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ITS Decision Enhancements: Developing Case-Based Reasoning and Expert Systems and Incorporating New Material

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Publication Date

2004-10-01

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ITS Decision Enhancements: Developing Case-Based Reasoning and Expert Systems and Incorporating New Material

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**California PATH Research Report
UCB-ITS-PRR-2004-41**

This work was performed as part of the California PATH Program of the University of California, in cooperation with the State of California Business, Transportation, and Housing Agency, Department of Transportation; and the United States Department of Transportation, Federal Highway Administration.

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California. This report does not constitute a standard, specification, or regulation.

Final Report for Task Order 4140

October 2004

ISSN 1055-1425

ITS Decision Enhancements: Developing Case-Based Reasoning and Expert Systems and Incorporating New Material

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ACKNOWLEDGMENT

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The authors would like to express special thanks to Jennifer C. Lewis, University of North Carolina at Chapel Hill, whose work on Intelligent Transportation System contributed to some of the materials used in this report.

ITS Decision Enhancements: Developing Case-Based Reasoning and Expert Systems and Incorporating New Material

Abstract

The ITS Decision website has been developed for the user who is interested in learning about various Intelligent Transportation System (ITS) technologies. Two tools have been developed that will help those users who wish to address a specific problem, obtain information relating to their particular context. These are the Expert System and the Case Based Reasoning tools.

The Expert System tool queries the user on the problem context and the problem in general. It then presents information on different types of ITS technologies that may be used to address the problem.

The Case-Based Reasoning tool, at present, contains information about three technologies. One of these is a transportation demand management mechanism, specifically the employer based transit pass program. The other two are Automatic Vehicle Location/Computer Aided Dispatch, and Freeway Service Patrol. A user interested in using any of these technologies enters the parameters of his context, i.e. city size, fleet size, as response to queries. The tool then presents him with cases of different locations where the specific technology has been used. The cases are presented in order of their resemblance with the input parameters. The users could access more information on any of these cases by clicking on the hyperlink.

Although not a part of this project, a cost-benefit tool is also added to the website. On using the three tools sequentially, or as per requirement, a user gets a comprehensive view of the benefits or otherwise of using a specific ITS technology.

Keywords

Automatic Vehicle Location, Expert Systems, Freeway Service Patrol, Transportation Demand Management.

Executive Summary

In the attempts of planners and engineers to address transportation problems, they may consider conventional capacity improvement methods and/or deploy intelligent transportation systems (ITS). Instances of ITS being deployed to address transportation problems are employee pass programs, freeway service patrols (FSP) and advanced vehicle location & computer aided dispatch (AVL/CAD). These ITS solutions have various advantages. The advantage of freeway service patrols, for example, is that, they can be implemented in the short run and focus on responding to incidents, which cause 25% to 50% of the congestion problems in urban areas.

This project is intended to help planners and engineers make informed decisions regarding ITS technologies. The ITS Decision website is designed as a platform where most information about state-of-the-art ITS technologies is available in a relevant form. By relevant form, it is meant that the user can access the information she is seeking without having to sift through a lot of other irrelevant information. General information about ITS strategies may be obtained at the ITS Decision website using the Services & Technologies menu. For instance, the user can select FSP and obtain textual information about the nature and impacts of FSP. In addition, the ITS Decision offers tools to help planners and engineers find appropriate ITS actions for the transportation problem of their interest, and obtain more information about their performance.

The Expert System, embedded in the “Match ITS to your Needs” menu, asks about the problems that the planner or engineer is trying to address. Then, it diagnoses the problem and suggests ITS remedies. For instance, if the problem is incidents and induced congestion, then FSP and installing Variable Message Signs might be the suggested solutions. At this point, if the user is interested in the question “who else has used it,” then the Case-Based Reasoning tool becomes relevant. The user can match historical cases that are most similar and see the impacts (e.g., benefits and costs as well as qualitative information about the program). Communities often want to first look at whether a remedy is relevant to their situation and what has happened in cases when such systems were deployed. The expert system and case-based reasoning tools are meant to stimulate greater deployment of promising technologies in counties and localities that have not deployed such systems.

Although not part of this project, the tools lead to a final step of evaluating benefits and costs for ITS technologies using models. For instance, if the user is interested in AVL/CAD, then they can potentially use models to evaluate benefits and costs.

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1. Introduction

Intelligent Transportation Systems (ITS) are increasingly being used by transportation professionals as a solution to various transportation problems. From traffic signals centrally controlled by computers and electronic toll collection tags enabling drivers to pay without stopping at toll booths to changeable message signs giving information concerning the next bus, train or traffic conditions ahead and talking navigation systems that provide turn-by-turn directions through satellite technology, ITS has many applications.

Most major cities in the US now have an ITS program. However, ITS being a fairly recent technology, there is need for an organized database giving information about various technologies. While such information is widely available, it is often difficult to streamline to a specific context. To address this problem, Partners for Advanced Transit and Highways (PATH) and Center for Commercialization of ITS Technologies (CCIT) developed the ITS Decision website (<http://www.calccit.org/itsdecision/>) where information is made available to suit specific needs.

The objectives of this report are to:

- Describe the ITS Decision website.
- Document the addition of two important new tools, an expert system to help people determine what ITS services might be appropriate in their situations, and a case-based reasoning system to help them evaluate the benefits of such services.
- Provide a sense of future development needs.

These tools, as well as the information base now contained in the site, were first envisioned as part of the PLANiTS Project, which commenced in 1992.

1.1 Description of Website

In this website, material is organized at several levels of detail to suit various types of users. There are short summaries of ITS user services including what the service is, where it has been implemented, and what is known about its performance for. There are also full reports on each user service containing detailed information on implementation and performance. The on-line library contains electronic copies of reports and articles from leading ITS periodicals related to the service. This helps users by providing convenient access to publications that have been reviewed and judged to be useful. Links to related web sites are also provided.

The value that this website provides is in terms of rigorous screening of ITS information and clear descriptions of ITS technologies. The quality of ITS Decision is maintained by continual updating of existing material and addition of new topics as they emerge.

1.2 Motivation for Website

In 1995 PATH was overseeing all of the federal field operational tests of ITS in California. Out of concern that what was being learned about ITS in these and other field tests was not easily accessible to potential implementers, the idea of such a website was born. A decision was taken to design an information source that would describe ITS services, summarize what was known about their benefits and costs, and provide references to more detailed information.

There was substantial advocacy for ITS at the time. As such, there were reasons for apprehension that the over-enthusiasm might lead to unnecessary and incorrect use of ITS technologies. The aim of the website development was to provide objective, credible information. So where possible, there was a conscious effort to include information about *measured* benefits, costs and implementation experiences. When presenting findings, the implementation context was also presented, and any important shortcomings in the analysis, on which the findings are based, were proposed to be noted.

Further, because ITS is rapidly changing, the information has to be up-to-date. Also, it has to be easy to use. This meant having a good indexing system. There is also a conscious effort to provide information at different levels of detail for users with different needs. The policy maker might want only the highest level of information, while the researcher would want detail regarding evaluation methods, test conditions, and research findings. Naturally, our objective is that everyone who might be interested has the information.

The web provided a good medium: easy dissemination to a wide audience and convenience in keeping current material organized in multiple dimensions and in presenting at several levels of detail. It made it possible to handle large quantities of information without the medium becoming unwieldy.

1.3 Website Development

Work began on the site in late 1995. A part of the work was subcontracted to Dr. Asad Khattak at University of North Carolina, Chapel Hill, who, along with his graduate student Patrick McDonough developed the case based reasoning tool. The site initially went on-line in July 1996 with information on a few ITS services, a guest book, and a form for providing feedback from users. Since then, the site has gone through several major stages and reorganizations.

- In 1998 the name LEAP, learning from experience and analysis of projects was adopted and the layout, site structure, and indexing systems were designed and implemented.
- In 1999 the files were reorganized.
- In May 2000, the name was changed to ITS Decision. Graphics, file organization, navigation, cross-referencing, on-line library, and resources were re-designed.
- In October 2001, work began on the expert system to help users determine which ITS services and technologies would be useful in their circumstances and a case-

based reasoning system to help them estimate the effects of various services in their circumstances.

- In May 2003, ITS Decision was again re-designed following usability testing to improve graphics, navigation, file structure, cross referencing. The on-line library was put in a searchable database. The expert system was put on line. Further, the project responsibility moved from PATH to CCIT.
- In early 2004, the software migrated from the PATH server to the CCIT server.

1.4 Website Contents

Table 1 lists the various topics for which reports and summaries on ITS technologies are made available on the website, the URL being:

http://www.calccit.org/itsdecision/serv_and_tech/list.html

Table 1: Various ITS subjects dealt with in the website.

Archived Data	Traffic data collected over periods of time and in formats that can be used to manage and study existing transportation systems or to plan new ones.
Automatic Vehicle Location	Real-time remote tracking of vehicles using satellite or other telecommunications signals.
Carsharing	Automated scheduling and management system that gives multiple users access to shared vehicles (usually without keys) at different times and in different locations for a fee.
Collision Avoidance	Systems to warn drivers of dangerous situations or that take over operation of the vehicle either in part or completely.
Congestion Pricing	System that charges users more for use of a

	facility (usually a roadway) during congested periods and less for uncongested periods.
<u>Electronic Toll Collection</u>	Automatic, contactless collection of tolls using surveillance methods, usually radio or infrared tags and readers.
<u>Fare Payment Technologies</u>	System that allows transit riders to pay fares electronically.
<u>Freeway Service Patrol</u>	System that provides assistance in incident clearance.
<u>Freight Operations</u>	Automated vehicle location, surveillance, communications, sensor and scheduling systems that are applied to freight vehicles.
<u>Incident Management</u>	System of detection and clearance of incidents and management of the congestion they cause.
<u>Parking System Technologies</u>	Tell travelers about availability of parking spaces; some allow electronic, remote or electronic payment.
<u>Public Transit Technologies</u>	The use of some combination of automated vehicle location, advanced fare payment, traveler information and other technologies in a transit system.
<u>Ramp Metering</u>	Use of traffic signals at freeway on-ramps to control the rate of vehicles entering the freeway.
<u>Remote Emissions Sensing</u>	Sensors that instantly measure emissions of vehicles as they travel.
<u>Ridematching</u>	Automatic system that matches people wishing to carpool, according to origins, destinations and travel times.
<u>Rural ITS</u>	ITS technologies that meet the information, mobility, and safety needs of rural areas.

Safety	Automated warning systems that use sensors, communications and other advanced technologies (e.g. video image interpretation) to alert travelers to danger.
Telecommunications	The communications infrastructure connecting ITS technologies to one another. Includes a wide range of media, such as the Internet, fiber optic lines, satellite, microwave and radio.
Telecommuting	Working off-site, generally at home, and interacting with co-workers via telecommunications.
Traffic Management	Directing traffic flow using a range of technology applications; dispensing information to travelers based on data collected and analyzed on a continuous, real-time basis.
Traffic Signal Control	An interconnected, electronic system that controls a network of traffic signals.
Traffic Surveillance	Detection of vehicles' movements by means of sensors in or near the roadway or mounted in vehicles.
Travel Demand Management	Strategies that promote increased use of high occupancy vehicles and public transit.
Traveler Information	Pre-trip information about current or expected traffic conditions and en-route information regarding hazards, temporary travel restrictions, congestion, and route advice; can be available via broadcast media, the Web, phone or changeable signs.
Weather Applications	Surveillance and forecasting methods used to detect weather hazards and alert travelers affected by them or transportation managers

	required to respond to them.
Work Zones	Traffic management, traveler information and incident management applications used to enhance the safety of work zones.

1.4.1 Telecommunications overview, pop-up diagrams, glossary, and reports

http://www.calccit.org/itsdecision/serv_and_tech/Telecommunications/telecommunications_overview.html

Telecommunications are not an ITS service in themselves, but instead enable many ITS services. Therefore, they are treated differently. In addition to an overview of telecommunications used in ITS, a glossary of telecommunications terms, on-line reports on telecommunications, pop-up diagrams showing the telecommunications components, links, and information flows have been created for thirty-two different ITS services.

These pop-ups are at appropriate location in the text. A list of services with telecommunications pop-ups is at

http://www.calccit.org/itsdecision/serv_and_tech/Telecommunications/diagrams/telecommunications_diagrams.html . See a sample pop-up at

http://www.calccit.org/itsdecision/serv_and_tech/Telecommunications/diagrams/AVL%20GPS-based/avlgpsbased.htm.

1.4.2 On-line library

<http://database.calccit.org/itsdecision/>

As part of the 2000 re-design of the site, an on-line library was created. Reports and articles that the ITS Decision staff judged to be particularly useful were placed in an on-line library on the site. In many cases, these were directly accessible in electronic form from the ITS Decision site (this was the case for any PATH reports). In 2003 the library was placed in a database to make it searchable and easier to maintain.

1.4.3 Links

http://www.calccit.org/itsdecision/Links/gen_info.html

Since the site first began, we have included links to what we considered to be useful sites related to ITS. These have been checked and updated many times. We currently have six categories of ITS links: general information, architecture and standards, benefits and costs, research and publications, training, and major ITS organizations.

Table 2 and 3 contain the descriptions of these web sites that ITS Decision provides in its “Links” section.

Table 2: General ITS Information

<p>ITS Cooperative Deployment Network http://www.nawgits.com/icdn.html</p>	<p>A shared Internet resource containing up-to-date news and resources. Members of the cooperative include most leading organizations and associations concerned with deploying ITS in the U.S. Features include free monthly email newsletter, access to online discussions, a shared calendar of ITS-related events and a resources. Sponsored by the National Associations Working Group for ITS (NAWGITS) and the ITS Cooperative Deployment Network (ICDN).</p>
<p>USDOT Intelligent Transportation Systems http://www.its.dot.gov/v/</p>	<p>Comprehensive federal site with links to all USDOT ITS programs. Includes a hotline, links to major USDOT ITS initiatives and on-line documents and links. Sponsored by the USDOT ITS Joint Program Office.</p>

Table 3:ITS Benefits and Costs

<p>ITS Benefits Database http://www.benefitcost.its.dot.gov/its/benecost.nsf/ByLink/BenefitsHome</p>	<p>Information about benefits from ITS projects dating back to December 1994, collected by the USDOT's Joint Program Office for Intelligent Transportation Systems. Sponsored by the USDOT.</p>
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<p><u>ITS Unit Costs Database</u> http://www.benefitcost.its.dot.gov/its/benecost.nsf/ByLink/CostHome</p>	<p>Cost estimates for a set of ITS elements. These cost estimates are categorized as capital, and operating and maintenance (O&M) costs. Collected and developed by the USDOT's Joint Program Office for Intelligent Transportation Systems. Available in spreadsheet format. Updated periodically. Notification of updates can be arranged for.</p>
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These sites all link to each other and some of the same material is included in each, as it is in ITS Decision, but each is organized differently and serves a different purpose.

1.5 Continuous monitoring of ITS developments

ITS staff monitors the PATH database, the ITS newsgroups, the ITS publications, and transportation conferences and gathers information to keep the website current.

1.6 User communications and feedback

When the website was first launched, it included a guestbook and questionnaire to get feedback on the site. About 100 people responded. The feedback was generally positive. Users also sent questions and requests for additional information. These were answered. Later, as the novelty of the web wore off, users were less inclined to spend time on questionnaires or signing a guestbook. Another questionnaire was posted after the 2000 re-design. The response was minimal. As part of the project to develop the case-based reasoning system and expert system, a questionnaire was distributed to a large sample of Institute of Transportation Engineers (ITE) members by ITE, the administrators of which generously allowed ITS Decision to use its questionnaire software at no charge. The same questionnaire was emailed to a sample of Caltrans employees. The response rate in both cases was disappointing. However, because of the large sample, 46 responses were

received from the ITE survey. These responses indicated that the type of information on the site and the tools that were under development would be useful to users.

In 2002 the ITS Decision webmaster conducted a usability survey with 12 transportation engineering graduate students. This consisted of giving people who had not visited the site before, a few tasks to perform using the site. The steps they took to perform the task were recorded as well as the time each task took. Then they were asked some questions about the site. The test for each person lasted about ½hour. The feedback from this survey led to the re-design of the site in 2003. Before the new site was launched, six usability tests were conducted on the new site. These showed that the changes made to the site had corrected the problems with the earlier design.

1.7 Monitoring usage

Usage statistics on the site have been gathered since it began in 1996. They have been interrupted from time to time because the site moved to a different server. These usage reports allow us to see the domains from which our users come, the words that lead to the site, the referring sites, and other information helpful in determining how and how much the site is being used.

Figure 1 shows the number of distinct users that access the site each month and Figure 2 shows the ITS Decision request for pages. Because the website URL was changed with the re-design in May 2003, some of the external connections to the site, particularly those that linked to files within the site were lost and usage dropped. Usage remains low and is a source of concern. The problem appears to be that it is not being linked to from the major search engines, although there is a link to the site from the previous home page.

Material from ITS Decision was also used in developing the IDAS sketch-planning tool for ITS, and in developing the ITS Benefits module for LearnNet, the new distance learning system, for the Federal Government by the Technology Transfer Program of University of California's Institute of Transportation Studies.

