performers. One of the world's largest laboratories dedicated to surface transportation, the United Kingdom's TRRL, has recently been reorganized. Although still a government-owned enterprise, it must compete for most of its research activity, similar to a not-for-profit research organization in this country.

The nature of some research almost necessitates joint work to be successful. Clyde Woodle and Bill Peerenboom, both former executive directors with the ATA Foundation Trucking Research Institute (TRI), suggest that their Alternative Fuels Study had to be accomplished jointly to have any chance of success. Several years ago, truck carrier management watched with growing anxiety as California state government researchers began work on alternative truck fuels. Concerned that this work might require use of new fuels, with which they had no experience, TRI invested in studies that would provide realistic assessments of the new fuels including equipment changes, costs, emissions, reliability, fuel economy, maintenance, and operational factors.

An initial study was conducted to screen a large number of alternative fuels such as ethanol, methanol, compressed

natural gas, and liquefied natural gas to determine those that had real possibilities. Several looked promising.

It then became necessary to study the use of alternate fuels in realistic operational settings; however, to do this required developing research and test protocols, obtaining alternate fuel powered vehicles, persuading carriers to operate them in revenue service, and installing an adequate fuel supply and distribution infrastructure throughout the area of the experiment. It also required getting the carriers to agree to keep the required records of fuel consumption, maintenance, operational performance, and reliability necessary for realistic testing. In addition, the carriers would be required to run conventional vehicles in the same service, to permit direct comparisons between conventional and alternative fuel systems.

Because this required extra work and expense on the part of the carriers and subjected them to service risks, DOE and other interested public entities became partners to cover the additional costs, both initial and continuing. Even with the assurance that all extra costs would be covered, some carriers refused to participate, fearing that customer service and reliability might suffer, hurting customer relations in a highly competitive environment.

The deal making required to assemble, reassure, and contract with this diverse group took a number of months of hard work, but the results were gratifying. The use of several fuels could be simultaneously evaluated from technical, economic, institutional and operational perspectives. Moreover, the evaluation was accomplished by institutions that would require confidence in the findings, should it be necessary to implement them.

PARTNERSHIPS AND ALLIANCES BY STATE RESEARCH ORGANIZATIONS

Many state research programs have benefited from joint programs, some organized as temporary to address a specific problem and others organized to facilitate and carry out research programs over a sustained period. Organizing such efforts, "deal making," however, does not come naturally to many researchers, because it appears to be a digression from the primary task, takes significant effort, and shared management and responsibility requires a dilution of control. And if not threatening to the research organization itself, partnering with others can sometimes threaten parent organizations, who fear the prospects of subordinate units making ties to others, outside their control.

One respondent from a midwestern state tells of an experience that occurred when he was CAO. He believed that his research unit, located within the DOT, would be enhanced by the establishment of a strategic alliance with two public universities. He proposed the creation of a new state "transportation institute," in which the state would agree to guaranteeing a minimum level of funding, and the universities would agree to provide space, intellectual and equipment resources, and faculty and students to assist when appropriate. The institute would be overseen by a board composed of DOT, industry, university, and legislative interests. The institute would also compete for research sponsored by federal and other national organizations. The entire enterprise would, if successful, permit an expanded visibility and capability for transportation research within the state, and enable the leveraging of research funding.

This CAO was disappointed, however, because he did not remain in office long enough for the new institute to become completely rooted and build the constituency needed for permanence. The CAO who replaced him had little interest in research, and research managers within the state either did not or could not maintain the momentum. Within a short time, the agreement was canceled. Either the capacity for deal making (and fostering) was not adequate or it was not seen as necessary.

Commenting on the nature of research partnerships, Charlie Wootan, former director of the Texas Transportation Institute—a long-lasting robust partnership of Texas A&M University and the Texas DOT—said, "it takes two to make a partnership and only one to make it a failure. Both parties have to cooperate in the development, funding and conduct of the program to ensure success. There also has to be true commitment on both sides, not just involvement in the program, to make it work. Trust is a critical component of a successful partnership. Like a handshake, there can be no upper hand but a balance and respect for the needs and capabilities of each partner. And finally, partners must work toward accomplishing common goals, standing 'shoulder to shoulder' as allies rather than 'nose to nose' like adversaries."

SUCCESSFUL STATE DEAL MAKING

The importance of successful deal making can be seen in both Kentucky and Minnesota in recent years. In each case, a university transportation research center has been established and headed by a former CAO with a technical background and an appreciation for the importance of research. The backgrounds of these managers provides them with an understanding of the concerns of the respective DOTs and their customers, suppliers, and contractors. They also understand the universities and the legislative process at both the state and national levels. However, one of the major distinguishing characteristics of these programs is the scope and scale of their interactions and arrangements

with all of the varied interests that must work together to make transportation effective. Boards and committees overseeing the research include representatives from many of these interests. Special projects are initiated in conjunction with effected groups, pulling together ad hoc alliances to sponsor work where appropriate. Joint ventures are also formed with private sector researchers, although care is taken not to compete with commercial interests. When federal programs present opportunities for funding (e.g., ITS programs), they organize and promote joint actions across a wide spectrum of state interests. They are effective to the extent they can recognize and create joint research endeavors with win-win potential for all participants while minimizing threats to others.

This creative organizational capacity was at work in the creation of the centers themselves. While still CAO for Kentucky, Calvin Grayson obtained the passage of a resolution by the state university's board of trustees establishing a transportation research center. When he left state government, he noted that the university had not implemented the resolution, and offered to become a half-time employee of the university for the purpose of organizing a service center, under the terms of the resolution, focusing on the implementation of research.

Independent of all this, the succeeding DOT administration, in a cost-cutting move, agreed to transfer its in-house research unit to the university. In time, Grayson seized the opportunity to combine the two units into a transportation research center, effectively acting as an extension of the DOT staff, but located on campus. He developed other constituencies including road construction, local government, and legislative interests, both as a basis for a more effective identification of research needs and also to enhance prospects for product implementation, stimulation of innovation, and technology transfer. By combining interests across a wide spectrum and a broadly conceived work program, including both technical and policy issues, he was able to develop, even within a relatively small state, a threshold of activity comprehensive enough to generate the capability and visibility necessary for a robust program. His understanding of the value of "deals" in the creation of win-win situations, where a diverse constituency can be persuaded to support research on a sustained basis, was an essential component of this enterprise.

In 1987, while still CAO for Minnesota, Dick Braun noticed that court mandated oil overcharge funds of more the $2 billion were being granted to the state from Exxon Corporation. He approached the governor about using some of the funds for the establishment of a transportation research center at the University of Minnesota. This resulted in a $2.75 million grant to the university for the center. When Braun left the state DOT, he moved to the university to establish the center. He set up an array of boards and committees to oversee research activities, including Mn/DOT, university, and other interests. Fortunately, succeeding Mn/DOT CAOs have supported research. A strong university-DOT partnership developed that permitted successful competition for federal and state funds for research. Braun also used his legislative skills to obtain funds at key points through state and federal legislative delegations. Some of the most advanced demonstrations of ITS technologies involving public-private partnerships between state, local, and private agencies have taken place in Minnesota. There is little doubt that transportation research in Minnesota has flourished during the 1990s, in no small part as a result of the deal making skills of Braun and his colleagues.

However, the employment of former general managers as research managers is not always successful. The manager must also have a technical background and an understanding of the research process. At least one European country has experienced difficulties when positioning former top managers as heads of research. Although the top managers had good understanding of the clients and customers, they tended to believe that internal reorganizations were the answer to most problems, and the resulting disruptions resulted in poor morale among researchers and difficulties in retaining skilled staff.

Although former top managers may have a greater facility to make deals and form useful alliances, it is clear that they have no monopoly on such activity. Perhaps one of the most visible examples of successful deal making in state transportation research was orchestrated by a state research director. David Albright, director of research for the New Mexico State Highway and Transportation Department, expanded and energized his unit through the use of marketing techniques and economic factors (see chapters 5 and 6). However, his rebuilding efforts also profited from his creation and active encouragement of supportive alliances.

Shortly after he began his rebuilding program, Albright realized that his relatively small staff and budget would never be large enough to adequately respond to the transportation research needs of New Mexico. However, New Mexico had some unusual research assets, including two major federal laboratories (Los Alamos and Sandia) that had major transportation and human factors research work underway. These laboratories were interested in expanding their work into the civil sector. The state also had two universities (University of New Mexico and New Mexico State University), which included faculty with some transportation research expertise, and that also had an interest in expansion. Albright contacted each place, made visits, and studied the structure, interests, and main players at these institutions. He studied alternative partnership

models used elsewhere. He then drafted a partnership agreement that emphasized the commitment of the partners to "merge competitive organizational strengths" and to "cooperate to meet the transportation challenge by fostering creativity in theoretical design; integrity in data analysis; precision in engineering; compassion for individual travelers; and commitment to the nations economic well-being." Discussions were started about the physical location for the partnership. Alternative names for the partnership were also considered.

In January 1992, members of the partnership made a joint trip to Washington and to the TRB annual meeting. The impressive research credentials of the partnering institutions made a favorable impression on the FHWA, which resulted in the first funded research of the partnerships [now calling itself the Alliance for Transportation Research-(ATR)]. This initial effort built on earlier work by the Los Alamos National Laboratory in neural networks that had application for highway traffic monitoring. Thus, the ATR had its first funded project before opening its first office. It was also clear that this was work that none of the partners could have obtained on their own.

Albright then leveraged this early success to obtain additional funding from the state and developed an annual work plan to support the additional resources. He established an executive committee to provide policy oversight and to reach out to policy level people in each partnering organization. They in turn asked for representation from the DOE (the parent organization of the two federal labs) and the FHWA. They also established an industry advisory board to facilitate outreach and participation by the private sector. Soon, the more actively involved program managers from participating partners established an operations committee. Later, outreach efforts resulted in international research initiatives, which were added to a wide-ranging program, including traffic modeling, pavement research, ITS, safety research, and mobility for the elderly. In less than a decade transportation research in New Mexico had grown from an obscure $250,000 effort to nearly $15 million per year. Just as important, the program now had stature, visibility, and access to and support of management. Much of this expansion was a direct result of creative deal making that harnessed the unique characteristics of a relatively small state in ways that advanced a research agenda of a scale and breath that could make a difference.

