Research Management
Peer Exchange

Hosted by the
Oregon Department of Transportation

FHWA-OR-RD-99-11

June 2-4, 1998

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Research: A strategic tool for use by management in achieving the goals and objectives of the Department.

1.0 INTRODUCTION

The Oregon Department of Transportation hosted a Research Management Peer Exchange June 2-4, 1998. The members of the peer exchange team included:

- Bruce Gates, Professor, Management Consultant, Willamette University
- Scott Sabol, P.E., Director, Delaware Transportation Institute
- Bob Schmiedlin, P.E., Wisconsin Department of Transportation (WisDOT)
- Nick Fortey, P.E., Division Contact, FHWA
- Liz Hunt, P.E., Interim ODOT Research Manager

To prepare for the peer exchange, each panel member was mailed a binder that included ODOT background information including:

- Historical information,
- Organizational charts,
- Lists of current SPR funded and State Program funded projects,
- Recap of the current FY selection process and results, and
- Work plans for presentations made during the introductory session.

Panel members were also asked to complete a form that included state DOT and research program information. The completed forms are included in Appendix A.

The objectives of the peer exchange process were to:

- Identify how ODOT can improve the quality of the research results.
- Examine how ODOT can better implement research findings.
- Identify methods to determine the value of research.
- Determine how much emphasis ODOT should place on research done by other sources.

To collect information addressing the objectives, core questions were asked of all the participants. The participants included ODOT managers, Research Unit customers, Oregon State University researchers, Albany Research Center researchers, Portland State University researchers, and FHWA staff. A complete list is included in Appendix B. Participants were provided with copies of the questions before the one-on-one interviews. Responses were discussed during the meeting with the peer exchange team. The core questions and common responses from the participants are shown in Table 1.1.

Table 1.1. Core questions and common responses.

Question	Common Responses
What do you and your staff do to learn about outside research results and activities?	❑ Internet, journals ❑ TRB Conference ❑ Formal and informal contacts ❑ ODOT Library
What are the elements of value that are added by research?	❑ Timely ❑ Credible ❑ Documented ❑ Unbiased ❑ Cost-effective ❑ Policy oriented ❑ Specification oriented
How should upper management influence the direction of research and development in ODOT?	❑ Management to provide recognition for innovation. ❑ Management to provide funding. ❑ Management to provide a presence. Appearance of management being involved can make a difference. ❑ Management to provide strategic direction to the RAC. ❑ Management to require Research accountability.
How can credibility of the Research Unit be improved?	❑ Complete projects on time, on budget. ❑ Select projects that are applicable, relevant and with identified risks associated with implementation. ❑ Produce quick responses. ❑ Produce valid results.
How can research implementation be improved?	❑ Transfer the information in other ways than only a report—workshops, training sessions. ❑ Marketing, marketing, marketing. ❑ Maintain communication.
What do you see as the role of research in ODOT?	❑ Research can satisfy expectations of the travelling public by providing new and innovative solutions. ❑ Research can filter research done by others. ❑ Research should be the technology transfer agent.

Successes and resulting action items based on the Peer Exchange are presented in terms of the stated objectives.

2.0 SUCCESSES

ODOT has a research program and structure that they can be proud of, especially considering the size of its staff and the funding level. Generally, the research process in Oregon is an organized, logical and workable process. All of the basic pieces are in-place to be able to conduct a research program that meets the needs of the department: a process to identify departmental needs, a staff dedicated to research, support of top management, champions or allies scattered throughout the organization, various associations or connections both within and outside the organization; and a customer base that is in need of and wants the results that the research program is able to provide. In addition:

- ODOT has successfully introduced new technology through workshops including the recent training in composite materials.
- Several positive comments were made regarding the recent research strategic planning session.
- The research selection and oversight process is a significant improvement.
- Research has expanded its customer base to include more non-traditional research.
- There is an entrepreneurial spirit in pockets of the organization that significantly contributes to research productivity.

3.0 ACTION ITEMS RELATED TO OBJECTIVES

3.1 IDENTIFY HOW ODOT CAN IMPROVE THE QUALITY OF THE RESEARCH RESULTS

Quality research is defined as research done that meets the needs of the Department in the most efficient way.