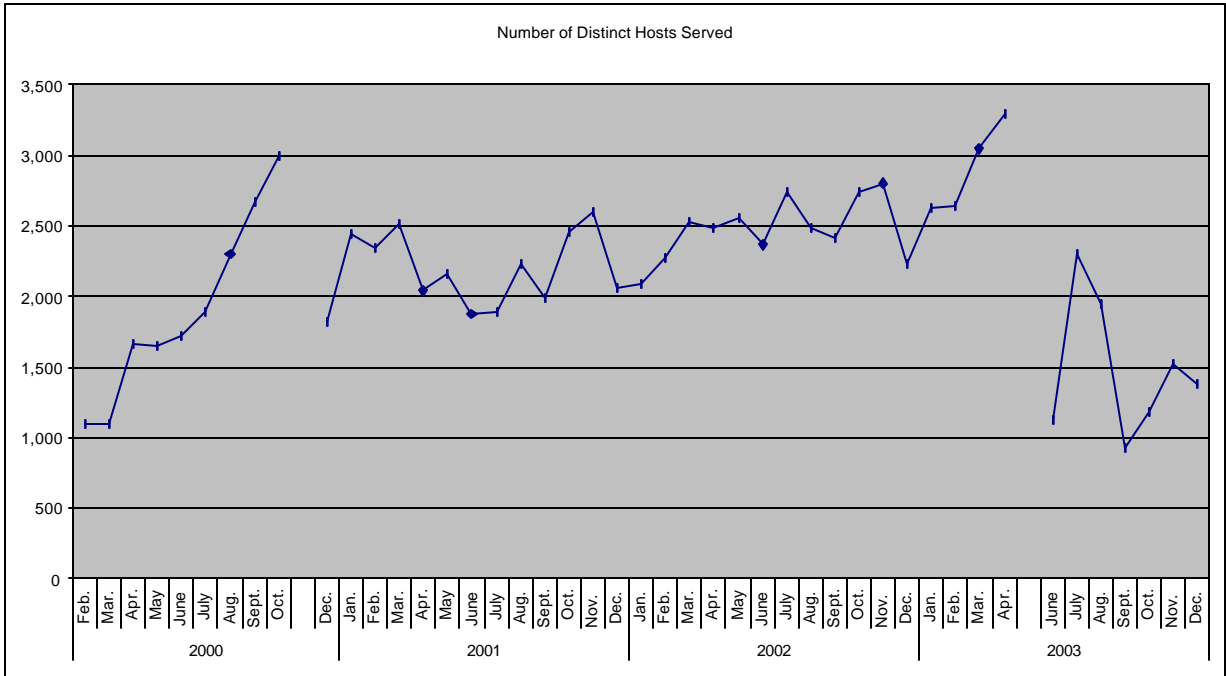


Figure 1: Number of distinct hosts served

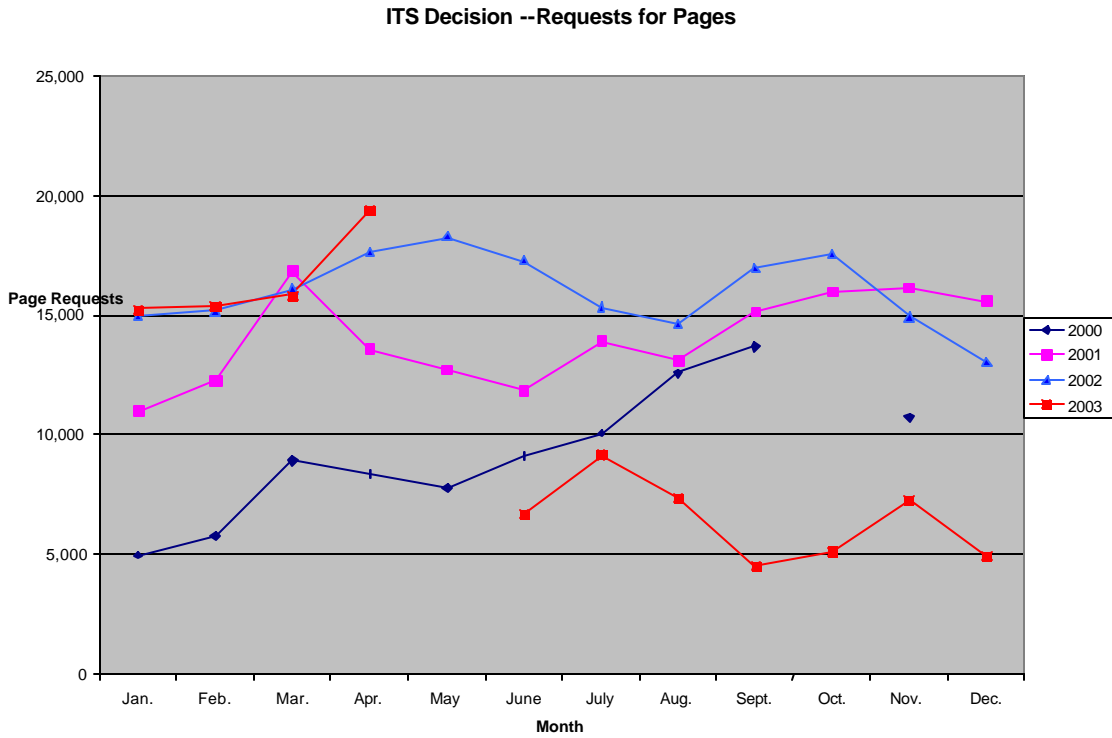


Figure 2: ITS Decision request for pages

1.8 Publicity

The site has been continuously promoted through distribution of brochures at meetings and conferences, sending of news releases to ITS Publications and websites, contacting search engines regarding the site, getting transportation websites to link to ITS Decision, and making presentations.

1.8.1 Brochures

The first LEAP brochure was produced in 1997. It has been updated approximately every year since. Brochures have been distributed at annual ITS America meetings, TRB meetings, CAATS meetings, PATH conferences, and other meetings and conferences. They are also made available to Caltrans and are distributed with other PATH materials. A batch of 500 brochures was printed in January 2004. The cost per brochure is roughly \$1.00.

1.8.2 Press releases

In 1999, press releases about the site were sent to various ITS publications and news groups. Press releases were sent after the 2000 re-design and again after the 2003 re-design.

1.8.3 Presentations

The site has been demonstrated at numerous PATH conferences and meetings and at a meeting for Caltrans employees in 2001. In January 2004, it was presented to the TRB Intelligent Transportation Systems Committee at the TRB Annual Meeting. The most recent presentation to Caltrans (June 17, 2004) has been included in Appendix C.

1.8.4 Contacts with search engines

Search engines have been contacted periodically over the course of the project to let them know about the site. After the 2003 re-design the new URL was submitted to Google and

Yahoo. The other search engines charge for listing a site, and are not as highly used. The positions on the search results shift from time to time and depend on the search criteria. This website appears first on a Google search for ITS Decision. One of the motivations for the subtitle “A gateway to understanding and applying Intelligent Transportation Systems” was to get Intelligent Transportation Systems into the title.

1.9 Results of Survey on Preferences for ITS Information

In May 2002 we conducted a survey of a large sample of ITE members using ITE survey software. There were 46 responses of which 56% were consultants and 36% were with city, county, state and federal transportation agencies. Fifty-six percent did traffic engineering, 15% planning, and 10% operations. Sixty percent had been involved in planning implementing or operating ITS, mostly in signal coordination and optimization and special event management. Sixty three percent generally thought of ITS when thinking how to address a particular transportation problem. Those who did not, said it was not applicable, it was too costly, or the technologies were not well understood. When considering implementing ITS, the questions that came to mind were how it works, how effective it is and how reliable. The factors that people thought were very important in judging if a particular ITS project should be undertaken were: how well it has worked (80%), cost-effectiveness (63%), funding sources (54%), public acceptance (46%), competition for funds (29%), political feasibility (24%), and who else has tried it (22%). The information they wanted about an ITS project in another area were: how well it worked (89% considered this information very important), implementation challenges (72%), technologies utilized (65%), characteristics of the area (50%), the implementation process (43%), how it was integrated with other areas or services (43%), who operates it (28%), and sources of funding (28%). When asked how useful they would find various website contents, 76% thought tools to help estimate the effects of particular ITS services in their area would be very useful, 63% favored information about specific ITS services and where they are appropriate, and 50% favored assistance in determining which ITS projects are likely to be appropriate in your area and 48% favored assistance in developing an ITS plan. Responses from the nine Caltrans respondents

were similar. The surveys generally confirmed that ITS Decision, with the “Match ITS to Your Needs” and the case-based reasoning systems (described in later sections) would provide the type of information potential users need.

1.10 Usability Surveys

The two usability surveys took a different form. In the first, 13 transportation graduate students were asked to perform 3 tasks:

- Task 1. If you wanted to find a full-length report on “Weather Detection,” how would you do that?
- Task 2. If you needed to find articles on “Safety,” where would you go?
- Task 3. If you wanted to find all the information available on our site about “Pre-trip Traveler Information,” how would you do that? Stop when you think you’ve found all of the available information.

The path they took and the number of steps needed were recorded. This allowed the surveyor to see which features of the site worked well and which did not. Many problems with the navigation and organization of the site were uncovered.

After the site re-design, a similar survey was conducted. People liked the graphics and the searchable on-line library, and found it much easier to navigate. Although they liked the idea, they found the two “Match ITS to Your Goals” and “Match ITS to Your Problems” sections confusing. As a result these were reorganized into a single “Match ITS to Your Needs” section and the presentation was improved.

1.11 Other ITS websites

As part of the re-design in 2003, ITS staff reviewed all the existing links on the ITS Decision site and all ITS sites located in a Google search. None digested the information as ITS Decision does. None described services and technologies and summarized what is known about how they perform.

The ITS Cooperative Deployment Network site is very informative, with news and a forum on various ITS topics. The newsletter section has a search function, but if “ramp meters” is given as an input for example, nine matches are obtained. The matches include items under the headings discussion, deployment, now on-line, breaking news etc.

The USDOT ITS site is big. Its problem is its large size and corresponding lack of focus. It has links to publications on ITS, maps showing what ITS elements are implemented where, news, speeches, and a search function. A search for ‘ramp meters’ returns 236 records, and an additional 1195 records for ‘ramp’ and 7036 records for ‘meters’. The entries were barely legible. When one clicks on the first, one gets the ITS Benefits Database.

The ITS Benefits and Unit Cost Database is very well organized. It is a good place to go for costs. The benefits are organized by application.

1.12 Enhancing Quality by Adding New Topics and Updating Content

As the pace of implementation increases, there is both more information available regarding ITS and more interest in such information. For example, telecommunications has emerged as a key technology for ITS implementation. ITS has expanded to include weather sensing and use of archived ITS data. We have responded by updating the website to include these topics.

In addition to periodic updates, we have also updated sections whenever important new information became available. Now most ITS information is available on the web, so new reports and articles have been added to the ITS Decision on-line library. In order to ensure that ITS Decision contains the most current information a few steps have been taken:

- 1) a monthly review of the ITS magazines and journals, the PATH database, the various ITS web sites, ITS-related newsgroup postings, and new PATH reports have been conducted to obtain material for updating ITS Decision and

2) New ITS information have been actively sought out at conferences and in all discussions

We have continued to be selective in what we include in ITS Decision, both to assure high quality and to save users the time of sifting through repetitive and marginally useful information. To maintain its value, the site has been and also must be, kept current by people who understand ITS, who can evaluate it objectively, and who can present information effectively.

1.13 Adding Decision Support Tools: Expert Systems & Case-Based Reasoning

In the past years, we have added two important new tools, an expert system to help users determine what ITS services might be appropriate in their situations, and a the case-based reasoning system helps determine how such services were implemented and how well they performed in similar circumstances.

These tools, as well as the information base now contained in the site, were first envisioned as part of the PLANiTS Project. The following subsections gives a schematic description of the PLANiTS project before describing the two tools in detail in the next section.

1.13.1 The PLANiTS Project

The PLANiTS concept was a computer-based tool for planning and analysis of ITS actions (Figure 1.3) that was developed by PATH in 1993-1995. PLANiTS (Planning and Analysis Integration for Intelligent Transportation Systems) was intended to facilitate the deployment of ITS actions by providing tools to evaluate the impacts of various ITS actions. At that time, experience with ITS was limited and the Internet was limited largely to universities and defense establishments. As such, it was not possible to fully implement PLANiTS, and only simple prototypes were developed.

PATH's ITS Decision web site, which first went online in July 1996, was partly inspired by the PLANiTS concept and constituted the information base that would be included in

PLANiTS. Since then, much experience has been gained with ITS, and this experience has been analyzed, summarized, organized and made available to the public on this web site. ITS Decision now contains not only this information base, but also three other PLANiTS elements, a catalogue of ITS actions, as identified in the National ITS Architecture, and goals of the transportation system, as defined by PATH and by the California Transportation Commission.

The PLANiTS Concept

Figure 3 shows the PLANiTS components, which are described in the following paragraphs. Italics indicate focus areas for the proposed project.

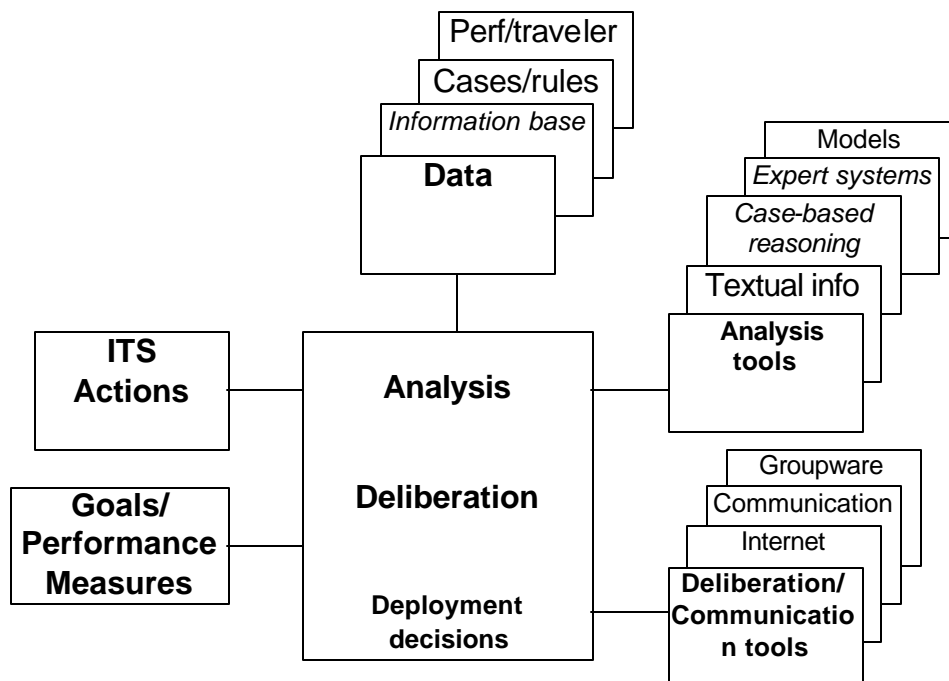


Figure 3: The PLANiTS concept

ITS Actions and Goals/Performance

PLANiTS has an action base that contains information about implementable ITS actions; and a goals/performance base that contains performance measures/goals for a particular

area. ITS Decision already contains the action base and an overall goals/performance base. The PLANiTS process starts by identifying the problem (traffic congestion, safety, etc.) and then identifying appropriate ITS actions/solutions or taking a particular ITS technology (e.g., electronic toll collection, freeway service patrol) and finding the appropriate implementation context. Users can also obtain information about ITS technologies and impacts if they are not sure about the problems or ITS solutions. This is the function of the Expert System.

Data

The data in the PLANiTS database consists of a database, a case base, and an expert base. The ITS Decision already contains evaluations, research reports and distilled knowledge about the performance of ITS actions implemented in real-life situations. This project will update and expand the case base for freeway service patrols, automatic vehicle location and computer aided dispatch systems for transit. In addition, to appeal to planners and demonstrate the flexibility of the method, we have added an employee pass program case-base.

Deliberation/Communications Tools

Though an important component of the original PLANiTS methodology, we will not focus on the stakeholder deliberation and communication aspects of the methodology. Rather the overall thrust of this research effort is to help potential implementers and technology vendors access and evaluate relevant ITS actions in terms of performance measures within specific real-life contexts.

The two tools, expert system and case-based reasoning, added to the website based on the concept of PLANiTS are described in the following sections.

2. Expert System

The expert system is a rule-based diagnostic and assistive tool that provides intelligent advice. Currently, the user may access the expert system from the following perspective.

- The user may be looking for ways to address a particular problem. In this case the system asks questions about the problem and its environment. It then presents the user with alternative actions to mitigate the problem, helps the user determine which actions should be studied further and what information will be needed.

The expert system developed in this research functions as the gateway to the case-based reasoning system, playing much the same role as a human consultant who is trying to determine the needs and goals of the client and to match these with an effective course of action. It includes a series of questions and responses designed to clarify the users' needs and quickly lead him or her to courses of action that warrant further investigation. The diagram on the following page illustrates how the system works. The boxes with dashed outlines indicate how the different elements of the system are combined to produce the expert system output.

In developing the system, users of the ITS Decision website and potential users have been surveyed to determine their information needs and develop the “if then” rule structure. In order to discover efficient methods of eliciting information, websites that have systems to help users choose a particular service or product, out of a large number that are offered, have also been surveyed.

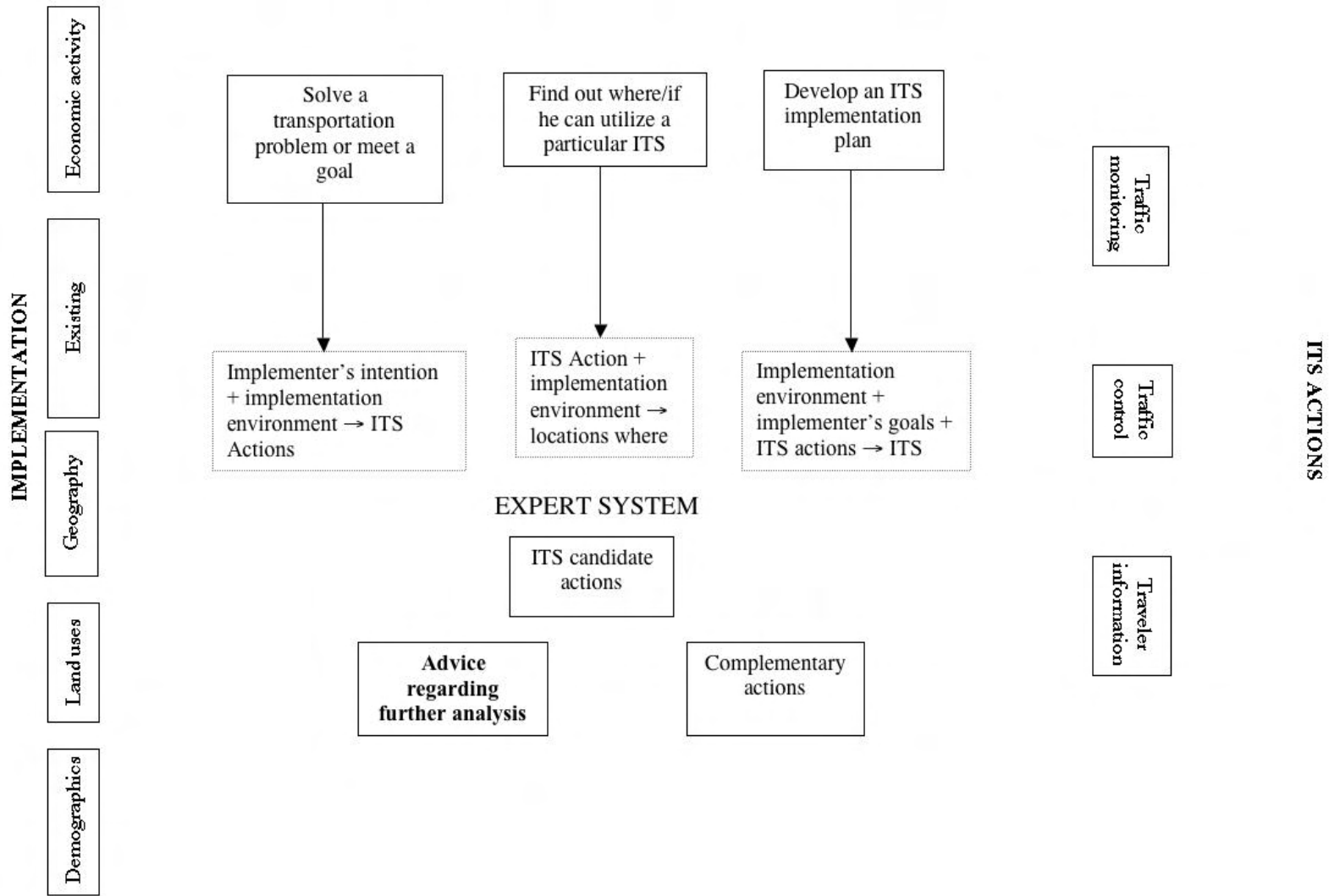
Given that ITS actions must compete with conventional improvements for funding, it is important to educate potential implementers about synergies between conventional and ITS actions. For example, a freeway widening may also include surveillance and information technologies, e.g., video surveillance and changeable message signs.

