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Managing Change in State Departments of Transportation

Scan 6 of 8: Innovations in Organization Development as a Result of Information Technology

Prepared for:

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FOREWORD

Change Management in State DOTs

State departments of transportation are operating in an environment of unprecedented change. Evolving demands for transportation services, new technologies, workforce composition, stakeholders' concerns, and a constantly changing political environment create continuing demands for institutional change. To address these challenges, many state DOTs are undertaking a range of initiatives such as strategic planning, organizational restructuring, performance measurement, process engineering, and outsourcing.

Both anecdote and survey suggest that change management is now the major preoccupation of senior management. However, the rate of change is very uneven and not well-understood. Indeed, there appears to be more *innovation* than *imitation* -- since the creative approaches being introduced are not documented or widely discussed. Little "literature" on state DOT change management has been developed -- either case studies or "how to" material.

AASHTO's Strategic Interest

A 1998 AASHTO report on "The Changing State DOT" identified drivers of change and approaches being taken by state DOTs in change management. AASHTO's Year 2000 Strategic Plan activities then introduced an element concerned with facilitating institutional change. Meanwhile, a newly reorganized TRB Committee on Strategic Management, through calls for papers and annual meeting sessions, focused on studying the range of changes occurring in transportation organizations. This led to the formation of a committee to plan a special workshop on strategic management under the joint sponsorship of the Transportation Research Board Committee on Strategic Management, AASHTO Standing Committee on Quality, and the Federal Highway Administration (FHWA).

The Strategic Management Workshop

The two-day workshop (June 25-27, 2000) in Minneapolis was organized to facilitate peer-to-peer discussions among the CEOs and senior staff of the state DOTs about their experiences in managing internal and external change. This workshop focused on sharing recent experiences with managing internal and external change and lessons learned. Twenty state DOT CEOs participated in the workshop, and 35 state DOTs were represented by CEOs or senior staff. Conference dialogue dealt with three principal management challenges:

1. Strategic planning-related initiatives
2. Workforce and reorganization-related initiatives
3. Process and program delivery-related initiatives

The discussions identified a wide range of specific issues within each area that attendees felt deserve organized review via case studies, assessment of the state of the practice, and identification of promising concepts, approaches, and tools. Workshop participants used the results of these discussions to identify research that would help state DOTs lead and manage their changing organizations. Twenty-two research problem statements were crafted around the three subject areas.

TRB, at the urging of AASHTO and participating CEOs, immediately set up an NCHRP panel, chaired by Mary Peters of Arizona DOT, to develop a multiyear NCHRP research program under the 20-24 program established for special AASHTO research related to DOT administration. The panel combined and prioritized problem statements into eight strategic management issues for priority research. In view

of the lack of written material on these subjects, the panel decided to start with broad "scans" of the state of the practice in each area to provide guidance for a substantive multiyear research program. Each scan would summarize the challenges, document examples of current innovations, and recommend the appropriate initial components of a research program. The eight-month scan program -- including presentations at AASHTO Board meeting roundtables -- represented a highly unusual rapid-response approach to the priority placed on these issues by AASHTO and TRB.

Cross-Cutting Findings from the Initial Eight Scans

The eight scans produced considerable evidence of the number and breadth of change management initiatives within state DOTs. In general, these initiatives are concerned with the agencies as institutions, their mission and leadership, organization and workforce, process, and resources. The principal, common forces of change include:

1. Deliberate reorientation of strategic objectives in response to program limitations (Scan 3, operations), new technology (Scan 6, information technology), or funding (Scan 8, innovative finance)
2. Evolution of new forms of cooperation for improved service delivery with other public agencies (Scan 7, partnerships) and the private sector (Scan 2, outsourcing)
3. Workforce strategies (Scan 5) in response to downsizing, retirements, competition, and the need for new capabilities
4. The need to institutionalize and measure change management (Scan 1, strategic leadership) and improve agency image in the overall constituent context (Scan 4, positioning)

Overall, state DOTs today appear to be evolving away from single-purpose entities with standard approaches to producing a limited number of well-understood products and services. Instead, they are moving toward more flexible organizations designed to respond to constantly changing missions with ever-increasing efficiency through a shifting coalition of partners and stakeholders. Managers of these changes can clearly benefit from access to collective experience, including a better sense of the state of the practice and specific resources based on the more promising approaches. The scans identify some of the most valuable experience and provide important pointers to key issues for further dialogue and research.

Individual Scan Highlights

<u>Scan 1 -- Innovations in Strategic Leadership and Measurement for State DOTs</u>: Strategic planning itself is increasingly widespread in state DOTs. However, many CEOs find that the process often breaks down in the implementation stage -- creating buy-in and "institutionalization" of key change vectors. Yet some promising solutions are being found, including widespread participation of a variety of stakeholders in the process, a customer focus in terms of strategy and priorities, top management commitment to implementing the strategic agenda, ongoing communication to promote it, and "omni-directional alignment" among goals, performance measures, and budgets. Further research in each of these areas is needed to strengthen and integrate strategic management practices. *(Scan by T.H. Poister and D.M. Van Slyke of Georgia State University)*

Scan 2 -- Innovations in Private Involvement in Project Delivery: Outsourcing -- commonly employed for construction and design services to cope with lumpy demands or staff downsizing -- is spreading to other functions within the project and service delivery functions. It is increasingly important to understand the relative costs and quality of work conducted in-house versus by external private firms. Current evidence is not conclusive, as cost comparisons may not have been systematic. More research and more collaborative efforts are required by transportation organizations to identify best practices and possible standard procedures. *(Scan by Dr. D. Hancher, P.E. and R. Werkmeister, P.E., University of Kentucky)*

Scan 3 -- Innovations in Institutionalization of Operations: Systems operations and management is already considered a mission priority by many state DOTs. However, the several types of operations-related activities -- ranging from ITS to maintenance of traffic -- are stovepiped and decentralized in most state DOTs. In most cases, there appears to be no common department-wide policy framework around which to organize for efficient integration of services and sustainable funding. Some member departments are establishing performance measures by conducting customer surveys, but implementation for program management is still in the very early stages. Further case study research into promising approaches is needed to connect customer interests and performance measures to integrated operations activities. *(Scan by Philip J. Tarnoff)*

Scan 4 -- Innovations in DOT Communications, Image, and Positioning: The scan focused on states known to be addressing issues of communications, image, and positioning. Those that were most advanced focused on improving both internal communications with staff and external communications with the public, elected officials, and the media. Some innovative states are assessing their image and identifying ways in which to clarify and improve it with the public, recognizing that image enhancement and improved constituent communications may lead to an improved position for the agency, to new resources, and to a more supportive audience for the agency's work. Increasingly, states report that proactive efforts to better communicate and to position the agency positively with decision makers have led to increased public support and legislative funding for the DOTs. Additional research in communications, positioning, and marketing to various constituencies was felt to be needed. *(Scan by K. Stein and R. Sloane of Howard/Stein-Hudson Associates)*

Scan 5 -- Innovations in Work Force Strategies: State departments of transportation face severe challenges in recruiting and maintaining their workforces. Innovative approaches are being taken to recruitment of core competencies such as IT and senior civil engineering. Retention and succession approaches were also investigated, including mentoring and reverse mentoring. However, more case study and research are needed in defining, recruiting, and retaining the necessary workforce. *(Scan by C. Gilliland of the Texas Transportation Institute)*

Scan 6 -- Innovations in Organization Development as a Result of Information Technology: The rapidly changing environment of IT is challenging DOTs to deal with emerging opportunities and problems. This scan identified the range and types of new opportunities related to IT itself as well as related organizational development implications. Key issues include organization of the IT function, the cost-effective degree of outsourcing, and a range of management issues such as handling information overload, funding, procurement, and training. These areas suggest future research directions. *(Scan by C. Cluett and K. Baker of Battelle Seattle Research Center)* **This scan is the topic of this file.**

Scan 7 -- Innovations in Public-Public Partnering and Relationship Building in State DOTs: A wide variety of partnerships among state DOTs; other state, local, and federal agencies; and public stakeholders are improving project and program delivery and increasing efficiency across agency or jurisdictional lines. Promising areas for partnering include achieving environmental streamlining, rationalizing state-local maintenance responsibilities, and joint community problem solving. Examination of successful partnerships and relationships identifies common elements of success and provides a starting point for the development of new partnering tools more applicable to longer-term, peer-to-peer relationships among DOTs; other state, local, and federal agencies; and non-governmental stakeholders. *(Scan by Mark Ford of HDR-Portland)*

Scan 8 -- Innovations in Project Financing: There is now a very rich menu of innovative revenue sources and finance techniques. New revenues are available from toll facilities, HOT lanes, value or congestion pricing, special assessments and fees, shared resource projects, and/or joint development. These revenues can be combined to leverage scarce federal aid through both debt and equity approaches, capitalizing on the new flexibility within the federal aid and some state programs. Such new approaches to project financing can also benefit from innovative project development approaches. Research is needed on promising approaches to mainstream these approaches within transportation agencies. *(Scan by A. Reno and L. Hussey of Cambridge Systematics, Inc.)*

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EXECUTIVE SUMMARY

New information technologies (IT) offer state Departments of Transportation (DOTs) tools that can help them more efficiency and effectively perform the tasks that they have been doing, as well as providing the ability to introduce new strategies to accomplish their missions. At the same time that IT introduces new opportunities, it can impose new demands on the organization that it must resolve. The rapidly changing environment of IT challenges DOTs to deal creatively with both opportunities and issues. The objectives of this scanning project are to:

- explore the range and types of new opportunities IT is affording DOTs as well as the organizational issues that arise as a consequence of new IT;
- identify innovative organizational development (OD) strategies that DOTs are currently using or could use to deal with the opportunities and challenges presented by IT; and,
- identify the most promising areas for future research on this topic.

The project scope involves six component scans:

- Scan 1 = a literature review of transportation-relevant IT.
- Scan 2 = state DOT uses of and perceived utility of various IT for DOT success.
- Scan 3 = a literature review of IT-enabled and/or IT-driven OD innovations.
- Scan 4 = state DOT uses of and perceived utility of OD innovations for DOT success.
- Scan 5 = issues and challenges associated with IT and IT-related OD innovations.
- Scan 6 = how state DOTs structure and manage the IT function and satisfaction with IT function performance.

Findings from Scans 1 through 6 are summarized in the following four tables:

Table 1. Findings from Scan 1 and Scan 2

Most commonly used IT	IT with greatest impact on DOT success
• CAD/CAM • Infrastructure-based sensors • Internet/Intranet • Cell phones • IT in support of real-time traffic information	• CAD/CAM (computer aided construction design/manufacture) • Internet/Intranet (web sites for road/weather conditions and traffic information and e-business) • Infrastructure based sensors (real time monitoring of traffic conditions & flow) • GPS and GIS (support road surveys and construction planning; information exchange with other agencies) • Cell phones (improved field communications) • IT in support of real-time information (route choice and travel time decisions; traffic flow and asset management) • Modeling, simulation, visualization, and database technologies (planning and analysis)

Table 2. Findings from Scan 3 and Scan 4

Most commonly used OD	OD innovations with greatest impact on DOT success
• Customer focus • Stakeholder engagement • Communication enhancements/flexibility • Enhancements in teamwork • R&D/innovation focus	• Customer focus (IT allows greater customer focus--more convenient and better products/services such as electronic information and e-business) • Stakeholder engagement (IT has contributed to a shift from telling stakeholders what the DOT is going to do to engaging them in decision making and planning processes)

Table 2. Findings from Scan 3 and Scan 4 (continued)

	• Enhanced functionality, safety, and reliability (on-going product/service quality improvement is not new but a greater number of sophisticated IT products/services will make it more taxing and new IT enablers will be required to do this well) • Flexible, distributed, or asynchronous work arrangements (IT enables this and it is seen as important but only the Maryland DOT explicitly stated that it had a requirement to have 10% of their eligible employees telecommuting by 2002) • Communication enhancements/flexibility (use of e-mail, cell phones, and wireless communications) • Collaborations and partnerships (IT has facilitated and driven a greater emphasis on partnering with public as well as with private organizations to do research, collect and share data and information, and exchange services; also has contributed to viewing employees and stakeholders as partners) • Employee empowerment (IT has encouraged involvement of staff organizational decisions; solicitation of employee ideas; greater delegation, use of e-mail to increase communications; more training and job enhancement) • Enhancements in teamwork (DOTs did not emphasize of IT enabled better teamwork but IT is making better project management of contractors, cross-mode project teams, and teaming partnerships with public & private stakeholders more critical) • Preventive maintenance (IT capabilities can improve preventive maintenance but also it is bringing about a greater emphasis on more sophisticated asset management strategies) • Process reengineering (although DOTs did not emphasis IT enabled process reengineering techniques, reengineering as become a routine improvement approach which is have become necessitated as a result of the continual adoption of new IT)

Table 3. Findings from Scan 5

IT issues/challenges	State DOT responses
• Alignment of the DOT and IT Visions	• Most of the DOTs reported that the DOT and IT visions are pretty well aligned and that IT is playing a more prominent role in the DOT vision. DOTs with a centralized state IT group rather than an internal IT function were more likely to feel that there could be better alignment. [Note: While most DOTs are establishing a more integrated cross-functional approach to determining vision, strategy, and direction, the Maryland DOT reported that it has purposely moved away from an integrated approach.]
• How the DOT identifies, assesses, and selects IT and IT-related OD innovations	• None of the DOTs reported a highly systematic approach. This is even more true for OD innovations than for IT per se. Despite this, many of the DOTs think they are doing a reasonable job. On the other hand, a sizable minority of DOTs felt the Federal DOT and associations could do more to help in this area. There is still too much trial and error on the part of each DOTand there is not enough information available to assist them in assessing and selecting the best of the available IT and to determine the best ways to customize and implement various generic IT applications.

