Advanced Tools for Technology Transfer in Transportation

Final Report

Prepared by

Clare E. Bland
Dean Deeter
Hau To

Castle Rock Consultants
2600 Eagan Woods Drive, Suite 460
Eagan, MN 55121

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16. Abstract (Limit: 200 words)

This Federally-funded study aimed to identify and document advanced tools which have potential to be utilized for transportation technology transfer (T^2) in Minnesota. Within the study, the existing and future needs for T^2 in the state were considered. Profiles were then developed of the customer groups that T^2 activities are targeted toward. Guided by this information, a series of advanced tools for T^2 in transportation were identified and documented. The study concentrated on tools that had not yet been utilized for T^2 in Minnesota, though they may be in use at other locations or within other domains. It was determined that various technologies exist or are in development which could be used for T^2. Using the findings of the study, it is recommended that outreach activities involving Minnesota's T^2 stakeholders be undertaken to determine the most appropriate tools for local use, and to plan for pilot testing of one or more of these tools.

Although the study concentrated on the Minnesota T^2 programs, it is hoped that the findings will be applicable to other areas with similar T^2 needs and activities.

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- Tom Peters, formerly Research and Technology Engineer, Federal Highway Administration;
- Laura Dale Bischoff, formerly Librarian, University of Minnesota Center for Transportation Studies; and
- Karen Billiar, Financial Services Manager, Mn/DOT ORA.

In addition, the authors would like to express appreciation to the very many additional people involved in the T^2 process, both agents and end users, who assisted the authors in responding to requests for information and participating in interviews.

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EXECUTIVE SUMMARY

This Federally-funded study was performed for the Minnesota Department of Transportation (Mn/DOT) Office of Research Administration (ORA), and aimed to identify and document advanced tools which have potential to be utilized for transportation technology transfer ($T^{2)}$ in Minnesota. It is hoped that although the study concentrated on the Minnesota T^2 programs, the findings will be applicable to other areas with similar T^2 needs and activities. It should be noted that it is not envisioned that the advanced tools documented within this report can or will replace the suite of existing T^2 tools currently in use in Minnesota and elsewhere. Rather it is hoped that the existing "tool box" of T^2 mechanisms can be augmented with some of these advanced tools where appropriate. The various T^2 tools which are already in use in Minnesota were not the focus of this study, and therefore are not documented in this report. A list of these current tools is provided in Appendix A.

Within the study, a series of telephone interviews and meetings with both T^2 and transportation practitioners in Minnesota helped identify the existing and future needs for T^2 in the state. Profiles were then developed of the customer groups that T^2 activities are targeted towards. Literature searches and a series of telephone interviews with national T^2 experts were undertaken in order to identify new or emerging T^2 tools that may be applicable for use in Minnesota. Various characteristics of these tools were documented. Finally, the tools were analyzed with respect to the customer profiles previously created to assess whether and how they could be implemented in Minnesota. The tools identified within the project were grouped into three categories according to their state of development. The categories and tools are listed below.

Type 1 - Proven and Current Advanced Tools. These tools have been proven to be effective in other locations, and are considered to be directly applicable in their current forms to assist with Minnesota's transportation T^2. The tool identified in this category is:

- Tool 1.1 Conference-based training.

Type 2 - Proven but Under-utilized Advanced Tools. These tools have been proven to be effective in information dissemination and training in fields other than transportation. These tools are in use in other disciplines, and although the technologies involved are appropriate for transportation-related T^2, a transportation application would need to be developed. Therefore for the purposes of this study they are considered to be "under-utilized" in Minnesota's transportation T^2. The tools identified in this category are:

- Tool 2.1 Electronic bulletin boards;
- Tool 2.2 Digital libraries;
- Tool 2.3 Self-guided tutorials;
- Tool 2.4 Electronic clearinghouses;
- Tool 2.5 "Listservs";
- Tool 2.6 Newsgroups; and
- Tool 2.7 Electronic expert directories.

Type 3 - Emerging Advanced Tools. These tools are those which are still undergoing research and development or pilot testing. These tools are not available for immediate use, although they may become available in the future. These tools are considered to be of potential interest for transportation T^2 in Minnesota. The tools identified in this category are:

- Tool 3.1 Virtual reality devices;
- Tool 3.2 Real-time "in-field to help desk" diagnosis / problem solving systems; and
- Tool 3.3 Voice responsive electronic notebook databases.

Next steps include a focus group at which the results of the study will be presented to Minnesota T^2 stakeholders. Based on the recommendations from the focus group, partnerships will be developed to pilot test one or more of the tools.

1. INTRODUCTION

1.1 T^2 Framework

In Minnesota, T^2 is performed by Mn/DOT's Office of Research Administration (ORA), other Mn/DOT functional area offices - environment, maintenance, and pavements, for example, and the University of Minnesota's Center for Transportation Studies (CTS). Mn/DOT and CTS collaborate in a variety of ways to optimize their respective efforts in T^2 and to ensure minimal overlap of services to their combined customer groups. In essence, these programs exist to:

- share and implement the results of research across the public, private, and educational sectors;
- expand practitioner knowledge of existing or emerging technologies; and
- educate others on new products, procedures or equipment.

As a very broad generalization, Mn/DOT tends to concentrate on publicizing and implementing the results of research, communicating mainly with Mn/DOT personnel throughout the state. The CTS T^2 program focusses primarily on training and information dissemination to transportation professionals at the local government level. The Minnesota Local Road Research Board (LRRB), representing state counties and cities, utilizes T^2 programs at Mn/DOT and CTS for dissemination of research results and training in new technologies. Both the Mn/DOT and CTS T^2 programs provide services to other state agencies, private industry and consultants.

Technology transfer in Minnesota has several links to national and international networks. Through the distribution and exchange of publications, research web sites on the Internet, participation on committees, and other formal and informal communication channels, Minnesota has established relationships with research and technology transfer organizations worldwide.

Within the U.S., the national Local Technical Assistance Program (LTAP) has provided technical assistance, training, and products to local transportation agencies through T^2 centers for more than

12 years. LTAP T^2 centers receive funding from the Federal Highway Administration, state departments of transportation, and universities, among other sources. Currently there are 57 T^2 centers including six centers offering assistance to Native American Tribal Governments. The LTAP T^2 centers, located at universities or state highway agencies, serve tribes and more than 38,000 rural and local agencies.

At the national level, LTAP focusses on enabling local agencies to improve their transportation network by performing the following activities:

- increasing expertise in transportation at the state and local levels;
- providing a channel for local users to access materials prepared at the national level;
- promoting research findings in an effective manner; and
- using tailored resource materials to meet the needs of local level transportation personnel.

Also at the national level are groups such as the Transportation Research Board's (TRB) Technology Transfer Committee, the American Association of State and Highway Transportation Official's (AASHTO) Research Advisory Committee (RAC), and other FHWA Technology Transfer Programs. While somewhat more diversified than the LTAP Program, these programs and committees provide a formal communication network for state transportation agencies.

In effect, there exists, on a national scale, a well-established, formal technology transfer system for implementing new technologies at the national, state, and local government levels. This in-place system operates as a series of partnerships between states, within states, and with federal and state government agencies. Individual T^2 agencies and LTAP have worked hard to create an environment of trust and credibility with their customers and a culture that promotes learning in a non-threatening way. These are necessary elements to implement new technologies to a customer base of independent agencies responsible for making their own decisions and managing their own operating budgets.

1.2 Study Background

In order to optimize the findings of transportation research, T^2 professionals have a series of established practices and procedures available to them for translating and promoting technical information. This information is customarily shared with a wide variety of individuals and organizations, who have an equally wide variety of backgrounds and levels of technological expertise. The target audiences of such T^2 activities can include a wide range of agency personnel at the Federal, State, and local levels, including city and county engineers, maintenance workers, transportation planners, and legislators, for example. In addition, private industry target audiences can include engineering consultants and contractors.

The introduction of new materials, technologies, and practices in the transportation field continues to change the industry, and the pace of change itself is likely to continue to accelerate in the future. These developments pose a challenge to those agencies with responsibilities for T^2:

> *as transportation-related materials, technologies, techniques, and services evolve, what is the most economical and effective way of sharing this knowledge and teaching these new skills to practitioners?, and what methods are the most effective in getting results?*

At the same time, and given the rapid evolution of information and communications technologies, the possibilities for making T^2 easier, more cost effective, more efficient, more appropriate, and individually tailored to the various target audiences, are evolving constantly. Technological developments may also make it possible to reach additional target audiences and larger numbers of individuals than has previously been possible.

1.3 Study Purpose

The goal of this study was to identify advanced tools for T^2 and to assess these new techniques to determine if and how they may be applicable for T^2 in Minnesota. The study was funded by the

Federal Highway Administration (FHWA) Region 5 Office, and performed for the Minnesota Department of Transportation (Mn/DOT) Office of Research Administration (ORA), and the Minnesota T^2 Program / Local Technical Assistance Program (LTAP), based at the University of Minnesota's Center for Transportation Studies (CTS).

To achieve this goal, profiles were created of the various customer groups served by the T^2 programs in Minnesota, and tools for transportation T^2 that are not yet in use within Minnesota were identified and documented. Lastly, the question of which of these tools would be suitable for the various customer groups was considered.

It should be noted that it is not envisioned that the advanced tools documented within this report can or will replace the suite of existing T^2 tools currently in use in Minnesota and elsewhere. Rather it is hoped that the existing "tool box" of T^2 mechanisms can be augmented with some of these advanced tools where appropriate. The various T^2 tools which are already used in Minnesota were not the focus of this study, and therefore are not documented in this report. A list of these current tools is provided in Appendix A.

1.4 Study Scope

This study represents the culmination of the first two phases in a five phase process which it is envisioned will enhance the Minnesota T^2 programs. The first phase was to conduct a literature search and to interview national experts for the purpose of developing a list of advanced T^2 tools. This list includes tools new to the market as well as proven tools developed and used by other T^2 groups. The second phase comprised evaluating and rating the T^2 tools in terms of their ability to effectively and efficiently improve T^2 within the environment of the Minnesota transportation community, as representative of state government and T^2 / LTAP programs.

The subsequent phases of the project, not yet performed, are as follows. The third phase will be to select several highly rated technologies, to obtain the technologies - through loan, lease, or purchase - and to use them within Mn/DOT and the Minnesota T^2 / LTAP in pilot T^2 situations.

The fourth phase will be to evaluate the tools in terms of their efficiency and effectiveness in improving T^2 in the pilot installations, and the final phase will be to implement for more permanent use those tools which were piloted most successfully.

This report is intended to provide an overview of some new and emerging tools and to suggest some issues which may affect how these are received by users. It is acknowledged that further consideration of the functionality of the tools, the technical feasibility of their implementation in Minnesota, their costs for development, implementation, and maintenance, and user acceptance will be necessary prior to any of the tools being deemed appropriate for pilot testing or implementation.

1.5 Study Approach

The study was guided by a Technical Advisory Panel comprising Micky Ruiz, Technology Transfer Manager, Mn/DOT ORA; Cheri Trenda, Director, Minnesota T^2 Program / LTAP, University of Minnesota CTS; Tom Peters, formerly a Research and Technology Engineer, with the FHWA, and Karen Billiar, Financial Services Manager, Mn/DOT ORA. The study comprised two phases, described below.

1.5.1 Phase A - Identify Technology Transfer Tools

Two tasks were undertaken in order to identify a useful list of potential T^2 tools within Phase A. The efforts within these tasks are described below.

Task A-1: Determine Minnesota's Technology Transfer Needs

At the outset of this task, meetings were held with key members of Mn/DOT's Office of Research Administration (ORA), the Minnesota Technology Transfer (T^2) Program / Local Technical Assistance Program, (LTAP), based at the University of Minnesota Center for Transportation Studies, and the Federal Highway Administration. As a result of these meetings, the customers

of Minnesota's T^2 initiatives were categorized, and the various types of technology requiring transfer in Minnesota were categorized. Both these activities were conducted bearing in mind the appropriate T^2 tools or mechanisms which could be utilized to communicate particular types of information to certain types of customers.

In parallel with this activity, a list of approximately 15 representative T^2 customers and agents within Minnesota was compiled. These individuals were then surveyed regarding T^2 in Minnesota. Subjects were selected in order that at least one individual from each of the customer groups was interviewed wherever possible. The interviewees were contacted by fax and subsequently interviewed by telephone in order to obtain the required information.

The interview commenced by explaining to subjects the T^2 customer groups previously developed. Further questions involved asking subjects to provide some details about their role in T^2 in Minnesota. Then, for each of the customer groups, various questions were asked concerning:

- customers' working environment;
- whether this environment placed any constraints on what forms of T^2 work for particular types of customers;
- how customers generally access information;
- the facilities available to this type of customer, such as telephone, e-mail, video viewing facilities, etc.;
- any feedback subjects had received concerning how this type of customer prefers to receive information, and what tools work best for them;
- the customers' comfort levels / familiarity with the T^2 tools currently in use; and
- any general perspectives on the T^2 process in Minnesota.

It should be noted that due to the survey time frame and the resources available for the survey activities within the project, the findings of the interview were not intended to be statistically significant. They were intended only to provide an overview of the T^2 needs and preferences of the customers involved in or affected by T^2 in Minnesota. The information gathered within this

task was documented as Technical Memorandum 1, which is contained in Appendix B of this report.

Task A-2: Investigate Available Technology Transfer Tools

In Task A-2, using the transfer needs identified in Task A-1, literature and Internet searches and a series of telephone interviews were performed in order to identify T^2 tools. Throughout this task, the focus of investigations was on the available T^2 tools and mechanisms, rather than any specific products, equipment or procedures. The needs previously identified were important in helping focus the search on those tools most applicable to Minnesota, and also to help ensure that the search was broad enough to address all the necessary issues.

The literature searches were performed with valuable assistance from the Center for Transportation Studies Librarian. Resources searched included the University of Minnesota LUMINA database, the nationwide educational database, ERIC, and the ABI Inform database. In addition to these literature searches, various searches were performed using the World Wide Web (WWW). Both these types of searches were performed using a list of key words. However, the WWW searching also involved searching the sites of various institutions known to be active in the areas of T^2, and in the use of advanced technologies for information dissemination, training and education.

A telephone interview process took place in parallel with the above searching tasks, and involved interviewing a series of experts in a variety of T^2-related fields. Working with the project Technical Advisory Panel (TAP) an initial interviewee list was compiled. This list was designed to encompass experts from a variety of organizations and interest groups, including:

- the academic research community, including specialists in education, distance learning, communications and computing technologies, digital media, artificial intelligence / expert systems, and learning sciences,
- FHWA regional offices;

- the FHWA Office of Technology Applications;
- state Department of Transportation research and T^2 personnel;
- library technology professionals;
- private sector information dissemination and training specialty organizations;
- defense and aerospace T^2 agencies;
- the Transportation Research Board T^2 and Computer Technology Committees;
- the American Association of State Highway and Transportation Officials; and
- the American Public Works Association.