Action items identified that will help achieve this goal include:

- Place greater emphasis on technical content when managing research projects (versus administration).
- Increase the pool of researchers (Wisconsin's NOI (Notice of Interest) process).
- Increase the frequency and level of involvement of the TAC, for example, whether to grant no cost time extensions.
- Educate all Units in the Department of the project selection process.
- Consider best way to staff socioeconomic, planning, public transit and multi-modal issues ETG. Should Environmental be included?
- Consider applicability, relevancy, and implementation during project formulation, selection and conduct.
- Identify research liaisons in Regions, design sections, etc. to identify problems, needs, and innovations.
- Seek direction on the appropriate split between front-end (project development)/back-end (implementation) efforts and number of projects managed.
- Review the balance of funding between Research and Planning.

3.2 EXAMINE HOW ODOT CAN BETTER IMPLEMENT RESEARCH FINDINGS

- Create research liaisons in Regions, design sections, etc. to identify problems, needs, and innovations. The liaison would also act as the technology transfer conduit.
- Promote research done by others and the Unit through periodic "brown-bag" presentations to appropriate audiences. Invite upper management.
- Perform follow-up of implementation activities.

3.3 IDENTIFY METHODS TO DETERMINE THE VALUE OF RESEARCH

- Publish research results in professional journals.
- Present research results at professional conferences.
- Complete research in a timely manner.

3.4 DETERMINE HOW MUCH EMPHASIS ODOT SHOULD PLACE ON RESEARCH DONE BY OTHER SOURCES

- Organize research done by others to address ODOT needs. Our expertise should be used to identify valid research results.
- Strongly encourage Director to get TRIS/Research in Progress database operational.
- Coordinate with FHWA to get information about research done in other states.

4.0 ADDITIONAL ACTION ITEMS IDENTIFIED

4.1 MARKETING

*The sole purpose of marketing is **getting** and **keeping** customers. (Theodore Levitt)*

- Make use of public information officer and the tools being used by that office (survey).
- Participate in Commissioner tours to local Districts.
- Identify research liaisons in Regions, design sections, etc. to identify problems, needs, and innovations. The liaison would also act as the technology transfer conduit.
- Amend the project solicitation/selection process to include more communication with the problem submitter to insure understanding.
- Provide assistance to problem statement submitters in preparing and marketing problem statements.
- Establish a regular contact schedule with other ODOT sections to both provide information and identify needs.
- Promote research done by others and the Unit through periodic "brown-bag" presentations to appropriate audiences. Invite upper management.
- Integrate additional partners in the program (private industry).

4.2 CONTRACTING

- Include Gantt charts in all work plans. Require quarterly updates by the principal investigators. Gantt chart to include scheduled milestones and contacts with Technical Advisory Committee.
- Specifics of OSU contract need to be revisited to include items such as overhead rate and tuition reimbursement.
- Explore flexible services type contracts to allow rapid response.
- Increase the pool of researchers (Wisconsin's NOI process).
- Seek solutions to shorten internal timeline for contracting.

5.0 PEER EXCHANGE MEMBERS' NOTES

5.1 WISCONSIN

Remembering that WisDOT is undergoing changes that will significantly alter the way they do business, there were, never-the-less, many observations made and things learned (and re-learned) that can be used by WisDOT in their new role as the Technology Advancement Unit.

- Be more proactive.
- Communicate with the district staff including more active contact with the district technical committees.
- Use the Office of Public Affairs staff to help sell research and to communicate the accomplishments to all customers.
- Take advantage of the research champions and use them to further the effectiveness of technology advancement.
- Follow through on implementation of technology.
- Strengthen the Technology Transfer role even more than it is now (including the use of one page epistles similar to ODOT's Research Notes).
- Continue to have an eye towards the national perspective and the networking it provides so we can stay better connected.

5.2 DELAWARE

Observations to take back to Delaware Department of Transportation (DelDOT):

- ODOT's organizational structure and research process lend themselves to a successful program.
- WisDOT's Notice of Interest approach is an effective method for soliciting widespread interest in performing research.
- WisDOT's post-project performance evaluation helps track success of projects.
- The need to pressure TRB to allow for research-in-progress updates in TRIS is not just a Delaware issue.
- Stopping "bad" projects early helps avoid "tainting" the perception of research.
- ODOT's recognition of people enhancing innovation at DelDOT helps reward special efforts.
- Post-projects implementation workshops for affected DelDOT units and others are useful.
- ODOT's planned use of the communication staff for Research Unit objectives is good.
- Use research staff as a "quality filter" for reports coming to DelDOT.