BARRIERS

Some research managers recognize the need for such alliances, but are restrained from effective action by agency policies and regulations. Partnerships are new to some departments, and this in itself is a barrier. One research director explained that his unit was barred from participating in a research consortium because of a state rule prohibiting the granting of state funds without receiving identifiable goods in exchange. Others tell of the difficulties of establishing alliances when starting from such a small staff base-there just never seems to be time.

Doubtless there are some situations where organizing partnerships may be beyond the reach of research directors; however, even they should remain alert for opportunities. Leona Kolbet, research coordinator in Nebraska, succeeded in organizing the Midwest States Regional Pooled Funds Program, including the University of Nebraska, Nebraska Department of Roads, and eight other neighboring state DOTs along with the FHWA. Significantly, this consortium was created by a small state research program with only one staff member, who performs most of its research by contract. Although there were procedural barriers, the creativity and vision of an innovative research manager, who was also a deal maker, made the difference.

Historically, its seems clear that some of the most enduring and successful state research programs in our nation have been based on deals between state DOTs and other institutions with compatible research interests. For example, the VTRC was formed in 1948 between the then Virginia Highway Department and the University of Virginia, and the Texas Transportation Institute (TTI) was established in 1950 between the then Texas Highway Department and Texas A&M University.

Clearly, the scope, scale, and speed of new technological development, in combination with internal budget pressures is radically changing the old models for organizing research, both in the private and public sectors. Partnerships and other ad hoc relationships are being employed as never before. State research organizations can take advantage of this environment to expand the scale and breath of their activities by actively working to establish relationships with appropriate and compatible research entities. This study confirms that such deal making is an important attribute of robust research organizations.

CHAPTER EIGHT

INSIST ON ACCOUNTABILITY

IVORY TOWERS

Alex MacLachlan, former Senior Vice-President, DuPont Corporation, was describing the low point for corporate research in his company. For several decades after research had been credited with the invention of nylon—a product that generated windfall profits—corporate research had been a sacred cow, something that management accepted with little question. However, in an age of increased global competition, questions were also being raised as to whether the benefits were worth the cost. In 1983, the company's top management decided that the links between corporate research and the parent company had become too tenuous and called on MacLachlan to do what was necessary to strengthen them.

In 1981, the director of the TRB confronted a similar situation when he was talking with the CAO of the Georgia DOT. The Georgia CAO was an engineer who had risen through the ranks of the department, had been a member of the TRB Executive Committee, and was known to be a supporter of research. However, now he was questioning his state's support for TRB, and especially the NCHRP, believing that the program was skewed towards planning when the real needs were related to crumbling infrastructure. "You are not focusing on the important problems," he said. "You've got to get out of your ivory tower and get real."

BARRIERS TO ACCOUNTABILITY

There are a number of reasons for this attitude. One is history; the establishment of research organizations in major corporations after WWII followed from the technical sophistication of many post-war products. As noted in *Third Generation R&D:*

> Businessmen, naive about technology, hoped to buy science and emulate the success of a DuPont; and aggressive, sometimes arrogant directors of new, rapidly expanding research and development functions demanded independence and isolation to pursue their ideas (*11*, p. *x-xi*).

Another barrier is a lack of understanding and even a common language between researchers and general managers.

> Language and conceptual understanding have been problems. In the United States, in particular, executive leadership has come up through marketing and finance functions, traditionally the most powerful. Training for these functions has not required scientific literacy. The scientific and engineering community for its part has viewed business people with suspicion or disdain—as hucksters and bean counters. Even today there is a widespread doubt among many scientists and engineers that formal business education can have any useful relevance to their work (*11*, p. *x-xi*).

A third barrier is the uncertainty of research outcomes and the difficulties associated with fitting this uncertainty into management's need for quantitative performance measure:

> Another source of friction is the issue of reconciling the unpredictability of discovery with the desire to fit technical programs into a framework for the orderly management of the business. Western business executives have been indoctrinated in the concept of management based on measurement. Measurements of activity (for example, sales or units produced) serve as surrogates for measure of productivity. Cost accounting and control systems have been extended into practically every corner of the enterprise. The research and development function, however, has characteristically resisted this pressure for short-term measurable results, because the results most of the time cannot be seen to be counted. Other functions in the business resent the R&D resistance to being held accountable on comparable terms (*11*, p. *xi*).

In the absence of quantitative measures for management of research,

> Research and development is treated as an overhead item, and budgets are set in relation to some business measure (for example, sales) and at a level deemed reasonable by industry practice. Budgets may be projected several years ahead but usually are set annually. Within this budget framework, decisions about areas of concentration and project continuation may be left largely to R&D management. There is no assurance that the R&D organization, left to its own devices, will pursue programs related to business or corporate strategy, either in focus or in degree of innovation and risk (*11*, p. *xi*).

Perhaps the greatest barrier stems from management's general lack of understanding of research and of their responsibility to manage it like other functions.

It is well-established business lore that many senior managers see their role in R&D planning as one of providing money, not providing the leadership and discipline demanded for excellence. A survey by the Industrial Research Institute reported that fewer than one-third of senior managers involve themselves even at the most rudimentary level of formal R&D project evaluation and selection (*11*, p. 3).

This reluctance can be observed in state DOT and other transportation research activities. In some cases, top management is so unsure of its role that it appears almost

intimidated, especially in the academic setting. A major commercial association in the transportation field recently raised an endowment to establish a university-based research program dedicated to improving the technology on which their members depended. A board of directors was appointed to oversee the research program, with a membership made up mainly of CEOs of companies belonging to the association. An individual, who was a highly qualified scientist in an appropriate field, but whose background had provided little financial experience, was given the job of managing the resulting program. For several years the members of the board struggled in their efforts to understand the financial aspects of the program; where the money came from, where it was going, whether research budgets were appropriately related to perceived priorities, how close were programs following budgets, and how budgets and expenditures were changing from year to year. In their businesses, these individuals would have insisted on obtaining the financial information that they required; however, in the research setting, they were reluctant to assert themselves, lest they unduly circumscribe the research atmosphere. Ultimately, they insisted on adequate financial information, and assisted their research director in understanding their needs, but not before much time had passed during which the development of trust was retarded.

Management's reluctance to manage is especially unfortunate when combined with the tendency of researchers to become enamored with technology and its challenges, sometimes to the exclusion of financial and economic concerns. John Wootton, former director of the United Kingdom's TRRL, noted that this organization suffered some of these problems. From its creation in 1933 through the 1960s, the research program was left largely to its director. He relates that "there was clearly a great deal of free and long term thinking in the 1950s and early 1960s." An old collection of photographs shows two examples of free thinking research that was possible in this period, but which would not be tolerated in the atmosphere of tight budgetary constraints and customer sensitivity that now exist. The first example is an anticollision radar system, with the radar dish mounted on the roof of a car. This can be seen as a forerunner of the Intelligent Cruise Control and anticollision systems now being developed. The second example is an automatically guided and controlled Citroen car, which followed a coaxial cable on TRRL's test track at Crowthorne, a forerunner of the automated highway. In both instances, the research was too far in advance of the available technology to realistically expect useful applications.

DEMAND FOR ACCOUNTABILITY

Whether the problem lies with top management or research management, the lack of basic accountability in the research function results in isolation and a decline of trust and connectedness with the business. When general management views research as an overhead function, and relies on "hope" that research can produce useful products, it may only be a matter of time until research itself will find itself in decline. The ivory tower appellation is one to be avoided by any research manager who desires to build a robust program.

The private sector is losing its naivete about research and is rapidly moving toward increased accountability, though it is not always sure how this can be achieved. Alex MacLachlan notes,

> Research organizations are still viewed as vital but in a significantly different way than in the past. They are expected to be cost-effective in every sense of the word. In some companies research organizations have been severely downsized and in some even eliminated. The latter companies believe they can purchase the technology they need to support what they feel are their real strengths, which might be marketing, product design or manufacturing. The ones that downsized and reoriented expect their research organizations to get them the technology they need at the lowest possible cost and at a speed that outdistances competition (*20*, p. 6).

Even with the best of intentions, holding research accountable can be a tough assignment. Sometimes it is even more difficult when developed on a large scale. During the early 1980s, the vice-president of IBM's corporate research program was giving a guest a tour of corporate research facilities in White Plains, New York. The several large buildings scattered over an extensive campus providing offices and labs for several thousand researchers impressively demonstrated that this major U.S. corporation took research very seriously. As they visited lab after lab, covering a dizzying array of technology, it became apparent that even this very gifted corporate officer had little or no idea what some of these labs were doing. This was not the place where new technology was developed for the marketplace—development work was done within the operational divisions of the company. Rather, White Plains was the focus of corporate research, where new ideas with breakthrough potential were explored. After hearing one scientist give a largely incomprehensible description of his work, the guest questioned how one managed such an enterprise: how were priorities established, how were resources allocated, and how was it possible to terminate nonproductive lines of inquiry. In short, how did one establish accountability in such a diverse and incomprehensible environment?

This corporate research vice-president replied that he followed the practice of meeting with each of his six division heads twice yearly. In the meetings he asked only one question: "What has your division produced in the past six months that may be useful for the company?"

"But," the guest protested, "these people are not developing products. Many are doing basic science, which is unlikely to produce marketable products."

"I didn't ask what products, I asked what had been produced that might be useful for the company. Initially I got answers relating to how many technical papers had been published, how many presentations had been made at professional meetings and the like. While I encouraged such activity, I would insist that I was not asking about that. And I didn't expect that they would have invented a marketable product. But I did expect to hear how what they had learned might connect in some understandable way to the company's business. By repeating this question at each meeting, my managers realized that I wanted answers, so they asked similar questions of their lieutenants, and so on down the line. Eventually the question was asked of someone who understood what the researcher at the bench was doing, and how long he had been at it, and whether there were reasonable prospects for success in a reasonable time. And that person was asking the researcher himself. Some sense of discipline was thus developed, so that those who were better at promising than producing were diverted to more useful endeavors, and unlikely efforts were cut short. The trick is to establish a balance between creation of a stimulating atmosphere where innovation can flourish, while at the same time maintaining a sense of discipline and responsibility. When you think about it, the question I ask is not unlike the ones I get from corporate management. I just want accountability from top to bottom."