Wherever interviewees provided details of secondary contacts who may be able to provide pertinent information, or other Internet-based resources, these leads were also followed to the extent possible within the project timeframe.

As each tool was identified, information on the basic characteristics of the tool was collected during the interviews themselves, and through supplementary research. The findings of the interview and search process were then compiled and summarized. These findings are documented in Deliverable 1 - Candidate Tools for Technology Transfer. The contents of Deliverable 1 - Candidate Tools for Technology Transfer, were expanded to form Chapter 2 of this report.

1.5.2 Phase B - Assessment of Technology Transfer Tools

Phase B also comprised two tasks, described below.

Task B-1: Compile General Information on Technology Transfer Tools

First, as Phase A investigations were underway to identify tools, Task B-1 involved compiling further information on each tool which was expanded upon in follow-up communications as needed. Details sought for each tool included:

- characteristics of the tool;

- circumstances under which the tool can be used;
- costs for developing and maintaining the tool;
- advantages and disadvantages of using the tool;
- potential barriers that may prevent use;
- success stories from other agencies using the tool;
- time the tool has been in use (if any); and
- any feedback from customers who have used the tool.

The results of this task were overview profiles of the various tools identified during Phase A. (Depending on the state of development of the specific tools, not all of these details were applicable.)

Task B-2: Assess Tools' Applicability to Minnesota

Once this information was gathered, in Task B-2 the potential for each tool's utilization in Minnesota was assessed. The information documented for each tool as part of this task, included:

- how each tool could meet the needs of Minnesota's T^2 practitioners;
- how each tool could meet the needs of Minnesota's T^2 customers;
- mechanisms in place that will enable Minnesota to use the tool; and
- general attitudes of Minnesota transportation professionals towards the tool.

The information gathered within Task B-2 is presented in Chapter 3 of this report.

2. IDENTIFIED TECHNOLOGY TRANSFER TOOLS

As the tool identification and investigation process commenced, it became clear that very many tools existed which could be used for T^2 information dissemination and training. Numerous applications which could be classed as "multi-media" tools, for example, were identified. The use of the Internet for T^2 was also widespread. In order to condense the tools into useful categories, each application was considered independently of its delivery mechanism, wherever possible. For example, a self-guided tutorial tool could be delivered to end users via a variety of means, such as the Internet or a CD-ROM. Similarly, the same self-guided tutorial could be a multi-media tool, or purely text-based. So for the purposes of this project this tool would be classified as a self-guided tutorial, irrespective of the delivery mechanism, or the format and complexity of the material.

It should be noted that many of the tools listed below are in use in some manner in the transportation arena, and possibly also within the transportation T^2 industry. It is acknowledged that some implementations of these tools may not have been identified within the relatively short project timeline. Project participants also expect that additional tools may exist or be undergoing development that were not identified within the project. The tools identified within the project were grouped into three categories according to their state of development. The categories and tools are listed below.

Type 1 - Proven and Current Advanced Tools. These tools have been proven to be effective in other locations, and are directly applicable in their current forms to assist with Minnesota's transportation T^2. The tool identified in this category is:

- Tool 1.1 Conference-based training.

Type 2 - Proven but Under-utilized Advanced Tools. These tools have been proven to be effective in information dissemination and training in fields other than transportation. These tools are in use in other disciplines, and although the technologies involved are appropriate for

transportation-related T^2, a transportation application would need to be developed. The tools identified in this category are:

- Tool 2.1 Electronic bulletin boards;
- Tool 2.2 Digital libraries;
- Tool 2.3 Self-guided tutorials;
- Tool 2.4 Electronic clearinghouses;
- Tool 2.5 "Listservs";
- Tool 2.6 Newsgroups; and
- Tool 2.7 Electronic expert directories.

Type 3 - Emerging Advanced Tools. These tools are those which are still undergoing research and development or pilot testing. These tools are not available for immediate use, although they may become available in the near future. These tools are considered to be of potential interest for transportation T^2 in Minnesota. The tools identified in this category are:

- Tool 3.1 Virtual reality devices;
- Tool 3.2 Real-time "in-field to help desk" diagnosis / problem solving systems; and
- Tool 3.3 Voice responsive electronic notebook databases.

The tools listed above are described in the following subsections. Table 1, contained in Appendix C, provides a summary of the advantages and disadvantages of each of the advanced T^2 tools considered.

2.1 Type 1 - Proven and Current Advanced Tools

One "proven and current advanced tool" was identified, and is described below.

Tool 1.1 Conference-Based Training

Conference-based training refers to any training technique with which participants at different locations interact. It can be performed electronically using networked computers, via audio using telephone lines, and through live video using microwave, satellite, or compressed video. Systems vary in their levels of complexity and functionality.

Characteristics of the Tool

Conference-based training can be categorized into two main types, as follows:

Non-real-time conferencing. This tool provides trainer-student and student-student interaction, and can be accessed via a specially equipped classroom or a personal computer (PC) with the necessary software and telecommunications capabilities. Courses are presented on-line and the students can access these at a convenient time. Students can also correspond with the course tutor and other students.

Real-time conferencing. This tool involves all participants taking part simultaneously in a prescheduled class. A common approach is televising trainers live to one or more locations. Some interaction with students is possible using audio and sometimes also video links with remote classroom sites. Two-way digital teleconferencing, using compressed video technology, offers a greater degree of interaction between students and trainer, as it makes the transmission of video from the students back to the trainer's location more feasible.

Both non-real-time and real-time conferencing can take place via the Internet, although downloading video or complex graphics may be slow. The use of the Internet does facilitate the downloading of course materials on demand.

Circumstances Under Which the Tool Can Be Used

The necessary equipment required for Internet real-time video-conferencing include a PC with a network connection and appropriate software. In addition, a camera and digitizer are needed to record images. Another viable alternative to Internet desktop video-conference is by way of high speed LAN (Local Area Network) or WAN (Wide-Area Network) technologies. Since video-conferencing can be accomplished from a user's computer station, it could be a convenient training and T^2 tool for use at the users' place of work. The costs of sending employees to workshops and classroom training can accumulate - travel expenses and enrollment fees have to be taken into account. Additionally, usually only a select number of employees may attend. Conference-based training could reduce the cost of training and increase the number of users who can receive training. It is also a convenient method for allowing one-to-one, one-to-many, or many-to-many forms of information dissemination and training.

Another form of video-conferencing is via "analog video transmission". Delivery mechanisms for this type of conferencing include cable television, microwave, or satellite links. To implement analog video-conferencing, a studio conference room equipped with appropriate lighting, microphones, cameras, and telecommunications facilities, is required. The conference transmission can be viewed using standard television equipment or projection systems.

Status of Tool

Analog video-conferencing systems are currently available, although system enhancements are continuing to be developed. Purchasing the required equipment for this option can be costly. For agencies who are likely to use such facilities only on an occasional basis, renting from private service providers is a practical alternative. The technique of Internet-based video-conferencing is still being improved, but technologically stable systems exist that are commercially available.

Costs of Developing and Maintaining Tool

For Internet-based real-time video-conferencing, in addition to the costs of a personal computer and Internet access, a camera and digitizer are required which can be purchased from approximately $100. For a commercially available system - which usually includes a small video camera, video-capture card, communications interface, microphone, and software - the price ranges from approximately $1,000 to $3,500 per computer unit. The cost PC-based video-conferencing is likely to decrease as the required hardware and software start to become offered as standard equipment with PCs.

An alternative to purchasing a commercial package would be to use "CU-SeeMe". This conferencing system provides the software and communications channel required for conferencing. The system, developed by Cornell University, is available free of charge via the Internet.

Video-conferencing services can also be purchased on an hourly basis from private service providers. Using these services involves travelling to an equipped facility. The costs for using these services may include one or more of the following:

- room rental, from $250 per hour;
- scheduling costs for use of the facilities, from $50 per room;
- telecommunication charges, from $150 per hour;
- plus optional charges such as a computer interface, electronic white boards, flip-charts, additional lighting, and any other audio visual equipment.

If an organization intends to make extensive use of video-conferencing, a private facility can be established, although at much greater cost.

Advantages and Disadvantages of Using Tool

The following are advantages of using conferencing tools:

- depending on the complexity of the system utilized, users can receive a variety of different types of materials, including visual images and audio;
- these techniques allow geographically dispersed students and teachers to communicate with one another;
- non-real-time conferencing allows users to access information and undertake training when it is convenient for them and does not require them to comply with a fixed class schedule.
- the use of conferencing tools reduces the need for users to travel to a central location to receive training;

The following are disadvantages of using conferencing tools:

- at present, Internet-based video-conferencing systems supplied by different vendors are not compatible, requiring users at different locations to have purchased their equipment from a single vendor if they are to communicate with each other;
- while some Internet-based systems deliver TV-quality images, others show barely moving pictures in small frames. Also, speakers' lips and gestures are not always synchronized with the audio. These characteristics may make conferencing less appealing to users; and
- video-conferencing via satellite transmission can be costly.

Any Implementation Issues or Barriers to the Tool's Use

All users of a conference-based system need to be comfortable with the technology in order for this tool to be most effective. With such systems, especially those that do not have the visual component, the lack of on-the-spot presence by the lecturer or trainer can make it hard for students at a remote location to concentrate. Video-based systems may not communicate the richness of body language and nuance that face to face training offers, and even experienced lecturers and trainers may require coaching in conference-based communicating in order not to appear "wooden". Often gestures and inflections of speech need to be exaggerated in order to be communicated via these types of systems.

A primary implementation barrier is likely to be the cost of equipping a facility with the required systems. One solution to this barrier may be undertaking a cooperative venture, with cost and facility sharing by a number of agencies.

Success Stories

Mn/DOT has developed a video-conferencing system for use within the agency. This system uses the agency's T1 data network and comprises 17 equipped conferencing rooms: three in the Twin Cities metro area, and a further 14 in district offices throughout the state. It has been estimated that the metro area video-conferencing facilities are used approximately 55 percent of the time, while out-state locations are used approximately 10 percent of the time.

Between eight and forty participants can take part in a video-conference using the system. In addition to audio and video conferencing, the system also allows some document sharing although user feedback indicates that this facility offers only basic features. The conferencing system uses omni-directional microphones at each site and is voice-activated. The estimated costs for equipping each site are $150,000. The system has been in use for approximately 18 months, and at present is used primarily for meetings rather than training and education. Further information on this system can be obtained from Bob Hansen at (612) 297-4000.

The United Kingdom Open University experimented in 1994 with Internet-based video-conferencing as a distance learning tool for an undergraduate psychology course. Students taking part in the course were able to participate in group discussions, run experiments, obtain one-on-one tutoring, listen to lectures, participate as subjects in experiments, work in project teams, and prepare plenary session presentations.

This was all accomplished without physically attending class or in-person meetings. Internet video-conferencing was made possible using the CU-SeeMe system. User reaction to the "Virtual Summer School" was positive with 80 percent of the twelve participants qualifying it as a success.

Further information on the Virtual Summer School can be found on the Internet web site: *http://kmi.open.ac.uk/kmi-misc/virtualsummer.html*. Further information on the CU-SeeMe software can be found on the Internet web site: *http://cu-seeme.cornell.edu*.

The Tel-8 System is a two-way, fully interactive, satellite-based telecommunication system linking the Departments of Transportation of six states - Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming - in FHWA Region 8, and four universities - Colorado State University, North Dakota State University, Utah State University, and the University of Wyoming. It is a three-year endeavor aimed at trialling communications and T^2 tools for those states with geographically dispersed populations. Features offered by the system include:

- distance learning made available through the universities;
- technical workshops;
- information exchange forums;
- technical meetings; and
- viewing of Transportation Research Board presentations.

At the end of the three-year timeline, decisions will be made as to whether the system will continue.

Feedback from Users

Conference-based training, although not a new concept, is still not widely used in transportation related T^2 applications. The feedback from those users who have used such systems is generally positive. It is likely that although many users may prefer person-to-person interaction, conference systems offer a practical alternative in particular circumstances, such as when users are widely dispersed. Communications using these systems may not provide as "rich" an interaction experience as in-person training, but conferencing systems do offer a higher quality interaction than is possible with a paper-based distance learning course, for example.

2.2 Type 2 - Proven but Under-utilized Advanced Tools

Seven "proven but under-utilized advanced tools" were identified, and are described below.

Tool 2.1 Electronic Bulletin Board

An electronic bulletin board is a computer-based version of a traditional bulletin board. A user can access it at their convenience, read information posted there, respond to questions or requests for information, and post their own questions.

Characteristics of the Tool

The functions that can be performed with this tool include:

- sending electronic mail (e-mail), which may be restricted to other subscribers to the bulletin board;
- posting messages in a "public" area of the bulletin board that are available for reading and comment by anyone who dials in;
- accessing special interest libraries, where users have uploaded articles, lists, documents, photos, or software which other subscribers can download and use; and
- participating in conferences: users calling into the board can arrange to log in at the same time for "real-time" discussion of a topic.

A bulletin board systems operator (or "sysop"), moderates or monitors the system. This is usually the person who has the bulletin board software running on their computer, but sometimes a volunteer who helps monitor the messages, post items in the library, and provide support and guidance to users. Users access the bulletin board by dialing in using a computer, modem, and telephone line.

Circumstances Under Which the Tool Can Be Used

To access an electronic bulletin board, a user needs access to a PC installed with the appropriate software, a modem and a telephone line. Some bulletin boards can be accessed through the telnet process, so that Internet connectivity is required. Others can only be accessed through a telephone call to the host computer which may involve long-distance dialing. As this tool requires computing and communications access, a relatively stable environment such as a traditional office setting may be the most appropriate location for using this tool, although access using more expensive, ruggedized equipment may also be an option. Given the increasing number of facilities, such as colleges, schools and public libraries, that offer public access to the Internet, a user may not need their own equipment to make use of this tool.

Basic keyboard skills and some training in the use of PCs in general, and in the Internet and bulletin boards in particular, is required. As users have to take the initiative to access a bulletin board and interact with other users, this type of tool may be most appropriate for those users who are generally well motivated and proactive in seeking information.

Current Status

Bulletin boards have been in use for several years in various domains, and are a stable and proven technology. Very many bulletin board products offering various functions are available. It has been speculated that with the development of the Internet and the world wide web as an easy and inexpensive publishing platform, bulletin board services may decline in popularity. However, the use of Internet telnet links to bulletin boards have made them more easily accessible, such that they are likely to continue to be a popular means of exchanging information

Costs of Developing and Maintaining the Tool

The costs involved in establishing and maintaining a bulletin board vary by provider, and some systems offering limited services are free. The charges levied by most bulletin board providers can involve one or more of the following items:

- a set-up fee, from approximately $25;
- a monthly or yearly fee, from approximately $15 per month, or $95 per year; and
- additional fees for the volume of messages and other materials posted on the system.