- Obtain district/front-line/field-level input to the process and feed appropriate results to those groups, also.
- Have top management communicate DelDOT broad-based priorities to research and other units to help in setting areas for research.
- Consider split of planning and research funds (SPR) to best meet Department goals and objectives.
- Consider use of Gantt charts in work plans.
- Consider DelDOT staff as co-authors.
- Consider use of intermediate deliverables in projects.

5.3 FHWA

- Distribute the peer exchange report to all FHWA Division Offices and to FHWA Headquarters.
- Work with FHWA Headquarters staff to ensure peer exchange reports from other State's are more widely distributed. Summaries of common and significant findings should also be shared widely.
- Emphasize to Headquarters the importance of bringing the TRIS/RIPS on line as soon as possible.
- FHWA should focus on maximizing the dispersal of quality research findings. While the use of computer databases such as TRIS and RIPS are valuable tools, FHWA should also employ staff to evaluate and synthesize promising research and implementation activities done nationally and internationally.
- FHWA should increase the investment in technical training of its staff to ensure the agency can effectively promote new technology.
- Procedures to allow shared staff arrangements among FHWA, ODOT, Oregon Universities, and other State agencies should be developed and efforts made to promote staff exchanges.
- As a cornerstone in our efforts to promote transportation leadership, FHWA should develop university-level educational materials to ensure future graduates are well-versed in new technology.
- The National Highway Institute should develop a course on conducting research studies.

5.4 CONSULTANT

Bruce Gates was contracted to participate in developing the interview questions, assisting in the interviews, and to prepare a paper on the role of innovation in ODOT. Bruce's finished paper, *Research as a Tool for Innovation in ODOT,* is included in Appendix C.

6.0 CONCLUDING STATEMENT

The Peer Exchange Panel unanimously endorses the Peer Exchange process as a method to improve the ODOT research management process. The forum provided an opportunity to meet and candidly discuss research issues from a variety of perspectives.

APPENDIX A

STATE DOT AND RESEARCH PROGRAM BACKGROUND INFORMATION

PEER EXCHANGE
DOT AND RESEARCH PROGRAM BACKGROUND

State: Oregon

DOT size (number of employees)	4,400
Number/type of modes controlled by DOT	Highways, aviation, public transportation, rail and freight, bike and pedestrians, safety
Miles of highway owned by DOT	7,500
Annual research budget: ■ State	$165,000
■ Federal	$1,000,000
Percent SPR funds to: ■ Planning	75%
■ Research	25%
Organizational position of research unit	Policy/Research Section; Transportation Development Branch. See organizational chart.
Percent of $ spent on research: ■ in-house	40%
■ universities	40% (universities and other government agencies)
■ consultants	20%
Emphasis areas	Structures and asphalt concrete pavements

PEER EXCHANGE
DOT AND RESEARCH PROGRAM BACKGROUND

State: DELAWARE

DOT size (number of employees)	1,500
Number/type of modes controlled by DOT	Highways & Transit under DOT. Marine port (Wilmington) and airports under quasi-State control. Pedestrian and bicycle under mixed control. Rail under mixed control.
Miles of highway owned by DOT (state owns 88% of all roads0	5,800 route miles (12,000 lane mi.)
Annual research budget: ■ State	$250,000 - $300,000 (projects only)
■ Federal	$350,000 from SPR plus occasional special "extras" some years
Percent SPR funds to: ■ Planning	approx. 75%
■ Research	approx. 25% (increased if needed)
Organizational position of research unit (Provide organizational chart, if available)	under Division of Planning. Research is not a "standalone" subunit in Planning
Percent of $ spent on research: ■ in-house	5%
■ universities	85%
■ consultants	10%
Emphasis areas	structures, mat'ls, planning, traffic, finance, multi- and intermodal, environment, transit

PEER EXCHANGE
DOT AND RESEARCH PROGRAM BACKGROUND

State: Wisconsin

DOT size (number of employees)	4,200
Number/type of modes controlled by DOT	Highways, and aids to air and transit systems
Miles of highway owned by DOT	13,000 centerline miles
Annual research budget: ■ State	$250,000
■ Federal	$1,300,000
Percent SPR funds to: ■ Planning	75%
■ Research	25%
Organizational position of research unit (Provide organizational chart, if available)	Various
Percent of $ spent on research: ■ in-house	30%
■ universities	70%
■ consultants	
Emphasis areas	Traffic, Safety, ITS, Pavement Performance, New Products, Environment, Planning