The expert system can be accessed at the URL:

http://www.calccit.org/itsdecision/Match_Needs/mainmatchpage.htm

This is the “Match ITS to Your Needs” section of the website. Based on the PLANiTS idea of finding the right action for the environment and problem, the “Match ITS to Your Needs” page first asks the user about the environment in which he/she plans to implement ITS. Then it asks for the needs the user wishes to address. Then the site tells the user what information should be collected and based on the information, which ITS services would be useful. Figure 4 gives a schematic representation of the functioning of the expert system.

Figure 4: How the Expert System will work



On clicking Match ITS to your needs, the URL

http://www.calccit.org/itsdecision/Match_Needs/mainmatchpage.htm

takes the user to the following webpage displayed in Figure 5.

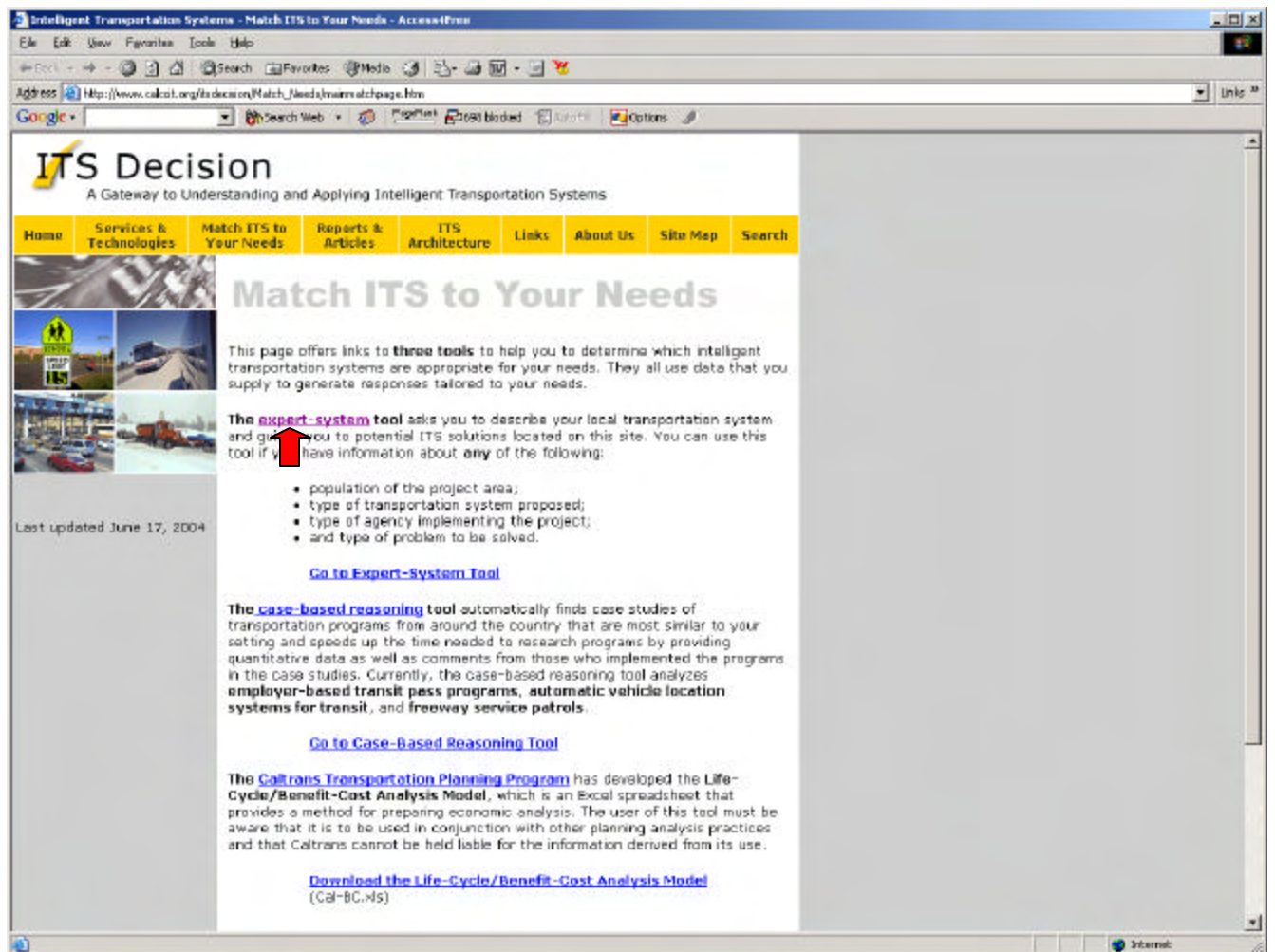


Figure 5: Match ITS to your needs webpage

The 'expert-system' tool hyperlink as highlighted with the red arrow takes the user to an explanation of the expert system tool at the URL

http://www.calccit.org/itsdecision/Expert_System/expertexplain.htm

The 'Go to Expert-System Tool' takes the user to the tool itself at the URL³.

http://www.calccit.org/itsdecision/Expert_System/newexperttool.htm

Figure 6 displays a screen shot of the webpage containing the expert system tool.

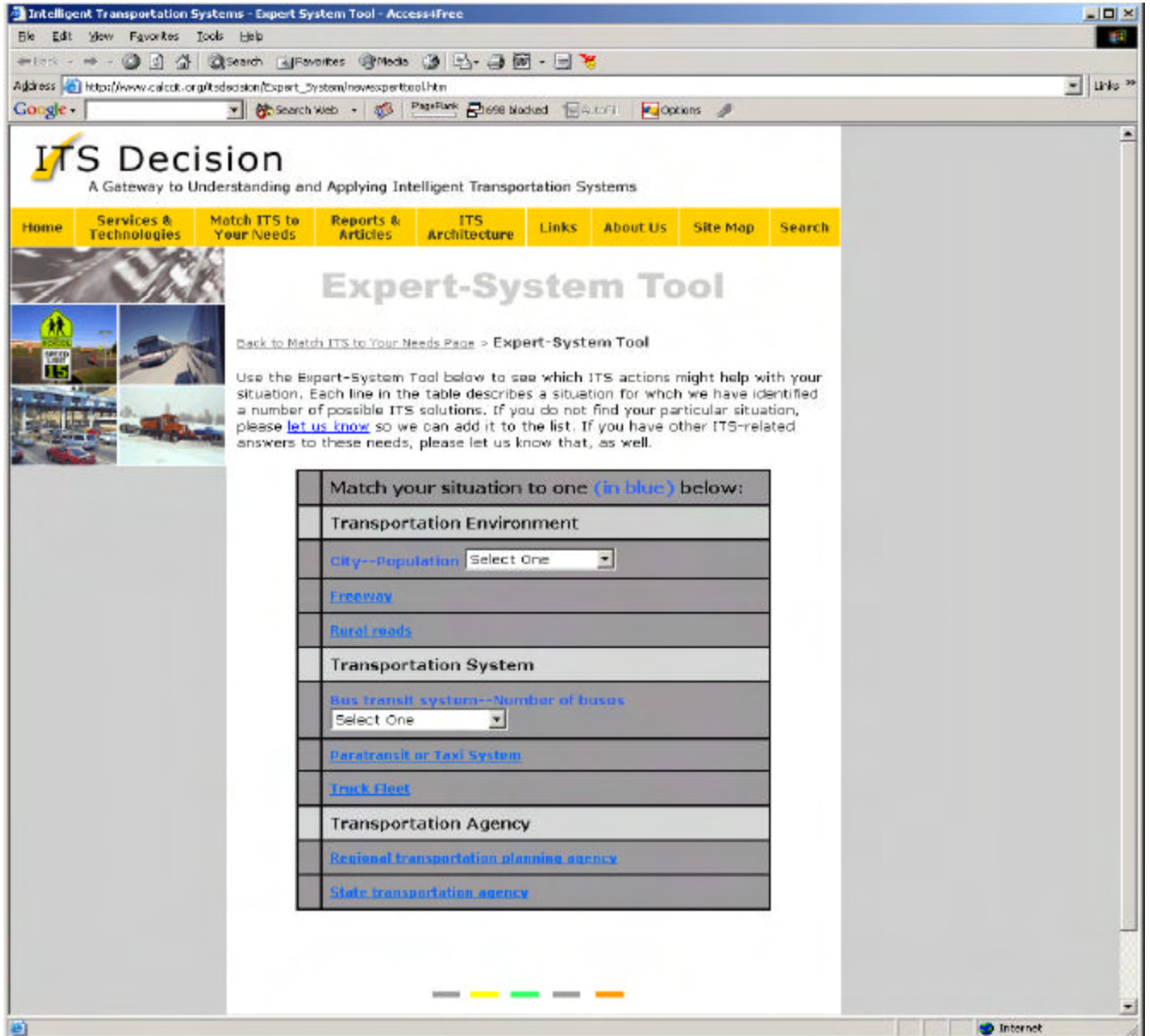


Figure 6: Expert System Tool

Through this interface, the interface queries the user on whether the area of concern relates to one of the following three alternatives:

transportation environment, for instance, a city of a certain population (less than 50000, 50000 - 499999, greater than 500000), freeway or rural roads,

transportation system, for instance, a bus transit system of a certain fleet size (less than 25, 25-199, 200-499, more than 500 buses), paratransit or taxi system or truck fleet,

transportation agency, for instance regional transportation planning agency and state transportation agency.

If the user selects the alternative ‘city, population 50000-499999’, she is taken to the subsequent webpage where she is asked to choose the problem that she would like to address. The options given are ‘reduce congestion, reduce accidents, improve traveler information, improve information for planning and operations, improve transit and increase mobility for people without cars.’

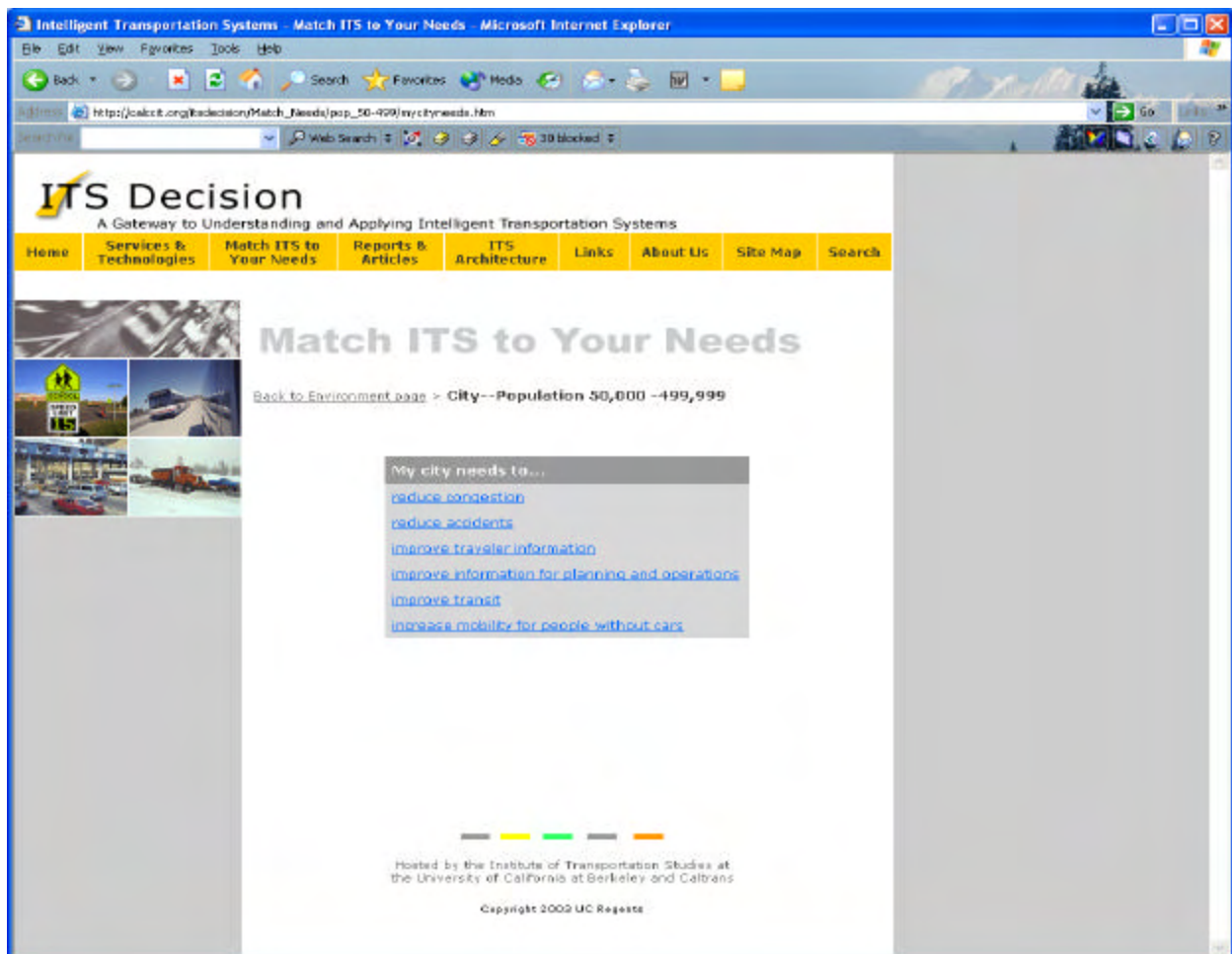


Figure 7: Solution options

Clicking on any of the options leads to WebPages that describe all possible ITS solutions for the problem at hand. 'Improve traveler information' for instance, displays the webpage shown in Figure 8.

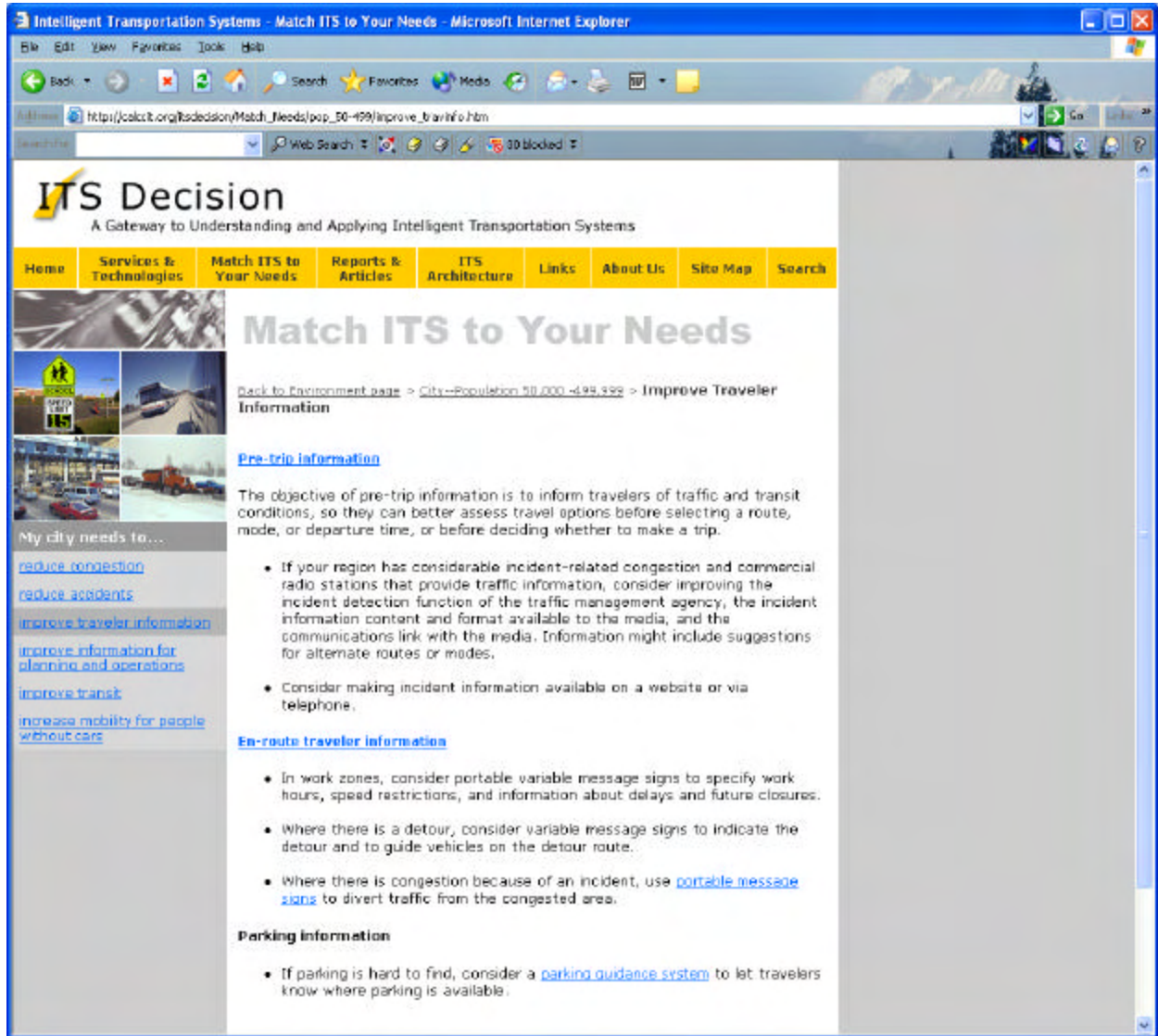


Figure 8: 'Improve Traveler Information' option

Clicking on any of the hyperlinks on this page, takes the user to containing detailed information about the technology. The hyperlink 'pre-trip information', for instance, takes the user to the webpage shown in Figure 9.