Advantages and Disadvantages of Using the Tool

The advantages of using an electronic bulletin board include:

- the technology facilitates "one to many" communication;
- the tool can be inexpensive to establish;
- the system could also be monitored at little or no cost if the help of a dedicated volunteer sysop can be enlisted;
- interaction between users does not have to take place in real-time, therefore users can access the bulletin board at their own convenience; and
- the tool may encourage more open exchange of ideas as the race, age, and gender of users is not automatically revealed, as is the case with video-conferencing, for example;

The disadvantages of using an electronic bulletin board include:

- in order for the tool to be most effective, the sysop needs to monitor the bulletin board consistently to ensure that the discussion topics remain relevant, and to provide support to users. If this person is performing these activities voluntarily, it may be hard for them to devote the time required;

- depending on how wide a topic the bulletin board covers, how stringently the sysop filters information, and how many users tend to access the facility, the system could become inundated with postings, making it difficult for users to locate information potentially of interest;
- whereas a bulletin board with a broad-based subject domain should enable peers to expand their knowledge and activities in that area, it could become difficult to locate information on a specialized topic within that domain; and
- on a similar note, as the bulletin board concept tends to promote relatively informal information exchange, a user accessing the facility cannot be guaranteed they will necessarily find the information they need when they need it.

Any Implementation Issues or Barriers to the Tool's Use

This type of tool depends on the willingness of many users to interact using this type of technology, in other words, the tool will be most useful with the regular participation of a "critical mass" of users. In a way, this tool is only as useful as the contributions of its users.

Success Stories

As so many electronic bulletin boards exist, an overview of some of the many professionally-oriented bulletin boards is contained in the "Directory of Scholarly and Professional E-Conferences". This has been prepared by a private organization and is available at *http://www.n2h2.com/KOVACS/*. This listing includes bulletin board resources in addition to other tools such as listservs and newsgroups, discussed below. Due to the large number of bulletin board service providers which exist, details of individual providers are not provided here.

Tool 2.2 Digital Library

A digital library is a collection of resources which could include books, journals, newsletters, periodicals, graphical images, maps, and photographs, for example. Essentially, the resources

of a traditional library have been digitized such that they can be accessed using computing and communications technologies. This type of library is usually accessed via the Internet, and the user is able to search the contents of the library in various ways, such as searching by author name, or using keywords.

Characteristics of the Tool

A digital library differs from an on-line catalog and related search tools as in addition to being able to view a listing of the relevant items, the user is able to view images of the actual journals or photographs, for example, on their remote computer. Users may also download documents onto their computer for their own use. The basic components of a digital library are:

- the digitized resources;
- a facility for searching the contents of the library;
- equipment for digitizing new additions;
- the means for accessing the library, for example, an organization's own computer network, or the Internet; and
- the functions which enable the necessary administrative and management tasks to be performed.

Circumstances Under Which the Tool Can Be Used

To access a digital library, a user needs access to a workstation with which to access the resources. This could either be a dumb terminal or a networked personal computer (PC) if it is a restricted access library run through a proprietary network. Alternately, if the library is accessible through the Internet, a PC and the appropriate software and communications linkages are required. As this tool requires computing and communications access, a relatively stable environment such as a traditional office setting may be the most appropriate location for using this tool, although access using more expensive, ruggedized equipment may also be an option. Given

the increasing number of facilities, such as colleges, schools and public libraries, that offer public access to the Internet, users may not need their own equipment to make use of this tool.

Depending on the whether the library is accessed using the Internet, basic keyboard skills and some training in the use of computers in general, and in the Internet in particular, would be required. In order to optimize this tool, some training in search techniques would also be useful.

Current Status

Numerous digital libraries exist or are in the process of being developed, however, most of these are pilot projects taking place in academic institutions. Due to the vast amount of information available for potential inclusion in a digital library, these pilot implementations tend to concentrate in a fairly specialized domain.

In 1994 the National Science Foundation (NSF), the Department of Defense Advanced Research Projects Agency (ARPA) and the National Aeronautics and Space Administration (NASA) jointly awarded $24.4 million to fund a national digital libraries initiative. The initiative comprises six research projects which are currently underway. The four-year projects are centered at Carnegie Mellon University, the University of California, Berkeley, the University of Michigan, the University of Illinois, the University of California, Santa Barbara and Stanford University. The project's focus is to advance the means to collect, store, and organize information in digital forms, and make it available for searching, retrieval and processing via communication networks in user-friendly ways.

Costs of Developing and Maintaining tool

The costs involved in establishing a digital library can be substantial. Although new books and journals are increasingly available in electronic format as well as in the traditional paper format, thereby making their inclusion in a digital library easier, establishing a library of any useful size would involve digitizing a large amount of pre-existing information. Information can be digitized

either by scanning or by photographing the item with a digitizing camera. It has been estimated that the cost of scanning a 300-page book containing limited graphics averages around $30 in the 1990s, including labor and equipment costs. A contemporary estimate for converting photographed images into the required format is approximately 35 cents per page. In addition to the initial investment in digitizing the library holdings, a means of accessing the resource is needed. If an organization already uses internal networking or if the system will be accessed using the Internet, providing user access will require much less investment.

Advantages and Disadvantages of Using the Tool

The advantages of a digital library include:

- geographically dispersed users can access documents without having to travel to a library location, or without having to request a document and wait for it to be forwarded to them;
- theoretically, multiple users can access a digitized document simultaneously;
- once documents have been digitized, their condition cannot deteriorate as traditional paper-based resources can, neither can they be misplaced within the library nor go missing; and
- some more advanced search facilities use natural language processing to interpret a user's search entry according to the likely meaning intended by the user rather than in a literal sense.

The disadvantages of a digital library include:

- significant initial investment is required to digitize the library holdings;
- users who are comfortable with searching for and using paper documents may take time to adjust to performing these functions using a computer;
- the most cost-effective digitizing methods can result in lower resolution of text and images than paper documents; and
- freely available access to digitized documents can create difficulties concerning copyrights, royalties, and distribution rights.

Implementation Issues / Potential Barriers

The primary barrier to the implementation of a digital library is likely to be the investment needed to digitize a meaningful amount of information. An agency would also need to consider how best to ensure that users have easy access to the digital library in order to maximize the agency's investment. The agency would also have to consider the costs of providing appropriate initial training and ongoing user support.

Success Stories

As outlined above, various institutions are creating and testing the use of digital libraries. These institutions include the University of California Berkeley (at *http://elib.cs.berkeley.edu/*), Carnegie Mellon University (at *http://www.informedia.cs.cmu.edu/*), and the University of Michigan (at *http://calypso.sils.umich.edu/UMDL/*). In addition, the Library of Congress has established a digital library (at *http://lcweb.loc.gov/*). All these facilities are in the prototype and testing stage to an extent.

Tool 2.3 Self-guided Tutorials

This "family" of tools includes a variety of types of application, with varying degrees of complexity, and using a variety of delivery mechanisms.

Characteristics of the Tool

In essence, this type of tool can be defined as a structured package of training materials, prepared by a trainer or expert, and organized into lessons or modules, which an individual user can work through at their own pace. Typically, lessons are worked through by the user, who, at the end of a lesson or module, is tested by the system on the contents of that lesson. A system may suggest to a user that they revise any topics on which the user incorrectly answered a question,

and direct the user to the location of that information within the lesson. The system may then re-test the user on that topic when they have reviewed the material.

The tutorial could be stored and accessed in a number of ways. Material could be stored on magnetic media, compact disks, or videodisks, and accessed through a personal computer (PC) equipped with the appropriate disc drives / reading devices. Alternatively, the training materials could be housed remotely and accessed via the Internet, for example, using a PC and the necessary communications hardware and software.

The tutorials themselves can vary widely in sophistication. The most basic system could be a computer-based equivalent of a traditional training manual, containing only textual material. Alternately, the tutorial could present the user with audio and video clips, graphics and photographs, and would therefore be a "multi-media" tool.

Self-guided tutorials can also vary in the amount of "intelligence" that the system offers. A more sophisticated system using artificial intelligence (AI) techniques could adapt to the user's pace of learning, their depth of pre-existing understanding of the topic, and any mistakes made during the tutorial. Thus an AI-based system could identify the user's strengths and weaknesses, and modify the content and level of detail presented in the tutorial accordingly.

Circumstances Under Which the Tool Can Be Used

This type of tool is very flexible. Based on the needs of their end users, organizations could custom build an application, selecting the most appropriate delivery mechanism, format and complexity of materials. Although this tool does not have to be presented using computing and telecommunications technologies - the tutorial could in theory be contained in a structured paper-based training manual - for the purposes of this study more advanced systems will be discussed. As the tool requires access to a PC and maybe also the Internet, this tool is best suited for users who have ready access to these facilities. However, if some or all users within an organization

do not have full-time access to a PC, a unit could be dedicated for training purposes, enabling multiple users to access self-guided tutorials.

If tutorials are housed on the Internet, users could access on-line tutorials created by any agency. Collaboration between T^2 programs to develop complementary tutorials could reduce duplication of effort. For example, if the 57 LTAP centers each developed just one tutorial for use on the Internet, accessed via links from a master directory page, users across the country and beyond could easily access these resources.

Status of Tool

Very many applications exist which can be classed as self-guided tutorials, some of which are well established. Some of the more advanced systems - which make use of Internet access or AI techniques, for example - are still in the developmental process.

Costs of Developing and Maintaining Tool

Due to the wide range of types of self-guided tutorial systems, the costs of developing these tools vary. Some less complex tutorials can be created in-house at an agency which may reduce development costs. Production and maintenance costs also vary widely. For example, if a tutorial is to be housed on a CD-ROM, CD duplication costs need to be taken into account. If a tutorial requires updating, a production run of new CDs must be financed and distributed. Housing tutorials on the Internet greatly decreases the costs of both distributing and updating the material. From the time when an updated version is provided, all users can access this latest version.

Advantages and Disadvantages of Using Tool

The advantages of self-guided tutorials include:

- as users may access the tutorial and work through lessons or modules at their convenience, this type of tool may put training within the reach of those users whose schedules do not permit them to attend classes at fixed times;
- users may be able to make fewer trips and save time by not having to travel to class locations;
- more advanced tutorials, which use AI techniques to adapt to the user's pace of learning and level of prior knowledge, allow more advanced users to proceed more quickly through the modules, increasing the likelihood that these users will remain motivated in and challenged by the tutorial; and
- users have the freedom to proceed through as much or as little material as is convenient for them at a given time;

The disadvantages of self-guided tutorials include:

- users who are accustomed to in-person training may feel isolated if this interaction is totally replaced with self-guided tutorials;
- the tool may not be effective for some types of learning, for example, in cases where in-field practical tasks need to be taught;
- in-person training enables the user to ask questions of the trainer on related topics that are not within the subject range of the tutorial - self-guided tutorials may preclude this.

Any Implementation Issues or Barriers to the Tool's Use

Organizations should carefully consider whether a topic is appropriate for self-guided learning. Some topics may not be best taught using this method, and others may be most effective when a combination of self-guided learning and in-person training is utilized. Agencies may increase the popularity and usage of this tool if users are also provided with a means of connecting with a trainer and fellow students, to facilitate discussion of problems and approaches. The learning experience may be more effective when supported by peer to peer interaction.

Success Stories

An Internet, text-based self-guided tutorial has been developed by the Cornell Local Roads Program (CLRP), on the subject of procedures for flagging in work zones. This tutorial, which was developed over a period of approximately 18 months, was created in house. The tutorial comprises 6 lessons. At the end of each lesson the user completes a quiz to test their knowledge of the subject matter. If any questions are wrongly answered, the program directs the user to the appropriate place in the tutorial to revise that topic. At the time of writing, the tutorial is nearing completion. The CLRP aims to test the program with local highway officials, other LTAP centers, and the FHWA in Region 1. Development of additional tutorials will depend on user response to this initial product.

A series of multi-media self-guided tutorials, housed on CD-ROMs, have been developed by Purdue University in association with, and funded by, the Indiana DOT and the FHWA. The tutorials cover a range of transportation and construction related subjects, and feature audio and full motion video clips. It is hoped in the future to house the tutorials on the Internet to ease accessibility, to reduce the costs of producing the CDs, and to enable more easy updating of tutorial content. One of the reported drawbacks of using these tools was a lack of CD-ROM drives at some state DOTs with which to read the CDs.

As part of the contract to prepare the CDs, enough were produced to circulate two copies to each state DOT and one to each FHWA office. Although no formal evaluations have been performed, the most recent CDs have been distributed with evaluation forms requesting feedback on the usefulness and usability of the tutorials. For further details, contact Don Johnson, of the FHWA, at (317) 226-7480, or Bob McCulloch, of Purdue University, at (765) 494-0643.

A multi-media, self-guided tutorial, which makes use of expert system techniques to adapt to the individual student, has been developed by the Institute for the Learning Sciences (ILS) at Northwestern University. An application was developed to train the customer service representatives of a utility company in the United Kingdom. The tutorial involves the user

responding to simulated customer service calls. The user queries the customer or answers their questions by selecting a response from a pre-defined list. The system builds a realistic dialogue between the simulated customer and the user. When the user correctly responds to a situation, mentors provide encouragement via pre-recorded video clips. If a mistake is made, a video clip of a service representative is activated, providing anecdotal information concerning a similar scenario where they made the same mistake. Documentation and diagrams are also available to the user to help them determine appropriate responses to customers problems.

Feedback from Users

As the CLRP system has yet to be tested with users, no feedback is currently available on this system. The ILS has provided numerous training applications for different organizations, including systems for utility companies, TransAsk - a database designed to teach novice military officers the principles of transportation planning and execution, and an exhibit for the Chicago Museum of Science and Industry that museum visitors use to diagnose simulated medical problems. User feedback to all these systems has been very positive. As the ILS systems use clips of anecdotes from experts and peers concerning appropriate and inappropriate actions, these applications simulate peer-to-peer interaction. As users learn by doing, correct responses and procedures are reinforced by practicing tasks.

Tool 2.4 Electronic Clearinghouse

For the purposes of this study, an electronic clearinghouse may be defined as a repository of information relevant to a particular domain, such as transportation in general, or pavement research, for example. This information is stored and retrieved using computing and communications technologies. The information housed in the clearinghouse could comprise various types including:

- documents, as in a digital library;
- lists of contacts and experts in the domain;

- details of events, such as conferences, workshops, and meetings;
- details of other resources that the user can access.