APPENDIX B

PEER EXCHANGE PARTICIPANT LIST

PEER EXCHANGE PARTICIPANT LIST

Tom Lulay, ODOT Executive Deputy Director

ODOT Research and Technology Transfer Unit Staff

- Alice Passannante, Research Analyst
- Brett Sposito, Senior Research Specialist
- Marty Laylor, Research Coordinator
- Eric Brooks, Research Specialist
- Rob Edgar, Research Coordinator
- Wes Heidenreich, Technology Transfer Center

ODOT Technical Services Branch Staff

- Terry Shike, Interim Technical Services Branch Manager
- Jeff Gower, Pavements Engineer
- Jeff Scheick, Traffic Engineer
- Galen McGill, ITS Manager
- Mark Hirota, Interim Bridge Engineer
- Pieter Dykman, Environmental Services Research
- Donna Kilber, Environmental Services Project Management

ODOT Transportation Development Branch Staff

- Ron Schaadt, Interim Deputy Director
- John Merriss, Interim Policy/Research Section Manager
- Mark Ford, Interim Transit Manager
- Paul Norris, Interim Planning Section Manager
- Monte Turner, Transportation Development Branch Public Information Officer

ODOT District 4 (Maintenance Office)

- Bob Wood, District 4 Manager, Corvallis

ODOT Region 2

- Tom Lauer, Region 2 Project Delivery Manager

FHWA Division Participants

- Jeff Graham
- John Gernhauser
- Elton Chang
- Bruce Johnson

OSU Researchers

- Chris Bell
- Jim Lundy
- Rita Leahy
- Dave Rogge
- Kate Hunter-Zaworski
- John Westall
- Bob Layton

Department of Energy – Albany Research Center Researchers

- Steve Cramer
- Bernie Covino
- Gordon Holcomb
- Sophie Bullard

Portland State University

- Jim Strathman

APPENDIX C

Research as a Tool for Innovation in ODOT

By

Bruce Gates, Ph.D.

Research as a Tool for Innovation in ODOT

Bruce L. Gates, Ph.D.
Professor of Management
Willamette University

As part of my contract with ODOT to participate in the recent Research Unit Peer Exchange process, I agreed to prepare a brief summary of the role of research and innovation within that agency. The following is my effort to synthesize current literature on organized innovation with results of the Peer Exchange interviews. Please note that one aspect of our interviews, which I think was sometimes confusing, was a failure to distinguish clearly between research, the activity, and ODOT's Research Unit. I have tried to be careful to make the distinction in what follows.

Strategy & Innovation

A critical element in formulating and implementing strategy in many *businesses* is producing and managing innovation. Innovation is a direct requirement of specific business strategies such as differentiation (requiring product innovation) and cost leadership (requiring process innovation). But it is just as true that the ability to generate innovations in these and other areas *permit* a business to pursue certain strategic directions. If a firm is unwilling or unable to commit resources to process innovation, for example, it is unlikely that it will be able to achieve competitive advantage via cost differentiation.

The strategic importance of directed innovation has given rise in recent years to a whole new way of evaluating and formulating organizational strategy, and that is the concept of "core competence". The idea that capabilities or competencies drive strategy, as well as the converse, has been around for some time in the writings of Douglas McGregor and Igor Ansoff, for example. But the most recent incarnation is generally attributed to Gary Hamel and C.K. Prahalad. The intent of identifying the firm's core competencies is to distinguish capabilities that are fundamental to a firm's performance and strategic direction from those that are more peripheral. In their words, core competencies are those that "…make a disproportionate contribution to ultimate customer value or to the efficiency with which that value is delivered."

It's undoubtedly true that the nurturing of core competencies contributes directly to the attainment of any business' two primary goals: attaining competitive advantage over rivals and growth. Obviously, neither is an appropriate goal for public agencies like ODOT. Nor is a risk-averse competitive posture that often attends their pursuit. Nonetheless, the overarching principles whereby these goals are assumed to be achieved – providing *greater value* to consumers at *lower cost* – seem perfectly consistent with contemporary principles of sound public management.

During the Peer Exchange, the team interviewed ODOT Deputy Director, Tom Lulay. In response to the question of ways upper management could and should influence the direction of R&D, Lulay provided several valuable insights:

- Innovation is essential in ODOT, and thus the appetite for research by ODOT managers needs to be encouraged.