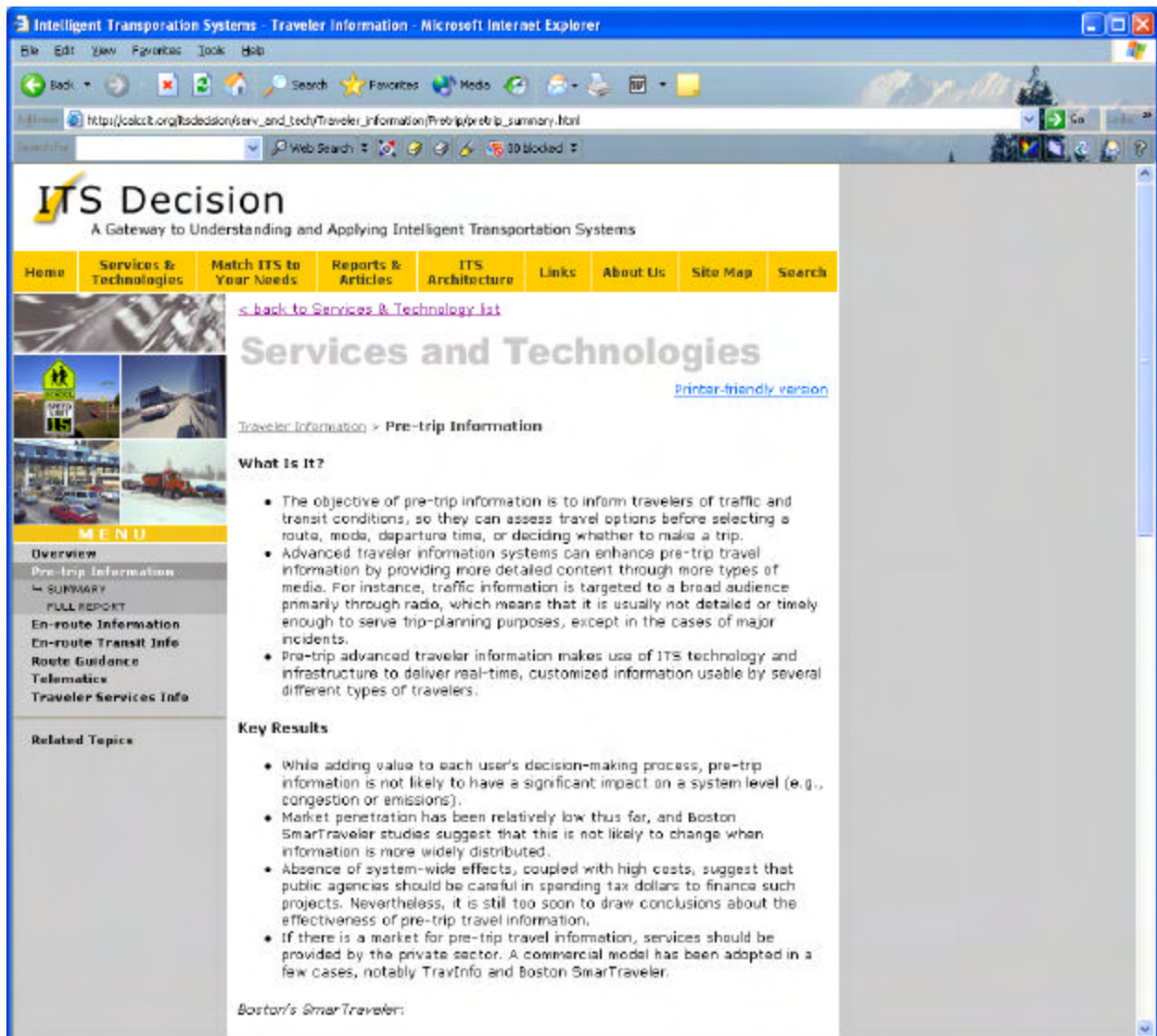


Figure 9: 'Pre-trip information'

3. Case-Based Reasoning

After identifying a particular ITS action by using the ITS expert system, users are often interested in questions like “who else has used it, what were the impacts and what was learnt?” More generally, Case-Based Reasoning (CBR) is a decision making method used by human beings throughout their daily lives. Wangenheim describes CBR as “...based on a model of human cognition dealing with knowledge in form of concrete experienced examples”(Wangenheim 2000). Janet Kolodner describes CBR as drawing on previous experiences and “adapting old solutions to meet new demands,” and points out numerous examples in society, such as lawyers relying on other cases for precedent, and doctors making diagnoses based on the similarity of symptoms to those seen in past patients to aid someone currently in their office (Kolodner 1993). Whether they describe it as such or not, CBR is also used every day by transportation planners and public officials who try to make decisions by drawing on their previous experiences. Therefore, to summarize, CBR is:

- A decision-making process that focuses on the similarity of a present problem to one or more specific problems that were solved in the past
- A process that does not necessarily rely on measures of central tendency, such as averages, standard deviations, and medians, but also provides the qualitative case context
- A process that informs decision-makers by examining the context and richness of individual cases from the past
- A familiar process that is a normal, intuitive method of decision-making for humans in everyday life

3.1 Case-Based Reasoning, Planning, and Case Quality

Khattak and Kanafani previously described the process by which CBR could be used for planning processes. Their 1996 paper discusses how a CBR system for transportation planning could be focused around what they call the *Planning Vector*, which is further divided into the *Action Vector*, containing the proposed actions that are being considered in the planning process, the *Criteria Vector*, containing the performance measures to track progress towards the goals

sought by the actions, and the *Environment Vector*, containing information about the context that is pertinent to the subject actions and the impact of the actions (Khattak and Kanafani 1996). Khattak and Kanafani point out that with new technologies or planning ideas, such as recent developments in Intelligent Transportation Systems, it is often difficult to find quality data that can be objectively measured and compared to other cases. This is the case in the TDM field as well. TCRP Web Document 22 points out that virtually all the transit agencies interviewed for their study cited a significant lack of information on true program effectiveness (COMSIS 2003). This means that while it is relatively easy to contemplate potential actions for the *Action Vector*, or gather data about an existing context (city size, number of miles of existing freeways, buses operating in peak service, etc.) for the *Environment Vector*, it is often the *Criteria Vector* which is the weakest of the three in planning scenarios. Khattak and Kanafani point out that in light of such limitations and variations in data, it may be important to assign cases a quality variable, to let CBR system users know that some cases that were entered into a CBR system may have come from more rigorous studies, or a data source with greater credibility. As CBR systems grow, data-gathering methods can be refined to ensure that new cases added to the system are more likely to be high in quality, and therefore, of higher potential relevance to user input to the system.

3.1.1 Limits of Case-Based Reasoning

Amen and Vomacka clearly state what CBR *cannot* do in a paper discussing the suitability of CBR for materials selection in steel treatments. In particular, they point out that a CBR system has no optimizing functionality to perform on data, and neither creates nor refines data. It is used for searching and not calculation, though additional functionality could be added to a CBR system to make this possible. Furthermore, CBR systems may identify similarities but not reasons, and can theorize about how cases are related, but cannot fathom why (Amen and Vomacka 2000).

Another issue in developing CBR systems is what is known as “the inseparability problem.” This occurs when two existing cases in the case base, when compared to the input scenario, produce identical similarity scores because they possess identical values for the attributes that are evaluated. While this is a greater problem in applications where there is often one correct

answer, such as in an application that recommends strategy for a corporate computer support desk, the inseparability problem can easily appear in the evaluation of transportation projects and policies as well. One common source of inseparability problems is when cases have missing values or incomplete information. David McSherry effectively explains this problem: “If two cases differ only in the value of an attribute whose value is missing in both cases, the two cases are rendered inseparable by the missing values. On the other hand, two cases that would otherwise be inseparable will lose this status if one has a missing value for a attribute for which the other has a known value” (McSherry 2000). In a CBR system with very limited data, the likelihood of the inseparability problem occurring is higher. If one imagines a hypothetical CBR system that calculates similarity based on three variables, with all three being nominal, and not scalar variables, the potential for identical scores can be quite high. If a CBR system returns the ten most relevant results from such a system and seven of the ten have identical similarity scores, this is not a very helpful system to the user. Adding more variables to the logic that determines similarity is the most efficient way to minimize this problem.

3.1.2 CBR versus other database systems

One benefit of CBR systems is that they are not susceptible to some of the flaws of relational database systems, such as bringing back infinitely huge numbers of results for a query, or zero results for a minor refinement of the same query (Amen and Vomacka 2000). Since a CBR system retrieves results based on similarity, whether the system processes 100 or 10,000 cases, the system will always present the most relevant results first.

3.1.3 Learning Abilities of CBR Systems

One researcher developed a CBR system used to evaluate direct marketing strategies. This system has a module that allows it to “learn” about the effectiveness of individual marketing strategies by allowing the users of the CBR system to validate whether or not the strategy deemed most relevant by the CBR system was helpful in the sales process. Using the feedback from users, Chiu’s system employed a Genetic Algorithm (GA) approach to adjust the weights of factors used in the CBR similarity calculations based on the historical data of many users selecting cases. In the GA-CBR system, the tool is constantly re-classifying the weights of the

attributes in the database based on the historical responses of the tool's users. As the system is used, and users rank the quality of the solutions they receive, the software determines which attributes in the data are most highly correlated with high user rankings, and adjusts the attribute weights accordingly. In turn, the solutions that are rated highly by the users return to the case base with greater relevance scores, and become new cases that can enter the process as well. This may or may not undermine the expert judgments filtered into the system in applications that seek a result more complicated than the sale of insurance, but this is not addressed in Chiu's paper (Chiu 2002). For transportation planning CBR systems that evaluate policies such as pass programs, it is difficult for such a system to learn in a way that is useful to the user, as the time to implement solutions proposed by the system may take months or years to provide observable results.

3.2 Case Studies

The three major types of case studies included in the tool are described in the following section. The case studies included at present include the employee pass program, the freeway service patrol (FSP), automatic vehicle location & computer aided dispatch (AVL/CAD). The case-based reasoning tool provides structured and organized information about relevant historical cases to potential implementers. It is on the Internet, initially to facilitate decisions regarding ITS.

Given that several historical cases exist (and many are documented at the PATH-supported ITS Decision website), users can use the tool to select historical cases *relevant* to their situations.

3.2.1 Employee Pass Program

In the employee pass program, transit passes are issued to employees by the employer. Some employers re-imburse the cost of transit. Others participate in the transit pass program and arrange for the transit passes to be provided on-site at the work place.

What are the kinds of success that have occurred due to this program, and how have they been achieved? The answer to that lies in the work of Fitzroy and Smith, who found, in 1998, that the introduction of an unlimited travel pass with regional validity was the principal reason that the number of public transit trips in Freiburg, Germany doubled in the decade from 1984 to 1994

(FitzRoy and Smith 1998). Interviews by Conklin et al found that Tri-Met's "Passport" program increased transit ridership at participating employers by 57% after the first year of program operation (Conklin et al. 2002). An evaluation of the UPASS program at the University of Wisconsin showed a 31% to 45% increase in transit ridership after the introduction of the UPASS on campus. At the same time, the percentage of students driving to the university decreased from 54% to approximately 40% (Meyer and Beimborn, 1996).

Beyond their proven success, the most compelling aspects of employer-based transit pass programs are the speed with which they can be implemented, the wide number of people who can be introduced to transit through a single institution, and the low costs compared to expensive and time-consuming capacity enhancements. The next section explores how pass programs achieve the results mentioned in the previous paragraph.

How Employer-Based Transit Pass Programs Work

The employer-based transit pass programs have an institutional focus. Depending on the local regulatory environment, the program may be part of a regulation. But more likely participation in employer-based pass programs is voluntary. This is because governments sometimes mandate comprehensive trip reduction programs, and allow employers to choose which TDM strategies to use to reach trip reduction goals. Of the 30 employers surveyed in this study, only 4 have mandated trip reduction programs.

Costs and Benefits of Employer Pass Programs

Two types of benefits accrue from the successful implementation of an employer pass program: those that are individual and societal benefits of higher transit use, and those that are specific to the stakeholders and participants in the employer pass program. Typical transit-related benefits that occur may include less congestion and pollution near and at the employer site, as well as reductions in regional congestion and pollution problems, since work commute trips comprise the lion's share of peak period travel. Participating employees enjoy more transportation alternatives, gain the opportunity to read, work or relax while commuting, and save money on personal transportation costs by not driving.

Benefits that are more closely tied to the employer-based pass program can be further subdivided into employer and employee benefits. Employers can benefit by reducing their parking costs, or by allotting more spaces at the worksite for their customers. Transit benefits with a financial component also can improve company morale and employee retention, which was another of Shoup's findings in his Parking Cash-Out study (Shoup 1997). Additionally, two of the respondents to the survey for this project mentioned employee retention as a program benefit. One of them is quoted below:

“I spoke with the administrator from this company [Catholic Charities of Buffalo, NY] and she stated that this [their employee transit pass program] has had a very positive impact on employee retention due to the fact that over twenty percent of the employees are disabled and rely on our transit system for transportation. The program has a tremendous cost savings effect for the employees who participate.” – Geri Ratchuk, Niagara Frontier Transportation Authority

The respondent from the Downtown Denver Partnership also reported that one of the reasons it was convinced to implement a pass program was to raise their ability to retain employees. In some cases, employees purchasing monthly transit fare media with pre-tax dollars can lower employees' taxable income, which may also lower human resource costs for employers who pay a matching contribution in a 401k or other retirement plan based on a percentage of employees' salary. Employees receive increased travel alternatives and save money by not driving, not to mention reducing stress. Also, if the passes are not limited to peak period travel, the employee can use the pass at other times and gain additional utility for travel on weekends or at night. On the cost side, most travelers experience longer In-Vehicle Travel Time (IVTT) and Out of Vehicle Travel Time (OVTT) by switching to transit. Also, in cases where there is not a Guaranteed Ride Home program, they may lose flexibility to access certain destinations not served by transit in the middle of the workday. Tables 4 and 5 show the costs and benefits of switching from driving alone to using a transit pass, either as an individual or through an employer-based program (Littman 2003).

Table 4: Costs and Benefits of Switching to Individual Transit Pass

Switch to Pass for Individual	Benefit or Cost?
Likely IVTT Increase	Cost
Likely OVTT Increase	Cost
Lower Personal Travel Costs	Benefit
Loss of Flexibility for Midday Travel	Cost
Added Utility of IVTT	Benefit
Less Stress	Benefit
Purchase Full Price Pass	Cost
Must Visit Vendor Monthly	Cost

Table 5: Costs and Benefits of Switching to Employer-Based Pass

Switch to Employer-Based Pass	Benefit or Cost?
Likely IVTT Increase	Cost
Likely OVTT Increase	Cost
Lower Personal Travel Costs	Benefit
Guaranteed Ride Home Midday	Benefit
Added Utility of IVTT	Benefit
Less Stress	Benefit
Potential Discounted or Subsidized Pass	Benefit
Can Purchase Pass at Work	Benefit
Potential for Pre-Tax Deduction	Benefit

Barriers that Prevent Wider Adoption of Employer Pass Programs

Many employers perceive implementing a pass program to be a hassle, and unless participation in such a program is required, they will not participate. It is hard to convince employers who would prefer to focus on their business that they should start participating in a program that takes time and money to implement, but has no clear effect on their bottom line.

In 2001, Grant et al. found that some employers perceived selling passes at their worksite to raise program administration costs, and were more likely to participate if there were convenient offsite locations for employees to purchase passes that did not add the burden of any additional tasks to their human resources staff (Grant, Ecola, and Schroeer 2001).

A recent TCRP report found that unless monitoring of a pass program is mandated, very few employers or Transportation Demand Management planners are accurately tracking program impacts. Additionally, the report found that most goal-setting in regard to TDM programs is derived from public agency, and not employer goals. Employers seek guidance and find case studies and transportation coordinator training very helpful in implementing programs and understanding their value. This was found to be particularly true in areas that have ordinances mandating certain behaviors from employers, who want to remain in compliance (COMSIS 2003).

These studies and many more confirm the success of the employee pass program. Appendix A contains the details of the data collection and preliminary findings for the employee pass program. Appendix B contains the details of the development of evaluation logic.

Implementing Employee Pass Program

The user of this tool may first develop some concept about case-based reasoning by reading about it in the website. The introductory page of CBR is shown in Figure 10.

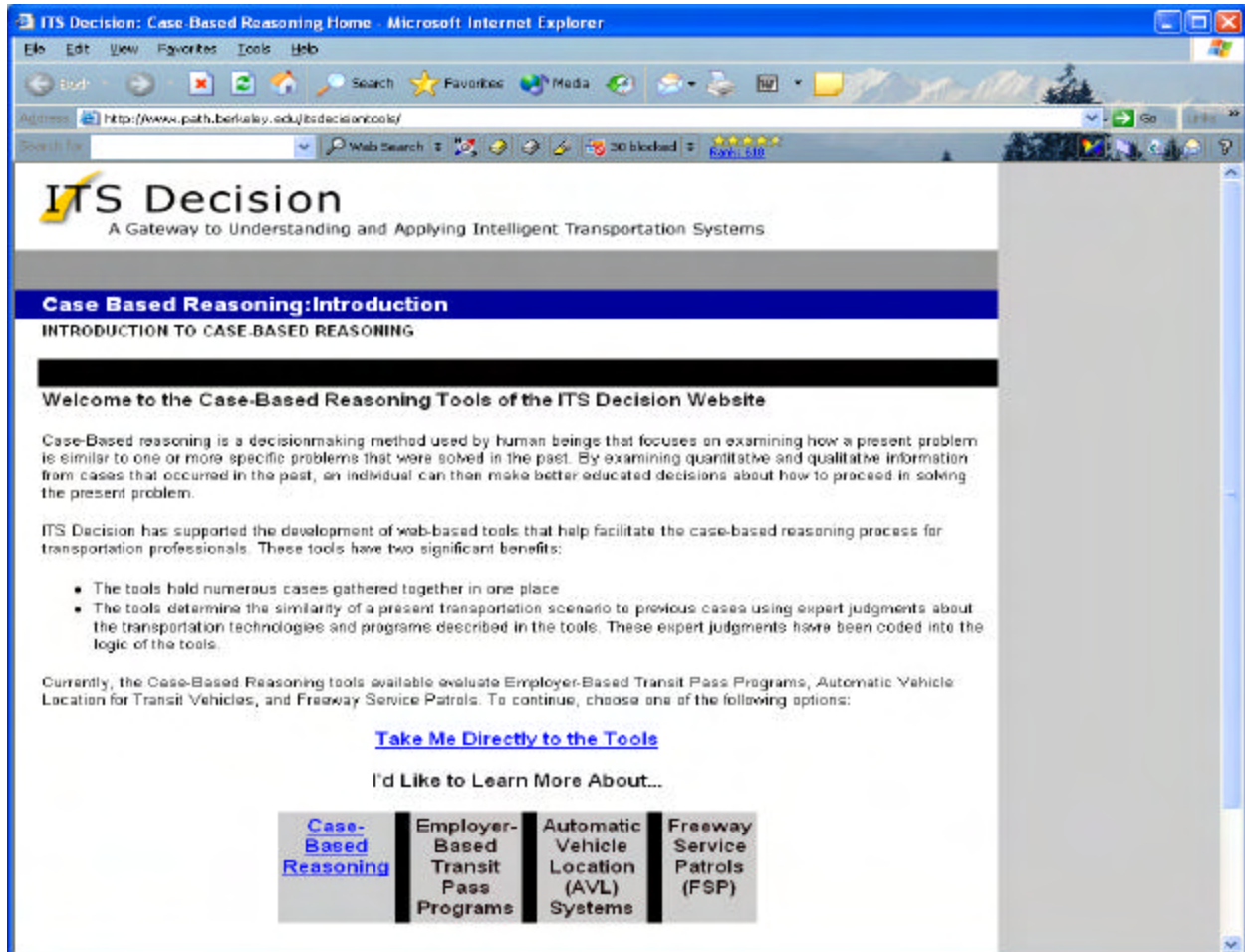


Figure 10: Introductory page for case-based reasoning

By clicking on the hyperlink, 'case-based reasoning' the user could read some general information about CBR. The hyperlink 'take me directly to the tools', the user gets to the webpage, where he selects employee pass program by clicking on that hyperlink.

This takes the user to the employee pass program webpage shown in Figure 11.