Characteristics of the Tool

A electronic clearinghouse differs from an electronic bulletin board in that it tends to be sponsored or regulated by a particular organization, such as Mn/DOT, resulting in a more formal collection of resources. Accordingly, it would be presumed that the information contained in a clearinghouse would have been reviewed by the operating agency for relevance, accuracy, and timeliness. Users can search the contents of the clearinghouse to locate information of interest.

An electronic clearinghouse could be located in the computer network of a particular agency, if intended for use only by employees of that agency. Alternately, it could reside at a Web site, and be accessed via the Internet if intended for wider accessibility.

Circumstances Under Which the Tool Can Be Used

To access an electronic clearinghouse, a user needs access to a workstation with which to connect with the resource. A clearinghouse could reside on an organization's own network and be intended for their use only, or it could be Internet accessible and intended for wider use. Some form of networked personal computer (PC) and appropriate software and communications linkages are required.

Depending on the whether the library is accessed using the Internet, basic keyboard skills and some training in the use of computers in general, and in the Internet in particular, would be required.

Current Status

Various organizations operate electronic clearinghouses, and each of these offers slightly different functionality, based on the particular needs of the organization. Most of these clearinghouses are Internet accessible so as to reach as wide an audience as possible. Although the Internet is still a relatively new facility for many users, within the medium of the Internet electronic clearinghouses are a well-established mechanism for information dissemination.

Costs of Developing and Maintaining Tool

The costs involved in establishing an electronic clearinghouse could vary widely depending on the information which will be made available, and the access mechanism, that is, whether it will be established on a proprietary network or on the Internet. If an Internet site is to be established for the clearinghouse, costs also vary by Internet service provider. A Web site can be created by leasing space on the server of an Internet service provider. For a basic level of service this can cost from around $25 for the initial setup fee, with a monthly service charge of around $20. A predefined amount of server space will be made available and extra space can be bought by the megabyte as needed.

Some providers will provide a customized domain name within these costs, whereas others charge extra. Registering a domain name for 2 years costs $100, with a renewal fee of $50. At the other end of the spectrum, a dedicated server account can be established at the host organization if the number of site "hits" is expected to reach several hundred thousand per day. This type of facility can cost from around $750 in initial setup fees, and a monthly service charge from around $1,500.

The labor required to compile and establish the site content will vary widely by organization and by the amount of information to be housed at the clearinghouse. In addition, if the clearinghouse is to contain digitized documents, then the costs of digitizing must also be taken into account. The resources required to maintain the clearinghouse, to keep the information up-to-date, and to add new materials should also considered.

Advantages and Disadvantages of Using the Tool

The advantages of an electronic clearinghouse include:

- a clearinghouse can offer a wide variety of types of information on a highly specialized topic;
- geographically dispersed users can access information;
- multiple users can access information simultaneously;
- information can be updated at a central location and made available instantaneously to many users; and
- as information can be updated for immediate access by users, electronic clearinghouses offer a very cost-effective means of distributing up-to-date information.

The disadvantages of an electronic clearinghouse include:

- users who are comfortable with searching for and using paper-based information may take time to adjust to performing these functions using a computer; and
- much of the information held at an electronic clearinghouse can be dynamic and require frequent updating, such as information on upcoming events. If the clearinghouse is to be credible with and useful to users, resources must be made available to routinely update such information.

Implementation Issues / Potential Barriers

An electronic clearinghouse can be a very effective means of distributing information to a large number of users. However, to ensure that the tool remains useable, care should be taken in determining and maintaining the focus of the clearinghouse. If too wide a topic is covered, the tool could become difficult to manage and keep current. In addition, users could have difficulties finding the information they need, or determining whether it is actually housed within the clearinghouse.

An agency implementing an electronic clearinghouse may already be involved in information dissemination using traditional means, such as newsletters and other mailings. If this is the case, to ensure that customers who do not have easy access to the electronic clearinghouse are not put at a disadvantage, it may be necessary to maintain both methods of distributing information. This would result in the agency having to operate parallel systems.

Success Stories

The U.S. DOT and FHWA maintain the Strategic Highway Research Program (SHRP) Information Clearinghouse, housed on the Internet. This clearinghouse offers many types of information including a general introduction to the program, details of upcoming events, and contact information for program personnel. In addition, users can access information on SHRP products, and can read digitized documents including SHRP Status reports, the program's Focus newsletter, and product reports and abstracts. The site also provides a link to the SHRP evaluation and implementation database maintained by the Washington State DOT. Users can post and read messages on an electronic bulletin board facility housed at the site. The clearinghouse can be accessed at *http://www.hend.com/shrp/.*

The Michigan Local Technical Assistance Program maintains a Internet-based T^2 electronic clearinghouse which serves as a national-level resource providing transportation professionals, students, and the interested public with access to transportation related technology, products, and information. This facility offers links to the Internet sites of other LTAP / T^2 programs, and other related sites of interest. In addition, the clearinghouse features a comprehensive news search facility with which users can search an archive of 6,000 articles published by LTAP / T^2 programs nationwide. Users can select to search for a topic by year and by LTAP / T^2 program, or may opt to search for articles on a topic from all the years and LTAP / T^2 programs represented. The user may also search for all articles contained in the database that were published by one LTAP / T^2 program from a specific year or from all years. Search results can be viewed in condensed or full versions. This clearinghouse can be accessed at *http://www.ltap.org/* .

The Northwestern University Infrastructure Technology Institute (ITI) maintains a series of Internet-based electronic clearinghouses, including sites specializing in:

- bridge information (at *http://iti.acns.nwu.edu/clear/bridge/*);
- general / ISTEA information (at *http://iti.acns.nwu.edu/clear/infr/*);
- highway information (at *http://iti.acns.nwu.edu/clear/high/*);
- T^2 information (at *http://iti.acns.nwu.edu/clear/tech/*); and
- water resources information (at *http://iti.acns.nwu.edu/clear/water/*).

As an example, the ITI Technology Transfer Clearinghouse contains: T^2 bibliographies and other compiled lists; T^2 electronic resources; T^2 journals; T^2 programs; and other T^2 related documents. Feedback from users has indicated that the ITI clearinghouses are valuable tools. Users have commented that they are excellent for locating general information, but that highly specific information can be hard to locate. This response is perhaps not too surprising as all the ITI sites cover quite wide-ranging subjects.

The American Public Works Association maintains an electronic clearinghouse for the use of T^2 practitioners under the auspices of the national network of FHWA-sponsored Local Technical Assistance Programs (LTAP). This clearinghouse is accessed via the Internet at the Web site: *http://patriot.net/~ltap/ltap.html*. This site contains details of all the 57 LTAP / T^2 centers with their addresses, telephone and fax numbers, e-mail addresses and profiles of individual center activities for 1996. It also provides details of the LTAP / T^2 Clearinghouse Activities, links to transportation resources on the Internet, and an LTAP / T^2 "spotlight site of the week". Details of upcoming events are also posted at the site.

Tool 2.5 Listservs

"Listservs", along with newsgroups, enable participation in discussions with other users interested in a particular topic. While newsgroups, which are discussed in a later section, are modeled after bulletin board message areas, a listserv is an e-mail routing list.

Characteristics of the Tool

Software manages the subscription list of those users who have requested to subscribe to the listserv. When a user sends a message to the listserv, the software routes the message to all members of the listserv.

Listservs can be open, that is, any user may "subscribe", or closed, that is, users may need to have the necessary credentials, usually job or experience-based, to belong to the listserv. There are two types of listservs. Moderated listservs generally are overseen by a coordinator who reviews messages posted to the list, ensuring that the message is pertinent to the listserv's core interests. Unmoderated listservs forward all information posted by users, sometimes resulting in a lot of "noise" on the listserv.

The listserv community is fairly constant. Listservs tend to be for personal or professional support and updating, while newsgroups are more for keeping an ear to the ground on a particular topic.

Listservs have numerous applications. Listservs may act as a resource for tapping into a group of experts in a given field. The user then can solicit information, advice and contacts from the group of experts online. This tool is a good mechanism for posting questions. Instead of laboriously searching for experts to answer difficult questions, users can pose their question to a listserv and their question could, in theory, be answered by a number of experts in that field. Listservs can also serve as a discussion forum. As this tool is based on the use of e-mail it can serve to connect geographically dispersed users. Listservs also enable quick communication with a potentially large number of other subscribing users.

This type of tool can be used for many models of information sharing. Using listservs, users can discuss ideas and from there, collaborate or draw consensus. It can also be a means of holding meetings or conducting research online.

Circumstances Under Which the Tool Can Be Used

The equipment needed for listserv access includes a personal computer (PC), modem, telephone line and e-mail software. If the listserv is intended for use solely within a single organization, messages could be transmitted using a Local Area Network (LAN). While PCs are becoming more commonplace within the office environment, PCs with the appropriate communications facilities are also often available at universities, schools, and public libraries. Through making use of these facilities, users who do not have access to PCs at their workplace can still make use of this tool. Users do not need to have exclusive access to a PC in order to access listservs, although direct access to the basic equipment makes transmitting and receiving information easier. A personal e-mail account is required.

With the growth in use of laptop computers, remote access is possible. For users who divide their time between the field and an office, listservs can theoretically be accessed in either environment. Listservs may also be convenient for those users who travel frequently.

Current Status

Listservs have been existence since the 1980's. Currently, listservs number in the thousands and serve a wide variety of interest groups. Virtually all academic institutions and government agencies have access to e-mail. This trend is reflected in the private sector, and e-mail and Internet access is increasingly common in homes. With the proliferation of e-mail usage, the popularity and usage of listservs have also increased.

Costs for Developing and Maintaining Tool

The costs of developing listservs are relatively low. Numerous products exist which help implement and maintain a listserv quickly and simply. Some of the popular listserv packages commercially available include LISTSERV, Listprocessor 6.0, and Majordomo. They range from being free to costing from approximately $600 per year.

Advantages and Disadvantages of Using Tool

The following are advantages of using listservs:

- if a user is familiar with the use of e-mail, minimal or no training in the use of the tool should be required;
- listservs simplify contacting a group of experts;
- information access can be performed at a user's convenience, and communicating with users in other time-zones is simplified; and
- correspondence using listservs connects geographically dispersed users.

The following are disadvantages of using listservs:

- electronic discussions can be disjointed and out of sequence due to e-mail arriving out of the order in which it was sent;
- the volume of incoming e-mail messages, some of which may not be of interest to an individual user, may become irritating;
- attachments to e-mail messages in different file formats could create difficulties for users in interpreting these incompatible formats; and
- delayed responses to questions posted may occur. A user posting a question or a request for information is also not guaranteed to receive any response.

Implementation Issues / Potential Barriers

Listservs provide a simple and easy method of reaching out to users with the same interests or in the same profession. It is a relatively inexpensive mechanism for information dissemination and outreach. As messages are broadcast to all subscribers, user information overload could occur. From the management perspective, the maintenance of listservs may become overwhelming. If the listserv is moderated and comprises a large number of subscribers, the amount of mail

requiring screening could become very large. The task of sorting and screening irrelevant information and updating lists may become quite cumbersome.

Aside from the technicalities, as listservs are used as a forum for electronic discussion, messages have the potential for being copied and redistributed. Users have to be aware that what they submit to the listserv may be reproduced, and that it may be quoted or cited elsewhere, potentially out of context.

Success Stories

Listservs and e-mail were used in a 1992 International Council for Distance Education conference in Bangkok. Participants in the conference could read papers relating to topics discussed in the conference in electronic form. Discussions were conducted at international and local levels. With the efforts of volunteers and pooled computer resources, the total cost of holding the conference online amounted to less than $100.

At Northwestern University's Infrastructure Technology Institute (ITI), listservs on infrastructure and time domain reflectometry issues are available on their library Internet web site. Users who visit the site can learn about the listserv's purpose and audience, subscription information, and content. These Internet tools are provided as a part of ITI's special library services. The software used is the LISTPROC application. Originally, subscribers had to go through an approval process. When process became burdensome to maintain, the listservs were made open to all interested parties. The listservs are managed by the Institute's Librarian.

For more information on the Northwestern Infrastructure Technology Institute's listservs, contact Renée McHenry at: Tel: (847) 467-4637, E-mail: r-mchenry@nwu.edu. Internet: *http://iti.acns.nwu.edu/library/nist.html.*

The American Public Works Association maintains an open listserv targeted at T^2 practitioners. This facility is used by T^2 professionals to request or circulate information, and subscribers to the

listserv receive a free subscription to the LTAP Network publication via e-mail. Details of how to subscribe to this listserv are contained at the LTAP T^2 Clearinghouse Internet site at: *http://patriot.net/~ltap/clearinghouse.htm.*

The "T^2All" listserv also serves the T^2 community, however, this closed listserv is restricted to the staff of the T^2 / LTAP programs and FHWA personnel. The facility was intended to streamline information exchange within the T^2 community, retaining its focus by excluding vendors, for example, from submitting messages. This listserv is used to inform subscribers of events, workshops, and planning for these events is also facilitated by the listserv. Some document exchange also takes place via the listserv. This system has been in use for approximately five years, and is reported to be an effective mechanism for targeted information exchange. Further information on T^2All can be obtained from Dave Fluharty of the New Hampshire T^2 Center at Tel: (603) 862-4348.

Feedback from Customers Who Have Used the Tool

Feedback from users of the Northwestern ITI listservs has been positive, although subscribers have commented that the facility would be useful if there were more "traffic" on the listservs. Listservs have been utilized for information dissemination, obtaining updates, and professional networking since the mid-1980's. Due to this tool's widespread use for academic, professional, and leisure purposes, it can be inferred that the tool has been favorably received by a variety of users with varying levels of technical expertise.

Tool 2.6 Newsgroups

There are several ways to access or take part in "electronic discussions". One way is to subscribe to a listserv - another is to join a newsgroup. The main difference between these two tools is that a user signs up to be included on a listserv e-mail routing list, whereas a user accesses a newsgroup area on the Internet and reads the messages posted as with a bulletin board. Newsgroup messages are posted publicly, available for any user to read and respond to. The

response to newsgroups may be performed publicly, for everyone to read, or via e-mail to the original author only.

Characteristics of the Tool

Newsgroups are "virtual" meeting places where people with mutual interests can correspond online. The in-person equivalent would be some form of informal meeting, or conversation. Accessing a newsgroup is a means of seeking out people with knowledge or interest in a specific topic. It may also be a way for users to get leads on a developing topic, technology, or concern.

There are approximately 15,000 newsgroups currently in existence, most of which are a part of the Usenet system. Usenet is the name given to the loose network of sites that carry Usenet newsgroups and Usenet news. These sites - called 'newsservers' - involving thousands of computers worldwide, pass newsgroup postings back and forth, whereupon the users of these newsservers can read them online using newsreading programs and World-Wide Web browsers with news capability, such as Netscape Navigator, for example. There is no central Usenet authority, it is a cooperative network: each newsserver agrees with their upstream provider which groups it will carry. Not all newsgroups are part of Usenet - Clarinet is a commercial information service that is available as an alternative to Usenet.