ACCOUNTABILITY IN TRANSPORTATION RESEARCH

Such discipline and accountability is also important within transportation research units. Although public sector top management generally continues to be less demanding, perhaps because research expenditures are often small, and because maintaining at least a minimal research effort is required as part of federal transportation legislation, successful research managers sense that this shortfall in top management must be offset by special efforts of their own. Research managers, accountable to top management for productive use of resources, must also establish systems for ensuring such accountability within their units.

Much has been written about how this might be done, some of which is related to the financial and economic metrics discussed in chapter 6. Many research directors from public and private sectors argue for a system of strategic planning in which R&D is among the tools used to achieve corporate goals. Some use benefit cost measures or other quantitative measures of effectiveness, whereas others employ more qualitative approaches. Some prepare unsolicited annual reports describing in detail the source of all funds and how they were expended along with results achieved. Some DOT units are developing productivity measures as part of the efforts of parent departments to become more accountable. This study does not espouse any particular method, but found that interviewees, the focus group, and the literature alike, demonstrated that accountability is an important attribute that contributes to trust and connectedness. Successful research managers will develop some approach appropriate for their circumstances that instills the discipline that comes from accountability.

Such oversight is sometimes resisted when principal project staff are academics; however, ways can be found even here. The VTRC, an alliance between VDOT and the University of Virginia, has had a robust program for decades. Part of their arrangement requires significant financial support for several professors in exchange for their part-time participation in the VTRC's program. If a professor's participation is deemed inadequate or unsatisfactory, the financial support can be reduced or withdrawn.

When Charlie Miller was Associate Administrator of the FHWA, he established the practice of asking each unit head to describe what his unit did last year; the financial benefits, if possible; and what each unit was planning to focus on next year. He felt there was a discipline that was derived from such an exercise that was especially needed in research.

Calvin Grayson felt that accountability for his university-based transportation center in Kentucky was so important that he voluntarily produced an annual report that was clearly a marketing mechanism, providing substantive information about his program, funding sources, and spending. He felt the issue of accountability was so important that he encouraged and obtained legislation requiring that such a report be presented to the governor each year.

Ultimately, accountability is a two-way street. Both top management and research management have essential and complimentary roles to play if research is to reach its full potential. Consideration should be given to including these issues in executive training provided for new CAOs and other senior transportation management. Such training should improve the prospects for senior management awareness of these responsibilities.

However, given the way CAOs are selected, their typical lack of technical orientation, short tenure, and other factors previously noted, top transportation management will often not recognize their role. In these cases, successful research managers will find ways to become accountable, even without such a requirement from above. The resulting discipline of the research unit and its personnel will make a contribution to a continuation of trust and connectedness and therefore to a robust unit.

CHAPTER NINE

EMBRACE POLICY RESEARCH

State activity in road transportation dates back to the early years of the 20th century, and for most of the intervening period the nation has enjoyed a broad consensus about its surface transportation policy. Initially roads were upgraded to improve the lot of increasing numbers of bicyclists; later it was to move crops from farm to market, and still later to enhance national defense and the interstate commerce of an increasingly industrialized nation. In each case, an expanded network of roads with improved operating characteristics and an increased capacity was viewed by most people as "progress." This progress was supported by elected representatives when taxes and other measures were required to provide needed improvements. The problems and issues associated with implementing this policy were related to the paucity of knowledge about traffic loads, design, construction, administration, operation, traffic forecasting, planning, right-of-way acquisition, and maintenance. Over the years, research addressed each of these issues and both our technology and methods have improved as a result. These "traditional" research topics were at the center of the problems associated with developing effective state transportation programs, and top management supported all reasonable efforts to find solutions.

POLICY QUESTIONS: TOP PRIORITY

Today, much of this national consensus has faded as questions have been raised about the negative aspects of our strong dependence on personal auto/truck/highway transportation. These problems include environmental degradation, equity considerations, and urban sprawl. Many citizens and policymakers question road improvements that might improve travel conditions in the short term, but whose long-term effects might induce still more travel, more pollution, and more sprawl.

Efforts to mitigate these negative effects have led to interest in increased investment in rail transit, commuter rail, trip reduction schemes, high-occupancy-vehicle lanes, congestion pricing, land-use controls, vehicle regulations, environmental mitigation, intelligent transportation applications, and other measures; all broader in scope and complexity than roads themselves. The costs of such measures are often unknown and their effectiveness generally uncertain. Study and research is required before acceptable policies can be promoted involving any of these topics, and these are but a subset of the broad range of issues often requiring policy research in today's environment.

At the same time, worldwide competition for industry and jobs has increased. Those concerned with economic development often urge further efforts to expand the transportation system, and transportation management must make choices between competing interests to assure the wise use of public funds. Top management of state transportation agencies must balance such issues if they are to be successful in moving their programs forward. Studies, information, and research that better informs such decisions are now at the center of management concerns, rather than the traditional concerns of an earlier time. These are the questions that CAOs must answer, whether in legislative hearings, citizens meetings, or before the media.

This is not to demean the value of continued research in the traditional areas. Finding better ways to plan, build, operate, and maintain our road systems is essential because such expenditures are now approaching almost $100 billion annually. Improvements that permit only small savings percentagewise can result in substantial economies. In addition, it is important that we continue research that takes advantage of technological advances in other areas, and continue to investigate the ever-changing array of materials, traffic loads, environmental requirements, and other factors that form the context within which our programs must operate. Wise management will appreciate these concerns and continue support for these activities.

POLICY RESEARCH AND ACCESS TO MANAGEMENT

Considering the nontechnical backgrounds and the short tenure of many individuals in top management of state transportation agencies today, it is not surprising that there is not automatic support for traditional research. Many CAOs assume that because we have been building and maintaining roads for almost a century we already know all we are going to know about this "prosaic" technology. Difficulties associated with educating the influx of new management helps to explain why research managers are concerned about methods to develop robust research programs. In such a setting, access to top management itself becomes a challenge.

As shown in chapter 4, lack of access to top management is a major barrier in establishing the trust that is a fundamental element in developing robust research organizations. Trust provides research management with an

opportunity to "sell" the relevance and utility of research in the traditional areas. Just as important, it provides an alert research manager with a valuable perspective on the needs and challenges of the department, which in turn provides important input to the directions of the research program itself.

One way that research managers can improve access to top management is to enlarge their mission to include the current concerns of top management, that is, to include policy research as an important part of their portfolio. For example, a research unit that has pavement expertise may successfully provide new knowledge on how to design and manage pavements so as to minimize costs or maximize durability. However, such success might well go unnoticed in the front office. Adding economic, geometric design, and traffic safety expertise provides the basic resources needed to better inform public debate about permissible truck axle loadings, truck taxation, and other size and weight issues. These issues are among those that top management must face. Anyone able to better inform top managers of the technical, economic, and safety issues surrounding such matters is unlikely to have to explain the relevance of their mission and is provided with an otherwise unavailable platform for explaining the relevance of pavement research itself.

Some state research units may find it difficult to make the transition to policy work. Some units are located too far down in the organization to be seen as relevant to policy issues. A chicken-and-egg syndrome emerges: Policy is seen as a way to get improved access to management, but access to management is first required to promote the idea of including policy research in the first place. The need for additional staff is another potential barrier. Expertise in economics, business, ecology, or finance may be necessary. However, getting approval for additional staff is difficult in today's downsizing environment.

This study has uncovered no magic solutions to these problems. However, it helps for research directors to be aware that policy research can be a valuable addition, and to be alert for opportunities to undertake policy-related projects. Successful research managers are sometimes able to take advantage of research findings that have special interest to top management to establish initial contact with the CAO and leverage this contact to promote other relevant policy work. David Albright, director of a small research unit in New Mexico, did this in his state (see chapter 7). Requirements for additional policy staff can sometimes be alleviated by creative alliances (chapter 7). Joint ventures with nearby universities, federal laboratories, or industrial organizations may enlarge the available talent pool so that complex policy issues can be addressed. Establishing relationships with those individuals currently conducting state policy work might also provide insights into management's policy concerns and future opportunities. Promoting policy research in a research organization may require watchful patience, but knowing that policy research is highly desirable and a complimentary component of research activity is a necessary first step, and may permit taking advantage of opportunities when they emerge.

THE TRB EXPERIENCE

Relationships between policy research, management's interests, and technical research apply to national research organizations no less than to those at the state level. From its founding in 1920 until 1980, TRB had provided a clearinghouse for technical information associated with road building, operation, and maintenance and associated activities including planning, administration, and financing. During the 1970s, other modal interests including transit, railroads, trucking, and aviation began to participate. TRB also included a growing body of material related to energy, environmental, and social equity concerns. However, it carefully guarded against taking positions on policy issues, believing that its mission was to make available information "on which others could make decisions."

Maintaining this policy became increasingly difficult for several reasons, some internal and some external. Internally, the National Research Council (NRC), TRB's parent organization, had in the 1960s, formalized its system of committee-driven policy studies, and by the 1970s this became the primary output of most of its major units. The NRC governing board, although approving of TRB's close connection to its sponsors and to its varied portfolio of activities, was increasingly restless about whether TRB should remain within the NRC, especially because its lack of interest in policy studies made it appear so different from other major units. In 1980, Frank Press was elected President of the National Academy of Sciences and chairman of the governing board of the NRC. He appointed a special committee to make recommendations on NRC organization. This committee recommended that TRB be moved up in the NRC hierarchy to report directly to the governing board and, further, that it begin to perform policy studies like other units of the NRC.

TRB's Executive Committee was initially split over this matter. There were many who felt that it was high time for TRB to make such a move, noting that top management had many concerns at the national level that required policy research and that there was no alternative organization where objective and unbiased work could be performed on complex policy issues. The NRC study format, using diverse committees of experts within an organizational structure that could not be controlled or influenced by study sponsors, was a unique resource, which the transportation community could well use. They also felt that such work would

compliment the technical activities that formed the base of TRB's already well-established portfolio. It was pointed out that top management was not as interested in technical activities as in the past, for many of the reasons noted previously. To this extent, management's interest in TRB had also diminished, and might further decline in the future.