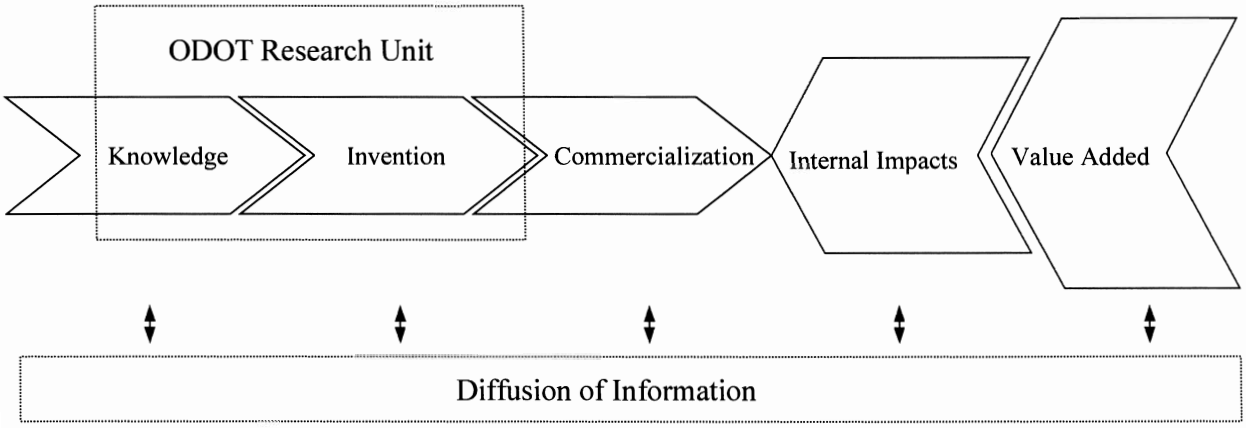
- The quest for new products and processes should be guided by the need for ODOT to regain and maintain a high level of public trust in the agency.
- Rather than pursuing high risk, cutting edge technologies, ODOT should focus innovative efforts that represent what agency Director, Grace Crunican, has called, "The Remarkable Use of New Technologies".
- Innovation always entails risk, but developmental testing can reduce it.
- In rapidly changing environments, it is essential for research to be timely (not "trendy" but timely).

Armed with these broad strategic directions for research within ODOT, what can be said about the process of innovation?

The Innovation Process

The process of innovation within an organizational context may be seen as comprising a number of interrelated activities, which impact both the organization and its external constituents. I've represented these as a value chain in Figure 1. I'll refer to the figure in various sections throughout this report.

Figure 1: The Innovation Process



1. **Knowledge Base Development:** Development and maintenance of a repository of basic knowledge in various areas of strategic importance, which in ODOT's case, are called "disciplines". Basic disciplinary knowledge is developed and maintained organizationally within the Expert Task Groups (ETGs). It is also developed and maintained externally, for example in universities, contractors, and other transportation-related organizations. I call this activity "basic research".
2. **Invention:** The creation of technically valid new products and processes through the development of new knowledge or, more typically, from new combinations of already existing knowledge. Technical validity is achieved through use of accepted inferential processes, which may involve controlled or uncontrolled (statistical) experimentation. I call this activity "applied research". Inventions that involve the "hard sciences" are the province of ODOT's Research Unit. Those involving the

"soft sciences," and which thus involve different empirical techniques, appear to occur largely within ODOT's planning units.

3. **Commercialization:** The creation of commercially valid new products and processes from technically valid inventions. Commercial validity entails assessing internal or producer feasibility and cost-effectiveness and assessment of end-user value added, e.g. "fitness-for-use". I call the internal phase of commercial assessment, which may be expanded to include non-scientific activities, for example analysis of life cycle costs, "applied research,"; and the external phase, "market research".
4. **Impacts:** Impacts begin the transition from innovation to consumer value added. And while innovation impacts myriad aspects of an organization's structure and activities, in my view there are three critical areas to concentrate upon within ODOT. First, how does innovation impact policy, or the broad principles and strategies that determine the agency's direction? Second, how does innovation impact product and process specifications? And third, how does innovation impact work performed, particularly at the field level?
5. **Diffusion:** Normally in business, only if innovation is successful does it become diffused: on the demand side, diffusion occurs through customers purchasing the resulting good or service; on the supply side, through imitation by competitors. Within a public setting, however, it seems appropriate to think of diffusion as occurring at any point in the innovation process, not just at the end. Presumably, the public sector represents a cooperative rather than a competitive environment, and presumably the sharing of information and innovation among jurisdictions is a paramount goal of the Research program. But, as the Peer Exchange report indicated, a primary mechanism for diffusion -- the federally supported Transportation Research Information System (TRIS) – is falling far short of its potential. The database is cumbersome to use and is apparently not current.