Table 3. Findings from Scan 5 (continued)

IT issues/challenges	State DOT responses
• Challenges and difficulties as a result of introducing new IT and OD innovations	• Internal and external challenges and difficulties were examined. Internal probes included: employee resistance, workload disruptions, information overload, and disturbances to management/employee relations. Employee resistance continues to be a problem for only one of the nine DOTs. With the exception of e-mail overload problems, DOTs did not report workload, information overload, or issues with management/employee relations as a result of IT. External probes included external obstacles and problems with IT being externally driven rather than selected on the basis of what best serves DOT needs. Many DOTs experience external obstacles (mostly bureaucratic hinderances) but most do not experience problems with IT being externally driven. They have the freedom to pick and choose the IT that is best suited to their needs.

Table 4. Findings from Scan 6

The IT function	State DOT responses
• How is the IT function structured?	• There is a trend for state DOTs to simultaneously move toward both a more centralized and a more decentralized IT structure. That is, while some IT components (e.g., enterprise wide architectures, enterprise information database systems, centralized procurement and administration) are being centralized, other components (e.g., local system support and ITS) are being decentralized. There is also a trend toward greater state centralization of standards and key systems across state agencies. Also there is a tendency for parts of the DOT IT function to be centralized in a separate state IT agency or group. The other major trend is increased outsourcing of components of the IT function (particularly development but also database administration and operations).
• How well the IT function is working?	• Centralization was found to have both positive and negative performance impacts. However, the biggest problem facing the IT function is a lack of resources, including money, skilled in-house staff, and basic infrastructure (such as wireless communication and fiber optics). Outsourcing components of the IT function resolves some of the problem but raises others—such as there is often not enough skilled in-house staff that can effectively manage contracted projects and many see outsourcing as not being a cost saving strategy. To facilitate the recruitment and retention of IT staff, some states have adjusted state IT salaries and benefits and/or introduced incentive. Other DOTs are more limited in their ability to increase salaries but have been able to introduce bonus systems and to offer good training opportunities to IT staff.

Based on discussions with state DOT representatives and a review of the relevant literature, six topics were identified for future research:

1. Organizing the IT Function in State DOTs: Centralization vs. Decentralization
2. Outsourcing Elements of the IT Function: Best Practices, Advantages and Disadvantages
3. How State DOTs can Learn to Thrive in an E-Business Environment
4. Identifying Criteria, Strategies, and Guidance to Assist DOTs to Assess and Select IT
5. Guidelines to help State DOTs Manage Information Overload
6. Finding, Procuring, Training, and Retaining IT Staff

CHAPTER 1

INTRODUCTION AND BACKGROUND

New information technologies (IT) offer state Departments of Transportation (DOTs) tools that can help them more efficiency and effectively perform the tasks that they have been doing, as well as providing the ability to introduce new strategies to accomplish their missions. At the same time that IT introduces new opportunities, it can impose new demands on the organization that it must resolve. The rapidly changing environment of IT challenges DOTs to deal creatively with both opportunities and issues. The objectives of this scanning project are to:

- explore the range and types of new opportunities IT is affording DOTs as well as the organizational issues that arise as a consequence of new IT;
- identify innovative organizational strategies that DOTs are currently using to deal with the opportunities and challenges presented by IT; and,
- identify the most promising areas for future research on this topic.

As background for a workshop on this topic, a survey was mailed to more than 900 DOT officials and stakeholders. Respondents (N=421) most frequently cited technology among factors expected to be driving change in transportation in the years 2010 to 2015. IT has contributed to major changes in state DOTs and can be expected to continue to have significant effects, many of which will be unanticipated. This project is intended to shed additional light on these impacts and to suggest research that will help guide DOT's ability to get the most out of IT.

SCOPE

The project scope includes the following:

- Two literature reviews. The first review addressed IT developments of potential use in the transportation sector. The second review surveyed recent organizational literature to identify innovations in OD caused by IT (or more precisely, enabled and/or driven by IT).
- Checklists to be filled out by state DOT interviewees. These checklists were designed to determine the extent to which DOTs were using the identified IT and OD innovations and their perceived utility. The checklists were completed by eight of the nine DOTs participating in this study.
- Telephone interviews with one or more representatives from each of the nine DOTs participating in this study. These interviews explored the responses to the checklists, further examined DOT uses of and experiences with IT, and probed issues that warranted further study.

APPROACH

Six scans constitute the working components of this project (Task 6). The first four speak to the "what" of IT-related innovation; that is, what IT developments and IT-enabled or IT-driven organizational developments may be of benefit to DOTs. The last two scans speak to the "how" of IT; that is, how are DOTs accommodating IT-induced organizational changes and demands on their organizations and how are they managing and structuring their IT function.

Scan 1. A literature review scan of transportation relevant IT and IT systems.

Scan 2. A scan of the extent to which DOTs employ the IT developments identified in scan #1 and the potential for these IT developments to contribute to DOT performance.

Scan 3. A literature review scan of OD innovations that have been enabled or driven by IT.

Scan 4. A scan of the extent to which DOTs use the OD innovations identified in scan #3 and their perceived usefulness.

Scan 5. A scan of issues and challenges associated with IT and IT-enabled/IT-driven OD innovations identified in the above scans and how DOTs are addressing these issues.

Scan 6. A scan of how DOTs structure and manage their IT function and the strengths and weaknesses of IT function performance.

DEFINING AND CATEGORIZING ORGANIZATIONAL INNOVATION

First, there is an important distinction between innovating (actually creating innovations) and adopting already existing innovations (innovations that have been developed by others). While some DOTs are creating innovations, most are looking to other DOTs, other organizations, and existing generic IT.

Second, innovations are commonly categorized as either incremental or radical -- a distinction that focuses on both the degree of impact and newness. An innovation can contribute to improving business as usual or it can fundamentally transform the business enterprise. Many organizational innovations occurring in state DOTs are incremental, but IT has the potential to bring about real paradigm shifts in DOT organizations. The scans conducted in this project show evidence of the beginnings of radical OD innovations as a result of IT.[1]

Third, there are three main types of innovation: product, process, and strategy. Each of these types of innovation can vary in degree (*incremental* versus *radical*).

- *Product Innovation*. Product innovation can be incremental in the sense of improving existing products or more radical in the sense of creating entirely new products. Creating entirely new products is becoming an increasingly important concern as product life cycles are becoming shorter and shorter. New product development and, increasingly, the speed of innovation are critical to business survival (Jonash and Sommerlatte 1999). Organizations are seeking to direct greater attention to new product development, while maintaining and improving their existing products.

- *Process Innovation*. Incremental process improvement is associated with the total quality and continuous improvement movements. Radical process transformation has been labeled reengineering (Hammer and Champy 1994). Hammer and Champy made the claim that incremental process improvement was no longer sufficient. Processes lagged so far behind what is possible given technological advancement that nothing short of

[1] The Transportation Research Board has sponsored several inquiries into strategies for encouraging and supporting radical change in transportation organizations. A recent draft report under the TCRP New Paradigms Project (TCRP 1999), though focusing on the transit industry, speaks to a central issue in this project when it says that the conventional paradigm which is "focused on management of publicly owned and operated assets will give way to a new paradigm focused on managing services and sustained by wide-ranging alliances, new information technologies and an obsession for the customer." These are the fundamental kinds of changes that DOTs are dealing with today, and IT is at the heart of their efforts to make the shift in organizational strategy from a focus on pavement and construction to managing operations and serving customer needs.

radical process reengineering can truly achieve maximum process efficiency and effectiveness.[2]

- *Strategy Innovation*. Strategy innovation can similarly vary in terms of being incremental versus radical. Incremental strategy innovations tend to involve new strategies for achieving existing goals and objectives, whereas radical strategy innovations involve a change in the mission, vision, goals and objectives themselves.

Figure 1 illustrates the general model used in this project. IT developments can either enable or drive organizational innovations (e.g., strategy, process, and product/service innovations). These organizational innovations can, in turn, cause various implementation impacts (organizational changes, issues, or problems) as well as the desired performance results, such as effectiveness, efficiency, and customer value.

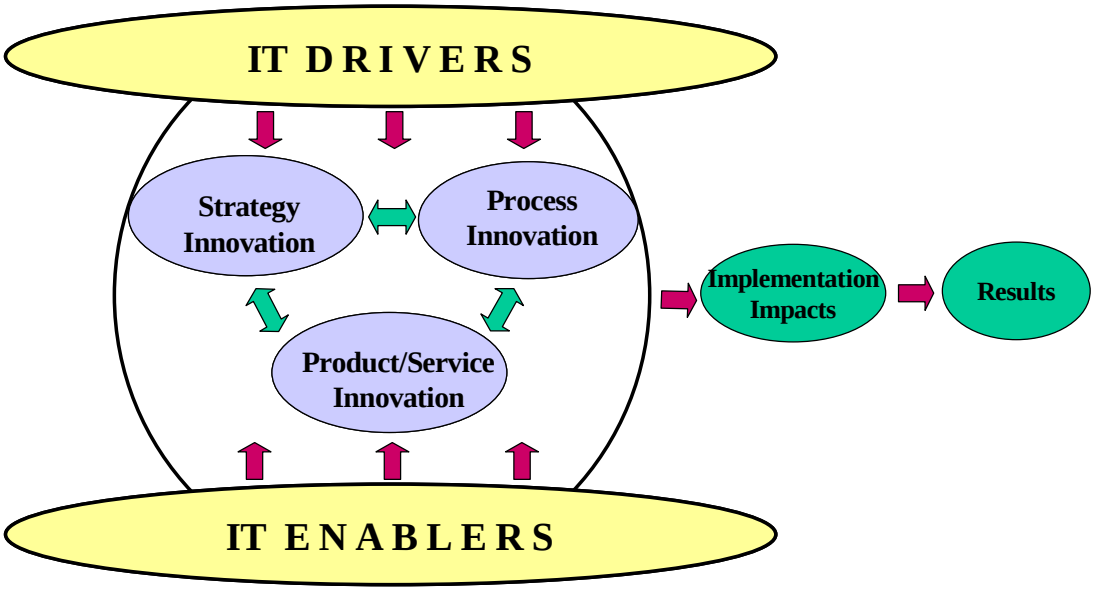

Figure 1. Model of IT-enabled and IT-driven OD Innovations.

[2] The case for radical reengineering seemed plausible and many organizations undertook large reengineering efforts, but results have been mixed. Many organizations, after spending a great deal of time and money, have had little pay-off (Carter 1999). There are several competing explanations for these failures, including an explanation proposed by one of the initial advocates of reengineering. Champy (1996) suggests that management has often been an obstacle to successful radical reengineering and that to ensure a successful reengineering of the corporation, management itself must be radically reengineered. Others suggest that organizations may not be capable of as much change as quickly as radical reengineering encourages. Still others claim that an ambitious model of the reengineered corporation without a sufficiently detailed plan of how to manage current operations while transitioning to the new model and how to ensure the effort is sustained has been a common problem. In other words, transition management is an important element of reengineering (Feldman 1999). Carter (1999) found that downsizing has too often posed as reengineering and is one of the reasons that many so-called efforts were unsuccessful. The clear lesson is that radical engineering is extremely difficult and that balance and caution must be exercised.

CHAPTER 2

FINDINGS

SCAN 1 AND SCAN 2: IT USE AND IMPACT

The first scan (the IT literature review) resulted in a comprehensive list of IT and IT systems, supplemented with a brief annotation of each of the IT entries and examples of the uses of that IT. The list provided the basis for a single page checklist to determine DOT IT use and perceived utility of the various IT and helped to guide discussions with the state DOT representatives (scan 2). The checklist also asked interviewees to add IT that they were using or aware of that were not included in this list.

Results of eight of the nine DOTs included in this study[3] are shown in Table 5. While it would be inappropriate to say that these results are representative of all DOTs, given the small number of cases and the non-random nature of the sample, some interesting findings are suggested. Five of the 25 listed IT are reported to be used extensively by over half of the DOTs interviewed. These include:

- CAD/CAM
- Internet/Intranet
- Infrastructure-based sensors
- Cell phones
- IT in support of real-time information.