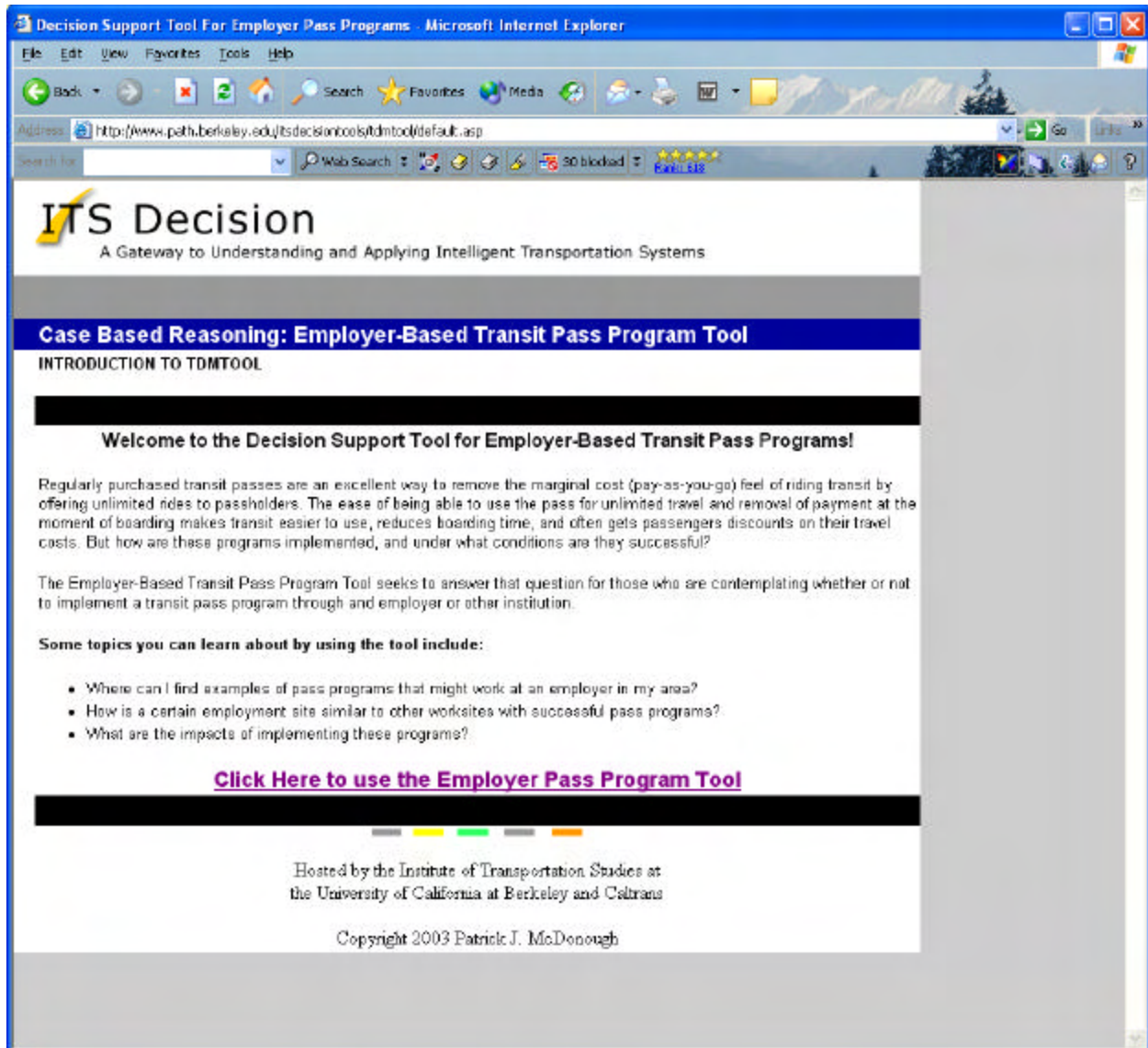


Figure 11: Introductory page for the Employee Pass Program

The hyperlink for the Employee Pass Program tool, takes the user to the next page, where he selects between a number of options, to find the set of options that describe his case most accurately. The selected options are shown in Figure 12.

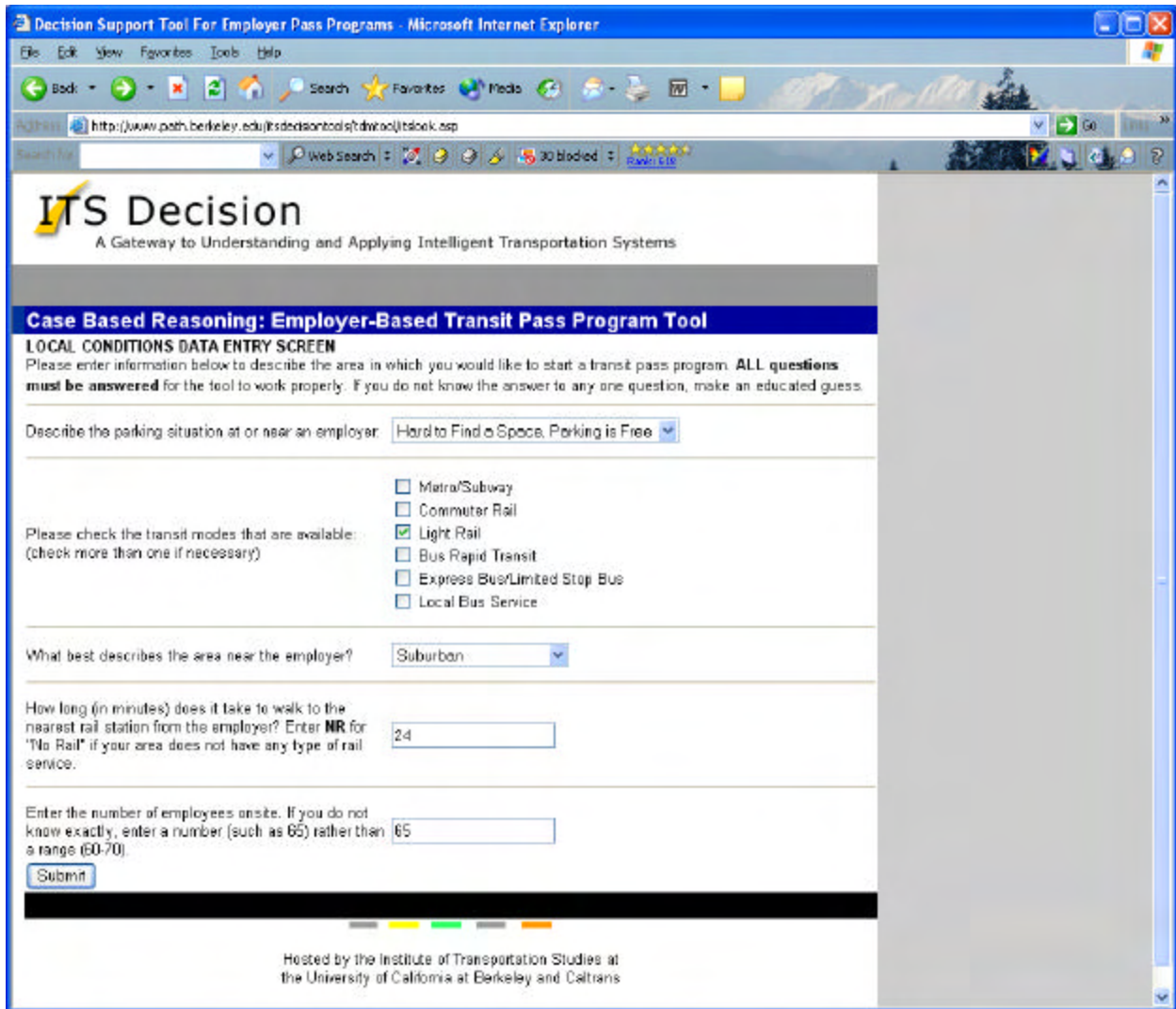


Figure 12: Options selected for Transit Pass Program tool

On clicking submit, the user gets to results page, where case studies similar to his are color-coded in order of similarity and displayed as shown in Figure 13. Users can see the degree of matching stringency, e.g., a tight or exact match is color coded green, a moderate match is shown as yellow and a relaxed match is shown as red.

Employer Pass Program Similarity Results - Microsoft Internet Explorer

Address: http://www.path.berkeley.edu/itsdecisiontools/tdm/oc/its_results_short.asp

ITS Decision
A Gateway to Understanding and Applying Intelligent Transportation Systems

Case Based Reasoning: Employer-Based Transit Pass Program Tool

PASS PROGRAM SIMILARITY SCORES
Click on the names of the employers to the left to see profiles of individual transit pass programs.

Employer (State)	Similarity Score	Employees	Area Description	Parking Situation (Cost/Supply)	Premium Modes	Minutes to Rail
Your Input		65	Suburban	Free/Scarce	LRT	24
Wesley Woods, Genetric Center of Emory University (GA)	83	645	Suburban	Free/Scarce	M, EXP	40
Catholic Charities (NY)	68	400	Downtown	Free/Scarce	LRT	1
Yahoo Inc. (CA)	66	1800	Office Park	Free/Scarce	LRT, EXP	11
The University of Montana (MT)	64	2050	Suburban	Pay/Scarce	None	No Rail
UC Santa Barbara (CA)	64	4500	Suburban	Pay/Scarce	EXP	40
University Village (WA)	57	1500	Urban, Non-Downtown	Free/Scarce	CR	60
City of Santa Rosa (CA)	57	1200	Downtown	Free/Scarce	None	No Rail
California Franchise Tax Board (CA)	57	6500	Downtown	Free/Scarce	LRT, EXP	10
City of Palo Alto (CA)	49	1200	Suburban	Free/Abundant	CR, EXP	5
Federal Transit Administration (DC)	49	275	Downtown	Pay/Scarce	M, CR, EXP	1
Cambridge Systematics, Inc. (MA)	44	100	Office Park	Free/Abundant	M	5
City of Berkeley (CA)	42	1313	Downtown	Pay/Scarce	M, CR, EXP	2
Hillsborough County, Florida (FL)	42	3500	Downtown	Pay/Scarce	EXP	10
Thivent Financial for Lutherans (MN)	42	1500	Downtown	Pay/Scarce	LRT, EXP	3
City of Seattle (WA)	40	15000	Downtown	Pay/Scarce	CR, EXP	15
Router manufacturer (CA)	37	800	Office Park	Free/Abundant	LRT, EXP	2
U.S. Environmental Protection Agency (NC)	36	1500	Office Park	Free/Abundant	None	No Rail
Regional Retail Center (CO)	36	3500	Suburban	Free/Abundant	EXP	NA

Figure 13: Case Studies selected by the Case-based reasoning tool

On clicking on any of these hyperlinks, the user gets detailed information about the case study.

Figure 14 displays the layout of such information on the webpage.

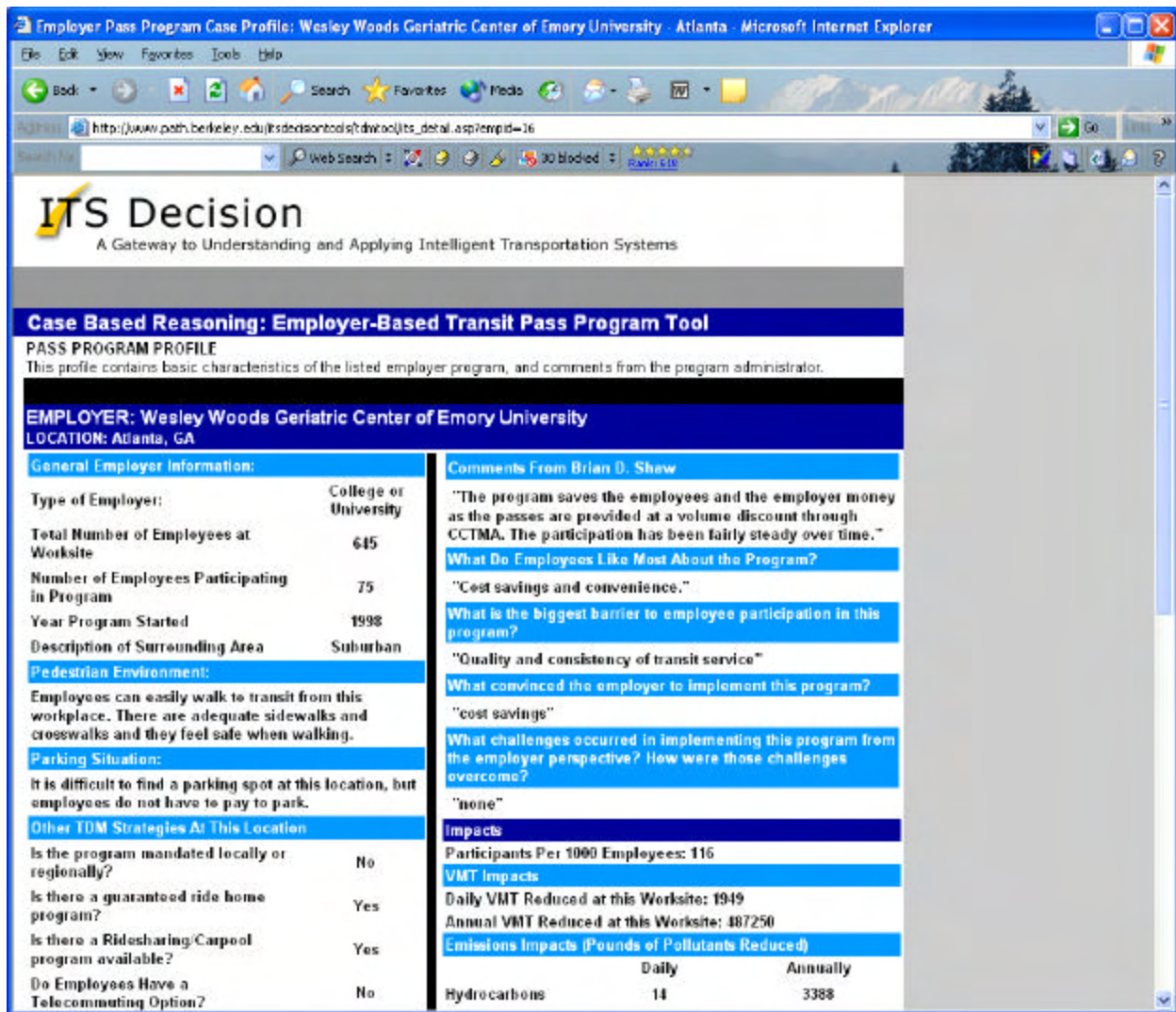


Figure 14: Details of a Case Study

3.2.2 AVL/CAD

Advanced Public Transit Systems (APTS) deal specifically with improving public transit. The benefits of APTS can include improved productivity, improved safety, travel time improvements, reduction in air pollution, and increased transit revenues. The costs often involve capital costs of equipment, operating, and maintenance costs. We will focus on advanced vehicle location systems and computer aided dispatch systems because they have been implemented fairly widely and provide us with a reasonably large case-base. Advanced Vehicle Location (AVL) is considered a "fleet management" technology, meaning that AVL focuses on the vehicle, improving the efficiency and effectiveness of the service provided, and on passenger safety. AVL systems, in their most basic form, help track the whereabouts of vehicles on a network.

While AVL has been in use since the 1960's, it has been through the recent introduction of global positioning systems and advanced communications technology that its use has really begun to increase for transit agencies. AVL is often also closely linked with computer aided dispatch systems (CAD), which use communications systems and real-time information obtained from AVL about bus locations to assist operators in directing bus schedules, departures, and arrivals. While CAD has mostly been targeted at paratransit systems, it has been used with resulting benefits in bus systems as well. AVL and CAD can also be combined with ATIS systems to provide travelers with real-time information about bus positions and scheduling.

With the abundance of anecdotal information from case-studies across the US, a substantial amount of research has been done on the qualitative, rather than quantitative, benefits of APTS; however, there are a few comprehensive studies of note. Lehtonen and Kulmala focused on a public transit system in Helsinki, Finland which implemented a system that used a combination of APTS applications: real-time passenger information, bus and tram priorities at traffic signals and schedule monitoring (Lehtonen and Kulmala, 2001). The results of their study showed that the overall use of the system had a benefit-to-cost ratio of 3.3. More specifically, the system experienced reduced delay at signals and improved service reliability, regularity, and punctuality. On both tram and bus, the number of passengers increased from the before to the after studies. In addition, they found 1-5 percent reductions in fuel consumption and exhaust emissions. While this study included several APTS applications, other studies focus more on the benefits of a single application.

Another comprehensive study, (Levine et al, 2000), studied the effects of an APTS deployment in 1997 by the Ann Arbor (Michigan) Transportation Authority. This system, termed an advanced operating system (AOS), included equipping "smart" buses with AVL and an on-board emergency system, creating a "smart" operations center, and providing ATIS information to make "smart" travelers. The results of this study found some improvement in on-time departures and modest improvements in transfer coordination for routes planned for timed transfers.

Other studies of APTS have investigated the benefits of AVL and CAD. Jones reports that after implementing AVL, Kansas City's buses experienced a 12 percent improvement of on-time

performance in a single year; Milwaukee, Wisconsin, indicated that 28 percent fewer buses were more than one minute behind schedule; and, the Mass Transit Administration in Baltimore, Maryland, reported a 23 percent improvement in on-time performance by AVL-equipped buses (Jones,1995). The Peng et al. evaluation of the use of AVL on transit in the City of Racine, Wisconsin, found the system to have an overall benefit-to-cost ratio of 3.0 (Peng et al.,1999). Its use resulted in improvements of on-time performance, a reduction in passenger wait-time, and reductions in operating and administration expenses. Dessouky et al examine how the use of AVL, automatic passenger counters, and a system with information on connecting passengers improve transfers (Dessouky et al,1999). They find that AVL improves timed transfers for buses with longer headway and that dispatching strategies using ITS can result in a reduction in passenger delay.

According to Weatherford, the Denver Regional Transportation District (RTD) implemented an AVL and CAD system, as well as an entirely new dispatcher-to-field communication system and on-board silent alarm, that resulted in the following benefits: a 12 percent decrease in the number of vehicles to arrive at stops early, a 21 percent decrease in passengers per vehicle who arrived at stops late, and a 26 percent decrease in the number of customer complaints (Weatherford, 2000). RTD also saw a 33 percent decrease in passenger assaults and a 23 percent decrease in lost service hours due to improved accuracy of bus positioning and radio reliability. Strathman et al. focused on the benefits of the implementation of an AVL and CAD system at the Tri-Met agency in Portland, Oregon (Strathman et al, 2002). These benefits included a 9.4 percent improvement in on time performance at route final destinations and a reduction in headway variability of 5 percent. Model results showed that “the AVL/CAD system allows the transit agency to provide the same level of service to a greater number of travelers with the same equipment, increasing the effective capacity of the bus system”.

On the supply side, AVL and CAD have the additional indirect benefit of providing an accurate means to monitor system performance. Cathey and Dailey find that AVL could be used to predict travel time and vehicle arrival and departures (Cathey and Dailey, 2003). Furth demonstrates how archived AVL and automatic passenger counters (APC) data could be used to improve

transit performance and management (Furth, 2003). However, neither of these reports presents quantifiable data on the purported benefits of AVL and CAD.