Conversely, some Executive Committee members expressed concern that policy work would require TRB to take positions on controversial issues that might offend major financial sponsors. This could lead to reduced support for technical activities, weakening TRB in the long run.

Ultimately, it was concluded that the time had come for the change. In 1981, TRB formed a policy study unit and began several major policy studies, including the STRS, which triggered the SHRP, the National 55 mph Speed Limit Study, and a study of the safety of twin trailer trucks. In each case, expert committees assisted by competent staff analyzed the evidence, debated its meaning, and came to conclusions and recommendations requiring action by either state, federal, or private authorities. Some of the recommendations were controversial, but difficult to ignore because of the quality of the work and also because the credibility of the institution and its processes were perceived as free of political or financial pressure.

The deliberations of the Executive Committee became more lively as the progress of the policy study work was regularly reported and as proposals for new studies were debated. Executive Committee members were drawn primarily from top management ranks of state, federal, and private transportation organizations. They knew that these matters were important and relevant to their own organizations. They were involved as a matter of intellectual interest, knew they had something to contribute to the debate, and knew that the work would make a difference. However, within a few years, they became impatient at simply approving studies that other TRB committees would perform. They believed that collectively they represented a resource that could and should be used to address major issues. They were willing to continue to oversee the administrative approval process that is the bulk of the Executive Committee's work, but they wanted more, and urged TRB's management to find ways to more effectively exploit their talents on matters of national interest.

Management was initially uncomfortable with this suggestion. The Executive Committee agenda was already full—where would the time be found to deal with major policy issues? The NRC's study process required that committees concerned with policy questions be selected for their expertise to deal with well-defined issues, and that the NRC approve the membership of such committees one at time. They did not permit any committee, however well intentioned or however high level, to make recommendations on any issue it might choose. In addition, TRB Executive Committee members were likely effected parties on almost any issue it might address. For example, there were trucking interests on the committee that might benefit from any recommendation to increase the size and weight of trucks. Would recommendations on this matter be taken seriously, should the committee decide to make such recommendations?

TRB's management, with the advice of its chairman, proposed a lengthening of the Executive Committee meeting to 2 days, using about one-half day for the discussion of some major policy issues of interest to the committee. Staff work was done before the meeting, white papers were prepared, and resource people selected to brief the committee. Then the committee was free to question resource people, make suggestions, debate the issue, and try to arrive at a consensus. These discussions became known as "Red Meat" sessions (the name was irreverently coined from the vision of throwing a piece of red meat to a pack of animals). About one-half the time conclusions were drawn that had relevance to the regular programs of TRB, to outreach areas important to TRB's future, or to study topics requiring special study committees. In other cases, no conclusions were reached as to actions required by TRB. The committee understood that it could not make formal recommendations outside of TRB, but they could agree on major issues in transportation that needed attention, and could call attention to these issues by using such devices as the publication of its "Ten Most Important Transportation Issues," published in *TRNews.*

Aside from such valuable results, the most important consequence for TRB was the energizing and enlivening effect the Red Meat sessions had on the committee itself and the impression of its members of the relevance of TRB to management's concerns and to the transportation industry. No longer were complaints heard about "how TRB was living in an ivory tower, was a captive of purely academic concerns, and needed to get in touch with the real world." New financial sponsors were added, largely because such sponsorship provided a seat at the Executive Committee table, and these interests could no longer afford to ignore TRB. The discussions at the table and the stream of influential policy studies being issued required that they be a player. Executive Committee membership could not materially influence the output of any particular study, but it could provide a way to keep up with what TRB was doing and ensure that studies of interest to their group could be proposed.

POLICY RESEARCH: A KEY ATTRIBUTE OF ROBUST PROGRAMS

Although TRB's experience in policy research has been unambiguously positive, does this argue that it is necessarily

an attribute of any robust program? Interviewees did not always mention policy research when asked to give a list of major attributes, but almost all answered yes when asked if it was a positive factor. Part of this seeming ambivalence may stem from the assumption by some that policy research is always a part of research. Conversely, one respondent expressed concern about diluting traditional research interests with other issues such as policy or planning. Federal funding and attending regulations often result in combining planning and research into a single unit. Those concerned with traditional research sometimes feel that research necessarily takes a subordinate role in such arrangements. Combining traditional research, planning, and policy research into one unit would seem to have the most promise in providing access to top management. However, the director of such a diverse unit would have to be convinced of the importance of research or the research might well suffer. The scale of planning may be such that such combinations themselves are unreliable predictors of success—depending too much on the personal interests of the combined unit's manager.

The combination of traditional and policy research, however, seems less ambiguous. As one top state manager with research experience stated, "Any research unit that does not include policy work in its mission will be marginalized by management, because that is where management's major interests lie."

Gene Ofstead, former Assistant Commissioner for the Minnesota DOT, combined policy and technical research in that state, because of the need to integrate research with the strategic planning assessments proceeding throughout the department. He felt it permitted research to know of and be able to respond to policy issues, and to address gaps in knowledge identified in other functional areas in their efforts to meet strategic goals.

Professor Lester Hoel of the University of Virginia believes policy research is an essential component of a robust research program, because of top management's primary concern with policy issues, and the improved access to management and to their concerns that policy research provides to the research activity.

Gary Allen, Director of the successful VTRC, confirms this assessment. He describes how VTRC policy research activities became known to Ray Pethtel, a new Transportation Commissioner. Pethtel had been the staff director of the Joint Legislative Audit and Review Commission for the 12 years prior to his transportation appointment, and in that capacity had reviewed a number of the state's transportation programs. When appointed Transportation Commissioner, he acknowledged the value of the VTRC's policy assessments to top management, but could not understand why the state continued to spend money on engineering and physical research questions. Allen was able to explain why engineering research also had a valued place in their portfolio. Without the policy research channel, however, he might not have had the opportunity to explain this need or the credibility with top management to make the case.

Allen pointed out that decades ago, before the VTRC, had established much credibility, the Council hired an economist who conducted analyses of transportation costs. He prepared a chart that showed transportation costs for the state increasing much faster than gas tax revenues. In a routine presentation, this chart caught the attention of the Transportation Commissioner, who apparently saw its potential in making the case for a tax increase. From that point on, the Commissioner became a supporter of the newly minted research unit. Successful marketing of research can take unusual turns.

Some state research directors have noted the policy interests of top management, but are also aware of the greater interest in traditional research topics by unit managers, and feel caught between the two conflicting demands. Fortunately, policy research tends to be less expensive than traditional research, the latter often requiring laboratory and other expensive equipment. Nevertheless, a unit that clearly has both policy and traditional research in its mission statement is in a better position when such conflicts occur than one that is seen as irrelevant to policy questions. It would appear better to have top and middle management vying for research attention than to be seen as irrelevant to top management's concerns.

Fortunately, ISTEA, and the more recently enacted TEA-21 (both are federal transportation acts), provide some encouragement to policy research, with increased emphasis on intermodal solutions, economic growth, and environmental sensitivity. This legislation also provides more flexibility in the use of federally mandated, but state controlled research funds. This relaxation may permit traditional research units the opportunity to engage in topics of broader interest including policy research

TOP DOWN AND BOTTOM UP

Transportation research programs, whether viewed at the national level or within individual states, have generally done well in outreach to customers insofar as those customers are the operating units with state DOTs. Most have at least rudimentary committee structures with representatives from operating units that facilitate the submission of problem statements and prioritize projects. The National Cooperative Highway Research Program (NCHRP)

has a thorough system for submission of problem statements, staff review, checking for duplication, national polling, and committee ranking and prioritizations. The federal program administered by the FHWA also has a series of review panels it utilizes to oversee projects and various program areas. Such systems ensure that programs remain focused on current and real problems as experienced and identified by practitioners in the field and enhance prospects for the implementation of results.

Unfortunately such systems at the national level can also result in apparently unrelated bottom-up collections of projects that are vulnerable to charges that they lack focus, are sometimes duplicative, and are organizationally untidy. Total reliance on decentralized research efforts also would risk missing major requirements with a longer range focus and on cross-cutting opportunities. Close customer orientation resulting from a decentralized approach has major benefits, while at the same time acknowledging the need for occasional strategic examinations of needed programs. Strategic examinations can result in major shifts in research priorities. When the results of the STRS study were first released, and it became clear that its primary emphasis was a recommendation for major new research in infrastructure, there was an immediate negative reaction from researchers and others interested in planning, traffic operations, design, and administration. Protests were heard about how the new program would make it even easier to reduce the meager attention that such subjects were then receiving. In retrospect, there is no evidence that such reductions occurred. On the contrary, it would appear that SHRP's success made the research pie larger for all, once management began to see more clearly the connection between its problems and focused research.

At the state level, exclusive reliance on bottom-up approaches risks missing future issues and allows for the continued funding projects that may themselves appear less relevant in future years. This can make research appear irrelevant when management is forced to make decisions on new issues before research realizes there is a problem. Strategic assessments of research that examine the entire research program in the light of the total and upcoming program of the parent unit and its customers are required to fill in these missing links. If such assessments are not conducted by the research unit itself, they may be conducted by others, with less predisposition toward research. Also, such assessments are policy studies; units with policy study experience are more likely to consider strategic assessments and see themselves as competent to conduct them.

In summary, including policy research as part of the state transportation research portfolio is important for several reasons. A major reason is that it provides a communications channel between research and top management. This access is important because of the window it provides to the research manager to better understand the challenges facing the parent organization and thus to steer the research program in relevant directions. Policy issues are at the center of top management concerns and constitute the major challenges to the accomplishment of the state transportation function. Policy research can have a positive impact by better informing management decisions. Policy research also provides the opportunity for the research manager to sell the benefits of research to top management and to strategically access the research role and long-term program within the parent department. A research unit that does not include policy research will have a more difficult task in marketing its value to top management concerned primarily with policy issues.

CHAPTER TEN

EMPOWER THE STAFF

Empowerment is a much-used societal buzzword applied to a wide variety of situations, and everyone seems to be for it. An "empowered citizenry," for example, is not only a politically correct notion, but also seems to be a desirable goal when viewed from all points on the political spectrum. Management books are fond of noting that the fast moving, globally competitive economy requires businesses with employees that feel and act empowered to make quick decisions. They need to feel that their organizations have socially useful missions and that they each play a vital role in its achievements. Managers of public sector organizations also cite the benefits of an empowered staff. Whatever the requirements and benefits of such empowerment, they are applicable to employees of research organizations no less than others are.