To create a newsgroup within Usenet, the candidate newsgroup has to go through a discussion and voting period. The procedures to establish a newsgroup are documented at the Internet Web page: *http://www.learnthenet.com/english/html/29start.htm.*

Circumstances Under Which the Tool Can Be Used

The requirements for newsgroup access include an Internet connection and a newsreader program such as Eudora, Netscape Navigator, or Microsoft Explorer. Internet connection requires a personal computer, modem, telephone line and an Internet service. These facilities are increasingly available in the workplace, as well as at public libraries and colleges for use by the

public. With the increase in use of laptop computers, remote access to newsgroups is not out of the question, but bandwidth on portable systems can be limited.

Using a newsgroup requires keyboard skills, and basic knowledge of personal computing and the Internet. For this tool to be successful, users need to take a proactive approach in searching out and responding to information.

Current Status

The newsgroup concept was launched in 1979 by a small group of Duke University graduate students. Connections were made between campus computers to exchange information within the UNIX community. At the same time, a University of North Carolina graduate student wrote a program for software for distributing news. The network - Usenet - grew into a voluntary, cooperative exchange of newsfeeds. This system eventually evolved into many electronic discussion groups.

Costs for Developing and Maintaining Tool

The costs of developing a newsgroup are minimal. If an organization already has Internet access, then no additional equipment is required. Labor costs would be incurred by an organization in respect of the time expended creating and maintaining the newsgroup.

Advantages and Disadvantages of Using Tool

The following are advantages of using newsgroups:

- as competition increases between Internet service providers, access costs can be expected to decrease;
- users have control over their preferred level of involvement in a newsgroup, and may play either an observing or a participatory role;

- connecting with geographically dispersed users is made possible; and
- communications between users from a variety of organizations and sectors, and across hierarchical structures, are facilitated, encouraging networking and information exchange that may not occur otherwise.

The following are disadvantages of using newsgroups:

- users cannot rely on receiving a timely response to a query posted on a newsgroup. It may take days before a question is answered, and there can be no guarantee it will be answered at all; and
- information received from newsgroups can be anecdotal in nature, and further research may be necessary to verify information received.

Implementation Issues / Potential Barriers

Within many organizations, the possibilities of Internet access privileges provided in the workplace being used to access non-work-related sites or newsgroups is an issue. The advantages and disadvantages of this tool, and the potential for misuse within each organization must be considered prior to endorsing use of newsgroups. Users may also interpret this endorsement differently, and in some cases it may be very difficult to differentiate work-related use from general interest use or personal use. An organization may need to produce guidelines as to what constitutes professional development and information gathering.

Success Stories

Many thousands of newsgroups exist, of which many are transportation related. The popularity of newsgroups as a means of information exchange is demonstrated by the sheer numbers of newsgroups available.

A myriad of resources can be found on the Internet regarding newsgroups. For example, Deja News - *http://www.dejanews.com/newusers.html* is the World Wide Web interface to newsgroups. It enables users to search, read, and participate in newsgroups. Another is the "Learn the Net" Web page - *http://www.learnthenet.com/english/html/26nwsgrp.htm.* At this particular site, general information about newsgroups in addition to information about creating, subscribing and searching newsgroups is provided.

Tool 2.7 Electronic Expert Directory

The electronic expert directory tool streamlines the process of seeking information from an expert in a particular field. Traditionally, if a user requires advice or information from an expert, a series of enquiries may be made, hopefully leading to the identification of a person with the appropriate knowledge and experience. However, this process could be time consuming, and the user may not successfully identify a useful source.

Characteristics of the Tool

This tool comprises a database of individual experts' names and contact details. For each expert listed within the directory, information on their specialty areas is also provided. The directory contains information relating to a specific domain - such as transportation in general, or highway maintenance, for example. The database can be queried by a user, based on a specific problem which the user needs to solve, or an interest area about which the user wishes to learn. When the user enters details about a problem or situation for which they need advice or assistance, the system would search the database to match the users problem with an expert who possesses knowledge and experience in that technical area.

The user would then contact the expert directly, by telephone or e-mail for example, to request technical assistance. The system acts as a "dating agency" between users and experts. The database could be provided on computer disks, or could be accessed using the Internet. Housing

the database on the Internet would make updating the database easier, as update disks would not need to be distributed to all users.

Circumstances Under Which the Tool Can Be Used

For systems interfaced via the Internet, a personal computer, modem, appropriate software and telephone line are required. For systems distributed on computer disks, a personal computer and appropriate software are needed. Since an application is likely to be custom designed to meet the needs of a specific agency, some initial training would be needed in order to familiarize users with the system. As this system could be valuable both for occasional or regular use, the user interface should be designed so infrequent users can easily use the system.

Current Status

Currently, various applications of this tool are being used in engineering related fields such as mechanical and electrical engineering. Some major corporations such as General Electric have also developed electronic directories of in-house experts for organization-wide use. Work to create a future generation of more flexible tools is underway. Using artificial intelligence (AI) techniques researchers are working to incorporate a degree of "intelligence" into the system, so that it can match users' entries - which could be expressed in a variety of ways - with experts in the appropriate technical field. Thus users would be able to enter a free-text query into the database, rather than having to search by keyword as with the present systems.

Costs for Developing and Maintaining Tool

The costs of developing and maintaining this type of tool would vary widely according to the number of entries in the expert database, and the mechanism by which users would access the information. Various preliminary plans were made for an expert directory which was to be made accessible to all 65 Federal Highway Administration offices nationwide. A rough cost estimate

of approximately $200,000 has been quoted for the costs of developing and implementing a tool on this scale.

Advantages and Disadvantages of Using Tool

The following are advantages of using an electronic expert directory:

- users can easily locate contact details of individuals with particular experience and knowledge, saving time and effort in the search process;
- users can contact experts directly, without having to go through a multi-stage process in order to locate the required expert.

The following are disadvantages of using a electronic expert directory:

- users might inundate those experts with knowledge of "in demand" topics with requests for assistance or information, creating an excessive burden for those experts.

Implementation Issues / Potential Barriers

For this type of tool to work successfully in an organization, all personnel affected by its use would have to cooperate. Users should not presume that because the details of an individual expert are contained in the database, that the expert will be able to give of their time freely whenever contacted. As was noted above, the use of such a system could result in some experts receiving large numbers of calls or e-mails, and they could not reasonably be expected to respond to all of these. It is likely that some "ground rules" would have to be established in order that particular experts are not overloaded with requests for assistance. In theory, facilities could be built into the system which would enable its administrators to collect statistics on the traffic generated by the expert directory. This should enable the systems' implementers to evaluate whether personnel are making use of the system, and whether particular experts are being overloaded with enquiries.

Success Stories

Teltech Resource Network Corporation custom-built a "knowledge-sharing network" for General Electric. This is an intranet-based directory of in-house experts, which is queried by a keyword search. Biographies of General Electric's experts are contained in the database. A "technical thesaurus" was also created, which contains technical concepts and terms specific to General Electric's areas of interest and expertise. The thesaurus is linked to the expert biographies, and users search the database by selecting a technical concept or term of interest to them.

For further information about TelTech's Knowledge Management System, contact David Magnani. Tel: (612) 851-7508, E-mail: DMagnani@us.teltech.com, Internet address: *http://www.teltech.com.*

Feedback from Customers Who Have Used the Tool

Customer feedback to General Electric's proprietary system has been positive. Results of an independent evaluation on a variety of applications created by the TelTech organization, showed a 16:1 return on investment. Documentation on these applications conclude that this type of tool works best for agencies with over 75 employees or system users who are geographically dispersed.

2.3 Type 3 - Emerging Advanced Tools

Three "emerging advanced tools" were identified, and are described below.

Tool 3.1 Virtual Reality

Virtual reality (VR) applications involve a user interacting with a "manufactured environment" which simulates some aspect of the real world, such as an operating theater or a building. A computer-generated graphical representation of a particular environment is displayed to the user who can "move around" in this virtual environment and interact with objects, or other users,

represented there. The interaction between the user and the environment can occur in several ways, according to the type of system.

Characteristics of the Tool

"Immersive VR" involves the user wearing a headset - the output device - through which the simulated world is visually and aurally presented. In "desk-top VR" the simulated world is presented using a monitor such as a regular PC-type monitor. VR input devices vary in sophistication and range from a simple joy stick or mouse, through to a "data glove" or even a full body "data suit". Data gloves and suits are outfitted with sensors to track the movement of the hand or body, as well as an overall position / orientation tracker. Within the virtual world a representation of the users "input device" can be seen through the headset or monitor. For example, a user wearing a data glove can see a graphical representation of their own hand moving and manipulating objects.

Circumstances Under Which the Tool Can Be Used

Virtual reality applications can be used for training by simulating a user's work environment in which the user can practice performing tasks. Immersive VR systems are used in a specially equipped room. Due to the costs of the equipment involved, it likely that an organization would equip one central facility, to which users would need to need travel. Desktop VR applications could, in theory, be installed at a user's regular computer workstation, although again for reasons of cost is it likely that an organization would equip a limited number of workstations with the VR application software and required input and output devices.

Current Status

Although VR is a technology which may take some time to be widely available and which will continue to be further developed and enhanced for some time, many applications have been developed. These are intended for training and education as well as for leisure and entertainment

purposes. Not all of these applications are prototypes. An inventory of VR systems developed for education and training applications is provided at: *http://www.hitl.washington.edu/projects/knowledge_base/edapps.html*.

Costs for Developing and Maintaining Tool

The software development costs for implementing VR applications vary widely depending on factors including:

- the complexity of the environment and of the tasks which are to be simulated;
- the sophistication and degree of visual realism of the graphical representation of the virtual environment;
- the number and complexity of the different scenarios which are to be simulated by an application;
- whether an application is immersive or desk-top;
- whether one or multiple users are to be represented in the virtual environment;
- the degree and type of interaction between users in a multiple user application.

The hardware costs for VR applications also vary according to whether the system is immersive or desk-top, and according to whether the system is a single user or multiple user application. The required computer processing power alone can be extremely expensive added to which is the cost of the input and output devices.

Advantages and Disadvantages of Using Tool

The following are advantages of using virtual reality tools:

- the user learns by simulating the performance of tasks, rather than learning by more passive means, such as watching a video of the task being performed. This active learning is often more easily recalled when required to perform the task in a real environment;

- some tasks which have serious consequences if performed incorrectly, or tasks which take place in hazardous environments, can be safely practiced in VR simulation; and
- VR systems can make training more absorbing and stimulating for users, which should theoretically result in more effective learning.

The following are disadvantages of using virtual reality tools:

- some users experience dizziness or a form of motion sickness when utilizing immersive VR systems;
- depending on the environment and the particular tasks which are simulated, not all elements can be realistically simulated. For example, many VR systems do not provide tactile feedback. Users should be made aware of the limitations of the system, and how the simulated task performance will differ from task performance in the real world;
- VR systems are not appropriate for training on all types of tasks;
- although VR can be used for basic training on difficult or dangerous tasks, users will still require some task training and practice in the real-world environment;
- VR systems can be extremely costly to develop, implement and maintain.

Implementation Issues / Potential Barriers

The primary barrier to the implementation of this tool for use in T^2 is the cost of the technology. It is likely, however, that the real cost of VR will decrease as applications become more widespread and as the technology matures. Much has been made of the possibilities and limitations of VR applications in the popular press, which may have resulted in a "credibility problem" for VR's application as a serious tool. However, an additional, positive, consequence is that users are often very keen to try this tool to discover for themselves what it offers.

Tool 3.2 Real-Time "In-Field to Help Desk" Interaction

This prototype application is currently being tested in the environment of transit maintenance operations.

Characteristics of the Tool

This tool involves real-time communication between a user in the field and a technician operating a help-desk at another location, for example, the user's home base or a central office. The user wears a headset computer, through which the help-desk technician can deliver detailed information, such as technical diagrams, to the remote user. The equipment can also be used to take digital pictures of a situation or problem in the field and send these in real-time to the technician. The technician and the user can then discuss approaches to fixing the problem using two-way voice communication.

In the T^2 field, this tool permits long-distance, interactive, just-in-time training enabling the users to remain in their work environment. The user "learns by doing", and is coached through performing the task by the technician at the help desk location.

Circumstances Under Which the Tool Can Be Used

The tool is intended for use in the field, where the presence of a human trainer is uneconomical or not possible. In theory, all field personnel could be supplied with the unit, to be used when and if a problem arises which they have not solved before. Alternately, training scenarios could be scheduled for a specific user at a specific location, and equipment would be issued for a fixed period when the user leaves a home base. As the system consists of a headset and wearable computer, in principal, the user can still move freely and perform tasks with ease.

Current Status

Research is still being conducted on this tool. In 1995, a prototype system was developed to facilitate maintenance of mass transit and people mover trains. The project involved a team from Carnegie Mellon University and Daimler-Benz. The chosen pilot test site was Pittsburgh International Airport where in-field maintenance workers communicated with a help-desk for joint problem solving. Wireless communication was implemented using spread spectrum radio and leaky antenna cable mounted alongside the track. Papers containing further details of this system include:

- 1997, July, "Wireless and Mobile Computing in Train Maintenance and Diagnosis", Smailagic and Bennington, IEEE Vehicular Technology Society, 47th Annual International Conference, Phoenix, AZ.

Costs of Developing and Maintaining Tool

The customization and implementation costs for this application are unknown as it is not commercially available at present. Development costs for the prototype system were not available at the time of writing of this report.

Advantages and Disadvantages of Using Tool

The following are advantages of using the "in-field to help desk" interaction tool:

- the information provided to the users in the field can be tailored by the technician to suit the user's level of expertise and the context, for example, detailed technical diagrams can be transmitted, or simple, spoken instructions could be given;
- the help-desk technician can diagnose problems and suggest approaches based on images of the actual scenario;

- as training can be provided on an as needed, just-in-time basis, other training programs may be able to be streamlined;
- in theory, end users may learn more effectively through solving problems in situ, rather than receiving more formal training out of context; and
- problems may be solved more quickly as the user can access expertise on demand.

The following are disadvantages of using the "in-field to help desk" interaction tool:

- transmission range of wireless communication is limited unless satellite systems are utilized which may prove too costly;
- since the tool requires one-to-one interaction, if demand by in-field personnel is high, there may not be sufficient technicians available to satisfy the demand;
- an organization implementing this tool would need to be able to ensure that technicians are on-call at times when users wish to make contact;
- users may require extensive training in using the tool so they feel at ease with the technology;
- wearing the headset for prolonged periods of time may become uncomfortable;
- a large number of in-field units may need to be in use in order to justify the cost of operating the help-desk; and
- as this is an emerging tool, the equipment may be prohibitively expensive when first commercially available, before economies of scale in production are realized.