Table 5. State DOT Use of Information Technologies (IT)

Information Technology	A: Use of IT			B: IT's Contribution to Organizational Success		
	Not at all	Some	A Lot	A Little	Some	A Lot
Infrastructure-based sensors		2	6	1	3	4
Vehicle-based sensors	6	2		3	1	
Automated data collection systems	4	3	1	1	3	1
IT in support of real-time traffic information	1	2	5		4	3
In-vehicle Navigation Systems (IVN)	6	2		2	1	1
Internet / Intranet		2	6		2	6
Digital satellite photography	5	2	1	3	1	1
Voice-activated and voice-recognition systems	6	2		3	1	
Global Positioning System (GPS)	1	4	3		3	4
Automatic collision notification devices	6	1	1	2	1	1
Variable Message Signs (VMS)		4	4		6	2
Highway Advisory Radio (HAR)	3	2	3	2	4	
Closed-Circuit TV (CCTV)	3	3	2	3	1	2

[3] Interviews were conducted with representatives of the following nine state's DOTs: Arizona; Arkansas; Idaho; Kansas; Kentucky; Maryland; Pennsylvania; South Dakota; Utah. To date, eight of the nine states interviewed have returned the checklists. Efforts were made to schedule additional interviews, but were hindered by heavy state commitments during their respective legislative sessions.

Information Technology	A: Use of IT			B: IT's Contribution to Organizational Success		
	Not at all	Some	A Lot	A Little	Some	A Lot
Wireless communication	2	4	1		2	3
Cell phones	1	2	5		3	4
Pagers	1	3	3	2	2	2
Personal digital assistants (PDAs)	3	4	1	1	3	1
E-commerce (E-government)	1	6	1	2	4	1
Computer models, simulation and visualization, and database software		5	2		4	3
Geographic Information Systems (GIS)		4	4		4	4
Portable pen-based systems	2	6		2	4	
Remote access technology (e.g. Internet, Intranet, video conferencing, cellular, telecommuting)		5	3	1	5	2
Electronic payment systems	5	2	1	2	1	1
CAD/CAM	1		7	1		7
Decision Analysis Software	2	3	1		3	1
Insert and rank other IT in spaces below:						
• E-mail			1			1
• Computer Assisted Software			1		1	
• Public key/Digital signature					1	
• Fiber optics						

The following IT are perceived to be having the greatest impact on state DOT success:

- CAD/CAM—CAD is primarily used as an aid in construction design. It has had a big impact but is no longer a new IT, nor does it have the potential to radically transform the DOT. It is probably rated so high because other IT systems have not yet played out their full potential.
- Internet/Intranet—The internet/intranet has a greater potential impact which is clearly recognized by the DOTs. It is being used now for traveler information web sites and will increasingly be used to provide a full range of traffic and travel information to aid in trip planning and safety. It also provides the basis for e-business that is now just beginning to be introduced. The Maryland DOT has set a target that the percent of services available over the Internet will be 50% by 2002 and 80% by 2004.
- Infrastructure based sensors—Infrastructure based sensors are now being used to provide information for planning and analysis but they will be increasingly necessary to provide real-time information for users. Many DOTs currently have real-time weather and road condition information accessible to users but will increasingly be able to provide traffic flow and other information to make better use of current road assets, which could alleviate the need for more construction (at least to some extent). The Idaho DOT discussed a van equipped with high technology data collection devices that allows them to more efficiently collect road condition data. The Arkansas DOT also described a vehicle equipped with instrumentation they use to collect data on pavement and to conduct roadside inventory (signs, guardrails, etc.) while traveling at highway speeds. They are refining their IT to allow them to download data recorded on optical disk

remotely from the vehicle into their central system. This is an IT capability developed jointly by the DOT and the University of Arkansas, after determining that existing IT vendors didn't offer the capabilities they wanted.

- GPS and GIS—These systems support road surveys and construction planning and assist in information exchange with other agencies. They will become more important in the future.
- Cell phones—Cells phones improve communications with field staff and allow travelers to access automated voice information but, in the future, will most likely play a big role in providing interactive information and communication for travelers. Kentucky DOT talked about their statewide initiative to focus on a wireless communications system that will better link their field staff to the central office, as well as integrating other key agencies such as the State Patrol.
- IT in support of real-time information—As previously discussed real-time information will be collected via sensors and through of more sophisticated devises, such as digital satellite photography, in order to distribute this information to users to make travel decisions and to allow DOTs to conduct more real-time asset management.
- Modeling, simulation, visualization, and database technologies—Currently these technologies are used for planning-oriented analyses but in the future will be used for real-time traffic modeling and management.

The array of responses to this list makes it clear that most of these IT are used by at least some of the DOTs, and most of the IT reflect some or a lot of benefit for those who use it. Although some of these IT may be relatively new and as yet not highly diffused among DOTs, they are often seen as important for the success of DOTs that are using them. Less diffused but impactful IT are fruitful areas to examine for potential benefit to other DOTs. Digital satellite photography is an example of an IT that most DOTs are not yet using, but is reported to be highly beneficial by those that are using it. On the other hand, Highway Advisory Radio is example of an IT that is used by only a few DOTs, but none of the users report a lot of contribution to organizational success from HAR. Several interviewees said they would very much like to learn more about those IT they were not yet using and what other states are doing with them. The patterns of use and perceived benefit vary widely across this small sample of DOTs and suggest the need to look at each individual DOT situation carefully to understand what works, what does not work, and how the context for that DOT helps determine use and benefits.

While respondents thought the IT list was quite complete, some suggested additional IT. For example, enterprise IT of various kinds is becoming increasingly important for most DOTs. Also there are important customized IT applications. The Arizona DOT discussed a number of customized IT applications, including a management system that keeps track of maintenance activities on state highways, a system to track progress on construction projects, a contractor billing and payment system based on work progress, as well as an enterprise data warehouse that allows the Arizona DOT to integrate key pieces of information from a variety of systems to support high-level decision making across the organization. Maryland DOT discussed their Coordinated Highway Action Response Team program (CHART). Fiber optics is becoming more important to many DOTs to support the regional deployment of IT applications. Also most DOTs noted that they differentiate between IT and ITS (Intelligent Transportation Systems), considering ITS in some applications to be separate from IT.

While some IT has merely automated functions that the DOTs used to perform by hand (for example GPS, GIS, and CAD are replacing people with equipment), what is most clearly

emerging is that IT is doing far more. IT is enabling the DOT to conduct business in fundamentally differently ways. While some of these DOTs had a clear vision for the role of IT in supporting their future missions, others felt quite unsure about future directions for their use of IT, and took a generally conservative, low-risk approach to trying out and adopting new IT. Most DOTs are refocusing their missions to provide greater customer service, asset management, and efficient operations. Several of the DOTs interviewed thought e-government and e-business would have the strongest impact on their futures. This would include establishing new communication portals with customers, and implementing a variety of business transactions (such as electronic bidding) and providing services (such as electronic vehicle registration and electronic driver licensing) over the Internet. DOTs will need to determine what information services and products they want to make available to the public and the best means of providing these services and products. This in turn raises issues of the appropriate role for the DOTs as public agencies versus the private sector that also is seeking opportunities to add value to information services and to carve out viable market niches. The Minnesota DOT, for example, is providing ITS information to the private sector at no cost, such as road closure information for IVN systems and traffic routing information for private dissemination over cell phones and pagers.

At the same time DOTs are faced with so many new opportunities, they are finding themselves faced with new responsibilities to manage and maintain a rapidly expanding IT infrastructure as well as attending to increased demands of attending to their traditional business of maintaining aging road, freeway, and arterial systems. Increased opportunities and pressures are forcing DOT's to look at OD innovations in strategy, process, and products/services.

SCAN 3 AND SCAN 4: OD INNOVATION USE AND BENEFIT

Scan 3 resulted in a compilation and categorization of IT-enabled and/or IT-driven OD innovations. As with the IT list, each of the OD innovations on the list was supplemented with a brief annotation describing what it was as well as its relationship to IT. The OD innovations were categorized into strategy, product-service, and process innovations and further characterized in terms of incremental versus more radical OD innovations which formed the basis for a checklist to examine the extent to which state DOTs use and have benefited from each of these OD innovations (Scan 4). For details see Appendix C.

The results, based on eight of the nine DOTs, are shown in Table 6. Every one of the thirty-two OD innovations is used by one or more of these DOTs, and most of the innovations are perceived to be beneficial by the DOTs that use them. The most commonly used OD innovations are:

- Customer focus,
- Stakeholder engagement,
- Communication enhancements/flexibility,
- Enhancements in teamwork, and
- R&D/innovation focus.

Table 6. State DOT Use of OD Innovations that are Enabled and/or Driven by IT

Organizational Developments (OD)	A: Use of OD			B: How Successful?		
	Not at all	Some	A Lot	A Little	Some	A Lot
Strategy Innovations						
Incremental Strategy Innovations						
Customer Focus		3	5		4	4
Stakeholder Engagement		3	5	1	3	4
Performance-based Management or Management by Objectives	1	3	4		6	1
Asset Management		7	1	1	5	2
Supply Chain Management	4	3	1	1	3	
Sustainable Development	4	2	2	1	3	
Outsourcing/Privatization		5	3		6	2
Forecasting & Roadmapping to Guide Future Strategy	2	5	1		6	
More Radical Strategy Innovations						
Collaborations/Partnerships	1	5	2		4	3
R&D/Innovation focus	1	3	4		5	2
Life-cycle, Product Portfolio, Product Platform Management	3	5		1	3	1
Organizational Learning/Knowledge Management/Real-time Information	3	5		1	4	
Competency Building	2	5		1	4	1
Change Management	3	4	1	1	3	1
Product/Service Innovations						
Incremental Product/Service Innovations						
Enhanced Functionality, Safety, Reliability		5	3		4	4
More Radical Product/Service Innovations						
Product/Service Bundling	2	5	1	3	3	
Customization	2	5	1	2	3	1
Product/Service Delivery Innovations	2	4	2		6	
New "Smart" Products/Services	2	5	1	2	4	
Process Innovations						
Incremental Process Innovations						
Employee Empowerment		5	3		5	3
Enhancements in Teamwork		4	4		5	3
Flexible, Distributed, Asynchronous Work Arrangements		5	3	2	2	4
Electronic/Remote Training	2	6		2	4	
Performance Measurement and Assessment	1	6	1	2	4	1
Benchmarking	3	4	1		4	1
Preventive Maintenance	1	5	2		4	3
Communication Enhancements/Flexibility	1	2	5		3	4
Enhanced Project Management		5	3		6	2
Project-based Management		6	2	1	5	2
More Radical Process Innovations						
Process Automation		6	2	1	6	1
Process Reengineering		7	1	2	3	3
High Tech Diagnostics/Prognostics	2	5	1	1	5	

The OD innovations that have had the greatest impact on DOT success include:

- Customer focus—DOTs' primary focus is fast becoming to provide better products and services in a more convenient fashion to their customers. A whole new level ofcustomer focus is being enabled by e-business which, for most DOTs, is only in its infancy. The representative from the Idaho DOT stated that e-business requires a whole new economic model to be put in place and that this will take some time. Currently they only provide information and allow customers to access forms through their website, as well as allowing information requests and inquiries. The Kentucky DOT currently provides web-based electronic response to accidents, electronic permits, and electronic delivery of information. The Maryland DOT has a statutory provision to make government services available through the Internet, with a target of 50% of their services being available over the Internet by 2002, 65% by 2003, and 80% by 2004. They also plan to provide far more than their existing services—they will provide traffic information to help manage traffic flow, bus schedules, parking availability at airports, and eventually plan to partner with other organizations to make all types of travel and traffic information available to drivers through digital computer and cell phone devices. The Arkansas DOT characterized the current situation as a changing cultural environment in which DOTs now have an *obligation* to be more responsive to customer demands for information and convenience.
- Stakeholder engagement—In the recent past, DOTs told stakeholders what they were going to do, but now DOTs are engaging stakeholders in their decision making and planning processes. The Kentucky DOT pointed out that some DOT managers are not comfortable with this approach and that involving stakeholders in DOT decision processes requires changes in organizational culture. Stakeholders can also be highly suspicious of this change in orientation. Overall, however, the DOTs recognize the value of obtaining increased stakeholder input to their strategies and priorities, and IT is seen as enabling more efficient and effective stakeholder engagement.
- Enhanced functionality, safety, and reliability (quality improvement)—Most DOTs have had an on-going product/service improvement orientation which, in the past, was not highly related to IT. Although this is not a new orientation, it is becoming more demanding as products and services are increasingly complex and IT-based. Moreover, new IT will increasingly be needed to improve products and services in the future. Quality improvement will increasingly equate to IT enhancement.
- Flexible or distributed work arrangements—While this ranked fairly highly in terms of its utility, only the Maryland DOT strongly emphasized this area. They have a requirement in their business plan to have 10% of their eligible employees telecommuting by 2002.
- Communication enhancements/flexibility—DOTs are increasingly using e-mail, cell phones, wireless communications, and closed circuit TV to enhance communications with employees, stakeholders, and various collaborators and partners. They are focusing far more on external communication than was the case in the past, which is primarily IT enabled and driven.
- Collaborations and partnerships—Many DOTs are beginning to partner with other public as well as private organizations to do research, collect and share information, and exchange services. They also are viewing employees and community stakeholders as partners. The Maryland DOT has restructured its traditional decision making process to foster an internal partnership approach with managers and IT specialists making joint decisions based on business and customer needs. The Pennsylvania DOT has developed a very strong partnerships with both the metro and district planning organizations. They

jointly performed process reengineering to facilitate these partnerships. They also participate in a state-wide program, called the Agility Program, which allows state agencies to exchange services in an attempt to rationalize and economize government. For example, the DOT will paint lines for the Park Department in exchange for having their grass mowed by them. They also have a strong partnership with a private company, Traffic.com, where both organizations employ sensors to collect and share real-time traffic information. In addition, they have partnerships with private companies to plan and finance transportation improvements. The Kentucky DOT looked into partnerships but never really formed true partnerships because they could not work out the legal mechanisms.