SPECIAL NEEDS OF RESEARCH

By including this key attribute, this study makes a special claim for researchers, over and beyond other types of activity. This claim stems from the inherent nature of research, that is, that researchers are almost always in "new territory" and "plowing new ground." Some of their processes are familiar and repetitive, as for example, when they are collecting data or running statistical tests. However, the creative aspects of their work, for example, when they are developing candidate solutions to problems, are different for each new project. In other words, the researcher's work is a mix of the "new and creative" along with some "similar and repetitive," but the creative aspects are fundamental to the activity.

Nonresearch work also contains such mixes. Almost all professional tasks require the solving of problems, either internal or external, to achieve unit goals. As with research, some of it is new and creative and some is similar and repetitive. For research, however, the mix is tilted toward the new and creative component.

Successful research requires the creation of novelty. Research that fails to invent some good candidate solutions to problems will fail, because experiments directed toward testing those solutions are likely to be in vain. There is little gain in performing high-quality evaluations of a bunch of bad solutions. A successful research project, more than most other activities, must start with some good, and often novel, ideas.

Research is fundamentally dependent on new ideas. Some ideas may be obtained from people and organizations that have successfully solved the problem at hand in other states, other countries, or in other types of organizations with similar problems. The researcher's task in these situations is to perform analyses and tests to determine whether existing conditions make likely the successful transfer of the solution. If a completed solution is not available, knowledge of the progress of other researchers working on the problem is essential, both to capitalize on their insights and to avoid duplication of effort. In addition, if others are not confronting the particular problem at hand, then knowledge of relevant technologies that might be employed is essential in the devising of candidate solutions.

The applied researcher must also have a thorough understanding of the problem that is to be solved. To provide a useful solution, the recommended response must also satisfy a series of constraints. For example, if the problem is to develop a better piece of field test equipment, the resulting device should not only provide the accurate measures required, but must also be affordable, lightweight, portable, accurate across a variety of temperatures, safe, manufacturable, and sufficiently rugged for field use. To get a comprehensive understanding of all these conditions often requires more intimate contact with possible users across the range of their operational environments. This is beyond the scope of material normally available from published literature or reports. Contact across organizational lines may be required. Bureaucratic restraints on such out-of-channel contacts necessarily reduce the effectiveness of research efforts.

Such out-of-channel contacts should span not only horizontally across the organization chart, but vertically as well. One important vertical contact previously identified is between research management and top management. The failure of this particular vertical communications link can lead the research program in directions not aligned to management's concerns, and reduce the all-important element of trust.

Some of the required knowledge can be obtained through review of the relevant published literature, and most researchers are skilled in the use of libraries, reference works, databases, the Internet, and various search engines now available. Most research projects formally begin with an intensive review of this material to ensure

that the knowledge can be incorporated into the project at an early stage. Modern communications often permits this activity to take place at the researcher's desk or within the facilities of the researcher's unit.

GOOD IDEAS AND ACCESS TO OTHERS

Successful research, however, requires more than just familiarity with the literature. As noted previously, it also needs qualified ideas, with the hope that some of them will turn out to be useful. But where do good ideas come from, especially those involving the physical sciences and engineering? This issue has been the subject of endless speculation. Conventional wisdom holds the image of the solitary scientist suddenly receiving a lightening bolt of inspiration and insight and the answer to the problem. Another myth assumes that most discoveries are the result of serendipity, such as when penicillin was found after a researcher accidentally sneezed into a petri dish containing a germ-killing mold. No doubt, some very useful research proceeds from such experiences.

Psychologists at McGill University's cognitive neuroscience center, however, have been studying this question and have reached some different conclusions. Their research, based on 2 years of actually observing scientists at work, has concluded that good ideas more often come from testing and experimentation to see what works and what does not, and then properly interpreting the outcomes, whether positive or negative. Good interpretation depends on highly qualified individuals who really know their fields, so they can identify a surprise (say in an experiment) when they see one. Also, it depends on the use of analogy, so that the researcher can use the knowledge obtained in one area and apply it to another.

The McGill studies also point out the advantages of what they call "distributed reasoning," in which several scientists combine to solve a problem. Their most important discoveries came about when several participants built on each other's analogies and interpretations. This advantage, however, appeared only when members of the group had varying areas of expertise; when all members of a lab had similar backgrounds, progress was no faster than that made by individual scientists working alone (*23*).

Generating ideas therefore seems to spring from the interaction of people with related but different perspectives and knowledge. Some of this can take place within the research unit, if it includes the requisite skills. However, state research units are typically small and cannot possibly include the range of skills required for most projects, especially during the idea generation stage. Access to the varied skills available at a university is a real advantage; However, even a university with the right skills is unlikely to have all of the relevant knowledge. There is an uncommon need for such researchers to have the opportunity to interact with other professionals working on similar problems, on a person-to-person basis. Interaction often means travel either to meetings where such people congregate or to other labs and facilities where related research is underway. Furthermore, it may mean the ability to write or visit professionals at various levels in different divisions of the parent organization, who will be the users of potential solutions.

Interviewees were unanimous in their support of this notion. Although research managers might be expected to agree with the need for staff travel, top managers from both the public and private sectors also agreed that researchers have special needs in this regard. Alex MacLachlan was Senior Vice-President of DuPont and a member of the company's operating group until his retirement in 1993. His responsibilities included, but were broader than, research. He acknowledged that in times of stress, for example, when the company's financial position required major cost cutting, it was unrealistic to think that research would go untouched, and that at such times travel must be reduced. However, he always saw it as a temporary measure and that researchers, even more than others, must be allowed to travel and interact to be effective.

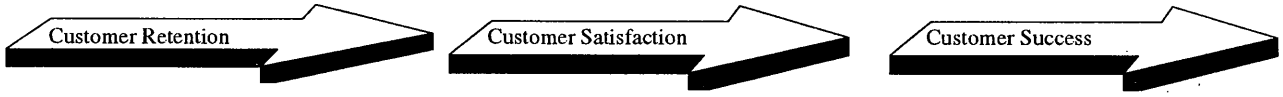
In a recent article, "The Challenge of Fifth Generation R&D," in *Research-Technology Management* (*24*), Debra Rogers builds on the ideas espoused by Roussel in *Third Generation R&D.* Roussel argued that 3rd generation R&D requires research to take its place along with other functions of the organization; to address strategic goals. Rogers says this designates "Enterprise as the Asset." She believes we are moving toward a 4th generation R&D with the "Customer as the Asset," and to 5th generation R&D with "Knowledge as the Asset" (Table 1). Exploring all of the implications of this formulation is beyond our scope, but it is interesting to observe some of the terms used to describe researchers working in the 5th generation environment, which include "self-managing knowledge workers, cross-boundary/organizational learning, and knowledge flow and symbiotic networks." This sounds much like the description of empowered staff noted earlier in this chapter. We may not be prepared for such advanced management concepts as those espoused in 5th generation R&D, but that does not preclude us from acknowledging the need for cross-boundary knowledge flows, wherever we are on the R&D management scale.

Charlie Miller served as a CAO in West Virginia and Arizona, in addition to serving as Associate Administrator for Research for the FHWA. He noted that the small size of many state research programs required that their most useful activities be to assess technology employed by other states and foreign countries for possible local deployment.

TABLE 1

CONTRAST IN R&D GENERATION

Management Operations	R&D Generation				
	No. 1 Technology as the Asset	No. 2 Project as the Asset	No. 3 Enterprise as the Asset	No. 4 Customer as the Asset	No. 5 Knowledge as the Asset
Core strategy	R&D in isolation	Link to business	Technology/business integration	Integration with the customer R&D	Collaborative innovation system
Change factors	Unpredictable serendipity	Interdependence	Systematic R&D management	Accelerated discontinuous global change	Kaleidoscopic dynamics
Performance	R&D as overhead	Cost sharing	Balancing risk/reward	"Productivity Paradox"	Intellectual capacity/impact
Structure	Hierarchical: functionally driven	Matrix	Distributed coordination	Multi-dimensional "communities of practice"	Symbiotic networks
People	We/they competition	Proactive cooperation	Structured collaboration	Focus on values and capability	Self-managing knowledge workers
Process	Minimal communication	Project-to-project basis	Purposeful R&D portfolio	Feedback loops and "information persistence"	Cross-boundary learning and knowledge flow
Technology	Embryonic	Data based	Information based	IT as a competitive weapon	Intelligent knowledge processors



Source: Rogers, D.M.A., "The Challenge of Fifth Generation R&D," *Research-Technology Management*, Industrial Research Institute, Vol. 39, No. 4, July-August 1996.

This required personal interaction with experts from other areas. Despite the political risks associated with international travel by public employees, the U.S. Congress acknowledged the importance of personal interaction in technology assessment in ISTEA, when it authorized money for technology assessment tours. These tours permit American experts to travel to foreign nations that are believed to have technology or policies that might have relevance to U.S. problems.

Staff of the VTRC are encouraged to interact with relevant organizations and individuals at many levels. These staff act as troubleshooters, with local and state officials, on pavement, drainage, traffic, or other problems throughout the state. They are also encouraged to participate on committees of TRB, NCHRP, AASHTO, and other similar organizations. The dean of engineering at the University of Virginia remarked once that one of the best things the VTRC staff did was travel. All of this enhances staff perspectives on work in their respective areas of interest, whether in other states or in foreign countries.

It may be observed that many independent research organizations and consulting firms that conduct research believe in maximizing professional interaction, including staff travel when required. Although some interaction is related to marketing, some is primarily for staff enrichment and empowerment. Norm Abramson, Executive Vice-President of Southwest Research Institute, noted that SRI encouraged professional activity and interaction, including the necessary travel by SRI researchers both as a recruiting tool for top-flight employees, but also to generate ideas and enhance the reputation of the SRI. He observed that such encouragement needed to be accompanied by policies that discouraged less important travel, while especially encouraging researchers to write and publish in professional journals and chair important committee activities in their respective fields; this despite the need to minimize overhead expenses to remain financially competitive.