Implementation Issues / Potential Barriers

Since the tool is still in the prototype stages, its benefits and cost-effectiveness compared to other methods of T^2 have not yet been determined. Potential barriers to the implementation of the tool include the cost of the technologies involved and the costs of maintaining the help-desk. In addition, careful consideration of the receptiveness of in-field personnel to the technology is required. It should be appreciated that the tool is not intended to replace existing training

programs, but that it is designed to provide supplementary assistance to in-field workers, to assist them in making decisions and in solving problems in more unusual circumstances.

Tool 3.3 Intelligent Electronic Notebook

The intelligent electronic notebook is a remote access information station. It makes use of artificial intelligence and expert systems techniques to offer information to users in the field.

Characteristics of the Tool

This application consists of a notebook computer which, using voice recognition, speech synthesis, natural language processing, and a knowledge base, can be interfaced by the user using voice input, rather than using traditional input devices such as a keyboard or mouse. The user is able to query the notebook for information in remote locations where obtaining input from co-workers, supervisors, or other sources may not be possible.

This electronic notebook can provide "static information" to the user, meaning that the user can only access what has been pre-programmed into the device. Other prototypes are currently being developed which may enable this type of notebook to be interconnected with other systems, supporting the transfer of digital voice, digital data, text and compressed video via satellite. This would enable the user to gain access to a far wider knowledge base, housed in other, larger information repositories.

The system uses natural language processing to infer the most likely words or phrases to have been spoken by the user if any ambiguity is present. The tool could be customized so that the system retains information about particular users, in terms of their speech patterns and expressions, and their intended meaning. The goal of this facility is to minimize the amount of information re-entry that would be required of the user, whether by speech or keyboard. However, this flexibility would require additional processing power, such that a particular unit may only be able to be used by a single user, or by a small group of users.

Circumstances Under Which the Tool Can Be Used

In the context of T^2, this application may be useful for meeting user information needs on location and on demand, in a "just-in-time" manner. As the tool comprises a notebook computer the system is portable, and if ruggedized could be used in a variety of in-field environments. As the user can input queries to the system using voice commands, no keyboard skills are necessary and users can interact with the system in a virtually "hands free" mode.

Current Status

Reticular Systems, Inc., in cooperation with the NASA Jet Propulsion Laboratory (JPL) is in the process of developing an intelligent electronic notebook that incorporates recent advances in voice recognition, speech synthesis, natural language processing, intelligent agents, user modeling, and object-oriented databases while exploiting the availability of high performance low cost workstations and notebook-sized computers. The notebook is being developed in order to help streamline some NASA missions operations such as controlling spacecraft and space-based platforms. The notebook's capabilities include command and control of systems, data analysis and visualization, planning, and scheduling. It also enables communication and collaboration with other operations personnel.

Findings from early tests of the system have been positive, and there are preliminary plans to commercialize the tool for other applications. For further information on the status of the tool, contact Sharon C. Ballard. Tel. (619) 279-9723. E-mail: sballard@reticular.com.

Costs for Developing and Maintaining Tool

Costs are unknown at present as the tool is still in the research and development stages.

Advantages and Disadvantages of Using Tool

The following are advantages of using an intelligent electronic notebook:

- keyboard skills are not required enabling users without prior experience in using computers to use the tool more easily;
- the user can easily capture events in real-time, use voice commands to enter data, and to modify and query the contents of the knowledge base;
- the virtually hands-free operation enables the user to perform other actions at the same time as querying the system;
- as users can obtain information in the absence of a supervisor or other expert, problem solving in the field may be achieved more quickly

The following are disadvantages of using an intelligent electronic notebook:

- when and if the such systems become commercially available, the costs for civilian applications may be prohibitive for some time before economies of scale in production are achieved;
- users who are accustomed to interacting with peers and supervisors to share information and solve problems may need time to adjust to "trusting" the information provided by a computerized system;
- some users may always feel more comfortable interfacing with and obtaining information from a person rather than a computerized tool;
- users will have to remain tolerant of the tool while they learn its limitations, both in terms of the knowledge it contains, and the ways in which the system's contents can be queried; and
- the accuracy rate of the best currently available speaker-independent continuous speech recognition systems range from 94 percent to 96 percent. At this rate, recognition errors could occur every two minutes. Users may have to repeat voice input, which could become irritating.

Implementation Issues / Potential Barriers

The main implementation issue associated with the tool may be that of cost. It is likely that this tool would have to be proven in a commercial environment, and economies of scale achieved in production, before public sector agencies would consider the tool's use for T^2 applications. This process is likely to take several years. As this tool is developed further, the success of civilian applications should be carefully analyzed to determine this tool's appropriateness for T^2. As is the case with the "in-field to help desk" interaction tool, this tool is not intended to replace existing training programs, but is designed to provide supplementary information to in-field workers.

3. APPLICABILITY OF TECHNOLOGY TRANSFER TOOLS FOR USE IN MINNESOTA

In Task A-1 of this study, various T^2 customer groups were defined. Although it is acknowledged that the needs of individual customers may vary even within a particular group, it was anticipated that customers belonging to one group are more likely to have similar experiences in terms of their T^2 needs and preferences. The T^2 customer groups identified were as follows:

- **policy makers.** This customer group includes individuals such as elected officials, senior management, and legislators;
- **supervisors and administrative support personnel.** This customer group includes individuals with responsibility for training such as workshop instructors, state department librarians, the supervisors of research contracts, and those involved with the circuit rider van program;
- **technical personnel.** This customer group includes individuals such as city and county engineers, researchers, and technicians; and
- **in-field personnel and seasonal / intern workers.** This customer group includes all those individuals who spend the majority of their time in the field, such as maintenance workers and field technicians.

In this section, each of the T^2 tools previously described are considered with respect to how they may be able to meet the needs of T^2 practitioners and customer groups in Minnesota. Table 2, contained in Appendix C, summarizes the potential applicability of each T^2 tool to the various customer groups.

3.1 Applicability of Tool 1.1 - Conference-based training

Conference-based training, a proven and current tool, can be implemented in a variety of ways, using equipment with varying levels of complexity, and at various costs. In order that a

conference-based training facility could be easily used by users from all the different customer groups, it may be that the systems which use PC technology and Internet access would have the widest applicability. Although members of the in-field personnel and seasonal / intern workers do not have dedicated access to computers, providing a single PC equipped with the required camera and telecommunications facilities at a reasonable number of district or field offices would enable these users to utilize the technology, at a lower cost than creating video-conferencing studios for analog conferencing at the same number of locations. By this means, the CU-SeeMe system provided at not cost over the Internet could be utilized. However, the use of PC-based systems as opposed to analog studio systems will require more training to be provided to those users.

3.2 Applicability of Tool 2.1 Electronic bulletin boards

An electronic bulletin board is a computer-based version of a traditional bulletin board. Users can access it at their convenience, read information posted there, respond to questions or requests for information, and post their own questions. Implementing some form of electronic bulletin board system for T^2 in Minnesota could meet a variety of needs, both of T^2 agents, and of the various customer groups. By posting information on an electronic bulletin board, T^2 agents could reduce the need to rely on mailings of printed materials, thereby saving labor, printing, and mailing costs. In addition, providing that users access the bulletin board on a regular basis, there is a possibility that less of a time lag in receiving materials will be experienced. As soon as the material has been posted at the bulletin board, it is instantaneously available to all users who dial in to the system.

It is believed that for the policy makers, supervisors and administrative support personnel, and technical personnel, customer groups, the use of this tool will require little additional equipment to be procured and installed, and minimal training to be provided. Users who are familiar with the use of e-mail should be able to utilize this tool quite easily. In the case of the in-field personnel and seasonal / intern workers customer group, providing a single PC equipped with the software and telecommunications facilities at a reasonable number of district or field offices would

enable these users to utilize the technology. Although more training - including basic computer training and keyboard skills - is likely to be required in order that this group would be able to make use of the tool, it is possible that the analogy of the traditional bulletin board may help these users to feel comfortable with the concept.

3.3 Applicability of Tool 2.2 Digital libraries

A digital library is a collection of resources which could include books, journals, newsletters, periodicals, graphical images, maps, and photographs, for example. Essentially, the resources of a traditional library have been digitized such that they can be accessed using computing and communications technologies.

Although this tool can be expensive to implement, it is suggested that it could serve to meet many of the information needs of the policy makers, supervisors and administrative support personnel, and technical personnel customer groups. Within Task A-1 it was ascertained that these users generally have access to computing and telecommunications facilities.

It was also learned that, in general terms, the members of the policy makers group have limited time available to read detailed reports on new transportation technologies or the products of research projects. In addition, printed materials sent to this group often are not read due to the length and number of documents received. Providing access to a digitized collection of resources, which could be provided in "executive summary" format, and which could be accessed on an as-needed basis, could help ensure that these users make more use of the available information. When a user wishes to receive more information on a topic of interest, details of how to acquire the full document could also be provided as part of the digital library. Compiling a digital library of "executive summaries", as opposed to full-length documents, would also reduce digitizing costs.

3.4 Applicability of Tool 2.3 Self-guided tutorials

This "family" of tools includes a variety of types of application, with varying degrees of complexity, and using a variety of delivery mechanisms. In essence, this type of tool can be defined as a structured package of training materials, prepared by a trainer or expert, and organized into lessons or modules, which an individual user can work through at their own pace.

It is believed that this highly flexible tool could be of use to all Minnesota's T^2 customer groups, although tutorials of varying content and complexity would be required for different users, even for tutorials on the same topic. As lessons or modules can be worked through at the users's preferred pace, the policy makers, supervisors and administrative support personnel, who often have limited time available to digest information, could work through selected portions of material little by little at convenient moments. For those technical personnel, and in-field personnel and seasonal / intern workers who spend little time in an office environment, from where this tool is likely to be accessed, tutorials could be accessed on an ad-hoc basis during periods of inclement weather when the users are confined to a district office or depot.

For T^2 agents, the use of computerized self-guided tutorials could result in cost savings, as once a tutorial has been designed and produced, it can be used and re-used on many occasions - providing the subject matter remains up-to-date. In addition, a tutorial could be designed such that updates to material can be made easily and inexpensively. The need for trainers to schedule in-person courses and travel across the state could also be reduced. Implementation of this tool using the delivery mechanism of the Internet is likely to enable users to access the available tutorials at the most number of locations, if publicly available facilities are used.

3.5 Applicability of Tool 2.4 Electronic clearinghouses

An electronic clearinghouse can be defined as a repository of information relevant to a particular domain, such as transportation in general, or pavement research, for example. This information is stored and retrieved using computing and communications technologies. The information

housed in the clearinghouse could include documents, lists of contacts and experts, details of events, and details of other resources that the user can access.

A T^2 electronic clearinghouse could be a very versatile option that could encompass some of the other tools discussed, thereby meeting multiple objectives of T^2 agents. If accessed via the Internet, users not only from around the state of Minnesota, but also customers of T^2 programs across the country could access material housed at the clearinghouse. In addition to the features listed above that could be provided via this tool, facilities offered from the clearinghouse site could include self-guided tutorials, and "chat rooms" - similar to the bulletin board concept - where users could hold electronic conversations to network and share information. If links to the electronic clearinghouse are placed at related sites, and at the sites of other T^2 programs, the tool would not only provide a service to a potentially large number of users, but would also serve to maintain a high profile for the Minnesota programs.

This tool is likely to be best received by the policy makers, supervisors and administrative support personnel, and technical personnel customer groups, given their general pre-existing familiarity with computers and e-mail systems.

3.6 Applicability of Tool 2.5 "Listservs"

"Listservs", along with newsgroups, enable participation in discussions with other users interested in a particular topic. A listserv is an e-mail routing list. Implementing listservs for T^2 could supplement some of the more formal training and knowledge transfer activities performed by the Minnesota programs, as this tool provides a mechanism for relatively unstructured peer to peer information sharing. A series of listservs, either organized around certain topics, or certain subsets of the user groups, could serve to enhance user perceptions of belonging to a group of people wider than their day to day circle of professional contacts. Similarly, for users who seldom have the opportunity to travel to other parts of the state, listservs provide a way to interact with peers from other locations.

As this tool could be implemented quickly at very low cost, it could almost serve as a pilot to ascertain how receptive users would be not only to this tool in particular, but also to some of the other electronic information sharing tools such as bulletin boards and newsgroups.

Depending on the topic and / or the type of intended users for a listserv, and whether the listserv was to be moderated or unmoderated, once the tool was created and a "critical mass" of users were utilizing the tool, the tool could be a very low maintenance facility from the perspective of T^2 agents.

As with the electronic clearinghouse tool described above, listservs are likely to be best received by the policy makers, supervisors and administrative support personnel, and technical personnel customer groups, given their general pre-existing familiarity with computers and e-mail systems.

3.7 Applicability of Tool 2.6 Newsgroups

Newsgroups are virtual locations accessed via the Internet, at which messages are posted publicly, available for any user to read and respond to. Responses to a newsgroup posting may be broadcast to all other users, or to the original author only. Accessing a newsgroup is a means of seeking out people with knowledge or interest in a specific topic.

Virtually all of the discussion above on the subject of listservs also applies in the case of newsgroups. The key difference between these two tools is that newsgroups are accessed via the Internet, rather than messages being sent to a user's regular e-mail account. In this respect, newsgroups require a more proactive stance in posting and retrieving information to be taken by users. It may be that a newsgroup already exists which could play a role in T^2 activities in Minnesota.

3.8 Applicability of Tool 2.7 Electronic expert directories

The electronic expert directory tool streamlines the process of seeking information from an expert in a particular field, and comprises a database of individual experts' names and contact details. It is suggested that this tool will meet certain needs of all the customer groups of Minnesota's T^2 programs. In order to ensure that the maximum use can be made of the tool, as wide a range as possible of types of experts and topics should be covered. As the tool acts as a type of "yellow pages" of experts, and the actual contact with experts is made by telephone or e-mail, it is hoped that even those users who are less keen to use computerized systems will perceive this tool as being an attractive option.

Almost all the members of the policy makers, supervisors and administrative support personnel, and technical personnel groups have relatively easy access to PCs, with which the expert directory could be accessed. In order to ensure that members of the in-field personnel and seasonal / intern workers group can make use of this tool, an option could be to provide a dedicated terminal with which to access the expert directory at all district or field offices. Care should be taken to provide a user-friendly interface such that occasional users, or users with little or no prior exposure to computerized systems, will find the tool easy to use. It could be advisable to provide an in-house telephone support service so users experiencing any difficulties can obtain assistance on using the system.

T^2 agents often act as information brokers, and use of this tool could reduce the burden on these agents, as users will be able to interact directly with experts. In addition, as users make contact with experts in particular fields they will build their own network of contacts for future use.