- Employee empowerment—DOTs are involving staff in organizational change decisions and projects at the earliest stage, introducing programs to solicit employee ideas, promoting greater delegation, and using e-mail to increase communications and allow greater employee involvement in decision-making. The South Dakota DOT has introduced what it calls an organizational health initiative that involves focus groups and surveys with employees to incorporate their needs and opinions into DOT decision making and programs.
- Enhancements in teamwork—Several DOTs are focusing on better project management of contractors; some have a number of cross-mode project teams, and many are trying to promote a greater sense of teamwork and a sense of partnership with their employees, the general public, and private stakeholders.
- Preventive maintenance—Preventive maintenance is an increasingly important area as asset management is becoming a major future thrust for DOTs. Only a few DOTs have progressed very far along the lines of asset management. In our study, only two of the DOTs stated that asset management is an important emphasis for them.
- Process reengineering—Process reengineering has become an on-going activity on the part of DOTs to improve processes in all areas. Several DOTs are reengineering their project management systems, and others are reengineering record keeping and finance systems. Major business process reengineering will indubitably be involved in transitioning to e-business and to enterprise-wide, cross-modal, asset management.

What is surprising, given the recent emphasis on performance measurement and assessment in the public sector, is that only one DOT (South Dakota) mentioned it as something that was being used extensively and was having a significant impact on DOT performance. Also outsourcing did not rank high among the OD innovations, although it seems it would be a useful strategy for coping with increasing opportunities and demands associated with IT. Outsourcing offers flexibility in responding quickly to market changes, which is difficult within the traditional state environment, and helps avoid the bottleneck that many DOTs are experiencing internally with regard to the kinds of specialized skills they need in the highly technical IT areas. Besides these pressures to outsource, the Arizona DOT has the additional requirement that they must justify to their state legislature why they keep functions in house rather than outsourcing them. Outsourcing components of the IT function are particularly common and will be discussed in Scan 6. Perhaps one reason that outsourcing did not rank more highly as a useful OD innovation is because many DOTs found outsourcing to have problems as well as benefits. For example, it is not perceived by several DOTs to be a cost-saving strategy. Effective outsourcing and the most useful areas to outsource could be a fruitful area for further examination. Finally, while asset management did not rank highly, it is emerging as an important OD strategy for the future.

SCAN 5: ISSUES AND CHALLENGES WITH IT AND IT-RELATED OD

How Well Aligned are the DOT and IT Visions, and What are the Key Directions for IT?

Most DOTs reported that their DOT and IT visions are pretty well aligned – most address IT in their DOT strategic plan and have developed a 4-5 year IT strategic plan. They also note that IT is playing a more prominent role in the DOT vision. Many interviewees, distinguishing IT from ITS, commented that IT is becoming as important as ITS. DOTs with a centralized state IT group rather than an internal IT function were more likely to feel that there could be better alignment. Most DOTs also reported that customers and community stakeholders are now more integrated into their strategic planning processes. While most DOTs have an integrated cross-functional approach to determining vision, strategy, and direction, the Maryland DOT reported that it has moved away from an integrated approach. They do not have a DOT-wide strategic plan. Although there is a DOT-wide IT Master Plan, it addresses IT at a high level, not at the level of specific IT applications. Each business unit is responsible for setting its own IT agenda; however, units are encouraged to partner with one another in a team approach as appropriate. The DOT sets general guidelines, but the business unit is free to independently pursue its needs. For example, the bridge department works with the U of MD to develop technical approaches unique to that department and has the authority to go forward has they see fit. There are a few cross-modal working groups to address common issues, such as remote access and wireless communication.

Key strategic vision directions include: (1) assimilating and quickly disseminating large bodies of data to staff and users; (2) developing enterprise architecture and enterprise information systems; (3) e-business that allows stakeholder engagement and Internet service delivery; (4) digital video systems for roadways; (5) fiber optics.

How Does Your DOT Identify, Assess, and Select IT and/or IT-Related OD Innovations and How Well is this Working?

One of the biggest challenges for any organization is its ability to keep abreast of what is going on in the technical world and how to apply these advances to its business. There is a tendency for executives to get buried in day-to-day operations. Few organizations have sufficient time to look at the full potential of what IT can do for their business. Most DOTs realize this is a problem but the bigger problem is their limited resources— they don't have the ability to take advantage of a fraction of what is currently available. However, this means it is even more important to systematically and wisely assess and select IT in order to allocate their scarce IT resources as effectively as possible.

None of the DOTs reported a highly systematic approach for addressing IT-enabled and/or IT-driven OD innovations, but several thought that they were doing a fairly good job of staying up-to-date with OD innovations. Others thought they needed to learn more about OD innovations. More surprising is that only a few DOTs have a systematic, on-going process for identifying, assessing, and selecting various IT innovations to pursue. Typically a team is formed to address issues or problems as they arise. Several DOTs stressed that they encourage staff to bring up IT ideas but none reported that this was a particularly systematic process. DOTs further reported that they keep in touch with other state DOTs to discuss what one another is doing, particularly as regards IT. In addition, there are collective initiatives underway to enhance this further. For example, a collective initiative led by the Kansas DOT is developing an inventory of what state DOTs are doing and figuring out how to best publicize/disseminate this information. Often a group of state DOTs is formed to explore a common need and then

circulate the information to the others. Some associations and agencies (e.g., AASHTO, FHWA) provide useful assessment information to support smarter decision making. These associations and agencies also assist in the development of tools by pooling resources across state DOTs. The Maryland DOT reported that it participates in FHWA scanning tours and in the highway exchange program and that they initiated, in collaboration with these other groups, an on-going e-group.

Only the Pennsylvania and the Idaho DOTs reported having a systemic system in place for assessing and selecting IT. The Pennsylvania DOT has the most systematic system. They recently introduced a new structure called the Information and Technology Management Committee (ITMC)—a cross-cutting group that keeps informed of and assesses technology and makes recommendations to senior management. The people on this committee have other jobs but are told that this assignment is a priority and are instructed to make time for it. This group keeps in touch with other DOTs in terms of what is going on with IT. The ITMC process has helped them become more informed about IT opportunities and priorities. The Idaho DOT has a high-level planning group that meets monthly. They plan to have new IT ideas presented to this group on a fairly regular basis to stimulate thinking in this area. This is a new approach and they do not yet know how well it will work. They have tried IT steering committees, policy committees, and other approaches, but they all fell apart after a while. They also have an Intranet system that contains information on each area of the DOT, including IT, and allows staff to provide feedback and make suggestions. External stakeholders can request forms or submit via e-mail their suggestions and ideas for improvement. All this feedback will become a part of their data warehouse.

With a few exceptions, most of the DOTs thought they were doing a fairly good job of keeping up with new developments in IT but recognized there was room for improvement. Some felt that the Federal DOT did not do enough in this area to assist them. They felt there should be greater assistance from both the Federal DOT as well as transportation associations. While some thought that they were able to stay fairly up-to-date through vendor publications and attending IT industry conferences, this view was not shared by all. The vendor publications and industry conferences are not sufficiently directed at government, let alone DOT needs. State DOTs could use more DOT-specific information. One interviewee suggested that the Federal DOT should sponsor (using state funds) annual, regional DOT IT conferences. There are some DOT IT conferences or special session groups now but they are small and primarily include IT experts. This interviewee felt that DOT IT conferences directed at DOT staff in all areas would be very well attended. One DOT interviewee quantified the current situation as being about 90% efficient in terms of states not having to reinvent the wheel. Others say it is still too much of a trial and error process on the part of each DOT. This individual also noted that one highly critical area is often not adequately addressed—namely, sharing the best ways to customize and implement various applications.

What Challenges or Difficulties Has Your DOT Experienced as a Result of Introducing New IT and IT-related OD Innovations?

In interviews, DOT respondents were probed as to both internal and external difficulties and challenges. Probes about internal difficulties included employee resistance, work load disruptions, information overload, and/or disturbances to management/employee relations. Probes addressing external difficulties involved external obstacles that prevented the DOT from adopting the IT they most needed, and problems with IT being externally driven rather than selected on the basis of what best serves DOT needs.

Internal Difficulties/Challenges

While one DOT reported that resistance to IT continues to be a problem, most DOTs reported that they have largely resolved this issue. There had been pockets of resistance in the past, particularly by middle managers. The key is to involve employees, particularly middle managers, early in the process. It is also important to provide them with adequate training early on so that they are not intimidated. One DOT reported some resistance on the part of maintenance staff. The training provided by an external IT agency was inappropriate (too high level) for maintenance workers who only used computers to report on tasks. This problem is now being corrected. No DOT reported any strategy other then early involvement and training to reduce resistance. Because so many DOT staff are engineers, most DOTs find the opposite problem is more of an issue for them. Engineers typically embrace IT and tend to be frustrated by the slow pace of IT change in the DOT. Although there is little resistance to IT, one DOT reported resistance to a particular IT-related innovation, namely, performance measurement. Performance measurement in state DOTs should be further explored as to how well this critical activity is being performed.

The use of e-mail has spread throughout DOTs but has had a negative as well as a positive impact. While e-mail greatly speeds up communications, many staff experience e-mail overload to the point that it prevents them from attending to more important matters. The Arizona DOT has implemented procedures to limit the number of people who have DOT-wide e-mail broadcast capability and developed a structured policy for e-mail usage. E-mail communication also increases expectations among staff not only to be informed of every decision but also to participate in these decisions. People are thinking of organizations in a more democratic than authoritative mode and IT has not only enhanced the ability but the perceived need to allow employees and customers a greater say in what the organization does.

External Difficulties and Challenges

Several DOTs reported external obstacles. Some reported that their state legislatures tend to resist IT initiatives. One DOT said that rather than working with the legislature, they have to work around them. Most DOTs do not feel that they have been externally driven to adopt various IT, but rather have been free to adopt whatever IT best suits their needs. However, several DOTs report that some IT systems are mandated by the state in order to increase efficiency. DOTs accept that their mission is to serve their customers, so although most IT is driven by customer demand, they do not see this as external intervention but as a partnership. Customers are increasingly included in DOT strategic planning activities and critical decisions.

SCAN 6: THE IT FUNCTION

Structure and Performance

The DOT representatives were asked to describe how their IT function was structured, particularly in terms of centralization and outsourcing. There is a tendency toward centralization of some aspects of the IT function and decentralization of other aspects (such as local unit IT support). For example, the Idaho DOT is moving toward centralized IT repositories, centralized enterprise systems, and centralized administrative and infrastructure support but will have decentralized systems managers at the local level who report to the local unit manager. The Pennsylvania DOT has a centralized IT group that oversees hardware and software development and is a service agency to all staff but there are also IT professionals who report to the unit managers (these decentralized IT professionals primarily oversee the LANs). Similarly, in the

Maryland DOT, a centralized IT group oversees the business systems but each major business area and engineering district is encouraged to have a first tier IT person who serves as a liaison back to the IT group. This person knows their local business functions, is on site, and can better address their specific problems. A similar system exists in both the Utah and Kentucky DOTs, but in the former, the local IT staff are technicians rather than professionals; in the latter, the local IT support professionals are regional, not part of each DOT unit. In the Kentucky DOT, the centralized IT group controls procurement and standard setting but there is a lot of liberty extended to regional DOT offices and field staff. This works well—ensuring adequate conformity while allowing local support and flexibility. In the Arizona DOT, a centralized Computer Services and Planning and Research Division houses the IT function that distributes and maintains IT equipment across 270 offices throughout the state, manages the Internet and Intranet, maintains a centralized data center, and coordinates all project management for IT projects for the DOT as a whole.

Several states are developing a centralized state IT group or agency that supplements or, in a few cases, supplants the IT functions of all state agencies. The degree of state IT centralization and, correspondingly, the extent to which the various state agencies are allowed to have their own internal IT function varies. Most state agencies in South Dakota, including the DOT, have a person assigned to a centralized state IT group but the state agencies have no IT staff who report directly to them. IT staff are assigned to the various agencies but they belong and report to the central state-wide IT agency. Because the South Dakota DOT once housed and managed the state IT group, there are many ex-DOT staff in this state IT group, but it is still not as effective as having their own IT function.