Gene Ofstead, former Assistant Commissioner for Transportation Research and Investment Management, Minnesota DOT, agreed with the special needs of research and encouraged the interaction of his researchers with other organizations outside of channels available through the normal chain of command. Moreover, he encouraged them to make alliances, joint ventures, and partnerships

with other organizations where such innovations were expected to further research objectives. The necessity of connecting research to major departmental objectives is too important to be circumscribed by bureaucracy.

To summarize, interviewees, focus groups, and the literature all argue that successful research requires a staff that is able to generate new and innovative ideas, and that idea generation is enhanced by interaction with others working on similar problems in a variety of settings. Accordingly, researchers need to feel free to interact with others across organizational lines and be given the opportunity to travel, when necessary, to interact with researchers working on similar problems in other organizations.

CHAPTER ELEVEN

CONCLUSIONS

Research managers desire to encourage research programs that are robust, that is, programs that flourish and thrive, are vital and enduring, and that contribute to the overall performance of parent organizations. Such programs must be effective; that is, they must produce a quantity of highquality, well-targeted products capable of application to real problems. To become robust, however, these programs must not only do good, but they must also be perceived as doing good.

Through the examination of a wide variety of research programs, located in both private and public sectors, in transportation and out, and in domestic and international settings, seven key attributes have been identified that correlate closely with robust research programs. Incorporation of these attributes should enhance a program's reputation and distinguish programs that are merely ordinary from those that are remarkable.

The findings of this synthesis, based on in-depth interviews, focus groups, state DOT research program peer exchange activities, and literature searches are as follows:

- State DOTs have an increasing need for the information, products, and processes that can be produced by research. This need includes improved materials, design, maintenance, and construction techniques, but also a diverse array of other intermodal issues, environmental and equity concerns, and operational opportunities.

- State DOTs also have strong disincentives for conducting such research. These include:

  1. The short tenure of CAOs;
  2. CAOs from nontechnical backgrounds, without an understanding of the origins of improved technology or how to manage research;
  3. Their position in a decentralized institutional environment: the recognition that other states, some larger, have similar problems, and the temptation to let the other states solve these problems; and
  4. The lack of a competitive imperative to improve performance and a resultant risk avoidance posture.

- Nevertheless, a research activity exists in each state, in part, because of a federal requirement that recognizes the need for research to be conducted near the customers for the research product and because states have some unique problems they must solve for themselves.

- Research directors are under some pressure to make their relatively small research units perform under these difficult conditions. They need to make the unit effective, that is, produce useful products considering the resources employed. They also need to make them robust, that is, make them durable and enduring and of a size that will permit them to respond to the major problems of their parent units.

- A very important positive factor associated with a robust program is a CAO who is predisposed towards research, understands its role in achieving organizational goals, provides adequate resources for identified research tasks, holds it accountable, and provides adequate supervision of the research function on a continuing basis. Conversely, a CAO predisposed against research may make it virtually impossible for the research director to develop a robust research program.

- Most new CAOs are neither strongly predisposed for or against research. Most take their jobs with little knowledge or interest in research. They often obtain their opinions of research by means of chance discussions with other executives in the department, by reading brochures and research reports, or through the impressions of the research director. By building a program with a strong reputation throughout the department, the research director improves the potential for favorable exposure to new CAOs.

Research literature, as well as interviews with top management and research directors for state DOTs, major private commercial firms, and foreign transportation organizations have determined that there are seven key attributes of robust research programs. This suggests that state research units striving for a more robust posture might look for ways to incorporate these attributes into their organizations. Two conditions are presupposed: (1) That the research unit is competent, has strong internal management, and is producing products of a quantity and quality consistent with resources employed and (2) That the CAO is typical, that is, is not strongly predisposed either for or against research.

- Given these conditions, the most important attribute of a robust research organization is the **establishment of a trust relationship** between itself and the parent organization, which it serves. The parent organization must see the research program as an important tool in

the accomplishment of at least some of its goals. It has to trust that research is directed at the solution of problems that it knows to be important. Similarly, the research unit must feel that it is a valued part of the organization and be treated accordingly. A number of the other attributes identified in this study are aimed, at least in part, in enhancing the trust relationship (e.g., economic orientation, accountability, and policy orientation).

- A **marketing orientation** is an important attribute of any robust research program. However, the disincentives in state DOTs, the small scale of the research enterprise, and the nontechnical backgrounds of most CAOs make it especially important that research be continuously presented in its best light. It is not enough for research to do good, it must be perceived as doing good. Some research managers (and their bosses) do not recognize this need, and research suffers as a result. Research managers must be aware that marketing is a more comprehensive function than touting the results of a research project on the printed page. Marketing consists of many of the key attributes mentioned in this report, such as creating opportunities for building trust in research, presenting materials in economic terms so that research is seen as an investment, performing research of particular interest to top management (which is often policy oriented), and creating alliances and partnerships with stakeholders to increase the value of the research to the organization.

- To make effective program decisions and communicate with top management research management must be **rooted in economics**. Although a research manager must of necessity be concerned with the science and technology associated with the research tasks at hand, this individual must also understand that the primary orientation of top management is economics and finance. New research projects must consider the research costs and risks along with the potential benefits in economic terms that can be related to the goals of the parent unit.

- Robust research programs tend to operate in an array of ad hoc alliances, and research management must **be skilled deal makers**. Technological diversity, competitive pressures, and short product development cycles are forcing commercial research activities into more ad hoc organizational arrangements for research. Joint ventures between firms, between firms and universities, and between public and private institutions are becoming more common. Robust state DOT research also tends toward such deal making for many of the same reasons. In addition, the limited resources available to transportation research make the pooling of resources inherent in joint ventures, providing the basis for more intensive, focused, and complete projects than would otherwise be possible. Furthermore, the decentralized institutional setting within which transportation exists often requires consensus decisions on the adoption or deployment of research products. Joint research between effected agencies can sometimes enhance the credibility of the outcome, especially on controversial projects where contending parties agree to work together. Research managers need to be aware of the positive potential that such deal making may have on their programs. They must be aware that such deal making is arduous at times and requires perseverance and the use of a broad base of contacts with expertise to assist in creating the alliance or partnership.

- Managers must insist that research be **accountable**. Top managers often, but erroneously, view research as an overhead function that operates best when left alone. Such management considers research only at intervals dictated by the budget cycle, decides on an amount for the next period, and may ignore research until the next budget period. The establishment of goals, objectives, and milestones, and holding research management accountable is often seen as inappropriate given the unfamiliarity of its processes and the inherent uncertainty of its success. Top management needs to see research as a tool for the accomplishment of its mission along with the financial, legal, technical, planning, operational, and other resources at its disposal. In addition, it needs to see the necessity for the management of these resources. In agencies where these accountability measures are available, top management must be accessible to the research manager in order to maximize the utility of research to the department. Top management must seek opportunities to fulfill its roles of providing direction, making available sufficient resources, and providing influence and support when appropriate. Furthermore, research management must seek to be accountable, even if top management does not understand its part in being accountable.

- **Including policy research** enhances the prospects of developing a robust research program. The combination of policy and technical research increases the scale of the research operation, a consideration in and of itself, at a time when research tends to be dwarfed by other functional units. More importantly, policy research addresses issues of more immediate relevance to top management and thus provides a platform for access and two-way communications with management. In turn, access provides alert research managers the opportunity to market the importance of technical research. It enhances the prospects of research being seen as an important tool for accomplishing the organizational mission of the parent.

- An **empowered staff** that has ready access not only to the literature, but also other researchers working on similar problems is an essential component of a robust research unit. Research staff have a special need over and above other professionals for access to those working on similar problems, because their work is fundamentally a search for new ideas and a major source for such ideas comes from those researchers with diverse backgrounds that see problems from different perspectives. Both top management and research management must understand this need and establish appropriate policies.

On the basis of the information gathered for this synthesis, the following are suggestions for further action and future research.

When investigating a topic as comprehensive as robust research programs, needs and deficiencies are noticeable for what could be accomplished if these gaps were addressed. Clearly, if research managers and senior management alike proposed the creation and maintenance of robust research programs, the value of the national research investment might be multiplied many times over. The suggestions cited here should enhance the opportunities for research managers and senior managers to incorporate the key attributes into existing research programs.

- There is a need for more research and preparation of materials to assist the research manager:

  1. In developing marketing efforts appropriate for a state DOT research unit.
  2. In developing alliances with other organizations to leverages the research manager's resources, improve access to needed skills, and enhance consensus building.
  3. In incorporating elementary economic and financial analysis for use in program development, management, and evaluation.
  4. In appropriate ways to account for research programs to higher management and to learn the skill of encouraging understanding of research by unknowledgeable senior managers.
  5. In introducing the research manager to policy research, anticipating policy issues before they become critical, and management of policy research.
  6. In incorporating research into department strategic plans and mission accomplishment tasks.

- Training courses could be prepared for research managers to assist their familiarity with items 1-6.

- Training programs for top DOT management (e.g., the AASHTO sponsored executive institute) might benefit from the inclusion of material on the need for and role of research in DOT organizations, the need to view research as an investment tool for accomplishing organization objectives, and the need to hold research accountable for achieving its objectives and milestones. Top management also needs to be acquainted with the values of including policy research in the portfolio and the special empowerment needs of research staff.

- Investigation of the barriers associated with building alliances and partnerships between state DOT research units and other governmental and private sector research entities is suggested.

- Methods could be investigated that allow the cycle time of research projects to match the user needs. This improvement will reduce the time between idea generation and results application with the ultimate goal of enhancing trust in research activities.

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APPENDIX A

Interviewees

(Positions cited here are those held at the time of the interview and/or prior relevant positions.)