Gillen presents a comprehensive analysis of the benefits of AVL (Gillen, 2000). This study identifies four prime objectives for the introduction of AVL by transit agencies in the US:

1. improved schedule adherence and timed transfers
2. more accessible passenger information
3. increased availability of data for transit management and planning
4. the efficiency/productivity improvements in transit services

These objectives can be met with AVL since it increases the firm's capability to monitor information on vehicle position and operational status. AVL can result in increased fleet utilization, reduced input factors such as fuel, labor and capital, improved revenue planning and efficiency through the use of on-board electronic fare collection, and an overall higher productivity and lower costs. The study also found that AVL does have a positive benefit on the number of passenger trips.

Researchers have yet to formalize the exact benefits and costs of APTS. Table 6 organizes the results of the above studies by benefit category. For more clarification, Table 7 shows the benefits of APTS to user, agency, and society by category.

Table 6: Benefits of AVL/CAD.

	Source	Location	B/C Ratio	Delay	Service Reliability	Passengers	Safety	Air and Fuel	Efficiency
General Studies	Levine et al., 2000	Ann Arbor, MI			<ul style="list-style-type: none"> Improved on time departures Improved transfer coordination 				
	Lehtonen and Kulmala, 2001	Helsinki, Finland	3.3	<ul style="list-style-type: none"> reduced delay 	<ul style="list-style-type: none"> Improved service reliability, regularity, and punctuality 	<ul style="list-style-type: none"> observed increase in passengers 		<ul style="list-style-type: none"> 1-5 percent reduction 	
AVL/CAD	Jones, 1995	Various			<ul style="list-style-type: none"> Kansas City: 12 percent improvement in on-time performance Milwaukee: 28 percent fewer buses more than one minute behind schedule Baltimore: 23 percent improvement in on-time performance by AVL equipped buses 				
	Peng et al., 1999	City of Racine, Wisconsin	3.0	<ul style="list-style-type: none"> Reduction in passenger wait-time 	<ul style="list-style-type: none"> Improvements in on-time performance 				<ul style="list-style-type: none"> Reductions in operating and administration expenses
	Dessouky et al., 1999			<ul style="list-style-type: none"> Reduction in passenger delay 	<ul style="list-style-type: none"> Improve timed transfers for buses with longer headway 				

Weatherford, 2000	Denver, CO		<ul style="list-style-type: none"> • 21 percent decrease in passengers who arrived at stops late 	<ul style="list-style-type: none"> • 12 percent decrease in vehicles arriving at stops early 	<ul style="list-style-type: none"> • 26 percent decrease in customer complaints 	<ul style="list-style-type: none"> • 33 percent decrease in passenger assaults 		<ul style="list-style-type: none"> • 23 percent decrease in lost service hours due to improved accuracy of bus positioning
Strathman et al, 2002	Portland, OR			<ul style="list-style-type: none"> • 9.4 percent improvement in on time performance • 5 percent reduction in headway variability 				<ul style="list-style-type: none"> • Same level of service to greater number of passengers
Cathey and Dailey, 2003								<ul style="list-style-type: none"> • Used to predict travel time and vehicle arrival and departures
Furth, 2003								<ul style="list-style-type: none"> • Archived AVL and APC data used to improve transit performance and management
Gillen, 2000					<ul style="list-style-type: none"> • positive benefit on passenger trips 			<ul style="list-style-type: none"> • Increased fleet utilization • Reduced labor and capital • Improved revenue plannings • Higher productivity and lower costs

Table 7: Benefits of APTS by user, agency, and society.

Benefits	ATIS	AVL	CAD
To User:			
Reduction in uncertainty	X		
Increased safety	X		
Faster, better service			
<i>More tailored to needs</i>	X	X	X
<i>Less wait-time</i>	X	X	X
To Agency:			
Increased ridership	X		X
Reduced operation costs	X	X	X
Improved service, particularly reliability	X	X	X
Better system monitoring	X	X	X
Better system performance	X	X	X
Better safety	X		
Increased revenues	X		
ADA compliance	X		
To Society:			
Less congestion	X	X	X
Less pollution	X	X	X
Better quality of life (health, peace of mind)	X	X	X
Less energy consumption	X	X	X

Implementing AVL/CAD

To demonstrate a transit case, assume that planners from a small-sized town are concerned about transit unreliability and rider ship. The town's planners and engineers can be exploring the use of AVL/CAD to improve their on-time performance and better manage their system. First, they can examine the current PATH supported ITS Decision website to receive information about AVL/CAD projects (historical cases) and their benefits and/or AVL/CAD might be suggested as a remedy for transit unreliability by the ITS expert system.

For the current context, the users will input their city size, the number of buses in their fleet and the type of AVL technology they might be interested in, as shown in Figure 15. The weights of each of these are as follows: AVL Type (30%), Urban Form (40%) and Fleet Size (30%).

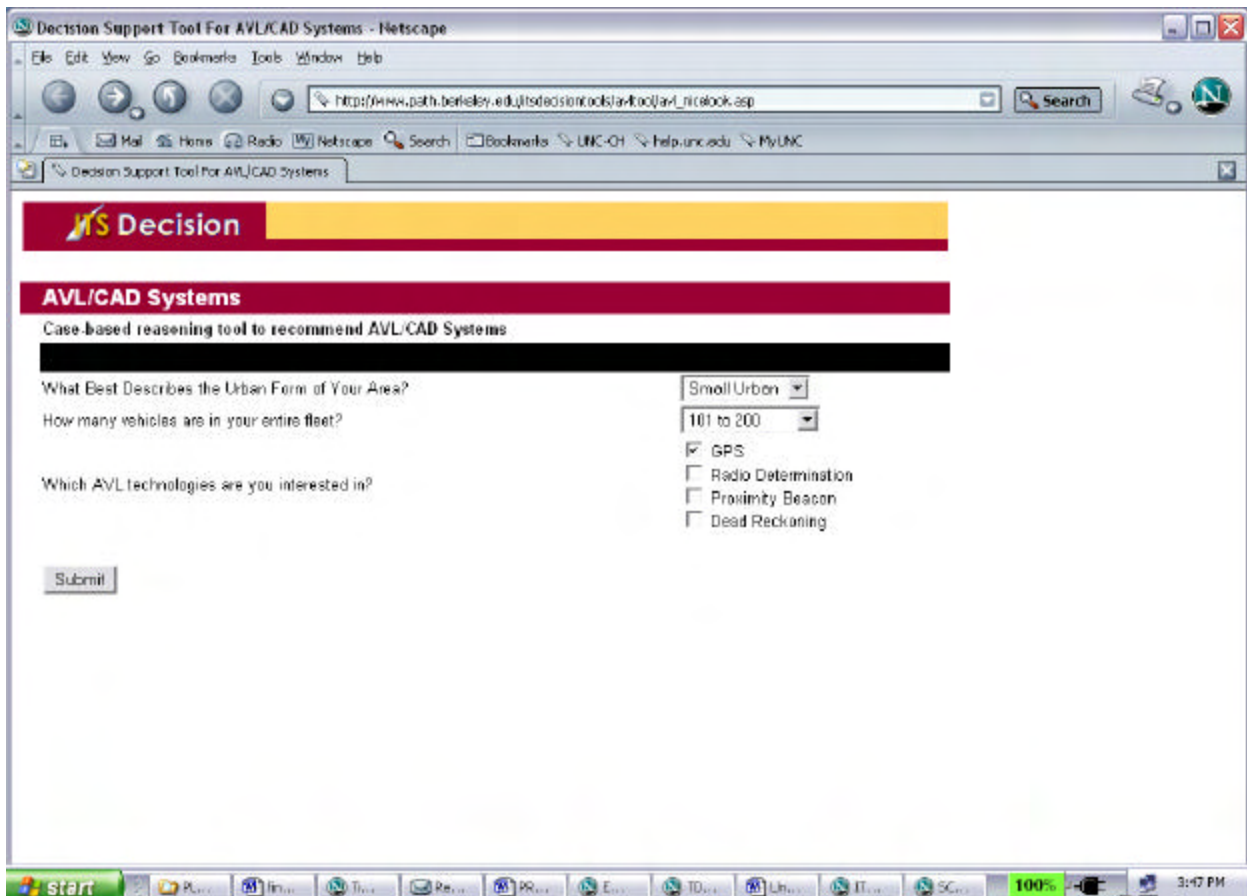


Figure 15: AVL/CAD webpage and options selected

The CBR system matches the historical cases to the present, inputted case, and provides a color-coding of similar cases. The weights used are: Urban Form 40%, Fleet Size 30% and AVL Type 30%. Again, users can see the degree of matching stringency. Thus the matched cases are retrieved, ranked in terms of similarity and displayed, according to the data structure developed for AVL/CAD.

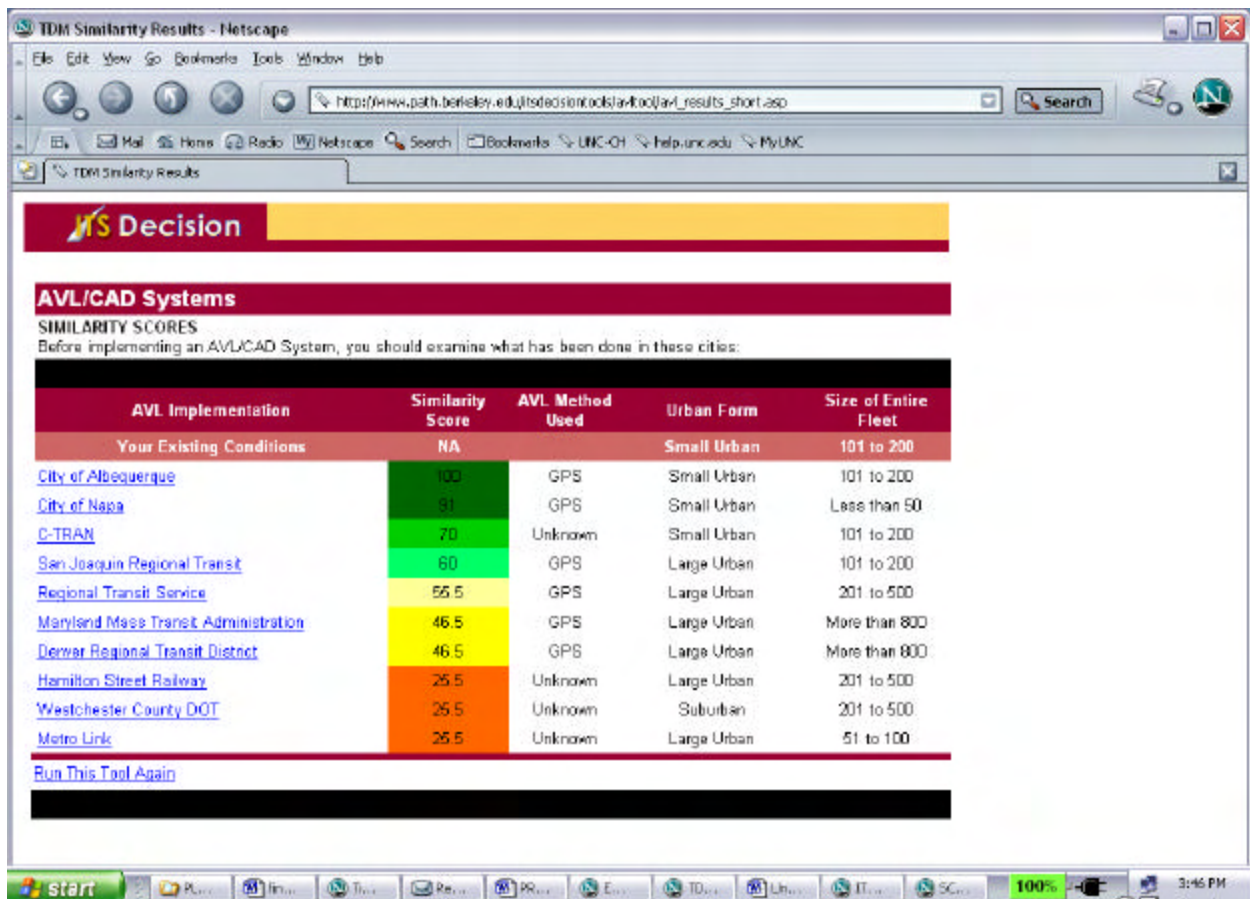


Figure 16: Cases retrieved by the CBR tool for AVL/CAD

Users can then search for the more detailed information contained in the historical cases. See the following screen for case details.

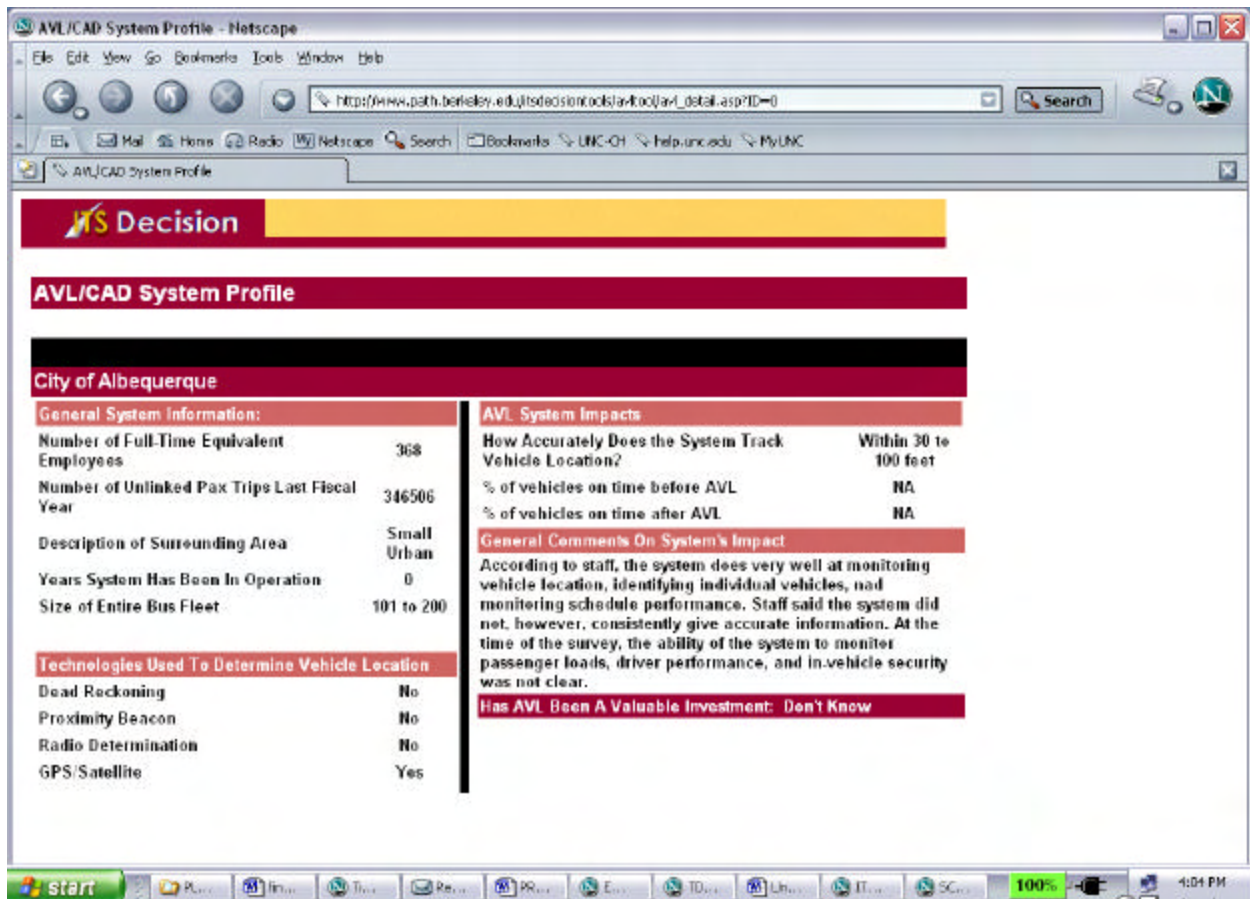


Figure 17: Details of one case study for AVL/CAD

Detailed information about the historical ITS cases was obtained from the interviews, literature and other Internet sites. Presently, we have case-bases for Freeway Service Patrols (FSPs), AVL/CAD system, and Employee Pass Program. The cases also contain qualitative information about degree of success, operational problems and case-quality is controlled by review of the report or information by researchers.

3.2.3 Freeway Service Patrols

Freeway Service Patrols provide surveillance and incident/emergency management. Using roving vehicles to patrol high incident sections of freeways, the purpose of freeway service patrols is to locate incidents, minimize incident duration, restore full capacity to the facility, reduce risks of secondary accidents to motorists and provide motorist assistance. In this capacity,

they have been considered the single most effective element of an incident management program for reducing incident detection time and duration (Fenno and Ogden 1998). Purported benefits of FSPs include reducing delay, congestion, fuel consumption, emissions, and the potential for secondary accidents (Fenno and Ogden 1998). An additional benefit of freeway service patrols is that they can provide a greater sense of security and safety among drivers.

Studies on freeway service patrols are often more specific when quantifying benefits and costs than other studies of ITS applications. The effectiveness of freeway service patrols can be measured by reductions in delay, often through reductions in accident response and clearance time, and associated benefits of reduced pollution and fuel consumption. Early reports on freeway service patrols indicate their relative success compared to their implementation costs. A 1994 study by the Minnesota Department of Transportation reports on the Twin Cities Metro Area's Highway Helper Program. This report states that for an operating cost of only \$600,000 the freeway service patrols reduced the time to clear stalls, the most frequent type of incident, by as much as eight minutes, resulting in \$1.4 million in time-savings. Cuciti and Janson state that the six month Courtesy Patrol Program in Denver, Colorado reduced traffic delay and had calculated benefit-cost ratios between 10.5:1 and 16.9:1 depending on analysis assumptions and the time of day (Cuciti and Janson, 1995). A 1996 FHWA report titled "Innovations in Transportation and Air Quality: Twelve Exemplary Project" states that a freeway service patrol program in San Francisco begun in 1992 has decreased air pollution and reduced fuel consumption by helping to reduce the effects of incident caused congestion, start-and-stop travel and vehicle idling. It has been estimated that the program has resulted in emissions reductions of 32 kg/day of HC, 322 kg/day of CO, and 798 kg/day of NOx. Another report prepared by the ATA Foundation in 1997 presents information in its appendix indicating that an incident management program run in Chicago, IL with a freeway service patrol has resulted in savings of 9.5 million vehicle hours of delay over a one year period. Using a model, the report estimates that a reduced freeway service patrol that would only address major incidents would still result in 5.6 million vehicle hours of delay over a one year period.

Latoski et al. present results of the Hoosier Helper Freeway Service Patrol in Northwest Indiana (Latoski et al, 1999). They found that the program's daytime operations have a benefit-cost ratio

of 4.7:1 and 24-hour operations have a benefit-cost program of 13.3:1. Stamatiadis et al. examine the success of the Massachusetts Motorist Assistance Program. They found the total benefit-cost ratio of the program to be around 19:1 (Stamatiadis et al.,1998).

Fenno and Ogden compile one of the more comprehensive studies of the “state of the practice” for freeway service patrols (Fenno and Ogden,1998). From a telephone survey of nationwide agencies with freeway service patrols, they found that reported benefit-cost ratios can range from 2:1 to 36.2:1 (Table 8).

Table 8: Results of Service Patrol Benefit-Cost Studies.