The Arizona DOT also has had some components of their IT function (the mainframe computing component) moved out of the DOT and consolidated in an external state agency. This was part of a statewide effort to achieve cost savings. The Kentucky DOT has a centralized state infrastructure agency and approximately one-half of the $24 million DOT budget goes to this central state agency.

As part of the IT centralization effort and to help reduce redundancy associated with multiple stand alone systems and databases, most DOTs are developing enterprise-wide architectures and information systems. Although they have a ways to go to achieve this integration and centralization, DOTs generally are not experiencing serious problems dealing with their legacy systems during the transition. Several DOTs are exploring the use of "middleware" to help interface and translate among their various systems.

Many IT performance issues being experienced by the DOTs relate back to the issue of IT centralization. The advantages of centralized IT include: (1) tight control over system architectures, making maintenance and hardware support easier, (2) fewer problems with system interoperability as systems are increasingly designed from a state enterprise perspective, and (3) the possibility that it may be easier to recruit good IT staff. The career opportunities could be somewhat greater within a larger consolidated IT group. Also, in some cases but definitely not all, it may be easier to exert pressure on the state to increase IT salaries.

There are also disadvantages to centralization. South Dakota, which has the most centralized IT arrangement (all IT staff belong and report to the centralized state IT group) sees significant drawbacks as well as some benefits. Their flexibility is limited and they have no independent resources to make IT investments. Each agency must wait in line for resources for every IT improvement or development they desire. The process is slow and every project, no matter how small, turns into a fairly large effort because of the requirement to use CASE

methodology for business system analysis and design to ensure well-engineered systems. They are in the process of redesigning their project management system (just the basics of budgeting and scheduling--not the engineering software) and it has taken an excessively long time. Moreover, although centralized IT staff are on site, they do not always understand the business processes as well as they should, and support in the field offices is not good. Not having their own IT staff makes it difficult to find people on staff who are capable of adequately managing IT projects. As a result, some projects have languished and others failed to meet their needs. The state DOT in Idaho similarly noted that the highly centralized and separate IT function they had in the past made it difficult to get adequate support and for this support to be sufficiently knowledgeable and integrated into their business systems. They are now decentralizing the support role, so these problems should be reduced in their new model.

Resources, Staffing, and Outsourcing

The lack of resources, both in terms of money, staff, and basic infrastructure is the major issue for most state DOTs. There are exceptions; the Kansas DOT has exceptional state resources. In many states federal funds are approximately 80 percent while states contribute about 20 percent. In Kansas this is almost reversed with federal funds representing about 20 percent and the state providing almost 80 percent of the funding. A major challenge for most DOTs is to creatively access funds and to allocate resources effectively. Partnering with the private sector and collaborating with other state DOTs to investigate new applications or conduct research is becoming increasingly important. Also coming up with ways to recruit, retain, and/or supplement their IT staff is a major concern for all DOTs.

Some DOTs have some mechanisms to improve the salaries and benefits of their IT staff but many have little latitude due to the existence of statewide personnel policies. In some cases, the state has raised salaries of particular groups of employees, primarily IT staff. For example, the state of Arizona introduced a new IT personnel plan to increase IT salary ranges in order to make the state more competitive in the job market. Pennsylvania also reevaluated and adjusted IT salaries.

DOTs that are more limited in what they can do in terms of salaries have found other ways to benefit and retain their IT staff, such as introducing a bonus system and offering good training opportunities. The state of Maryland introduced general incentive programs that agencies can adopt, many of which the Maryland DOT is employing. These include hiring bonuses, retention bonuses, annual mission critical bonuses that are tied to the work effort that a person is doing, and a program to reward employees who bring in good persons—a kind of finder's fee. The Kansas DOT introduced bonuses based on skill and project performance. In addition, they allow staff to attend 1-2 training programs per year—this training is typically offered in desirable areas and they are lenient in allowing staff to combine vacation with training. Providing good training can help to attract staff but it can also have a downside. For example, the Maryland DOT is becoming a very good training ground, developing experts in database management, programming, and hot IT areas. This has made their trained employees highly desirable to other organizations, and as a result they have lost many of their best IT staff.

Money is typically more available for contracting than it is to bring the in-house IT capability up to the level needed. Outsourcing is therefore becoming much more prevalent. Even in cases where salary adjustments have been made for IT staff, state agencies can't successfully compete to hire IT professionals in high tech IT areas, such as application development. In some instances, salaries are 30-50% under market. Thus, specialized areas of IT are frequently outsourced. Four of the state DOTs participating in this study outsource some

aspects of their IT function. Most outsource some of their application development, such as custom systems. The Maryland DOT outsources database administration and contracts with their network service provider as well as contracting out development work. The Pennsylvania DOT outsources the operations piece. Contractors are sometimes located on-site and other times not. A few DOTs noted some problems with outsourcing but believed these were just growing pains that would be worked out. Some perceive outsourcing to be more expensive than having DOT staff do most of the IT work in-house. Also, the relationship between internal staff and outside IT contractors is an area of stress for some DOTs. A few DOTs are focusing on implementing better project management methodologies to make this relationship work better. The strategy of the Arizona DOT has been to focus on developing in-house IT project management skills in order to enhance the management of specialized IT contractors. Finally, some state DOTs are experiencing substantial turnover in the contracting community.

Basic infrastructure that will allow the DOTs to pursue their future strategies is also lacking at this point in time. For example, fiber optics, satellite photography, sensors, wireless communication infrastructure are not in place to collect the data needed to develop the information databases and portals they hope to have available in the near future.

CHAPTER 3

INTERPRETATIONS AND CONCLUSIONS

IT is contributing to a major DOT paradigm shift. The basic DOT mission is shifting from a focus on construction and infrastructure maintenance to a focus on more effective enterprise-wide asset management, enterprise information management, enterprise resource management, stakeholder and customer engagement and e-business. At least from the perspective of the particular DOTs, or the particular DOT representatives, participating in this study, the concerns of greatest interest tend to be these larger strategic issues that are emerging as the result of IT becoming more important to their overall DOT vision and strategy rather than the particular issues pertaining to the introduction of IT and/or IT-related OD innovations. All but one of the DOTs indicated that they are no longer experiencing any real resistance to new IT developments and IT-related OD innovations. They are, however, interested in the general issue of customizing existing IT developments to address DOT needs, and given that DOTs are not uniform, the challenge is how to best customize IT applications to meet their specific needs. They also are interested in learning best practices and lessons learned in terms of structuring and organizing their IT functions.

Most of the interviewees expressed the desire to direct studies to IT-related issues, but not to IT per se because government sponsored research in the area of IT is slow and unnecessary, given that the private sector is out front in this regard. Most suggested that the real need was to facilitate larger strategic workshops that focus on the customization and dissemination of new applications, rather than to focus on IT development research. One DOT suggested that perhaps the best thing the Federal DOT and other transportation agencies could do was to sponsor (using state funds as necessary) national or regional conferences that focused on DOT and transportation-specific IT issues. It also was suggested that these conferences should be directed at a wide spectrum of DOT staff, rather than being geared toward IT staff per se. An alternative could be to organize one or more conference discussions under the existing AASHTO annual meeting and subcommittee structures. While there is a lot of IT available that has potential significance for DOTs, what is missing is the understanding of how best to adapt these IT to the specific needs of DOTs as well as to the varying needs and situations of each of the state DOTs. This includes the need to map out and understand State DOT processes that in turn determine a set of requirements that provide a rational basis for identifying technology solutions. This approach of first seeking to understand the DOT's business processes and requirements helps avoid an inappropriate focus on IT technology solutions that are looking for problems to solve.

CHAPTER 4

SUGGESTED RESEARCH

During the interviews with the state DOTs, each respondent was asked to suggest research topics that they thought would be of particular benefit along the lines of this topic. Based on discussions with state DOT representatives and a review of the relevant literature, the following topics for future research attention emerged from this scanning project:

Title: Organizing the IT function in State DOTs: Centralization vs. Decentralization

Issue, Objective and Expected Results: DOTs are operating their IT functions under a wide variety of different models across the country. A portion of the IT functions may be centralized, either within the DOT or at a higher state agency level, and others decentralized. There are tensions and tradeoffs, such as between conformity and flexibility, local control and central control, consistency and special needs, dependence and independence, procedural rigidity and responsive nimbleness, efficiency and redundancy, and complexity and ease of use. Research is needed to explore the relative advantages and disadvantages of the degree and types of centralization of the IT function in order to provide better guidance to state DOTs that are struggling to manage their IT functions with too few resources. This research should describe the different approaches or models being used, explore their strengths and weaknesses, and provide clear guidance to DOTs and states about how to more efficiently and effectively manage the IT function.

Costs: $100,000

Title: Outsourcing Elements of the IT Function: Best Practices, Advantages and Disadvantages

Issue, Objective and Expected Results: Contracting out, or outsourcing, various functions of an organization is an increasingly common practice, and State DOTs are beginning to experiment with outsourcing elements of their IT function. In many DOTs outsourcing is a cost-effective alternative to trying to obtain scarce funding within the organization to provide various IT services, such as application development, database administration, or network services. Internal staffing constraints motivate some DOTs to outsource. But outsourcing comes with real costs. DOTs may have to give up a measure of control over their IT functions, and quality assurance becomes an important issue. Research is needed to identify and document the range of IT functions that can be outsourced, the experiences of DOTs with outsourcing, and the pros and cons of outsourcing. Recommendations will be offered to guide DOTs in understanding what to outsource, when to do it, and how to do it cost-effectively.

Costs: $80,000

Title: How State DOTs Can Learn to Thrive in an E-Business Environment

Issue, Objective and Expected Results: E-commerce or e-business uses IT to fundamentally change the way in which organizations operate. Some State DOTs are beginning to use e-business to communicate information about their activities and provide products and services over the Internet to customers, suppliers, and other DOTs. E-business also offers opportunities to support public-private partnering, contracting, procuring, and a variety of other DOT functions. But DOTs are generally slow to respond to these opportunities because of a lack of understanding about how to participate in this new way of conducting their organizations' business. IT requires a whole new business model. Research is needed to review how other organizations are using e-business approaches, to understand which of the many DOT functions can take most advantage of the potential benefits of e-business, to clarify the pros and cons of e-business particularly for State DOTs, and to recommend a step-by-step transition approach for DOTs to move in this new direction.

Costs: $100,000

Title: Identifying Criteria, Strategies, and Guidance to Assist DOTs to Assess and Select IT

Issue, Objective and Expected Results: State DOTs are faced with complex and difficult choices when considering the acquisition of new IT. IT is mostly new to DOTs, it is changing and evolving rapidly, IT tends to be costly, and DOTs are under increasing pressure from their customers to get up to date with regard to IT. DOTs don't want to fall behind the curve in terms of their use of IT, but they also don't want to take undo risks with unproven technologies. DOT management tends to be conservative and the decision factors associated with IT procurement are typically new and uncomfortable. Research is needed to understand and organize the factors that are important for DOTs to consider as they move to adopt IT. The research should yield recommendations and clear guidance for identifying IT opportunities, prioritizing IT options, assessing the risks associated with IT acquisition, and tailoring new IT to best fit the needs of each DOT.

Costs: $100,000

Title: Guidelines to help State DOTs Manage Information Overload

Issue, Objective and Expected Results: The rapid diffusion of IT presents state DOTs with pressing challenges of how to more effectively manage vast increases in information and data. This raises questions of what data are most important, how data are to be acquired and disseminated, how long does certain information and data need to be retained, who needs access to various information, and how information can be controlled and security maintained. E-mail and the Internet provide new ways for DOT employees and customers to gain access to information, but little is understood about the consequences. The costs associated with quantum increases in data volume and complexity are large. Managers are drowning in e-mail. Research is needed to develop a set of recommended data management procedures for DOTs, and to describe the benefits of more careful attention to information flows both internally and externally.

Costs: $75,000

Title: Finding, Procuring, Training and Retaining IT Staff

Issue, Objective and Expected Results: The management and operation of IT requires a very different skill set compared with the traditional transportation engineer, operator or manager. In addition, these skills are in high demand in the marketplace today. When recruiting DOTs find themselves competing for scarce human resources with high salary demands, and when looking to upgrade existing staff, the training and staff retention costs are high as well. DOTs often are constrained with mandated salary caps, antiquated job classifications, and non-competitive benefits packages. IT staff turnover tends to be high, and the costs and challenges of addressing this problem are daunting. Research is needed to offer guidance to DOTs about how to address these problems and should include a recommended set of tools or strategies for managing their IT staffing needs. It should include an inventory of how DOTs are coping and should draw on organizational experiences and models outside of the DOT community for creative suggestions.

Costs: $80,000

A more careful costing of these candidate research topics will need to be developed based on an elaboration of the specific tasks to be carried out and the overall level of effort considered appropriate for each topic component. As suggested by a number of the DOT interviewees, these topics could be addressed, prioritized, supplemented, and refined in a workshop setting with representation from both USDOT and the state DOT offices. Most of the DOT participants in this scanning task endorsed the concept of a workshop or symposium that would bring to a discussion forum the best practices of all the DOTs with regard to current applications and future plans for the role of IT in their business.