Norman Abramson, former Executive Vice-President of the Southwest Research Institute

David Albright, Research Bureau Chief, New Mexico State Highway and Transportation Department and former President of the Alliance for Transportation Research

Gary Allen, Director of Research, Virginia Transportation Research Council

Robert Betsold, Associate Administrator for Research and Technology, Federal Highway Administration

Richard Braun, Consultant, former Commissioner of the Minnesota Department of Transportation and former Director of the Center for Transportation Studies, University of Minnesota

Ray Chamberlain, Consultant, former Vice-President of the American Trucking Association, former Executive Director of the Colorado Department of Transportation, and former president of Colorado State University

Calvin Grayson, former Director of the Kentucky Transportation Center and former Secretary of the Kentucky Transportation Cabinet

Lester Hoel, Hamilton Professor, Department of Civil Engineering, University of Virginia

Charles Larson, Executive Director of the Industrial Research Institute

Thomas Larson, Consultant, former Federal Highway Administrator and former Pennsylvania Secretary of Transportation

Alexander MacLachlan, former Senior Vice-President for Research and Development and Chief Technical Officer, DuPont Corporation, and former Deputy Under Secretary, U.S. Department of Energy

John McSherefferty, former President of the Gillette Research Institute

Charles Miller, Consultant, former Associate Administrator for Research and Technology, Federal Highway Administration, former Secretary of Transportation of the West Virginia Department of Transportation, and former Director of the Arizona Department of Transportation

Eugene Ofstead, former Assistant Commissioner for Transportation Research and Investment Management, Minnesota Department of Transportation

Scott Sabol, Director of the Delaware Transportation Institute

Ivar Schacke, International Director of the Danish Road Directorate and former Director of the Danish Road Institute

Ken Shiatte, Chief Engineer, New York Department of Transportation

Robert Skinner, Executive Director of the Transportation Research Board

David Winstead, Secretary of the Maryland Department of Transportation and President of the American Association of Highway and Transportation Officials

Clyde Woodle, former Director of the ATA Foundation, Trucking Research Institute

John Wootton, former Director of the United Kingdom's Transport and Road Research Laboratory

APPENDIX B

Current or Former Affiliation of Interviewees

Name	General Management	Research Management	CAO	Academic	Private Sector	Independent Sector	International
Abramson	X	X					
Albright		X					
Allen		X		X			
Betsold	X	X					
Braun	X	X	X	X			
Chamberlain	X		X	X	X	X	
Grayson	X	X	X	X			
Hoel				X			
C. Larson	X	X				X	
T. Larson	X		X	X			
MacLachlan	X	X			X		
McSherefferty	X	X					
Miller	X	X	X				
Ofstead	X	X					
Sabol		X		X			
Schacke	X	X					X
Shiatte	X						
Skinner	X	X				X	
Winstead	X		X				
Woodle	X	X				X	
Wootton	X	X					

APPENDIX C

Focus Group Participants

(Positions cited here are those held at the time of the interview and/or prior relevant positions.)

Gary Allen, Director of Research, Virginia Transportation Research Council

Robert Benke, Director, Office of Research Services, Minnesota DOT

Ann Brach, former Transportation Specialist, FHWA, Turner-Fairbank Highway Research Center and former research manager of Maryland DOT

Eric Harm, Engineer of Materials and Research, Illinois DOT; Chairman, RAC Region III; and Vice-Chairman, National RAC

David Huft, Program Manager, Research, South Dakota DOT and Chairman, National RAC

Yi Jiang, Division of Research, Indiana DOT

Leona Kolbet, Research Coordinator, Nebraska Department of Roads

Richard Long, Director, Research Center, Florida DOT

Wesley Lum, Chief, Office of Research, California DOT

Richard McReynolds, Engineer of Research, Kansas DOT

Robert Perry, Director, Transportation R&D Bureau, New York DOT and Chairman, RAC Region I

Martin Pietz, Director of Transportation Research, Washington State DOT and Chairman, RAC Region IV

Larry Scofield, Research Engineer, Arizona DOT

Pat Strong, Highway Research Engineer, North Carolina DOT and Chairman, Regional RAC II

Facilitator, Barbara Harder, B.T. Harder, Inc.

APPENDIX D

Interview and Focus Group Protocols

INTERVIEW PROTOCOL

Interviewees were given an explanation of the project and its objectives.

What factors in the executive's experience most contribute to the development and maintenance of a strong, effective, robust research program. Areas pursued in this line of questioning were:

- What is their impression of the research unit; what gave that impression?
- What supporting information does the executive have that gives the impression?
- What are the executive's expectations?
- What is the most likely mechanism for judging the program?

How important to the executive are the attributes discussed? (In the course of the interviews such information as how the research has helped the executive/agency is apparent, particularly in the anecdotal examples.)

Why is the factor(s) identified important?

Elaborate on the importance of the factor(s) through a discussion of real-life examples. When relating such examples, the interviewee should reveal how the research has helped the executive or organization, how expectations were met, and other related information.

Should information or documentation be available that demonstrates the principles, qualities, or attributes discussed in the interviews, these were requested. The reallife examples were considered for applicability to the discussion presented in the synthesis. These examples may provide instructive anecdotal material and can be useful illustrations for various concepts being described.

FOCUS GROUP PROTOCOL

The following were the discussion questions asked of the focus group:

- Briefly, what are some research programs that you think are effective and why is that so?
- In general, what makes a research program strong, lasting, and credible for the research and technical community; for senior managers? Are the answers different for both groups? How so?
- What does it take to develop a research program that has stable and continuing funding and management/ organizational support?
- What relationship is there to the physical output of the research and the credibility of the program with senior executives?
- For a research program to survive and truly thrive in state transportation departments what characteristics must be present? Bring out items already identified in the senior executive interviews:

  √ Grounded in trust—connectedness, linkage of research unit with parent, with partners (universities, FHWA)
  √ Unabashed marketeer—marketing
  √ Rooted in economics—risk, finance, returns
  √ Mutually advantageous deal maker—alliances and partnerships, strong networks
  √ Accountability—relevancy, the ivory tower syndrome/moniker, technology intimidation CAO to R&D, communication
  √ Policy oriented
  √ Empowered staff.

- From your perspectives as research directors, what barriers or limitations do you have in enabling effectiveness or robustness of your research program?

- What has made you well respected in your capacity as research director? (Do not get into a discussion of the meaning of successful.)
- Is there a difference between in-house research performance and contract research performance and the perceptions of the research program by the senior executives? If so, why?
- Concepts used in the private sector, can they be effective in the public sector?

  √ Reducing the cycle time from research problem idea to product application
  √ Use of multifunctional teams/concurrent or simultaneous engineering
  √ Quality programs in research and technology.

- Of the items we discussed does anyone have examples that can be used for the synthesis? If so, submit them after the end of the discussion.

APPENDIX E

Review of Research on Related Topics: Short Synopses

A remarkable amount of work has been done in the last 15 years that delves into a wide variety of RD&T topics. Many of the efforts have been sponsored by the state and/or federal transportation departments and carried out through the National Cooperative Highway Research Program or as a Transportation Research Board policy study. Included are synopses of the most relevant studies and research to show the extent of the investigations that were done for the purposes of enhancing the performance of research programs. A review of these studies shows that although excellent findings resulted from these efforts, each of the efforts indicates there is more work yet to be done. Where appropriate, information from the studies is excerpted.

RESEARCH MANAGEMENT AND ADMINISTRATION

Burke, J.E., *NCHRP Synthesis of Highway Practice 113, Administration of Research, Development and Implementation Activities in Highway Agencies*, Transportation Research Board, National Research Council, Washington, D.C., December 1984.

Although this synthesis was published in December 1984, it is still a reference document used for grasping the general administrative processes carried out by typical state research programs. The synthesis presents results of a survey of 44 state DOT agencies and includes case studies of 6 state programs. The study includes a detailed review of the then current state organizational settings and structures—the location of the research activity in the DOT, its reporting channels and the organization or administrator to which the research activity reports, the internal organization of the research group, the extent of use of contracted research, and the function of various types of technical and advisory committees. The synthesis provides a comprehensive discussion of research program development and management focusing on funding—the size of the programs in dollars and in percent of department budget, problem identification, project selection, results reporting, technology transfer, and implementation.

The synthesis identified six basic elements that are necessary for an acceptable research program.

- Support of top management
- Support of research clients
- Communication
- Management competency
- Staff competency
- Funding.

Reilly, E.F., *NCHRP Synthesis of Highway Practice 231, Managing Contract Research Programs*, Transportation Research Board, National Research Council, Washington, D.C., 1996.

This synthesis provides information to research managers on the contract procedures used in other states so those contract programs can be more effectively incorporated into state research activities. The topic of contract research became increasingly more important as the vast majority of states found that their RD&T program funding had more than doubled as a result of ISTEA. This increase in funding was accompanied for the most part by an inability to add administrative or technical staff to the research unit due to, among a number of reasons, department employee complement caps. To adequately use the increased funds, many states elected to perform greater amounts of contracted research with universities and private sector researchers.

The synthesis provides tools to help with the initial steps of problem identification and selection of problems that will comprise the research program; contractor solicitation and selection, contract negotiation, contract monitoring, and implementation of contract results. The synthesis noted that nearly all states conduct contract research, and 90 percent of the states responding to the synthesis survey reported moderate to large increases in their contract programs—increasing from 50 percent of the entire research program in 1987 to 70 percent of the research program by 1994. Although the synthesis documented contracting procedures, it provided a clear view of how many states are dealing with funding changes resulting from ISTEA.

Reilly, E.F. and B.T. Harder, *Guide for Developing a State Transportation Research Manual*, National Cooperative Highway Research Program, Transportation Research Board, National Research Council, Washington, D.C., April 1997.

ISTEA led the FHWA to institute regulatory changes that made individual states more autonomous and also more

accountable for their research programs. The resulting regulation specifies that states must develop, establish, and utilize a management process that identifies and implements RD&T activities expected to address priority transportation issues. In addition, states must also certify to the FHWA that their research programs conform to an approved management process—including documentation of that process being available for review by the FHWA. At the time of ISTEA, many states had no formal management process. The guide was written in response to this lack of process, as well as to address the increased program activities generated by the large funding increases provided by ISTEA.

The guide is a step-by-step documentary on how to institute a management process for a state research program. It written so that states can use the verbiage suggested in the guide to produce their own manuals describing their customized management process. A commentary is included to explain why each element is important and describe its most applicable use. An electronic version of the material is included so that states can select the options presented, tailor them to their specific circumstances (build the management process) and then produce the documentation required to meet the regulatory mandates. The guide is the most detailed account available of the management and administrative topics encountered by state DOT RD&T programs.

Bikson, T.K., S.A. Law, M. Markovich, and B.T. Harder, *NCHRP Report 382, Facilitating the Implementation of Research Findings*, Transportation Research Board, National Research Council, Washington, D.C., 1996.