Although innovation is stimulated by creativity, it is vital that creativity be channeled toward innovations that address an identifiable need – most frequently the need to solve specific problems. Problems, in turn, may be identified by customers, suppliers, or other stakeholders. Lacking the essential linkage between research activities and ultimate customers, R&D output all too often fails to result in marketable, manufacturable new products.

Based upon Peer Exchange interviews, it seems clear that ODOT's Research Advisory Committee (RAC), which is charged with filtering research proposals, provides a workable formal linkage between research activities, agency needs, and presumably consumer values. At issue, however, is RAC member awareness and support of ODOT's primary goals and strategies; some members said they were comfortable with their level of understanding and commitment, others indicated they were not.

The RAC also provides an indirect linkage between research and customers. It seems clear from our interviews that ODOT's Technical Service Branch Sections, which are heavily represented on the RAC, do a more than creditable job of monitoring and internally representing (frequently from a position of advocacy) some of ODOT's primary external customer groups, including the Federal government, the legislature, the governor, regional and local political jurisdictions within the State, and transportation end users. Our interviews left it unclear, however, whether the

innovative process would be further strengthened by directly including end user representation on the RAC.

Although the process is not always as linear as shown in Figure 1, innovation consumes time. The trend over the years has been for the elapsed time between the acquisition of basic knowledge and commercialization to become shorter, and indeed, competitive advantage is most often achieved through the timeliness of innovation. There are several strategies for speeding up the innovation process. First, timeliness may be achieved by speeding up each of innovation's component activities. Second, it may be achieved by reducing the elapsed time between them. Third, some activities may be eliminated. Fourth and increasingly commonplace in innovative industries, activities may be performed in parallel.

The achievement of timeliness is not without its significant costs and risks. Faster may (but not always) require more resources, even when activities are performed in series. If activities are performed in parallel, risk increases dramatically because significant resources may have been expended upon latter activities before basic concepts have been proven.

Given ODOT's resource limitations and generally risk-adverse posture, timeliness is probably best addressed by attempting to speed up the activities themselves through better contracting procedures (incentives for timely completion), monitoring, and control. It can also concentrate on simplifying and shortening the time between activities. In this case, it appears that simplifying the research application process (the elapsed time from knowledge to invention) has had two potentially desirable effects: it has increased the scope of research activities undertaken and it has shortened the elapsed time. It appears, however, that commercialization, which requires significant analysis and testing of marketable new products and processes, remains the primary barrier to timely innovation.

Several Peer Exchange participants indicated a need for "quick hit" research projects, which seemed to imply developing the capability to undertake limited-scope research that, above all, could be performed quickly. This raised the issue of access to flexible resources that could be quickly brought to bear, perhaps achieved through retainer-like personal services contracts. But Figure 1 would seem to imply that *where* in the innovative process such projects would be most successfully undertaken is a critical issue as well. It is doubtful, for example, that – unless it is severely and very carefully limited in scope – useful research involving commercialization can be performed quickly. This is true because latter activities in the innovation process tend to impact a greater number of organizational participants and interests than do those undertaken in the earlier stages.

Managing the Innovation Process

While innovation's primary activities are important, how they are managed as a whole is even more so. A crucial question that surrounds innovation is the degree to which and methods by which it can be controlled. It is generally recognized that a balance is needed between individual initiative or entrepreneurialism and the spirit of group ownership of invention. Organizations must provide appropriate autonomy and incentives for individual initiative and creativity to take root, but they must also promote cooperation and group ownership of invention if it's to be implemented successfully.

The Peer Exchange Team was generally impressed by the high level of entrepreneurialism manifest among many members of the research staff, the majority of research contractors interviewed, departmental staff, and the district offices. In large part it is this entrepreneurial spirit – curiosity combined with dedication – that helps forge the necessary linkages among research, application, and implementation. The linkages are greatly strengthened by the strong, but largely informal, interpersonal relationships that have built up among the key players.

Three organizational approaches are used to produce and manage innovation in business: 1) it may be generated internally, 2) it may be generated in partnership with other firms, or 3) it may be acquired. The approaches seem equally applicable to public institutions, as well, and indeed it appears that all three are employed in varying degrees within ODOT.