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APPENDIX A. TELEPHONE INTERVIEW PROTOCOL

Interview Guide for discussions with State DOTs
NCHRP 20-24(14) Task 6: Managing Change in State DOTs

Innovations in Organization Development as a Result of Information Technology

1. Explain purpose of this interview and our study: to understand how DOTs are using and being effected by Information Technologies (IT), and what organizational development (OD) strategies they are using in response to IT; that is, OD either driven or enabled by IT. What works and what does not? What approaches hold the most promise? Where do we need more research to better understand how state DOTS can best take advantage of and cope with IT?

2. Ask if they would like to review the interview notes to assure accuracy and completeness.

3. Review IT list.

   a. Any IT missing from the list? General comments on the list coverage?

   b. Which of the IT listed or added by you have had the greatest impact on your organization to date?

   c. Which of the IT listed or added by you hold the greatest promise for helping your DOT develop innovative solutions to DOT issues in future?

4. Review OD list.

   a. Are there IT enabled or driven OD innovations that your DOT has tried that are not captured on the list provided? Please explain.

   b. Which of the OD innovations listed on the sheet, or added by you, do you think hold the greatest promise for DOTs? Please explain. *Explore public/private partnerships, benchmarking, etc.*

   c. How well has your DOT been keeping up with (assessing and adopting as appropriate) these potentially useful organizational developments?

5. Discuss the DOT's approach to IT.

   a. How well has your DOT been keeping up with (assessing and adopting as appropriate) potentially useful IT and organizational developments?

   b. How does your DOT go about identifying, assessing, and selecting new IT and IT-based organizational changes or innovations? How well does this process work?

   c. Does the DOT have a clear vision that guides the selection and use of IT? How has IT impacted how the DOT sees itself developing as an organization?

   d. What are the most important directions for IT for the future success of your DOT?

6. Assess IT impacts.

   a. How has IT enabled organizational change –i.e., allowed your organization to do things differently/better? Please provide examples.

   b. Has IT driven any changes in your organization? For example, have IT developments triggered new customer demands or new stakeholder expectations that your DOT feels it must address?

   c. Has your DOT experienced difficulties dealing with the introduction of new IT and IT-based organizational changes? What are the main challenges? What can be done to help DOTs cope with the pressures and difficulties associated with IT-based organizational change?

7. Discuss the following aspects of the IT function in the DOT (and state DOTs in general):

   a. How is your IT function organized (centralized/decentralized; in-house/out-sourced)? What are the key lessons learned?

   b. What are the major <u>strengths</u> and <u>weaknesses</u> of your IT function?

   c. What are the major challenges confronting your IT function?

   d. How satisfactory is IT maintenance/service? Have you developed strategies to improve IT maintenance and service?

e. Has there been much difficulty with dysfunctional or failed IT projects? What do you see as the primary causes/solutions?

f. Have there been difficulties with various IT systems and strategies not working well together? What do you see as the primary causes/solutions?

g. Has it been difficult to recruit and retain IT staff? Have you developed any strategies to address this issue?

8. What areas of future research do you see as being needed in this area? What research would have the potential to yield the greatest value to state DOTs in their efforts to address the opportunities and impacts of IT on DOT organizations?

APPENDIX B. DATA CHECK SHEETS AND ANNOTATED DESCRIPTIONS OF IT
State DOT Use of Information Technologies (IT)

Information Technology	A: Use of IT by Your Organization*			B: IT's Contribution to Organizational Success*		
	Not at all	Some	A Lot	A Little	Some	A Lot
Infrastructure-based sensors	1	2	3	1	2	3
Vehicle-based sensors	1	2	3	1	2	3
Automated data collection systems	1	2	3	1	2	3
IT in support of real-time traffic information	1	2	3	1	2	3
In-vehicle Navigation Systems (IVN)	1	2	3	1	2	3
Internet / Intranet	1	2	3	1	2	3
Digital satellite photography	1	2	3	1	2	3
Voice-activated and voice-recognition systems	1	2	3	1	2	3
Global Positioning System (GPS)	1	2	3	1	2	3
Automatic collision notification devices	1	2	3	1	2	3
Variable Message Signs (VMS)	1	2	3	1	2	3
Highway Advisory Radio (HAR)	1	2	3	1	2	3
Closed-Circuit TV (CCTV)	1	2	3	1	2	3
Wireless communication	1	2	3	1	2	3
Cell phones	1	2	3	1	2	3
Pagers	1	2	3	1	2	3
Personal digital assistants (PDAs)	1	2	3	1	2	3
E-commerce (E-government)	1	2	3	1	2	3
Computer models, simulation and visualization, and database software	1	2	3	1	2	3
Geographic Information Systems (GIS)	1	2	3	1	2	3
Portable pen-based systems	1	2	3	1	2	3
Remote access technology (e.g. Internet, Intranet, video conferencing, cellular, telecommuting)	1	2	3	1	2	3
Electronic payment systems	1	2	3	1	2	3
CAD/CAM	1	2	3	1	2	3
Decision Analysis Software	1	2	3	1	2	3
Insert and rank other IT in spaces below:						
•	1	2	3	1	2	3
•	1	2	3	1	2	3
•	1	2	3	1	2	3
•	1	2	3	1	2	3
•	1	2	3	1	2	3

* For **Question A** circle 1, 2 or 3 for each OD to reflect how widely it is used in your organization now.
For **Question B**, circle 1, 2 or 3 for each OD that has been used by your organization to reflect its contribution to successful organizational development and functioning.

Information Technologies (IT)
<u>Infrastructure-based sensors</u> Sensors imbedded in the road, on the road side, or overhead can detect and count vehicles, discriminate type or size of vehicle, extract information from the vehicle about the vehicle's condition or its contents if it carries a transponder device, weigh the vehicle in motion, and perform other such functions that provide traffic managers with information to help with operations and management. New detector technologies include laser, microwave radar, ultrasonic, acoustic, and video imaging. These are supplementing existing technologies such as telephone line, fiber optic, coaxial cable, satellite, and wireless. An example would be an Automated Vehicle Location (AVL) system that a transit agency uses to track and report on bus locations.
<u>Vehicle-based sensors</u> Sensors in the vehicle can send information about the vehicle or its contents to external detectors along the roadway, to the driver of the vehicle, or to other vehicles. Information could include the presence of another vehicle in the blind spot (lateral collision avoidance), information about the vehicle in front or behind that could be used to regulate braking and acceleration (longitudinal collision avoidance), information about road hazards, night vision enhancement, and heads-up displays, and vehicle condition sensors that relay safety information to the driver, such as a tire failure warning system. Both infrastructure and vehicle-based sensors are being considered as components of an automated highway system (AHS). Sensors and signal devices can support capabilities such as signal preemption, allowing emergency vehicles or buses to alter traffic signal timing to facilitate efficient travel under certain authorized circumstances. Sensors on buses can count passengers, thereby facilitating the more efficient scheduling and management of a complex transit system.
<u>Automated data collection systems</u> Examples included on-board electronic recorders used by some commercial vehicle operators (trucks, buses) to record hours-of-service in place of manual entries into logbooks as required under existing regulations, thereby facilitating data entry by operators and data administration by fleet managers.
<u>IT in support of real-time traffic information</u> This information, also referred to as dynamic traffic information, provides drivers with actual up-to-the-minute traffic conditions on the roadway. This can include information on congestion, accidents, construction, or road weather. The information can be disseminated via radio, TV, the Internet, wireless technologies (PDAs, pagers, other), Kiosks, or in-vehicle devices (auto PC, IVN, etc.). Dynamic information can be integrated with static information, such as normal route guidance provided by an IVN, thereby providing optimal route guidance based on current conditions. This information can be provided to travelers pre-trip using television, the Internet, or the telephone, and also en-route using IVN devices, autoPC, wireless handheld devices, pagers, or cell phones.
<u>In-vehicle Navigation Systems (IVN)</u> These IVN systems may be portable or permanently mounted in a vehicle. They are typically coupled with GIS and include up-to-date map databases to provide visual and/or auditory route guidance (turn-by-turn instructions) to the driver. They may include dynamic information on current road conditions and congestion.
<u>Internet / Intranet</u> The Internet is becoming more widely used to disseminate various kinds of traveler and traffic information, including highway, transit, ferry, and other modal information. Typical applications offer real-time traffic conditions on a map-based display, with speeds, construction, and accident information. Video images are often components of these Internet sites. The Internet is at the heart of e-commerce and e-government. Transit web sites offer schedule, fares, route guidance, transfer information, and multi-jurisdiction integration. Information is made available on ride sharing plans, information for the disabled, micro road-weather information, and the like. The Intranet is used by DOTs to exchange operations and management information internally, and the Internet for external communications and information exchange, such as electronic dialogues. Information can be customized for the user and delivered via e-mail, wireless, or telephone. The Internet serves as an important conduit between DOTs and their customers, including Q&A, public notices, and customer satisfaction surveys. DOTs have web sites that they manage alone or in collaboration with ISPs. Private sector traveler information web sites typically access and add value to public traffic data. The Internet is accessible by DOT employees both at work and at home, thereby facilitating telecommuting.
<u>Digital satellite photography</u> Images of large areas, with details on roadways and traffic conditions, offer traffic managers a tool for better understanding and managing traffic networks on a real-time basis.

Voice-activated and voice-recognition systems

As IT proliferates in various in-vehicle devices, the ability of the driver to use these systems effectively without distraction becomes a critical safety issue. Voice-activated and voice-recognition systems provide a way for the driver to query the system and acquire needed information without taking his/her eyes off the road.

Global Positioning System (GPS)

GPS has many applications in transportation associated with providing real-time location on map-based systems. Applications include IVN devices, arrival-departure information for transit buses displayed at transfer stations, ferry locations displayed on the Internet, assignment planning and tracking for snow plows, location and tracking of railroad cars, and many other related uses. By 2002 a Nationwide Differential Global Positioning System will be operational across the country, providing exceedingly accurate locational information, thereby facilitating a host of new transportation applications, including navigation and route guidance; the management of fleets of vehicles; emergency notification or mayday services; roadway maintenance; and intelligent vehicle infrastructure. Expected benefits include increased safety, mobility, and operations efficiency. AVL systems (notes earlier) are often GPS enabled.

Automatic collision notification devices

When a vehicle is involved in an accident, the driver may either not know where he/she is located (at least not with precision), or may be injured and not able to call for help. These devices are automatically triggered by an impact and summon assistance without human intervention. They communicate exact location information, using GPS, to assist aid vehicles in quickly locating the accident site.

Variable Message Signs (VMS)

These kinds of roadway message signs are variously called VMS, CMS (Changeable Message Signs), or DMS (Dynamic Message Signs). They are typically connected by landline or wireless communications to a Transportation Management Center (TMC). Standard message sets are displayed on these signs to alert drivers to potential dangers on the roadway, such as restricted lanes, construction, accidents, traffic congestion, weather, and the like. Messages can be posted and changed by central operators via telephone or other communication devices. VMS come in different sizes, depending on use and required length of message content. VMS can be fixed or mobile.

Highway Advisory Radio (HAR)

HAR systems are based on short distance radio communication, typically from either permanently mounted or mobile transmitters. They are used to convey current traffic condition information over dedicated radio channels that are displayed to drivers on roadside signs. HAR is used for various types of traveler information, including weather, road conditions, accidents, construction, tourist information, ferry schedules and queue status, and other types of information. Messages can be posted and adjusted by traffic operators by phone, wireless communications, or manual replacement of message tapes.

Closed-Circuit TV (CCTV)

CCTV is being used extensively by DOTs, for both metropolitan and rural applications, to display current conditions to travelers and system operators either over the Internet or on standard television monitors. Communications can be landline (typically fiber optic) or wireless. The cameras are often of the Pan-Tilt-Zoom variety that allow traffic centers to scan all segments of a roadway within the full field of view. They are useful for displaying traffic flow and congestion or focusing on accident scenes. The displays benefit both drivers and maintenance and emergency service providers.

Wireless communication

Wireless communications are emerging rapidly with many transportation applications. Wireless has the advantage of allowing information exchange from remote locations that may not be easily or cost-effectively accessible by land lines. A good example is a road-weather information system (RWIS) that collects and transmits such information as road surface and sub-surface temperatures, wind speed and direction, precipitation, video images, and related data. RWIS facilities are placed in areas particularly vulnerable to icing, winter storms, flooding, and related environmental conditions that can impact safe travel, and these areas are often remote (such as a mountain pass). Wireless communications are often associated with VMS, HAR, CCTV and other data gathering sensors that feed data streams into TMCs to facilitate traffic operations. Individual travelers also have access to new wireless technologies for sending and receiving information that are used for trip planning, summoning emergency services, facilitating travel decision making, and the like.

Cell phones

Cell phones are becoming almost ubiquitous, especially in urban areas where cell coverage is greatest. They are used extensively by travelers for trip planning and as a safety backup device. Some DOTs and private sector firms offer access to real-time traffic information via cell phone and even post toll-free highway information numbers on VMS. An emerging use for cell phones is as probe devices that allow traffic operators to track vehicles with cell phones anonymously and map traffic speeds, congestion, and flow patterns using automated computer software. These data can then be processed and disseminated to all travelers to offer system-wide real-time information that is not restricted to only those locations that have installed sensors. Cell phone technology also allows users to transfer text messages, thereby opening up additional transportation information exchange possibilities.