Patrol Location	Patrol Name	Year Performed	Results
Charlotte, NC	Incident Management Assistance Patrol	1993	3:1 to 7:1
Chicago, IL	Emergency Traffic Patrol	1990	17:1
Dallas, TX	Courtesy Patrol	1995	3.3:1 to 36.2:1
Denver, CO	Mile High Courtesy Patrol	1996	20:1 to 23:1
Detroit, MI	Freeway Courtesy Patrol	1995	14:1
Fresno, CA	Freeway Service Patrol	1995	12.5:1
Houston, TX	Motorist Assistance Program	1994	6.6:1 to 23.3:1
Los Angeles, CA	Metro Freeway Service Patrol	1993	11:1
Minneapolis, MN	Highway Helper	1995	5:1
New York & Westchester Co., NY	Highway Emergency Local Patrol	1995	23.5:1
Norfolk, VA	Safety Service Patrol	1995	2:1 to 2.5:1
Oakland, CA	Freeway Service Patrol	1991	3.5:1
Orange Co., CA	Freeway Service Patrol	1995	3:1
Riverside Co., CA	Freeway Service Patrol	1995	3:1
Sacramento, CA	Freeway Service Patrol	1995	5.5:1

Courtesy Fenno and Ogden (1998).

Two related studies focus on Maryland’s freeway service patrol program: Coordinated Highways Action Response Team (CHART). Chang et al. report that in 1997, CHART resulted in a reduction of 15.6 million vehicle hours of delay and 5.85 million gallons of fuel (Chang et al 2000). Petrov et al. report that CHART reduced incident durations from 93 minutes to 42 minutes in 1999 and 77 minutes to 33 minutes in 2000. This meant savings of 23.36 million vehicle hours of delay in 1999 and 24.24 million vehicle hours of delay in 2000 (Petrov et al. 2002).

Freeway service patrols are only one form of the use of ITS in incident management. Maas presents findings on an incident management program enhanced by the use of ITS in Northern Virginia (Maas, 1998). Using the IMPACT model to simulate the program's benefits, this study found a 35 percent reduction delays. More importantly, the report concludes that ITS in the incident management program provides the greatest benefits in the early stages of the incident management process. Dumke and Doyle report on the use of freeway service patrols in work zones in Albuquerque, NM. They state that with the use of freeway service patrols, the average response time was eight minutes, the average clearance time of 45 minutes was reduced by 20 minutes, and the project experienced no fatalities (Dumke and Doyle, 2001). Other forms of ITS in incident management include the use of monitoring equipment and cell phone reporting programs.

From these studies, it can be seen that the use of freeway service patrols primarily results in reduced incident delays, with associated benefits of reduce emissions and fuel consumption. Table 9 shows a summary of the studies on the benefits of freeway service patrols.


Table 9: Benefits of Freeway Service Patrol by study.

Source	Location	Time-Savings	Incident Duration	Fuel Consumption	Air Quality	Benefit-Cost Ratio
MnDOT, 1994	Minneapolis, MN	<ul style="list-style-type: none"> \$1.4 million in time-savings 	<ul style="list-style-type: none"> Reduced by 8 min 			
Cuciti and Janson, 1995	Denver, CO					<ul style="list-style-type: none"> Between 10.5:1 and 16.9:1.
FHWA, 1996	San Francisco, CA				<ul style="list-style-type: none"> CO reduction of 322 kg/day HC reduction of 32 kg/day of, NOx reduction of 798 kg/day 	
ATA Foundation, 1997	Chicago, IL	<ul style="list-style-type: none"> 9.5 million vehicle hours of delay over a one year period 				
Stamatiadis et al., 1998	Massachusetts					<ul style="list-style-type: none"> around 19:1
Fenno and Ogden, 1998	various					<ul style="list-style-type: none"> between 2:1 to 36.2:1
Maas, 1998	Northern Virginia	35 percent reduction delays				

Latoski et al., 1999	Northern Indiana					<ul style="list-style-type: none"> • Daytime operations: 4.7:1 • 24-hour operations: 13.3:1
Chang et al., 2000	Maryland	<ul style="list-style-type: none"> • 15.6 million vehicle hours of delay and 5.85 million gallons of fuel 		<ul style="list-style-type: none"> • 5.85 million gallons of fuel 		
Dumke and Doyle, 2001	Albuquerque, NM		<ul style="list-style-type: none"> • average clearance time of 45 minutes reduced by 20 minutes 			
Petrov et al., 2002	Maryland	<p>reduced incident durations:</p> <ul style="list-style-type: none"> • 1999 – 93 minutes to 42 minutes, 23.36 million vehicle hours of delay • 2000 – 77 minutes to 33 minutes, 24.24 million vehicle hours of delay in 2000 				

Implementing FSP

Assume that planners from a town are concerned about incidents and induced congestion that is getting worse. The planners can be exploring the use of freeway service patrols to respond quickly to incidents and mitigate the incident-induced congestion. First, they can examine the current PATH supported ITS Decision website to receive information about FSP projects (historical cases) and their benefits or they might become interested in FSPs because it was suggested by the ITS expert system as a remedy for incidents and induced congestion. Figure 18 displays the general information appears at the FSP introductory page.



ITS Decision
A Gateway to Understanding and Applying Intelligent Transportation Systems

Case Based Reasoning: Freeway Service Patrol Tool

INTRODUCTION TO FREEWAY SERVICE PATROL TOOL

Welcome to the Decision Support Tool for Freeway Service Patrols!

Freeway Service Patrols (FSPs) are services run by cities, state DOTs, and other highway maintenance organizations that provide vehicles to shorten the time that traffic becomes congested after crashes, breakdowns and other delay-causing incidents on America's highways. Usually, this service takes the form of a pickup truck or tow truck with signage that can direct motorists approaching the incident scene to merge or move on, as well as provide assistance to those motorists involved in the incident itself.

By effectively clearing road incidents, Freeway Service Patrols reduce delays and congestion, and help improve overall urban mobility and air quality.

Some topics you can learn about by using the tool include:

- ◆ How many vehicles would be needed to patrol our metro area?
- ◆ What cost:benefit ratios have other FSP programs achieved?
- ◆ How many motorists are served by FSP programs in different metro areas?

[Click Here to use the Freeway Service Patrol Tool](#)

Figure 18: FSP general information

If the user wishes to further explore which historical cases are most similar to theirs in a systematic manner, then they can proceed further. For the current case, they will input their city's

context (Population, Incidents per year) and FSP attributes (Miles of roads to be served by FSP, routes and number of FSP vehicles) as follows:

The screenshot shows the ITS Decision web application interface. At the top, the logo 'ITS Decision' is displayed with the tagline 'A Gateway to Understanding and Applying Intelligent Transportation Systems'. Below this is a green header bar with the text 'Freeway Service Patrols'. Underneath, a black bar contains the text 'Case-based reasoning tool to recommend FSP Strategies'. The main content area is a form with five input fields and a 'Submit' button. The input fields are: 'Enter your city's population' (value: 2896016), 'Enter Your Number of Incidents Per Year' (value: 102000), 'Enter the Number of Miles of Road Served by Your FSP Program' (value: 127), 'Enter the Number of Routes you Serve with your FSP Program' (value: 12), and 'Enter the Number of FSP Vehicles in your FSP Program' (value: 56). Below the form is a black bar with a color-coded legend consisting of five colored squares: grey, yellow, green, grey, and orange. At the bottom, the text reads: 'Hosted by the Institute of Transportation Studies at the University of California at Berkeley and Caltrans'.

Enter your city's population	2896016
Enter Your Number of Incidents Per Year	102000
Enter the Number of Miles of Road Served by Your FSP Program	127
Enter the Number of Routes you Serve with your FSP Program	12
Enter the Number of FSP Vehicles in your FSP Program	56

Submit

Hosted by the Institute of Transportation Studies at
the University of California at Berkeley and Caltrans

Figure 19: FSP selected options for specific case

The CBR system matches the historical cases to the present, inputted case, and provides a color-coding of similar cases (see Figure 20). The weights used are as follows: Population-30%, Number of Incidents- 20%, Miles of Road Served by FSP Program-20%, Number of Routes served by FSP Program-10%, Number of Vehicles in FSP Program-20%. Thus the matched cases are retrieved, ranked in terms of similarity and displayed, according to the data structure developed for FSPs.

ITS Decision
A Gateway to Understanding and Applying Intelligent Transportation Systems

Freeway Service Patrols

CITY SIMILARITY SCORES
Before implementing your FSP Program, you should examine what has been done in these cities.

City	Similarity Score	Population	Incidents	Road Miles Patrolled	Number of Routes	Number of Vehicles
Year City	NA	2895916	102000	127	12	56
Chicago, IL	48.5	2895916	102000	127	12	56
Orange Co., CA	48	2846289	80000	145	10	30
Cincinnati, OH	40.5	331285	18200	88	3	5
Fl. Lauderdale, FL	40.5	152397	24000	81	6	7
Kansas City, MO	40.5	149066	40000	97	2	4
Sacramento, CA	40.5	407018	11700	90	4	17
Winston-Salem, NC	40.5	185776	13200	143	4	6
St. Louis, MO	40	348189	NA	161	10	14
Atlanta, GA	39	416474	16900	106	5	12
New York, NY	38.5	8008270	23570	217	7	21
Oakland, CA	38.5	399484	97000	362	20	57
Albany, NY	37.5	96658	8200	35	2	2
Columbia, SC	37.5	116278	4200	32	2	3
Denver, CO	37.5	564636	18000	61	5	10
Detroit, MI	37.5	951270	7000	66	4	5
El Paso, TX	37.5	563662	18000	31	2	6
Fresno, CA	37.5	427662	1660	35	2	2
Pittsburgh, PA	37.5	334583	6000	42	3	4
Raleigh, NC	37.5	270083	8500	48	2	4
Riverside Co., CA	37.5	1545307	16000	40	4	8
Greensboro, NC	36	223891	3600	39	3	4
Westchester Co., NY	36	923499	8600	71	2	9
San Diego, CA	35	1223400	18500	250	7	21
Greenville, SC	34.5	56002	NA	48	2	3
Miami, FL	34.5	362470	NA	27	4	4

Figure 20: Similar cases selected by CBR tool for FSP

Users can then search for the more detailed information contained in the historical cases. For instance, they might feel that another case is more similar to theirs and would like to explore it further. By clicking on it, they go to the screen that provides impacts information about the case. The following screen displays information about the impacts of FSP technologies and the benefit cost ratio calculated for the Chicago case. It also shows relevant qualitative information in the right hand panel. This information can increase the confidence of the user regarding what might happen in their context, although it in no way substitutes for doing a full-blown evaluation and cost-benefit analysis.

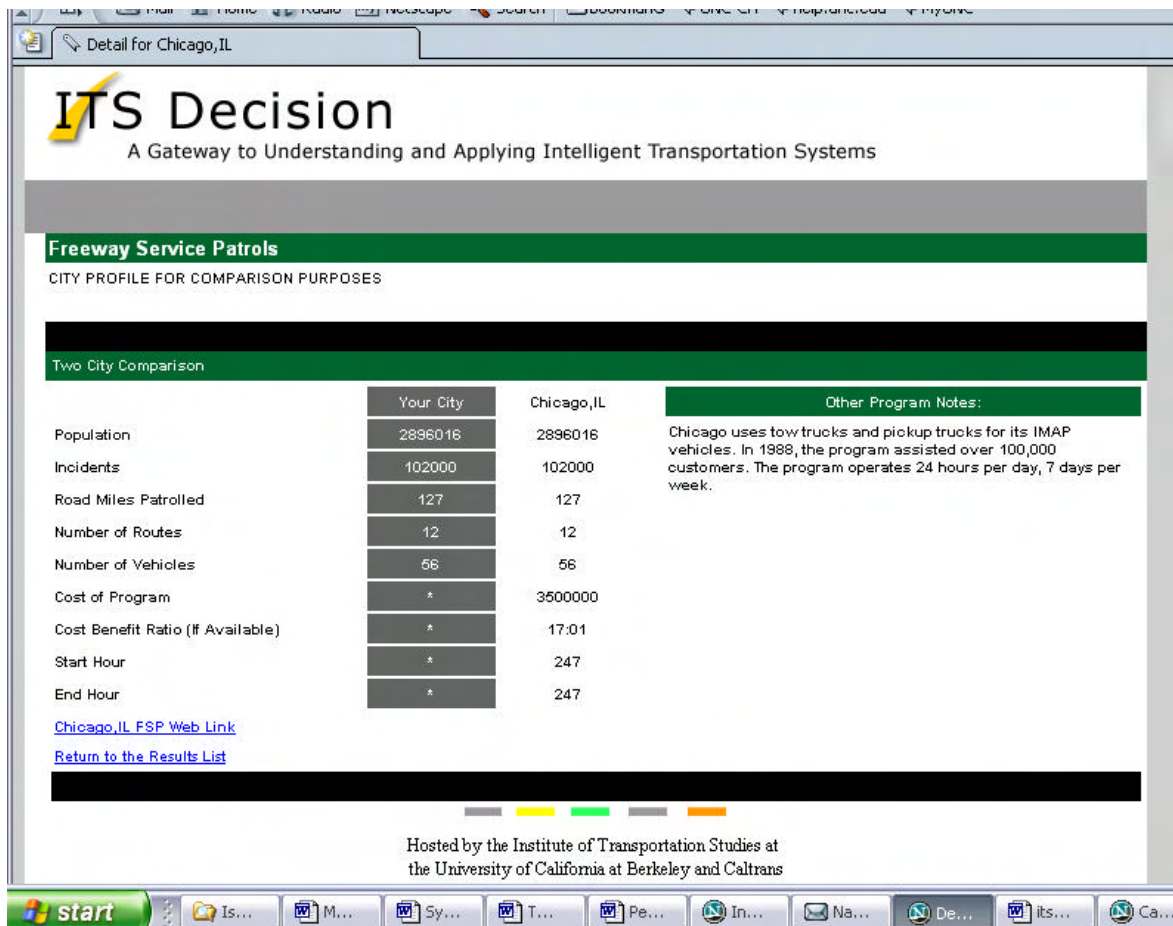


Figure 21: Details of case study selected

Ideally, the user could specify the impacts of interest that are unknown for their current case, but known in the historical cases. For example, they might be interested in (reduction in) response times, clearance times, and incident-induced delays and any insights, avoidable mistakes, and relevant lessons learnt. However, we did not have enough cases that gave such a level of detail, but in the future, such an enhancement should be considered.

4. CONCLUSIONS & FUTURE ACTIVITIES

We have successfully completed the tasks by updating the ITS Decision website and providing the expert system and case-based reasoning tools. They demonstrate the value of structuring data to provide useful information to the user. In the future we intend to maintain and update the ITS Decision website, refine the tools and add modeling tools to fully support a decision makers cognitive process and help them make informed decisions.

As we conceptualized in PLANiTS, the user will receive information from the ITS Decision website and also from the tools that can suggest solutions and provide information on how the solutions have performed elsewhere. The next step, as depicted in the figure below is to add models that will allow users to estimate benefits and costs for ITS technologies. The user will then be fully informed and be able to make good decision about whether to implement a particular ITS solution.

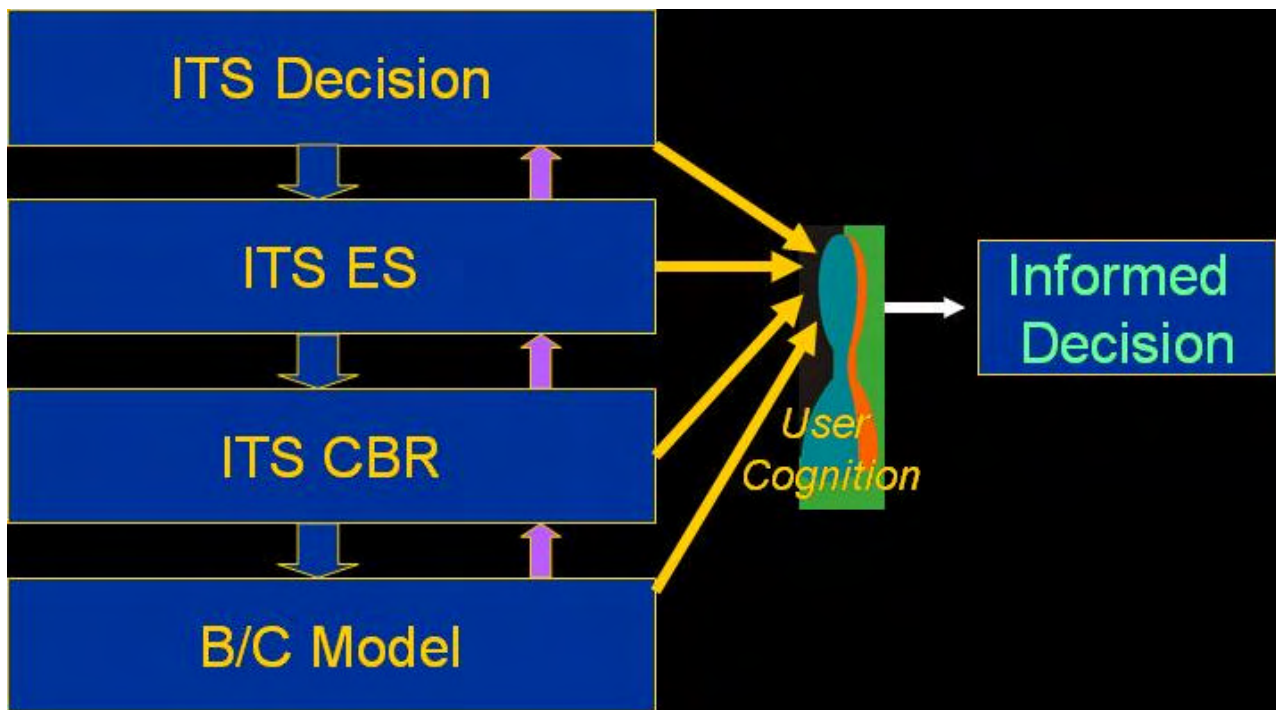


Figure 22: Input for Informed Decision

We have developed the expert system and case-based reasoning as a useful tool. Based on input from Caltrans, we will further develop the expert system and intend to add CBR for other ITS technologies and services. The further development and maintenance can follow the pattern used with the current contents of ITS Decision. As new information about services for which we already have case bases becomes available, we will update the case bases to include this information. As the number of cases of particular ITS services becomes sufficient to support case-based reasoning, we will add case-based reasoning for those services. The material for the case base development and updates will arise from our on-going monitoring of ITS developments conducted to keep ITS Decision current.

Some other future work can be done on the CBR tool in general and the employee pass program in particular. These are described in the following sections.

Incorporating Action Scenarios as Well As Environmental Factors for the CBR cases

While this tool currently works only with the *Environmental Vector* described by Khattak and Kanafani, it can be expanded to include the *Action Vector* as well without needing to collect new data. For example, if an employer conducted a willingness-to-pay survey among employees to see how much they would pay towards a transit pass, and how much employees would like the employer to subsidize, the employer could then enter the hypothetical payment amounts for each into an advanced user input screen that would calculate similarity not only on environmental factors, but also on the similarity of a proposed scenario.