Internal Innovation

Two different strategies characterize the internal management of innovation. The first, so-called *autonomous strategic behavior*, is a bottom-up process in which product champions -- generally mid-level managers who are typically affiliated with users of research -- pursue new product and process ideas; the ideas, themselves, may come from any and all sources. The champion's role is to shepherd an innovation through the entire process, from initial idea to (if successful) ultimate commercialization and marketplace success. Champions are interpreters who understand and are able to convey the value of a particular innovation in strategic terms, often through internal political processes. They thus derive their power and legitimacy through both an understanding of an innovation's fundamental technology, its feasibility from a producer standpoint, and its potential contribution to user value added and the broad strategic direction of the organization.

Within ODOT, champions tend to be members of the Expert Task Groups (ETGs) and/or Technical Advisory Committees (TACs). As members of the ETGs, champions develop strategic plans for their discipline areas and provide an initial evaluation of project submittals. As TAC members, they assist in developing, monitoring and controlling specific research projects. Formally, the TACs provide input to the ETGs who in turn advise the RAC on project selection. Informally, RAC members may be contacted by any project champions at large concerning project selection.

The second internal strategy, a top-down approach sometimes called *induced strategic behavior*, seems to be called for when specific innovations are deemed absolutely essential to an organization's current mission, strategy and structure – too significant or too dependent upon broad organization-wide ownership to be left to largely autonomous initiatives. Within ODOT, at least two general classes of innovation might call for an induced approach. First are those called for by national initiatives, the Strategic Highway Research Program or the Inter-modal Surface Transportation Efficiency Act for example. Second are innovations intended to deal with the negative externalities associated with transportation systems that impact the policies and activities of other agencies or jurisdictions – for example, noise, air, and water pollution; or traffic congestion.

Partnerships

ODOT performs a large portion of it innovative activities – particularly during the invention phase – via contracts with other agencies and universities. Contracts differ in one important respect from the so-called *strategic alliances* that are typical in today's innovative partnerships in business: there is no real sharing of the risks entailed.

While contracts allow the agency to extend its knowledge and research base, the Peer Exchange process indicated that contractor timeliness, particularly among university-based contractors, was often a problem. All members of the Exchange Team thought that ODOT should consider extending its contracting reach to include, at the very least, universities from other states and possibly private consulting firms.

Acquisition

If you don't have it, and can't develop it quickly enough, then buy it. Although acquisition of organizations is generally infeasible in the public sector, the acquisition of innovations created and commercialized by other agencies and jurisdictions is of paramount importance. The key to timely acquisition of knowledge is, of course, a timely and effective system of diffusion, which as I have already said, is a problem. Someone once said that insanity is doing the same thing twice and expecting different results; it seems equally insane not to know that something is being done for the second time.

Innovation: Risks & Value Added

There is little question that for successful companies at least, the potential rewards of innovation balance the financial risks, and the risks can be significant. Fewer than 1% of new products introduced by American industry are still on the market one year after their introduction. And for the most innovative of companies, which thrive by successfully differentiating their products from those of their competitors, the costs of being in the technological forefront can be can be stupendous. Intel's 1997 R&D expenditures, for example, were more than $2.3 billion, amounting to nearly 10% of net revenues. Increasingly, companies cut costs and spread risks through the establishment of strategic alliances, even among firms that in other markets might be competitors.

The innovator is not the only beneficiary of innovation. Also benefiting to various degrees are suppliers, imitators, and, of course, customers. The total value added through innovation may or may not favor the innovator. The extent to which an innovator can capture the total value from innovation is called appropriability. The critical issue for the innovator, of course, is how that value is distributed among the different parties to innovation.

NutraSweet, for example, generated huge profits for its inventor and innovator, Monsanto; presumably the male potency drug, Viagra, will do the same for its developer, Fizer. The case of the personal computer, however, is much different and, I suspect, is quite similar to innovations in transportation. While the overall benefits generated by the PC were also huge, the primary beneficiaries were not the innovators like Apple and MITS, but imitators like IBM, H-P, and Compaq; suppliers like Microsoft and Intel; and, by far the greatest beneficiaries, computer users.

I raise the issue of appropriability because it speaks to the issue of what parties to innovation will be willing to assume a share of the risk. Though potentially the greatest beneficiaries of ODOT-initiated or channeled innovation, it seems that Oregonians in the late-1990's are clearly risk adverse (as it seems are most Americans when it comes to issues of building and maintaining the nation's infrastructure). By its very nature as institutional expert, ODOT – while legitimately concerned with engendering the public trust – cannot be completely risk-adverse. Rather, it must

carefully weigh the potential benefits and risks of innovation on behalf of not only itself, but all Oregonians.