3.9 Applicability of Tool 3.1 Virtual reality devices

Virtual reality (VR) applications involve a user interacting with a "manufactured environment" which simulates some aspect of the real world, such as an operating theater or a building. A computer-generated graphical representation of a particular environment is displayed to the user

who can "move around" in this virtual environment and interact with objects, or other users, represented there.

Although it may be some time before VR systems become a serious option for T^2, largely due to their cost, this tool could in the future play a valuable role in training and knowledge transfer. Unlike many of the advanced tools considered in this study, VR systems can be used for the transfer of procedural knowledge - the "knowledge how" to do a task - as well as the transfer of factual knowledge. For those customer groups such as the technical personnel and the in-field personnel and seasonal / intern workers who are required to learn how to perform practical tasks, a VR application could augment in-field training. VR could also provide training in dealing with unusual or rarely occurring situations, as the training scenarios could be simulated on demand once programmed.

This tool is possibly the most futuristic of those considered within this study, and therefore the issues of user acceptance of and comfort levels with this tool would have to be taken into consideration.

3.10 Applicability of Tool 3.2 Real-time "in-field to help desk" diagnosis / problem solving systems

This tool involves real-time communication between a user in the field and a technician operating a help-desk at another location, for example, the user's home base or a central office. The user wears a headset computer, through which the help-desk technician can deliver detailed information, such as technical diagrams, to the remote user. The equipment can also be used to take digital pictures of a situation or problem in the field and send these in real-time to the technician. The technician and the user can then discuss approaches to fixing the problem using two-way voice communication.

As this tool is purpose-designed to assist in-field users to perform tasks in the field it is a prime candidate for use by the technical personnel and the in-field personnel and seasonal / intern

workers. Although a "high-tech" solution, its method of use would suggest that it would be more readily accepted by users than immersive VR applications. Within Task A-1, it was established that the in-field personnel and seasonal / intern workers customer group prefer T^2 tools that involve interaction with peers or trainers. This tool does not attempt to simulate or replace the need for interaction, but rather facilitates contact between users and joint problem solving. Therefore, this tool would seem to provide a balance between technology and human contact.

3.11 Applicability of Tool 3.3 Voice responsive electronic notebook

The voice responsive electronic notebook is a remote access information station. It makes use of artificial intelligence and expert systems techniques to offer information to users in the field. This tool could play a valuable role in supplementing existing T^2 mechanisms for the technical personnel and in-field personnel and seasonal / intern workers customer groups. Members of both of these customer groups can spend significant portions of their time working in the field, often in remote locations. In theory, the use of this tool could also reduce the burden on T^2 practitioners by providing information and training to these users on an as-needed basis.

Within Task A-1, it was ascertained that the technical personnel group tends to be very receptive to working, and acquiring familiarity, with new T^2 tools. However, it was also ascertained that members of the in-field personnel and seasonal / intern workers group can demonstrate some resistance to tools which make use of computerized systems. This latter group tends to spend significantly more time in the field than the technical personnel group, and so could in theory make more use of the voice responsive electronic notebook database tool. However, it is likely that the technical personnel group will be more at ease with this tool, and would therefore optimize their access to the tool.

4. SUMMARY AND NEXT STEPS

The Advanced Tools for Technology Transfer in Transportation study resulted in the identification of a series of tools which could be used for transportation T^2 in Minnesota. It is hoped that although the study concentrated on the Minnesota T^2 environment, the findings will be applicable to other areas with similar T^2 needs and activities.

The tools discussed in this report are at various stages of technological readiness. Some are reasonably well established and could be implemented in the near- to mid-term, provided that funding is available to undertake the required modifications or customization for their application in Minnesota. Other tools identified are in the research or prototype testing stages. It is suggested that the continuing development of these tools be monitored in order that their applicability for use in Minnesota can be reconsidered at a future date when further details are available on their performance and suitability.

Participants in this study intend to work with Minnesota's Technology Transfer Coordinating Committee (T^2C^2) to ensure that all future activities stemming from this initial study are as appropriate and effective as possible. The T^2C^2 was created in 1993 as an informal method of establishing links, channels and networks within the broader T^2 community in Minnesota. Current members represent the Federal Highway Administration, the University of Minnesota Center for Transportation Studies and Mn/DOT's library, research and training offices. Members participate in an ongoing effort to integrate and exchange information to ensure the efficient implementation of transportation innovations and optimize T2 resources and opportunities.

The activities performed within this study are considered to be the first step in a continuing process of enhancing the T^2 process in Minnesota. In order to optimize the investment made in this study, it is hoped that partnerships can be formed to jointly fund future work. It is believed that a valuable outcome of this study would be the establishment of an ongoing process in which the study findings would be periodically revisited. This would enable the Minnesota T^2 programs to maintain up-to-date knowledge on the technological readiness of the emerging tools, and to

identify still newer tools which have evolved since the initial study. The aim of these activities would be to create a staged vision for future testing and implementation of the most advanced tools.

Planning for an Advanced Tools for Technology Transfer in Transportation focus group, to be attended by Minnesota T^2 stakeholders and practitioners, is also taking place at the time of writing of this report. The focus group will involve presenting the results of this study for review and discussion. The purpose of these activities is to gain a wider understanding of the receptiveness of these stakeholders to the possible future implementation of the documented tools, and also to obtain input on which, if any, of these tools may be suitable for pilot testing within Minnesota. It is hoped to emerge from these activities with a series of recommendations on which tools could be considered for pilot testing in the near term. A report summarizing the findings of the focus group will be made available, and it is envisioned that these findings will also be appended to this report.

APPENDIX A

List of T^2 Tools Currently in Use in Minnesota

The list below provides an overview of the types of tools which are currently in use for T^2 in Minnesota:

- printed materials, including newsletters, technical summaries, research syntheses, and reports;
- field guides, such as the pavement distress identification manuals;
- training and informational videos;
- training courses, workshops, seminars, and conferences; and
- in-field demonstrations.

In addition, the Minnesota T^2 programs also act as information clearinghouses, providing technical assistance and referral, and access to library services to customers who call requesting assistance.

APPENDIX B

Technical Memorandum 1

Performance of Advanced Tools for Technology Transfer in Transportation

TECHNICAL MEMORANDUM 1

Revised: December 10, 1997

1. Introduction

This technical memorandum has been prepared within Task A-1 of the Advanced Tools for Technology Transfer in Transportation project. The goal of this task was to provide an overview of the technology transfer (T^2) needs and preferences of specific customer groups for T^2 initiatives within Minnesota. In addition, Task A-1 was designed to enable the creation of profiles of the types of customers served by the Minnesota T^2 programs, and to document the general perspectives of these customers on the T^2 process.

The findings of this task will be utilized to guide the subsequent project tasks which involve identifying and documenting T^2 tools which will meet the needs of both the T^2 customers and of T^2 agents within Minnesota. By these means, it is hoped to streamline and increase the effectiveness of knowledge transfer.

2. Task A-1 Approach

At the outset of this task, Castle Rock met with key members of Mn/DOT's Office of Research Administration (ORA) the University of Minnesota's Center for Transportation Studies (CTS), and the Federal Highway Administration. As a result of these meetings, a means of grouping the customers of Minnesota's T^2 initiatives was developed. In addition, the various types of technology requiring transfer in Minnesota were categorized. Both of these means were designed bearing in mind the appropriate T^2 tools or mechanisms which could be utilized to communicate particular types of information to certain types of customer.

In parallel with this activity, a brief list of representative T^2 customers and agents within Minnesota was compiled. Subjects were selected in order that at least one individual from each

of the customer groups was interviewed wherever possible. Additional subjects represented others involved in the T^2 process in a variety of capacities. The interviewees were contacted by fax and subsequently interviewed by telephone in order to obtain the required information.

The interview involved explaining to subjects the T^2 customer groups previously developed, and giving the opportunity to comment. Further questions involved asking subjects to provide some details about their role in T^2 in Minnesota. Then, for each of the customer groups, various questions were asked concerning:

- customers' working environment;
- whether this environment placed any constraints on what forms of T^2 work for particular types of customers;
- how customers generally access information;
- the facilities available to this type of customer, such as telephone, email, video viewing facilities, etc.;
- any feedback subjects had received concerning how this type of customer prefers to receive information, and what tools work best for them;
- the customers' comfort levels / familiarity with the T^2 tools currently in use; and
- any general perspectives on the T^2 process in Minnesota.

It should be noted that due to the survey time frame and the resources available for the survey activities within the project, the findings of the interviews are not intended to be statistically significant. They are intended only to provide an overview of the T^2 needs and preferences of the customers involved in or affected by T^2 in Minnesota. Three T^2 agents and seven end-users were interviewed. The interviewees covered the range of the customer groups with the exception of in-field personnel. The information obtained for the in-field personnel perspective was taken from the interviews with users who work closely with in-field personnel, such as maintenance supervisors. Findings of the interviews were then compiled and summarized. These findings are provided in Section 3.

2.1 Minnesota T^2 Customer Groups

As described above, customer groups were defined in order to match tools accordingly in later tasks. Although it is acknowledged that the needs of individual customers may vary even within a particular group, it was anticipated that customers belonging to one group are more likely to have similar experiences in terms of their T^2 needs and preferences. The T^2 customer groups identified in order to consider suitability of tools were as follows:

- policy makers. This customer group includes individuals such as elected officials, senior management, and legislators;
- supervisors and administrative support personnel. This customer group includes individuals with responsibility for training such as workshop instructors, state department librarians, the supervisors of research contracts, and those involved with the circuit rider van program;
- technical personnel. This customer group includes individuals such as city and county engineers, field engineers, researchers, and technicians; and
- in-field personnel and seasonal/intern workers. This customer group includes all those individuals who spend the majority of their time in the field, such as maintenance workers and field technicians.

At the outset of the project a list of the types of technology or information which could require transfer to each of these customer groups was compiled. It was originally intended that tools identified later would be mapped against these technology or information types as well as against the customer groups outlined above in terms of their appropriateness in communicating different types of information to different users. However, as the project progressed and tools were identified, it became apparent that the tools were best categorized according to each customer groups' needs rather than the types of information to be communicated. The list is, nevertheless, reproduced here for completeness:

Types of technology / information requiring transfer (new or existing)

- Equipment
  - Purchasing / selection
  - Modifications
  - Usage
  - Maintenance
- Materials
  - Selection / availability
  - Usage
- Procedures
  - Introducing new procedures
  - Training on established procedures
  - Refresher courses
- Guidance
  - Mandatory regulations
  - Advisory information
- General knowledge / public awareness

3. Task A-1 Survey Findings

The survey findings are presented in the following subsections in accordance with the predefined customer groups.

3.1 Policy makers

The policy maker representatives that were interviewed tended to be involved in the T^2 process by serving on various committees such as Minnesota's Local Road Research Board (LRRB) Research Implementation Committee (RIC), Mn/DOT's Technology Transfer Coordinating Committee (T^2C^2), and other bodies with T^2 responsibilities and interests. This group contains not

only T^2 decision makers and agents, but also "end users" of the T^2 process. In terms of the working environment of this group, individuals tend to spend the vast majority of their time in a traditional office environment.

In general, the working environments of members of this group do not place constraints on the forms of T^2 that will work best for them, that is, this group tends to have access to technological facilities such as video conferencing or electronic mail, rather, it is an issue of time. It was commented that the schedules of these customers were such that they had very little time to learn about the availability of new transportation technologies or the products of research projects. As time is of the essence for this group, information gathered from verbal briefings made by their staff, and concise pamphlets or newsletters are more efficient for this customer group. Members of this group stated that they were most familiar with the use of tools such as videos, conferences and seminars. It was also determined that, as a rule, this group prefers not to have to rely on detailed technical reports to obtain information. One comment made was that the perceived timeliness of information will affect whether or not these customers will make use of information provided to them.

3.2 Supervisors and administrative support personnel

The supervisors and administrative staff that were interviewed had various types of functions in the T^2 process. In some cases, similar to the policy makers, staff play an active role in T^2 activities in Minnesota by serving on various boards and committees under the auspices of Mn/DOT, FHWA, LRRB, and CTS. Members of this group may also play a role in identifying the general T^2 needs for personnel under their supervision. In addition, members of this group may be decision makers in terms of identifying which personnel will receive training. In many cases, members of this group work closely with the key policy makers.

For those supervisory personnel who are the end-users of T^2, rather than acting as T^2 agents, their working environment tends to vary by their position. Generally, they are out in the field less than

the technical and in-field personnel group, but more than the policy maker group. Interviewees reported that they are in an office environment between 70 and 100 percent of the time.

Accessing information does not prove to be a problem for most members of this group. It was determined that supervisors based in urban areas tend to find it easier to obtain access to newer technologies which will enable them to receive information, while in rural areas, a time lag in receiving up-to-date equipment is experienced. In some cases, however, it was reported that location is not the primary factor that determined what technologies were accessible, but rather the availability of resources.

The facilities that are available to this customer group differed between individuals. Personal computers and video viewing facilities are more common than electronic mail. Internet access and CD-ROM are only available to a small number of these customers. It was discovered that some users solve this problem by using resources at nearby universities and technical colleges. However, generally this particular group of users has more access to information on emerging technologies or practices using traditional means than other customers. Members of this group reported that they attend numerous conferences and seminars. They also directly receive many of the videos, trade journals, and newsletters which are distributed within their organization. Among the customer groups interviewed, members of this group tended to be the most informed about workshops and classroom training opportunities, both for themselves and for personnel under their supervision.

The preference for materials varied by the individual. Some customers reported that they preferred to learn about new technologies or practices by video, whereas others reported that they preferred printed materials, such as journals and newsletters. Generally, members of this group stated that they were familiar and comfortable with the use of all the established T^2 tools that are in common use.

Other members of this group are directly involved in performing T^2, their roles being to distribute information on new or existing technologies to end-users. In some cases, individuals directly

participate in research projects which will become the subject matter of T^2. In other cases, individuals have responsibility for collecting and distributing appropriate information. These individuals tend to be in an office environment for the majority of their time. Access to information occurs through individual contact, printed materials, video, audio, and the Internet and Wide World Wide Web. The technological facilities available to these users are current. They include Internet and e-mail access, PCs, video viewing facilities, and CD-ROM. The reported comfort levels with these T^2 tools is high throughout this group.

3.3 Technical personnel

The role of the interviewed technical personnel in the T^2 process is disseminating information to in-field, seasonal, and intern workers, and also, in some cases, ensuring that the research results, for example, are implemented. The information that this customer group receives has already been funneled through their immediate supervisor. These users reported that they operate in an office environment for the majority of their time, but the specific working environment is also dependent on the individual's position. Field engineers may spend approximately half of their time in the field, whereas a researcher may spend 100 percent of their time in a laboratory environment. As may be expected, technical personnel who spend more time with in-field personnel tend to spend more time in the field themselves.