Pagers

Pagers are as widely distributed in the population as cell phones. They are used as a way to wirelessly exchange information about travel conditions to travelers and can be customized by some vendors to provide only the information content and location specificity that the user desires. Implementations have included pager watches, which offer traffic information beamed to a users receptor watch in a package deal that might include other information such as sports scores, stock market data, or news headlines.

Personal digital assistants (PDAs)

PDAs are becoming increasingly widespread in the population, and some of them have wireless connectivity, allowing Internet access to traffic updates, map-based route-finding capabilities, point-of-interest information, and other useful traveler information. PDAs are also being built into cell phones, though this is a leading edge application that is not yet widely in use.

E-commerce (E-government)

E-commerce refers to business transactions conducted over the Internet. DOTs are increasingly adopting e-government strategies for the procurement of goods and services, for communicating with their customers, for managing construction bids, and for managing internal administrative processes such as payroll and travel. DOTs are providing their many types of forms over the Internet that used to be handled only in hard copy. Sharing of information over the Internet in this way requires significant efforts to standardize within and across agencies. A shift toward e-government requires the development and use of a variety of new computer software for financial management, timekeeping, literature search, database management, project management, construction management, and all the many other functions of a DOT.

Computer models, simulation and visualization, and database software

Models and simulation offer DOTs an opportunity to better understand the characteristics of complex traffic networks under a variety of conditions and to test how interventions might impact or benefit system performance, such as changes in signal timing and coordination, the use of ramp meters, or changes in lane design. Modeling may be used in other aspects of the management and administration of DOT operations. Visualization software offers new capabilities in communicating complex concepts, understanding relationships underlying large data sets, and facilitating the modeling and analysis of transportation networks and traffic flow. In support of these information management and analysis capabilities is new database storage, retrieval, mining, and management software that facilitates handling large volumes of information more efficiently. Electronic data exchange software (EDI) also supports the more efficient exchange of information.

Geographic Information Systems (GIS)

GIS incorporates location-based or mapped information into computer databases and provides software that allows the user to analyze a variety of data and information in terms of their locational attributes. DOTs, as users of GIS systems, would typically be responsible for the transportation “layer” in the GIS. This includes precisely digitized map information on roads, highways, points of interest, bicycle and pedestrian paths, and a variety of transportation facilities. Other agencies could contribute similar data on attributes of interest, such as the location of fiber optic cables, phone lines, power lines, and the like. Taken together, these data in a GIS, along with powerful analytic and display software, provide DOTs with a tool to plan new construction, system upgrades, and other modifications of the transportation infrastructure. In addition, geocoded data can be disseminated to travelers over devices such as IVNs to provide route guidance and other information that needs to be understood in its locational context. Mapped GIS applications in transportation require frequent updating in order to keep the information current with rapid changes in the transportation infrastructure and land use patterns.

Portable pen-based systems Pen-based technologies, which include PDAs, are typically used in the transportation field to allow easy remote access to data that reside on central transportation data base systems. They also allow field personnel to input and update data to the system, typically using pre-designed forms that are accessible in a portable handheld device. Pen-based systems are being used by DOTs in commercial vehicle programs for credential and weight verification at weigh stations and border crossings, and for tracking containers from ship to truck to rail.
Remote access (e.g.Internet, Intranet, video conferencing, cellular, telecommuting) IT is making it feasible for employees to work away from their main office, communicating by phone from remote locations, communications via the Internet and via dedicated access company computer networks, video conferencing in lieu of travel, etc.
Electronic payment systems DOTs are using electronic payment systems on passenger, commercial, and transit vehicles for toll, fare, and fee payment.
CAD/CAM New computer-aided design software (CAD) allows engineers to be more efficient and to communicate concepts to others more clearly and quickly.
Decision Analysis Software Software is available to aid managers and operators in analyzing complex sets of decision criteria and a wide array of information to aid in the decision making process.
IT of the future IT is changing and developing rapidly, so forecasting where IT is headed in the future is a highly uncertain business. Individuals working in transportation organizations are managing and exchanging ever increasing volumes of information. They can anticipate higher bandwidth computers that are even more portable. Advances in electronic information exchange hardware and software will facilitate interaction and communication among work groups and support the ability of employees to work offsite and on field assignments with greater access to company data. Individuals will be in constant touch with colleagues through portable communication and data exchange devices that can be easily connected through a single number for each individual. Automated systems will facilitate easy communication between company and customer. Voice recognition systems will be common, including automated language translators. Information and communication will cross national borders with increased transparency. Individuals, work groups, and entire businesses will be connected in cyberspace and supported with virtual reality capabilities. Portable, personal video-conferencing capabilities will increasing substitute for travel or the need to be located in central structures, and telecommuting will be more common than today. Of course, there will be developments in IT that we can't foresee or anticipate that will further alter the way we do business.

APPENDIX C. DATA CHECK SHEETS AND ANNOTATED DESCRIPTIONS OF OD INNOVATIONS THAT ARE ENABLED AND/OR DRIVEN BY IT

Innovations in Organizational Development that are Enabled and/or Driven by IT

Organizational Developments (OD)	A: Use of OD*			B: How Successful?*		
	Not at all	Some	A Lot	A Little	Some	A Lot
Strategy Innovations ***Incremental Strategy Innovations***						
Customer Focus	1	2	3	1	2	3
Stakeholder Engagement	1	2	3	1	2	3
Performance-based Management or Management by Objectives	1	2	3	1	2	3
Asset Management	1	2	3	1	2	3
Supply Chain Management	1	2	3	1	2	3
Sustainable Development	1	2	3	1	2	3
Outsourcing/Privatization	1	2	3	1	2	3
Forecasting & Roadmapping to Guide Future Strategy	1	2	3	1	2	3
More Radical Strategy Innovations						
Collaborations/Partnerships	1	2	3	1	2	3
R&D/Innovation focus	1	2	3	1	2	3
Life-cycle, Product Portfolio, Product Platform Management	1	2	3	1	2	3
Organizational Learning/Knowledge Management/Real-time Information	1	2	3	1	2	3
Competency Building	1	2	3	1	2	3
Change Management	1	2	3	1	2	3
Product/Service Innovations ***Incremental Product/Service Innovations***						
Enhanced Functionality, Safety, Reliability	1	2	3	1	3	3
More Radical Product/Service Innovations						
Product/Service Bundling	1	2	3	1	2	3
Customization	1	2	3	1	2	3
Product/Service Delivery Innovations	1	2	3	1	2	3
New "Smart" Products/Services	1	2	3	1	2	3
Process Innovations ***Incremental Process Innovations***						
Employee Empowerment	1	2	3	1	2	3
Enhancements in Teamwork	1	2	3	1	2	3
Flexible, Distributed, Asynchronous Work Arrangements	1	2	3	1	2	3
Electronic/Remote Training	1	2	3	1	2	3
Performance Measurement and Assessment	1	2	3	1	2	3
Benchmarking	1	2	3	1	2	3
Preventive Maintenance	1	2	3	1	2	3
Communication Enhancements/Flexibility	1	2	3	1	2	3
Enhanced Project Management	1	2	3	1	2	3
Project-based Management	1	2	3	1	2	3
More Radical Process Innovations						
Process Automation	1	2	3	1	2	3
Process Reengineering	1	2	3	1	2	3
High Tech Diagnostics/Prognostics	1	2	3	1	2	3

* For **Question A** circle 1, 2 or 3 for each OD to reflect how widely it is used in your organization now.
For **Question B**, circle 1, 2 or 3 for each OD that has been used by your organization to reflect its success to date in helping achieve organizational goals.

Innovations in Organizational Development that are Enabled and/or Driven by IT

Strategy Innovations

INCREMENTAL STRATEGY INNOVATIONS

Customer Focus (IT-enabled; IT-driven**)**

A strategic emphasis on customer focus typically contributes to incremental organizational innovation. Many organizations have reorganized around customers, customizing products and services to particular customer groups. Customer focus has extended beyond a focus on external customers to include internal customers. IT is not necessary but can make it easier to involve customers in key decisions and activities. IT developments that enhance the ability to adjust products and services to the particular needs (some of which are specific IT needs) have both enabled and driven customer oriented strategies.

Stakeholder Engagement (IT-enabled; IT-driven**)**

Stakeholders are demanding increased transparency, enhanced mechanisms for sharing information, greater decision-making involvement, and cooperation and coordination among players. There is increasingly a stakeholder community orientation toward formulating shared goals and priorities and developing collective strategies to problems that span organizational boundaries. Stakeholder engagement will contribute to strategy innovations, some of which will be incremental in nature but others may be quite radical, especially if strategic innovations involve partnering and alliances. IT can enable more information sharing and collective participation. IT also drives the demand for greater stakeholder engagement in that IT-based solutions and strategies too often fail when they are not embraced, supported, and informed by stakeholders.

Performance-based Management or Management by Objectives (IT-enabled**)**

Performance-based management involves the use of clearly specified, measurable performance objectives combined with performance measures and analysis to assess progress in achieving these performance objectives. Performance-based management should contribute to incremental learning and improvement. It is only somewhat IT-enabled in that IT can make data collection, analysis, and dissemination more efficient.

Asset Management (IT-enabled**)**

Asset management focuses on optimizing existing assets in order to decrease the need to acquire or build new assets. It is an incremental innovation because it is not really doing anything completely new. IT has enabled asset management strategies that were not possible in the past. For example, sensors and information management can permit real-time asset tracking and utilization monitoring and directing. Examples: (1) using sensors and other IT to record and disseminate information on the volume of traffic on various roadways to users on a real-time basis; (2) connecting roadway and intersection sensors to traffic lights to coordinate lights in a corridor and optimize traffic flows; (3) determining what assets can be out-sourced versus supplied in-house.

Supply Chain Management (IT-enabled**)**

Supply chain management focuses on managing the flow of materials from the supplier, through all phases of production (design, manufacture, marketing, etc.), to the end-user or customer. A strategic focus on supply-chain management tends to be an incremental innovation in that it merely enhances efficiency and effectiveness; it does not significantly alter the strategy of the organization. IT enables supply-chain management by allowing real-time electronic links with suppliers and customers. Examples: (1) IT-enabled coordination between customers and suppliers to achieve just-in-time delivery in order to decrease the need for and costs associated with large warehouses; (2) prioritizing maintenance and/or acquisitions to best optimize system readiness; (3) using a global positioning system to track delivery trucks and redirect routes based on last minute changes in customers' orders or to avoid traffic congestion areas.

Sustainable Development (IT-enabled**)**

Since the 1992 Earth Summit in Rio de Janeiro, sustainable development has become a common theme. In the architecture/engineering/construction industry, more than 700 industry, government, and academic leaders worldwide gathered in Washington, D.C. in February 1996 to develop an international collaborative research agenda for sustainable development. Sustainable development requires balancing environmental concerns with economic and social issues in a way that ensures both near term and future viability of the business, the environment, and the community. Sustainable development is not always dependent on IT but new IT developments and associated IT-enabled innovations may offer new sustainable development opportunities. A strategic emphasis on sustainable development usually leads to incremental improvements, although radical innovations are possible. However, an expectation that future radical IT advancements (e.g. "clean technologies") will inevitably solve problems should be avoided. Examples: (1) less polluting but economically viable road surface materials; (2) less polluting but socially and economically viable transportation alternatives.

Outsourcing/Privatization (IT-driven**)**

Outsourcing is a strategy that is increasingly being used by for-profit, private organizations to reduce the need to develop all the skill areas and production components required to run their organizations and produce their products and services in-house. Public sector organizations can do the same thing but, in this case, the strategy is referred to as privatization. Outsourcing and privatization can be IT driven in the sense that it is often difficult for an organization to acquire all the IT capability that it needs through hiring. It may also be difficult to fully utilize in-house IT specialists. Outsourcing or privatizing specialized skill areas and/or non-critical production activities can increase efficiency.

Forecasting & Roadmapping to Guide Future Strategy (IT-enabled; IT-driven**)**

Forecasting helps planners deal with an uncertain future by attempting to envision a range of future scenarios, examine their possible impacts, develop a common view of the most likely scenarios, and prepare for them. Forecasting and scenario analysis does not decide strategy, but improves how managers make strategic decisions. A classic example of forecasting involves scenario analysis by Royal Dutch/Schell that helped them prepare for the eventuality, if not the timing, of the oil crisis (Wack 1985). Roadmapping is a technique used by many companies to plan new product development but has since become a more

broadly used technique that can be applied to many kinds of planning activities, including product and product line roadmaps, sales roadmaps, industry roadmaps, and technology roadmaps. Roadmaps outline possible alternative strategies and endpoints and help organizations to estimate the resources required to achieve the desired destinations. Forecasting and roadmapping can result in incremental or radical strategy innovations. IT enables both forecasting and roadmapping. IT can also drive these activities because the pace of IT developments and consequently organizational and product change requires that organizations more actively and effectively assess and address future strategic directions. Also a new opportunity in market positioning (what market or particular market niche is being targeted) may be driven by new, particularly discontinuous IT innovations, that contribute to radically new products and services directed at a new customer base. Partnerships and collaborations (see below) is a more radical strategic innovation that is increasingly being adopted to enhance an organization's technology competencies and innovation potential and to help create a competitive advantage and secure its future market position.