What about suppliers? Out-of-state Exchange Team members indicated that Oregon has possibly lagged behind other jurisdictions when it comes to involving suppliers in the innovative process, particularly during the all-important commercialization phase; one activity that was specifically mentioned was installation of roadbed test sections. Unlike most suppliers of research, suppliers of paving materials and processes, structural materials, etc., stand to reap significant profit from the fruits of innovation in transportation systems. If so, then perhaps they should be made a more integral part of the innovation process - bearing some of the costs and some of the risks, in return for a fair share of the total value added.

And finally, are imitators. The Peer Exchange Team was concerned with identifying indicators of the value of research. One such indicator, mentioned by nearly all interviewed, was timeliness. Another indicator is publication of research results in refereed journals. But probably the ultimate indicator, which I do not recall being mentioned in any of the interviews, is imitation by other jurisdictions.

The Role of ODOT's Research Unit

I have superimposed on Figure 1 a box embracing what I understand to be the Research Unit's primary responsibilities in innovation. It is my understanding that ODOT's Expert Task Groups (ETGs) are the organization's principal repository of basic transportation knowledge, called disciplines. The ETGs are supported by internal and external networks of planners, researchers, and internal users of basic knowledge.

How do ETG researchers keep abreast of their fields? Peer Exchange interviews indicated the following: trade and academic publications, TRB meetings and publications, discussions with colleagues both within and outside ODOT, the Internet, and ODOT's library (whose staff is apparently adept at accessing the TRIS database). Having been on both sides of academic accreditation processes, which always seek information about "currency," I know how difficult it is to assess an individual's effectiveness in keeping current. The process is highly individualistic and, other than documenting that the organization provides the necessary supporting resources, depends largely upon entrepreneurial intangibles like creativity, curiosity, and motivation. Concrete evidence of currency in academic settings is provided by individual output, the most valued being publication of research in refereed journals; the same, I believe can be said, of ODOT researchers.

Invention has two primary ingredients: knowledge and creativity. Invention is essentially an individual creative act that establishes a relationship between concepts or objects that had not previously been related. It has been shown that creativity is most likely to be stimulated by interaction with other people. As a result, developing communication networks that emphasize strong relationships between internal and external producers of basic knowledge and users of research findings is one of the most important aspects of the management of R&D. Despite limited resources for out-of-state travel (and presumably limited resources with which to directly reward individual excellence, as is often done in private industry), I believe the entire Peer Exchange Team was impressed by the degree to which ODOT researchers established and maintained the formal and informal communications networks that spawn invention.

The effectiveness of other necessary linkages was less clear. Legitimate research needs emanating from individuals or organizational units not affiliated with existing research networks are probably not accommodated as well as they might. The Research Unit is responsible for soliciting proposals for research to be funded under the State Planning and Research (SP&R) program, and our review indicated that, while a simplified format for solicitation had increased both the number and scope of responses, further improvement in "publicizing" the Research Unit's capabilities and accomplishments would be beneficial. However, inasmuch as face-to-face interaction appears to drive much of what gets done in ODOT, the out-of-the-mainstream physical location of the Research Unit may make expansion of its role in either direction difficult.

The Research Unit is also responsible for technology transfer, and it is in this area that the Exchange Team believes that a real opportunity for improving effectiveness. It's clear that a fair amount of innovation occurs within ODOT's Regional and District offices, and it also seems clear that better dissemination of information regarding "best practices" would profit the entire agency. It appears that there is no systematic mechanism for doing so. Perhaps this is something for the Research Unit to explore further.

The scope of the Research Unit's innovation activities embraces primarily knowledge development and invention (see Figure 1). Its influence over commercialization, however, seems less clear. In fact, it is unclear exactly through what organizational mechanism this activity is directed. Given that this activity is the most risk-exposed, its management deserves a closer look.

A final issue that requires further investigation is the organizational (and funding) relationship between planning and research and their ultimate impact on innovation. How are the two activities different? One difference that virtually no one seems to challenge is the distinction between the "soft" and the "hard" sciences, which is manifest in a number of different ways within ODOT: the types of problems and needs addressed (people vs. things); the organizational units having primary responsibility for the investigations; their basis of expertise; the scope of the activities involved and their impact; and the methodologies employed. I cannot tell whether the dichotomy represents an insurmountable barrier to innovation, but it seems to be a question worth asking.