Technical personnel reported that they most frequently access technology information in the form of newsletters, specifications, manuals, flyers, and yearly reports. In addition, the use of videos to learn about new materials or practices is commonplace. For more in-depth information, short courses and demonstrations are attended by this group. Some representatives of this customer group reported that they prefer receiving information in the form of printed materials as they can peruse these materials at their own discretion and leisure.

Technical personnel, in the office setting, have at their disposal the facilities that are now commonplace in most office settings. Telephones and computers are easily accessible. Most of the subjects interviewed reported that they had access to e-mail, and those who did not are

currently working to obtain e-mail facilities. In more rural locations, it was reported that tools such as email and access to the Internet are less commonplace, but that they are gradually being introduced. Video viewing facilities are generally easily accessible.

With regard to technical customers' comfort levels with the tools currently in use, and those tools currently being introduced, it was ascertained that this group tends to be very receptive to these tools and that they do not have significant problems acquiring familiarity with new T^2 tools.

3.4 In-field personnel and seasonal / intern workers

The function of the in-field personnel in the T^2 process is most often that of the end-user, or recipient. This customer group generally receives and accesses information concerning new or existing technologies channeled through their supervisors, such as field engineers and technical support staff. The information they receive is most often in the form of classroom training, workshops, videos, and selected text materials.

Members of this user group tend to be in the field for between 75 and 100 percent of the time. Although their working environment does place some constraints on the forms of T^2 that are most appropriate for this customer group, it was determined that the learning styles of this group may play a more significant role in what forms of T^2 will work best for them. In addition, differences in educational levels reached and individuals' work experience also affect what mechanisms are appropriate. Given that it may be difficult for members of this group to take time away from their in-field work locations to participate in T^2, in-field training - such as live demonstrations and circuit rider van activities - may be the most effective.

Local experience has shown that hands-on training and visual materials are better received than lengthy written materials. Presentations by peers are also well accepted. Although in-field personnel do not have access to personal computers and video viewing facilities out on a job site, they often have access to such facilities when based in an office environment during inclement

weather or during time dedicated to training activities. It was reported that in-field personnel are, for the most part, comfortable with the T^2 tools that are currently in use.

3.5 General perspectives

A general impression obtained from the interview process is that the various T^2 activities in Minnesota are widely embraced by subjects and they consider Minnesota to have a very valuable program. It was generally perceived that when T^2 efforts are able to take place in a coordinated manner across organizational, city, and county boundaries, redundancies are eliminated, resulting in resource savings. Interviewees' support both for research activities and the T^2 process in Minnesota is strong. Subjects stated that they considered Minnesota to be "head and shoulders" above other states when it comes to T^2. It was also suggested that a key factor in this success is the high priority accorded to T^2 within Minnesota and the levels of resources devoted to T^2 related research and dissemination.

Interviewees considered agencies in Minnesota to be successful in creating programs that are easily comprehended. Subjects referred to activities such as the Spring Maintenance Expo which showcases new equipment and reviews the progress of the previous year. T^2 in Minnesota was positively perceived as incorporating the efforts of different groups such as academia, private and public sectors. Interviewees commented that the methods of T^2 are evolving and improving, noting that the videos and workshops currently available have made the overall process more interesting. Subjects appreciated the fact that the program has included maintenance training and has not overemphasized training for management and engineering staff. In general, it is perceived that T^2 activities in Minnesota effectively meet the needs of the various customer groups.

Nevertheless, some concern over the future of T^2 in Minnesota was expressed. There were some concerns about the future funding for the Local Technical Assistance Program (LTAP) / T^2 program. Another concern registered was that the technology information pool is so vast, it can be overwhelming for those customers who receive the bulk of the information. Some customers stated that information can get "buried in the paper shuffle." It was reported that customers are

sometimes also not certain which agency has sent which materials. One comment on the process was that "the information loses impact when the end-user does not know who is telling them what." This feedback may indicate a need to target information dissemination more efficiently or to more clearly identify the source.

More advance notice of training sessions offered was a suggestion made by some interviewees, who noted that in some cases not enough notification of upcoming short courses is provided. It was commented that an individual may often learn about training opportunities by word of mouth, but unfortunately this often happens when it is too late to register for the training. It was also commented that it seemed as if different organizations offered similar courses at similar times. Customers stated that they could use more guidance as to which training opportunities are most appropriate for them, and which offer the best value for the money. It was also suggested that T^2 efforts should be promoted more at conferences in order to increase general awareness of the program.

Representatives of the in-field personnel customer group reported that they felt remote from the T^2 process, and that they felt they did not know enough about the T^2 possibilities and resources available to them. It was perceived that greater field personnel representation is needed at those meetings where T^2 decisions are made. It may be that for the T^2 efforts to be perceived as more beneficial to these customers, in-field personnel need a more clear personal understanding of their role in the process.

Another comment on the T^2 process was that more guidance could be provided to customers on how and where to look for information on transportation technologies or practices. It was felt that there is a need for some type of on-call information or advice facilities to be made available to customers, accompanied by an awareness campaign to publicize the service. Although the Minnesota T^2 activities were recognized as being very effective in providing information to customers, it was suggested that the rate of adoption of new transportation technologies and practices would be increased if continuing assistance was available to customers such that they

could ask for clarifications or for more in-depth information as they worked to implement the technology.

A general conclusion that could be drawn from these comments is that a greater emphasis on obtaining customer feedback on the effectiveness and appropriateness of Minnesota's T^2 activities through ongoing evaluation activities may be valuable. (Since the completion of these interviews, an effort has commenced in which T^2 customers throughout Minnesota are being surveyed to obtain feedback on existing T^2 tools' effectiveness and appropriateness.)

4. Next steps

The next step of the project, Task A-2, involves undertaking literature searches and a series of telephone interviews in order to identify and document those T^2 tools which are most appropriate for implementation in Minnesota, taking into account the overall needs and preferences of customers identified in Task A-1.

Throughout Task A-2, the focus of the investigations will be on the actual available or emerging T^2 tools and mechanisms, rather than any specific products, equipment or procedures. The needs identified previously will be important to help focus the search on those tools most applicable to Minnesota, and also to help ensure that the search is broad enough to address all the necessary issues.

APPENDIX C

Summary Tables

Table 1 Summary of Advantages and Disadvantages of Advanced T^2 Tools*

ADVANCED T^2 TOOLS	ADVANTAGES OF TOOL	DISADVANTAGES OF TOOL
Type 1 - Proven and current advanced tools		
Tool 1.1 Conference-based training	Depending on system, users may receive information in a variety of formats including audio, video, and electronic documents Allows geographically dispersed users to communicate Non-real-time conferencing can be flexibly accommodated into users' schedules Can reduce need to travel to a central location to participate in T^2	Systems provided by different vendors may not be compatible, so groups of users needing to communicate may be limited to a single vendor Quality of video and video / audio synchronization varies widely, which may be distracting to users High specification systems can be costly
Type 2 - Proven but under-utilized advanced tools		
Tool 2.1 Electronic bulletin boards	Facilitates "one to many" communication Can be inexpensive to establish, and the human resources required to perform systems administration functions can be low-cost if performed voluntarily Permits non-real-time communication, allowing users to participate at their convenience As age, race, and gender of participants is not necessarily revealed, may permit more open exchanges between users	To keep focussed on subject matter, adequate human resources need to be available to be able to devote sufficient time to monitor the discussion topics Bulletin boards may become inundated with postings making it hard for users to locate information of interest to them Appropriate balance needs to be achieved between a broad subject base and making information easy to locate Users are not guaranteed that they will find the information they require when they need it

* It should be noted that this table is intended to provide an overview of the advantages and disadvantages of the T^2 tools considered within the study. Readers should consider these summary comments in the context of the full tool descriptions contained in the body of the report.

Table 1 (continued) Summary of Advantages and Disadvantages of Advanced T^2 Tools*

ADVANCED T^2 TOOLS	ADVANTAGES OF TOOL	DISADVANTAGES OF TOOL
Type 2 - Proven but under-utilized advanced tools		
Tool 2.3 Self-guided tutorials	Users may access and use tutorials at their convenience, reducing scheduling conflicts Can reduce need to travel to a central location to participate in T^2 More advanced systems can be adaptable to a user's pace and method of learning Users may proceed through as much or as little material as is convenient for them at a given time	Users may experience isolation if self-guided learning is used to replace in-person training entirely This tool may not be appropriate for some types of training, such as teaching in-field, practical tasks This tool may preclude users from asking a trainer questions on related topics not covered by the self-guided tutorial, as is possible with in-person T^2
Tool 2.4 Electronic clearinghouses	Can offer variety of types of information on specialized topics Geographically dispersed users may access information Multiple users can access information simultaneously Information can be updated at a central location and made available immediately to many users, resulting in a very cost-effective means for distributing up-to-date information	Users accustomed to using paper-based resources may not immediately be comfortable with using electronic resources If facility is to remain credible and useful, dynamic information must be updated frequently

* It should be noted that this table is intended to provide an overview of the advantages and disadvantages of the T^2 tools considered within the study. Readers should consider these summary comments in the context of the full tool descriptions contained in the body of the report.

Table 1 (continued) Summary of Advantages and Disadvantages of Advanced T^2 Tools*

ADVANCED T^2 TOOLS	ADVANTAGES OF TOOL	DISADVANTAGES OF TOOL
Type 2 - Proven but under-utilized advanced tools		
Tool 2.5 "Listservs"	If users are familiar with e-mail, minimal training may be required Simplifies contacting a group of experts Users may access system at their convenience Geographically dispersed users may communicate	Electronic discussions may be disjointed due to e-mail arriving out of sequence Volume of incoming messages may become irritating if many are not pertinent to a subscriber's key interests Difficulties may be experienced in interpreting attachments in different formats Users are not guaranteed to receive a response to a query, or responses may not be offered in a timely manner
Tool 2.6 Newsgroups	With increasing competition between service providers, access costs can be expected to decrease Users may choose to play an observing or participatory role Geographically dispersed users may communicate Communications between users from different organizations and sectors, and across hierarchies, can be facilitated	Users are not guaranteed to receive a response to a query, or responses may not be offered in a timely manner Information received may be anecdotal, and may require further verification prior to its use
Tool 2.7 Electronic expert directories	Users can easily locate details of individuals with particular experience and knowledge Users can contact experts directly, rather than undertaking a multi-stage process for information requests	Experts in more popular fields may be inundated with requests for information, and may not be able or willing to respond to all requests The costs in implementing and maintaining the system may be high.

* It should be noted that this table is intended to provide an overview of the advantages and disadvantages of the T^2 tools considered within the study. Readers should consider these summary comments in the context of the full tool descriptions contained in the body of the report.

Table 1 (continued) Summary of Advantages and Disadvantages of Advanced T^2 Tools*

ADVANCED T^2 TOOLS	ADVANTAGES OF TOOL	DISADVANTAGES OF TOOL
Type 3 - Emerging advanced tools		
Tool 3.1 Virtual reality devices	As users "learn by doing", more effective learning of practical tasks may result Potentially hazardous tasks can be practiced in a safe, simulated environment VR can make training more stimulating for users, which may result in more effective learning	Some users experience a form of motion sickness when using immersive VR Not all tasks can be realistically simulated Training using VR systems needs to be augmented with training and practice in the real-world At present, VR systems can be very costly to develop, implement, and maintain
Tool 3.2 Real-time "in-field to help desk" systems	Information provided can be tailored in real-time to the context and the user's level of expertise Help-desk technician can help diagnose problems and suggest solutions based on images of the in-field scenario Training can be provided in a "just-in-time" manner, which may allow other T^2 programs to be streamlined Users may learn more effectively by solving problems in situ Problem-solving may take place more quickly as users can access expertise on demand	Communications required for this tool may be costly If demand by in-field personnel is high, the available technicians may not be able to fulfil this demand, and technicians would need to be made available at any time when their help may be required Extensive training may be required before users are at ease with the technology Wearing the headset for lengthy periods may become uncomfortable A large-number of in-field units may be needed to justify the cost of the help-desk As an emerging tool, costs may be prohibitive until economies of scale in production are achieved

* It should be noted that this table is intended to provide an overview of the advantages and disadvantages of the T^2 tools considered within the study. Readers should consider these summary comments in the context of the full tool descriptions contained in the body of the report.

Table 1 (continued) Summary of Advantages and Disadvantages of Advanced T^2 Tools*

ADVANCED T^2 TOOLS	ADVANTAGES OF TOOL	DISADVANTAGES OF TOOL
Type 3 - Emerging advanced tools		
Tool 3.3 Voice-responsive electronic databases	Users do not need keyboard skills Users can capture and retrieve data in real-time Hands-free operation enables users to perform other tasks simultaneously as appropriate Problem solving in the field may be achieved more quickly	As an emerging tool, costs may be prohibitive until economies of scale in production are achieved Users accustomed to problem-solving by human interaction may need to adjust to "trusting" information provided by a computerized tool In terms of the voice interface, users will need to learn the limitations of the tool, and how best to optimize its capabilities Given the current capabilities of speech recognition systems, users may have to repeat voice input, which could prove tiresome

* It should be noted that this table is intended to provide an overview of the advantages and disadvantages of the T^2 tools considered within the study. Readers should consider these summary comments in the context of the full tool descriptions contained in the body of the report.

Table 2 Summary of Applicability of Advanced T^2 Tools to Minnesota's T^2 Customer Groups*

ADVANCED T^2 TOOLS	T^2 CUSTOMER GROUPS			
	Policy makers	Supervisors / administrative	Technical	In-field / seasonal
Type 1 - Proven and current advanced tools				
Tool 1.1 Conference- based training	✔	✔	✔	✔
Type 2 - Proven but under-utilized advanced tools				
Tool 2.1 Electronic bulletin boards	✔	✔	✔	✔
Tool 2.2 Digital libraries	✔	✔	✔	
Tool 2.3 Self-guided tutorials	✔	✔	✔	✔
Tool 2.4 Electronic clearinghouses	✔	✔	✔	
Tool 2.5 "Listservs"	✔	✔	✔	
Tool 2.6 Newsgroups	✔	✔	✔	
Tool 2.7 Electronic expert directories	✔	✔	✔	✔
Type 3 - Emerging advanced tools				
Tool 3.1 Virtual reality devices	✔	✔	✔	✔
Tool 3.2 Real-time "in-field to help desk" systems			✔	✔
Tool 3.3 Voice-responsive electronic databases			✔	✔

* It should be noted that this table is intended to provide an overview of the potential applicability of the T^2 tools considered within the study to Minnesota's T^2 customer groups. Readers should consider this overview in the context of the in-depth information contained in the body of the report.