MORE RADICAL STRATEGY INNOVATIONS

Collaborations/Partnerships (IT-enabled; IT-driven**)**

For the last decade organizations have been placing greater priority on managing their external environment by building stronger relations with customers, suppliers, and most recently, competitors. Competitor alliances initially focused on specific joint product development efforts, but increasingly are becoming longer-term basic R&D collaborations. Whereas supplier and customer partnerships tend to result in incremental innovations, partnerships with potential competitive and complementary organizations can lead to fairly radical innovations in organizational strategy. IT has enabled improved communication and information sharing between suppliers, producers, and customers. IT also both enables and drives collaborations and partnerships with complementary and potentially competitive organizations. IT drives these collaborations because increasing pressure to create better and smarter products and services at a faster and faster pace has made it impossible, or at least inefficient, to do this completely in-house. As more organizations engage in collaborations, it will become a competitive disadvantage not to follow suit. Collaborations are particularly prominent in high-tech sectors, such as the information technology and bio-tech industries (Powell, 1996).

R&D and Innovation focus (IT-driven**)**

A strategic focus on R&D and innovation are becoming a greater concern for more and more organizations. IT competition has reduced product life cycles and organizations must speed up product innovation to survive. It is also no longer enough just to produce incremental product improvements.

Life-cycle, Product Portfolio, Product Platform Management (IT-driven**)**

Life-cycle, product portfolio, and product platform management are intertwined strategies that allow the company to improve their overall near and longer term product/ service strategy. The key is to make sure that there are a sufficient number of products and services at each stage of the life cycle (conception, design, prototype, early production, mature product development, phase-out stage) in order to avoid gaps in the product pipeline. One

way of doing this is to focus on product platforms rather than just product lines per se. Product platforms are intended to promote new radical (even discontinuous) product innovations as well as the production and continuous improvement of existing products. This focus on product life-cycles and product platforms is driven by the faster pace of IT development and the corresponding shorter product life-cycles.

Organizational Learning, Knowledge Management, Real-time Information (IT-enabled; IT-driven**)**

Many prominent scholars suggest that we are moving into a new economic phase--- a knowledge-based economy. In this new economy, high tech knowledge-infused product and service offerings, rather than products that are primarily transformations of natural resources, will become the key to economic success. As knowledge increasingly becomes the key to success, organizations will have to become far better at promoting and managing their intellectual capital through knowledge management and the creation of a learning organization. The focus on knowledge management and organizational learning is driven by the need to develop high-tech knowledge infused products and services but IT can also help connect persons within and without the organization into knowledge sharing and knowledge creating communities. IT can also be used to capture, store, represent, and disseminate knowledge more effectively to members of the organization. Real-time information is becoming a critical input to knowledge management and organizational learning. It is also becoming a critical input to asset maximization (see incremental improvements in strategy). Real-time information dissemination is IT-enabled and can require advanced sensors and information systems. IT could also drive a need for real-time information in that organizations need to become increasingly adept at capturing new information if they are going to beat the competition in the innovation race.

Competency Building (IT-enabled**;** IT-driven**)**

Within the last ten years, the concept of core competencies has been introduced in the organizational literature and in organizational practice. The fundamental change in the nature of business competition is reflected in the shift from competing on price to competing on innovation. Central to the ability of a company to compete through innovation is the identification and nurturing of its core competencies -- those things that can distinguish the company from it competitors, particularly by the introduction of unique products to the market place. Organizations have necessary competencies and differentiating competencies. Necessary competencies are all those that go into creating value; differentiating competencies are those that give the organization its unique competitive advantage (Hamel and Prahalad 1994). Managers must select for strategic investment that set of organizational competencies that will most likely place the organization in the forefront of the delivery curve for a yet-to-emerge product or service. Since IT is an essential component of new products and services, ensuring that the organization has the competencies to stay on the forefront means that the organization will need to determine what IT competencies it will need to invest in.

Change Management (IT-enabled; IT-driven**)**

Change management refers to the ability to more effectively address and implement change, particularly fairly broad-based or organization-wide change. Change management involves establishing best practices to guide change analysis, change design, change implementation, and change assessment. IT can enable better change management to some extent but mainly

IT has driven a focus on organization change. Change, and thus change management, is a necessary consequence of increased competition and the shortened product life cycles resulting from the faster pace of product/service innovation. If an organization does not become effective in managing change, it will fall behind the competition.

Product/Service Innovations

INCREMENTAL PRODUCT/SERVICE INNOVATIONS

Enhanced Functionality, Safety, Reliability (IT-enabled**)**

Incremental product and service improvements are directed at enhancing the functionality, safety, and/or reliability of existing products and services. These incremental improvements can be, but are not necessarily, IT-enabled. Incremental product and service improvements are so commonplace that they barely count as product/service innovations.

MORE RADICAL PRODUCT/SERVICE INNOVATIONS

Product/Service Bundling (IT-enabled; IT-driven**)**

The notion of one-stop shopping has more recently combined into one product what had previously been several products. For example, the digital phone becomes a computer with an Internet connection that allows the user to use the phone as an electronic calendar, to access and send e-mail, etc. Bundling together a larger array of products and services must add real value for the customer and typically results in a fairly radical innovation that can change the current marketplace and the existing relationships between products and customers. Combining product functionality into a single, more convenient product is driven by high-tech product competition and enabled by new IT advancements.

Customization (IT-enabled; IT-driven**)**

Product and service customization allows the customer greater choice in terms of particular product features and functionality. One size often does not fit all. Customization can be driven in part by IT in that customers require services and products that are compatible with their existing IT systems. It is also enabled by IT in that IT advancements allow greater product and service flexibility.

Product/Service Delivery Innovations (IT-enabled; IT-driven**)**

Service or product delivery advancements have been a major component of service and product improvements. Service delivery automation, such as automated telephone information systems or electronic information systems, allow information services to be accessible to customers 24-hours a day. E-business technologies allow customers to shop 24-hours a day from the convenience of their home. Just-in-time product delivery has also been made possible through IT. IT is primarily an enabler of new product and service delivery innovations but it is possible that there are cases where IT might drive the need for delivery innovations. For example, if customers have computer systems in their cars, they will increasingly demand real-time access to various types of traffic and travel information.

New "Smart" Products/Services (IT-enabled; IT-driven**)**

IT competition has reduced product life cycles and organizations must continually innovate to survive. The key to competition is smarter, knowledge-infused, high-tech products and services. In fact, some argue that the rate at which organizations acquire, create, and effectively utilize knowledge to produce better products and services is becoming the only sustainable competitive advantage, especially in the ever-expanding sphere of knowledge-intensive industries (Stata 1989). It is estimated that knowledge has already become the source of about 3/4s of the value-added in manufacturing, and an even higher proportion in many segments of the service sector (Stewart 1997). This change is pervading even the oldest sectors of the economy, such as agriculture. Corn is no longer a simple commodity; it is becoming a knowledge-intensive product as hybrids rich in cornstarch are developed for industrial users and high oil content strains are created for food processors (Stewart 1997). Smart products and services are simultaneously IT driven and enabled. Examples: (1) global positioning systems are a smart product that allows drivers to access real-time traffic data; (2) DOT emergency services may increasingly be able to determine the exact location of vehicles in need by tapping into the global positioning system devices in the vehicles or by locating the position of their digital (cell) phone.

Process Innovations

INCREMENTAL PROCESS INNOVATIONS

Employee Empowerment (IT-enabled**)**

IT-enabled innovations often require greater staff training and empowerment. The most menial tasks can be automated and staff can be trained to perform higher skilled jobs. Developing IT skills can empower employees but it can also intimidate them.

Enhancements in Teamwork (IT-enabled**)**

IT, such as various types of groupware, can enable improved teamwork, especially in distributed teams. Enhancements in teamwork overlap to a large extent with flexible, distributed, asynchronous work arrangements below.

Flexible, Distributed, Asynchronous Work Arrangements (IT-enabled**)**

Flexible, distributed, and asynchronous work arrangements are important when labor markets are tight. Not all new work arrangements are IT dependent, such as flextime, but IT allows the worker to be more accessible when not at the central work place. Telecommuting is more possible as a result of IT. Johansen (1984) identifies groupware that has enabled asynchronous and distributed work groups as well as enhancing the performance of synchronous and co-located work groups.

Electronic/Remote Training (IT-enabled; IT-driven**)**

More and more jobs available today require some level of specialized training. Moreover, most jobs involve working with some level of IT and as IT changes rapidly, workers require new training. Training is becoming a more critical component of organizations. The need for training is in large part IT driven, but IT also enables more convenient and less expensive ways of delivering this training.

Performance Measurement and Assessment (IT-enabled**)**

Data collection and analysis is time consuming. The more IT-facilitated these efforts are, the less burdensome they will be.

Benchmarking (IT-driven**)**

Until the 1960s, companies mostly relied on comparing their current year's financial results with those of the prior year. Benchmarking shifted management's perspective outward, toward learning how other companies, or even other components within one's own organization, are able to do a better job and be more successful. Benchmarking should look beyond a company's immediate competitors to anyone who demonstrates evidence of employing the very best practices. The key is to find an appropriate benchmarking partner(s). The search can be internally directed to one's own organization or industrial sector or externally directed to similar organizations or very different ones that may excel at a particular process that is the object of the DOT's benchmarking efforts. Anderson and Pettersen (1996) provide step-by-step instructions for performing benchmarking that will successfully accomplish the desired purpose of creating innovation and improvement in one's organization. Benchmarking is more IT-driven than enabled. Benchmarking is increasingly important because IT has spawned and will continue to spawn organizational innovations. Organizations conduct benchmarking to keep up on the latest innovation of potential relevance and benefit to their organization.

Preventive Maintenance (IT-enabled**)**

IT can help assess failure rates of various hardware and software components and contribute to devising a system for performing preventive maintenance.

Communication Enhancements and Flexibility (IT-enabled**)**

Organizational communication has moved from being one aspect of organizations to becoming the very basis of organizational coordination – the central binding force that permits coordination among people and allows for organized behavior. Changes that have made organizational communication more important to overall organizational functioning and success include: greater work complexity, faster pace of work, more distributed workers, simultaneous, distributed work processes, and the fact that knowledge and innovation are becoming more critical to an organization's competitive advantage. Communication networks are increasingly essential to an organization's strategy. Communication in today's organizations has become far more complex and varied as a result of communication technologies. In addition, communication may be less under the control of management. Communication channels between staff within and without the organization can create networks that are outside normal management chain-of-command and can perhaps threaten management or put pressure on management to transform in various ways.

Enhanced Project Management (IT-enabled; IT-driven)

IT projects are becoming more prevalent and tend to be highly complex and difficult to manage. IT projects are often costly and complex and have helped to drive the need for better project management tools and techniques. IT-enabled project management tools have evolved to enhance the management of complex, uncertain projects. DOTs often undertake large, complex, and uncertain projects (many of these are construction rather than IT-based

projects) that require good estimates of time, cost, schedule, and critical paths. IT-based project management tools can help DOTs make better project estimates and path projections. Also scenario analysis tools can be used to develop better estimates of project cost ranges.

Project-based Management (IT-enabled)

There has been greater emphasis on project-based management in many organizations, a more radical strategic innovation than enhanced project management. Treating more and more activities as projects (with project numbers, costs, schedules, milestones, and goals) allows the organization to conduct activity-based costing and value-added analyses that help track how staff spend their time and how beneficially time is being allocated. IT enables project-based management.

MORE RADICAL PROCESS INNOVATIONS

Process Automation (IT-enabled; IT-driven**)**

Process automation continues to be a major phenomenon in organizations. Recently a large-scale automated system for streamlined and integrating administrative processes, developed by S.A.P., has been introduced into many large organizations. Once some processes are automated, there may be some drivers to automate other processes that feed into this system. Also if some companies are gaining a cost or speed advantage from automated processes, there is pressure on other companies to adopt automated systems to stay competitive.

Process Reengineering (IT-enabled; IT-driven**)**

Process reengineering, a term associated with Hammer and Champy (1994), is very similar to process automation. The point behind "radical" process reengineering is that technology has advanced in leaps and that incremental organizational change is not sufficient to take advantage of the new possibilities offered by this technology. To create a maximally efficient and effective organization requires radical reengineering of existing processes to take advantage of this new technology, especially new IT developments.

High Tech Diagnostics/Prognostics (IT-enabled; IT-driven**)**

High tech diagnostics and prognostics reduces down-time and detect and prevent problems before they manifest themselves. They are a high-tech version of preventive maintenance and quality assurance. High tech diagnostics and prognostics are primarily IT-enabled (sensors, etc.) but they may be IT-driven as well in that complex IT systems may be very difficult to maintain without these devices.