This work had three major goals: (1) identify and evaluate significant factors that influence the implementation of research results, (2) determine ways to improve technology transfer and facilitate interagency and public-private cooperation in applying research results, and (3) recommend strategies to create an environment conducive to innovation and timely application of research findings in surface transportation.

Among the many findings from this research, the general conclusions and recommendations from this work are most relevant to recap for this synthesis. The items listed here are specifically directed to senior managers and decision makers in the transportation community, especially in DOTs. These items show that there are significant strategies that can be applied to make the RD&T program more responsive to the application of innovation through effective implementation of research results.

- At all levels of state DOTs motivation to find and use new research is high.
- Institutionalizing effective strategies promotes markedly more successful implementation.
- Active encouragement of implementation is more important than previously understood.
- Implementation practices and strategies make the difference in research results application.
- Opportunity for effective dialog exists among researchers, decision makers, and users.
- Collaboration and pooling of resources will strengthen efforts.
- Targeted research leads to better implementation.
- Technically knowledgeable staff is critical for implementation success.
- Senior management and decision makers can and do play a critical role in implementation success.
- Rewarding, high-quality groundwork leads to an increased implementation effort.
- System-level changes for improving research results implementation are possible but require time.

Harder, B.T., *Documenting Peer Exchange Administrative Experiences*, NCHRP Project 20-38a, Transportation Research Board, National Research Council, Washington, D.C., 1998.

This study was prepared to assist in the planning and conduct of Peer Exchange meetings. These meetings are regulatory requirements and are conducted to enhance the management of state RD&T programs. Successful practices used within state DOT research units are exchanged using the vehicle of an in-depth examination of a host state program. The study investigated the experiences of the first 13 Peer Exchanges hosted by state DOT research units and documented the administrative processes carried out by them in the course of their preparation, conduct, and follow-up activities. States not having conducted their peer exchanges could consult the study report to determine methods and processes that were considered most effective and helpful for a successful meeting. Some of the items discussed are planning time required, location, team leader and team member selection, scope and objectives, agency participation and presentation to senior executives.

The data for the study were collected through in-depth interviews with the Peer Exchange team leaders and the host state research managers. (For the most part, team leaders were experienced peer research managers.) The report highlights two items of particular interest to this synthesis. First, states have much to learn about the management of their research programs and considerable knowledge is available from their peers. This shows a general deficiency in the interchange and coordination among the state programs. However, it does not state why that deficiency exists; perhaps it is because of insufficient resources or venues to accomplish such coordination or

lack of sufficient emphasis on such coordination by the state now that less of such effort is performed by the FHWA. Second, the report shows that these representative research managers are very concerned about research program visibility with and their access to senior management. Unfailingly, research managers and team leaders encouraged their peers to do *whatever is necessary* to have senior management attend and participate in the exchange team concluding session.

Roussel, P.A., K.N. Saad, and T.J. Erikson, *Third Generation R&D: Managing the Link to Corporate Strategy*, Harvard Business School Press, Boston, Mass., 1991.

This book describes concepts that senior executives can use to more effectively manage their organization's R&D function. It discusses three levels or generations of evolution in the way R&D is approached within a company. The three levels are:

1. First generation management—R&D is an overhead activity, a cost center. R&D budgets are set according to some predetermined measure, such as a percentage of revenue or sales, and are usually set annually. There is little or no connection between the research selected and the business strategy.
2. Second generation management—Managers outside the R&D function suggest topics for research. Individual projects may be aligned with business strategy, but there is no relationship of the program to overall company strategy or direction. Projects are justified on rate-of-return or the potential for payout/off, thus putting the program in a position of sponsorship of predictable, conservative projects yielding only incremental improvements, not breakthroughs having strategic impact.
3. Third generation management—Managing in this mode produces an R&D program that supports and enriches the overall business strategy and mission of the organization. The process is continuous and interactive, requiring an active partnership among the R&D leadership and the other key managers of the organization. Such a partnership will exist only if all involved are knowledgeable about issues and concerns of importance to each other. Third generation management requires active participation by an organization's general management for direction, guidance, and resources.

This book is based on the research and experience of three highly qualified members of Arthur D. Little, Inc., who, with others in their organization, have provided counsel in technology and research for diverse businesses in a wide range of industries.

RESEARCH METHODOLOGY

Manning, D.G. and A.R. Bacchus, *Manual for Scientific Inquiry into Transportation Problems: Research Methodologies—Draft Report*, NCHRP Project 20-7(74), Transportation Research Board, National Research Council, Washington, D.C., June 1997.

The purpose of this manual is to improve the quality of transportation research. The report was written in response to a perceived need for a single, comprehensive source of information on the conduct of research. Because great detail could not be included in one document, the manual includes an overview of state-of-the-art techniques for problem statement development; literature searching; development of the research work plan; execution of the experiment, data collection, management, quality control, analysis and interpretation; and reporting of results, as well as the requirements for systematic, professional, and ethical conduct of transportation research. The work is directed to individuals with college education, but with no formal training in the conduct of research. This report is the first effort within the transportation research community to define a level of competence expected from the conduct of research.

PROGRAMS AND FUNDING

Special Report 202, America's Highways: Accelerating the Search for Innovation, Transportation Research Board, National Research Council, Washington, D.C., 1984.

This study provided a unique approach to highway research in that it proposed solving significant highway problems from a unified perspective in the form of a major coordinated research program. The study committee identified six priority areas where concentrated research could produce innovations that would greatly increase the productivity and safety of the nation's highways—asphalt, long-term pavement performance, maintenance cost effectiveness, protection of concrete bridge components, cement and concrete in highway pavements and structures, and chemical control of snow and ice on highways. The report lays out a 5-year plan to conduct a program anticipated to require $30 million annually or $150 million over the course of the effort. It was recommended that funding for the program come from a set aside amount of 0.25 percent of federal-aid highway funds.

Several critical items in this report had remarkable impact on the transportation research community. The report highlighted the dramatic underspending on highway research—0.15 percent of the 1982 total highway program expenditures. This figure was declining at a significant rate, having decreased from 0.25 percent in 1968. In com-

parison, high technology industries were spending up to 6 percent of their gross revenue on research and development—40 times greater than highway research spending. Even low technology industries such as metals, mining, and paper spent eight times more on research and development. Similarily, other nations were investing in highway research at a rate exceeding 5—10 times the U.S. commitment. Understanding the effect this underspending would have on the nation's capacity to compete in an increasingly global economy was a substantive issue that gained the attention and commitment of highway decision makers. The report argued that a 1 percent reduction in pavement costs alone would save $100 million per year, well in excess of the then $70 million annual expenditures for all highway research programs.

This TRB special report provided a well-designed plan for achieving significant progress in addressing longstanding highway problems. The program was not endorsed on the technical merits of the research, but the concepts of cost savings—return on research investments, national competitiveness, funding availability, and other strategic issues. The constituency building and marketing of the program was a model for promoting buy-in from senior managers for subsequent efforts of strategic importance.

Reilly, R.J. and B.T. Harder, *Transportation 2020: Keep America Moving, Innovation: A Strategy for Research Development and Technology Transfer*, American Association of State Highway and Transportation Officials, Washington, D.C., 1989.

This report documents the status, benefits, and future needs of RD&T activities during the time immediately preceding the passage of the ISTEA in 1991. The report provided background material for use by AASHTO and others in the development of a national surface transportation program. Recommendations from the report were used by AASHTO for its input to the ISTEA legislation. The report discusses the need for a comprehensive strategy for the myriad research activities conducted at state and national levels. The AASHTO Board of Directors and RAC supplied detailed information on program and funding priorities, as well as priorities for expanding services in RD&T. The report highlights how RD&T financial support had eroded during the prior 2 decades and, with the declining funding, how correspondingly the potential for innovation was eroding. One of the most significant recommendations made in the report regarded the dramatic need to increase funding for state RD&T activities, for FHWA technology and research efforts, NCHRP, SHRP/LTPP, and ITS. In particular, the report recommended increasing state highway RD&T spending from all sources by 50 percent. The ISTEA legislation incorporated the majority of funding recommendations from this report. Notably, the report substantiated AASHTO's ongoing commitment to supporting innovation through RD&T programs both on a state and national level.

Transportation Research Board, Special Report 244, Highway Research: Current Programs and Future Directions, Transportation Research Board, National Research Council, Washington, D.C., 1994.

This report provides a broad overview of the highway research and technology (R&T) program—comprised of the FHWA, state planning and research, NCHRP, and private sector research efforts, portraying the current highway R&T program at a level that matches the interests of policy makers, top agency officials, and others who need to understand the program and exercise broad program oversight. The study committee was comprised of the members of the Research and Technology Coordinating Committee, a special committee convened by TRB and funded by the FHWA. The report contains the study committee's framework for classifying R&T activities and maps 1993 spending in terms of that framework. The report presents recommendations that describe the committee's vision of how highway R&T programs should be redirected to meet the needs of the highway transportation system in the next century.

The committee's vison for highway R&T for the next decade includes the following:

- Larger-scale program with more funding,
- Additional exploratory and high-risk research,
- Broader perspective within highway R&T,
- Comprehensive approach to barriers to innovation, and
- Increased research cooperation and coordination efforts.

Areas of emphasis for future highway R&T programs are:

- Reassessment of the U.S. transportation system and the role of highways,
- Greater attention to environmental research,
- Contracting for innovation—contracting and procurement practices,
- Support for breakthrough research, and
- Removing resistance to long-term and intermodal research.

THE TRANSPORTATION RESEARCH BOARD is a unit of the National Research Council, a private, nonprofit institution that provides independent advice on scientific and technical issues under a congressional charter. The Research Council is the principal operating arm of the National Academy of Sciences and the National Academy of Engineering.

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The National Academy of Sciences is a nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Bruce Alberts is president of the National Academy of Sciences.

The National Academy of Engineering was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encouraging education and research, and recognizes the superior achievements of engineers. Dr. William A. Wulf is president of the National Academy of Engineering.

The Institute of Medicine was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences, by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Kenneth I. Shine is president of the Institute of Medicine.

The National Research Council was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Bruce Alberts and Dr. William A. Wulf are chairman and vice chairman, respectively, of the National Research Council.

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