Towards a Standard for Calculating Impacts of different technologies

With so many planners and employers measuring different impacts of ITS programs, working towards a common set of metrics and methods to effectively measure using those metrics will help improve the similarity calculations of the case-based reasoning Tool. The simplest way to do this, for example for employee pass program, is to start with an annual survey for employees that asks for their primary travel mode to work, the number of days per week they use that mode, what costs they incur for both travel and parking, and how long it takes them to complete their journey from door to door, home to workplace. Once such information can be easily gathered

and well-established on an annual basis, it will be much easier to track impacts such as mode switches and VMT reductions.

Improving Program Cost-Benefit Analysis

While this project gathered a large amount of data on employer programs, several variables that we were curious about were omitted in order to keep the survey to a length that was short enough not to discourage participation. One of the most critical variables omitted was the cost of implementing the programs, which tends to be difficult to track since management of employer pass programs is often a partnership between workers within an employer and a full-time person at a TDM organization or transit agency that works with many employers. Future research in this area should try to capture the costs of running and administering programs so that the impact on congestion per dollar for pass programs (and TDM in general) can be compared against other initiatives which are easier to track in terms of cost, like adding a new station to a rail line.

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APPENDIX A

DATA COLLECTION & FINDINGS FOR EMPLOYEE PASS PROGRAM

In order to obtain profiles of a variety of employer-based pass programs, a survey was designed to be disseminated over the Internet to shorten the window of time used to gather data. The survey targeted people who would be most likely to know the impacts of TDM programs at particular employers- TDM planners, onsite employee transportation coordinators, and transit agency employees. Since most public employees in areas with significant transit service have access to email, it was assumed that a large number of potential respondents will not be excluded by not conducting a paper-based survey as well. The survey was publicized using the TDM list serve managed by Phil Winters at the University of South Florida, as well as the American Planning Association's Transportation Planning Division email list. A topic on the cyburbia.org discussion forums was also posted, and individuals listed in the Association for Commuter Transportation membership book emailed. After an initial flurry of 12 responses, the total gradually rose to 30 valid responses. A drawing for two \$50 amazon.com gift certificates added an additional incentive for TDM professionals to participate.

Of the 34 responses received, 30 were complete enough to be considered valid responses. Of the 30 valid responses, 25 respondents said they would be willing to answer questions in a follow-up interview by phone or email. Of the 25 who agreed to a follow-up interview, 22 were successfully completed. The web-based survey is presented in the subsequent pages.

Employer Pass Program Implementation Survey For Transportation Demand Management Professionals

What the survey is about: This goal of this survey is to collect data on how Employer Pass Programs for transit have been implemented at work sites across the United States. This survey is a joint effort between the University of North Carolina at Chapel Hill and the University of California at Berkeley.

The data collected will be used to aid Transportation Demand Management professionals in identifying employer pass program strategies that have worked in other metro areas that may have local applications. Your participation in this survey will lead to one of the first thorough datasets about Employer Pass Programs ever developed. When the project is completed, you will be given access to the data so that you can use it in your own planning efforts.

Who should complete the survey: Professionals in the field of Transportation Demand Management (TDM) who have experience with the implementation of employer pass programs, commute trip reduction programs, or similar efforts.

How to complete the survey: Please fill out the survey, answering the question in regards to ONE (1) particular employer. If you work with multiple employers, please feel free to submit the survey multiple times to profile some of your most interesting cases. The survey only takes a few minutes to complete. Click on the button below to to begin the survey. If you would like more information about the survey, please contact Principal Investigator [Patrick McDonough](#) at UNC-Chapel Hill. Additionally, you can contact the Academic Affairs Institutional Review Board at UNC-Chapel Hill at (919) 962-7761 or aa-irb@unc.edu if you have any questions or concerns about your rights as a participant in this study.

What you can win by participating in the survey: The window of time to be entered in the drawing has closed. We received about 45 qualifying entries and will draw a winner sometime in early May. However, the survey is still operational and you are certainly welcome to fill it out! Begin by clicking the button below.

**Employer Pass Program Implementation Survey
For Transportation Demand Management Professionals**

Your Contact Information	
Your Name	
Your Organization	
Your Phone Number	
Your Email Address	

Employer Worksite Basic Information					
<p>Please answer the following questions in regards to ONE (1) specific employer sponsoring an employee pass program in your area. We understand that you may not have all information immediately on hand. Please answer as fully as possible. If you need to go ask a co-worker a question to obtain data, the survey is designed to wait as long as necessary, as long as your browser window remains open. For information that is not available or unknown, enter <u>NA</u>.</p>					
Name of Employer: (note- if you would prefer not to list the employer's name, just describing the company, such as "Telecommunications Distributor" or "Regional Insurance Claim Center", or even entering anonymous - is okay)					
Employer Location:	<table border="1"> <tr> <td>City:</td> <td></td> </tr> <tr> <td>State:</td> <td></td> </tr> </table>	City:		State:	
City:					
State:					
Approximate Number of Employees At Location:					
Which of the following best describes the location of the employer?	Urban (Central Business District) Urban (Non-Central Business District) Office Park Suburban Rural Other				
What type of employer is this?	Private Sector Employment Site Government Employment Site University Other:				

**Employer Pass Program Implementation Survey
For Transportation Demand Management Professionals**

Pass Program Attributes	
Participation Information	
Employee Participation: Please be as specific as possible, and for information that is not available or unknown, enter NA .	
What year did the pass program begin at this employer?	
From what year is the data you are entering in our survey for this employer?	
Is this employer's participation in a transit pass program mandated or voluntary?	Mandated Voluntary
Employees Participating 5 or more days per week:	
Total Employees Participating in the pass program:	
Is there a Guaranteed Ride Home program available to employees?	Yes No
Does this employer offer Compressed Work Week hours to employees? (i.e. 4 days at 10 hours/day, 3 days at 12 hours/day)	Yes No
Does this employer have a telecommuting program for employees?	Yes No
Is there a carpool or rideshare matching service available to employees?	Yes No
What bicycle facilities exist at this employer?	Bike Racks Lockers Showers
What is the primary transit agency that the employees from this worksite access using the pass?	
Can the pass be used for transit service provided by agencies other than the primary agency?	Yes No
Program Impacts	
TDM Professionals track the impacts of their programs in a variety of different ways. However, we are only asking one specific question, and giving you the opportunity for a more open-ended free response to tell us about the impacts of your pass program at this particular employer. If information for the following question is not available or unknown, enter NA .	
Within the past 2 years , the number of employees who previously drove alone who switched to commuting by transit because of the pass program.	
Free Response Area	

In this section, we encourage you to tell us about what impacts the pass program has had at this employer, and how you measure those impacts. For example: Did you track impacts on Vehicle Miles Traveled (VMT)? Air quality? Employee retention? Absenteeism? Cost savings for employees? Cost savings for employers? What other impacts were there? How did you track them?

You may care to address some of the previous questions, or simply tell us what you think is most important about this program and the impacts it creates. Even if you do not have any "hard numbers," we are very interested in your impressions of how the pass program is working at this employer. **Note: Please do not use quotation marks, single or double- in the textbox below.** It will cause the web server to mistakenly shorten your answer.

In your opinion, how successful has this pass program been in getting employees to ride transit at this employer?

- Highly Successful
- Successful
- Somewhat Successful
- Not Successful

**Employer Pass Program Implementation Survey
For Transportation Demand Management Professionals**

Page 3 of 5

Pass Program Attributes	
Pass Pricing Information	
The next group of questions ask you about the costs in various employer pass programs.	
For information that is not available or unknown, enter NA .	
All costs are assumed to be in U.S. Dollars. If employees at this worksite can purchase passes with varying monetary values, please answer the questions in regards to the MOST EXPENSIVE pass.	
Pass Purchase Prices	
How much do EMPLOYEES pay (per month) towards the cost of an individual pass?	
How much does the EMPLOYER pay (per month) towards cost of an individual pass?	
Volume Discounts	
Is the employer receiving a volume discount for purchasing a certain number of passes?	Yes No
If you answered "Yes" to the previous question, how many passes need to be purchased to get the discount?	
If you answered the previous question, what percent is the discount off the regular pass price?	
Tax Deductions	
Can employees use pre-tax dollars deducted from their paycheck (like a 401k or 403b deduction) to pay for passes?	Yes No
If you answered "Yes" to the previous question, how many employees currently purchase passes using pre-tax dollars?	

**Employer Pass Program Implementation Survey
For Transportation Demand Management Professionals**

Page 4 of 5

Transit Service Attributes	
This section asks about the proximity and quality of transit service to the employer.	
Bus Service Attributes	
How close is the nearest bus stop to the main entrance of the employer?	Less than .25 miles .26 - .5 miles .51 - .75 miles More than .75 miles Don't Know
How often do buses arrive at this stop during morning and evening rush hour on weekdays?	Every 1-10 minutes Every 11-20 minutes Every 21-30 minutes More than 30 minute intervals Don't Know
What type of Buses run to this stop? (check all that apply)	Local/Regular Bus Express Bus Bus Rapid Transit
Rail Service Attributes	
How close is the nearest rail stop to the main entrance of the employer?	Less than .25 miles .26 - .5 miles .51 - .75 miles More than .75 miles Don't Know
What type of rail service runs to this stop? (check all that apply)	Light Rail Subway/Metro Commuter Rail Amtrak Monorail

**Employer Pass Program Implementation Survey
For Transportation Demand Management Professionals**

Pass Program Context

The next several questions are more general, and offer you a chance to give more detailed information about the program at this employer.

How supportive are public officials in your area of Transportation Demand Management strategies?	Very Supportive Supportive Neutral Unsupportive Very Unsupportive
--	---

Note: Please do not use quotation marks, single or double- in the 4 textboxes below. It will cause the web server to mistakenly shorten your answers.

What do employees like most about this program?	
What is the biggest barrier to employee participation in this program?	
What convinced the employer to implement this program?	
What challenges occurred in implementing this program from the employer perspective? How were those challenges overcome?	

Survey Follow-Up

Thank you for taking the time to complete the survey! We may be interested in contacting some survey participants for a 15 to 30 minute follow-up interview by phone or email to find out additional information about your programs. However, we will not contact you without your consent. Please let us know if you would be willing to participate in a follow-up interview. You do not have to choose "Yes" in this question to be eligible for the drawing.

Yes, I am willing to participate in a follow-up interview.

No, I prefer not to be contacted.

From: Patrick McDonough [patrick1@email.unc.edu]
Sent: Saturday, April 19, 2003 12:15 PM
To: rlinsey@octa.net
Subject: UNC TDM Follow-Up Interview: VERY Short!

Greetings-

Thank you for participating in the UNC TDM Study. Your input has been extremely valuable, and I am looking forward to sharing the results with all of you! You have been selected to participate in a follow-up email interview. The fastest way to complete the survey is to reply to this message, including the questions in the email, and write your answers below the question.

The follow-up consists only of 6 questions, 5 of which can be answered using 1-2 word answers. For each question, consider the employer location you profiled in the UNC TDM Survey. If you do not remember which employer you profiled, please open this link to find a list, sorted alphabetically by respondent's first name.
http://www.path.berkeley.edu/~leap/cbrtool/data_to_array.asp

Walking Questions:

1. How long does it take (in minutes) to walk from this location to the nearest bus stop?
2. How long does it take (in minutes) to walk from this location to the nearest rail station?
3. What statement would most likely be used by employees to describe the pedestrian environment near this location?
(choose A,B,or C)
A. I can easily walk to transit from my workplace. There are adequate sidewalks and crosswalks and I feel safe when walking.
B. I can walk to transit from my workplace, but it is not always easy. There are some pedestrian amenities, but crossing streets can be difficult or dangerous. At certain places on my walk, I feel that pedestrian safety could be improved.
C. It is difficult to walk to transit from my workplace. There are very few sidewalks and crosswalks, if any, and I feel endangered by traffic or other hazards throughout the walk.

Parking Questions:

4. What statement would most likely be used by employees to describe the parking situation at this location?
(choose A,B,C,orD)
A. It is easy to find a parking spot at this location, and I do not have to pay to park.
B. It is easy to find a parking spot at this location, but I have to pay to park.

- C. It is difficult to find a parking spot at this location, but I do not have to pay to park.
- D. It is difficult to find a parking spot at this location, and I have to pay to park.
5. If parking is not free, how much do employees pay to park?
(please provide an answer in the following format: \$2/hour, \$5/day,. \$X/month, etc.)

Voucher Question

6. Does this workplace have a transit voucher program that allows people to buy transit media using vouchers for 10-ride books of tickets, tokens, or other fare media that are not constrained by time (as opposed to a pass which is only good for the month of June, etc.)? If so, can you describe how most employees use the transit vouchers? If you have any questions you would like to ask about the study or the follow-up interview, please contact me.

--

Patrick McDonough
Carolina Transportation Program
919-967-5029
patrick1@unc.edu
<http://www.unc.edu/~patrick1/>
file:///C:/WINDOWS/Desktop/Final TDM Survey Docs/UNC TDM Follow-Up Interview VERY Short.txt

**Findings from the survey
Correlations of Interest**

While there were not enough respondents to do regression analysis, 2-tailed correlation tests did yield a few interesting results. They are summarized in Table A.1.

Table A.1: Correlations of Interest

Variable 1	Variable 2	Correlation	Sig. (2-tailed)
Mandated Program	Office Park	0.523	0.003
Amount Employer Pays Per Month	Compressed Work Week	0.546	0.003
Light Rail Presence	Physical Rail Proximity	-0.559	0.006
Mandated Program	Light Rail Presence	0.479	0.007
Pretax Deduction Availability	Physical Rail Proximity	0.553	0.009
Commuter Rail Presence	Users Per 1000 Employees	0.537	0.010
Rideshare Program	Users Per 1000 Employees	-0.539	0.014
Amount Employee Pays Per Month	Office Park	0.433	0.024
Commuter Rail Presence	Urban; Non-CBD	0.398	0.029
Monthly Parking Cost	Guaranteed Ride Home	-0.454	0.038
Multi-Transit System Pass	Users Per 1000 Employees	0.453	0.039
Metro/Subway Presence	Users Per 1000 Employees	0.443	0.045

All the correlations occur at the 95% confidence level or above, and while there should definitely be more study to better determine the nature of these relationships, a few relationships stand out.

First, the multi-agency transit pass' strong correlation with participation in pass programs (Users Per 1000 Employees) follows Fitzroy's findings in Freiburg, Germany, which are mentioned at the beginning of Section 2 of this study (FitzRoy and Smith 1998). Pass programs with greater regional access should garner more participation.

The correlation between subways and commuter rail and participation is also expected, as these two rail modes usually offer the highest level of speed among the different types of rail.

The correlation of mandated programs and office parks is significant, as is the correlation of higher employee payments for transit passes and office parks. One hypothesis to explain these

results is that office parks typically have lots of parking subsidized by employers available at no cost to employees, and employers in office parks are therefore less willing to subsidize transit as well.

Finally, light rail has a very significant positive correlation with mandated programs and an equally significant negative correlation with proximity to rail stations. This could be because many light rail systems in the United States have been constructed in the last 20 years, when more automobile-oriented land use patterns have been the predominant form of development.

APPENDIX B

DEVELOPMENT OF EVALUATION LOGIC FOR EMPLOYEE PASS PROGRAM

In order to use case-based reasoning to evaluate the similarity of individual cases to user input, Microsoft's Active Server Pages web programming platform was used to build a web-based computer application. The web application has a simple interface with less than 5 screens. The screen that displays the results also calculates the similarity of the input case to all cases in the case base before printing the results to the screen. The next few paragraphs explain how similarity is calculated.

For each of the input factors requested on the data entry page, a subroutine in the application compares the value of an individual input factor to the corresponding factor for the current case in the case base. If the similarity of the input factor and the factor and the current case is identical (for nominal variables) or very close (for scalar variables), that factor receives a similarity score of 100. The similarity score for the factor is then multiplied by the weight of that individual factor, and the product is sent to another subroutine which sums the similarity of the factors to produce a similarity score for the current case. The Figure B.1 demonstrates this process with the Urban Form factor. The algorithm then moves to the next case and repeats the process. After calculating the similarity of the input case to all the existing cases, it orders them from strongest similarity to weakest similarity using a bubble sort procedure.

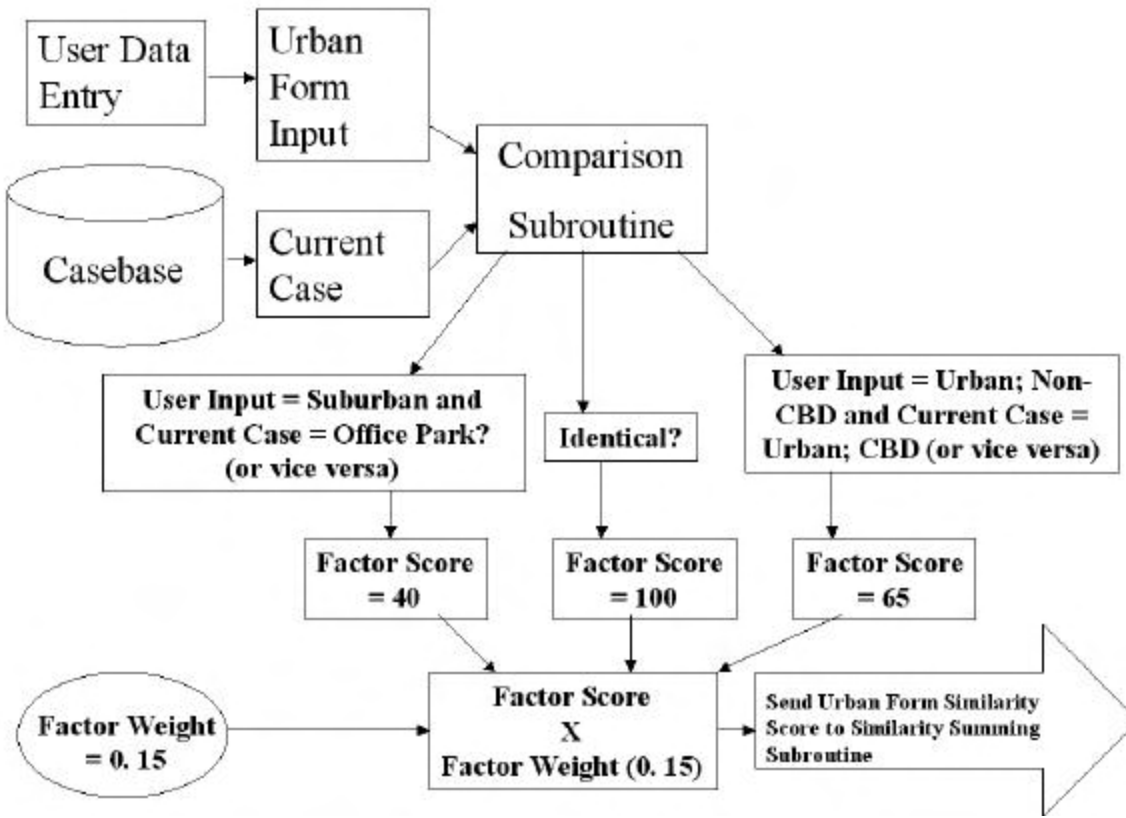


Figure B.1. Factor Score Calculation and Output for Urban Form Factor

How Scores Were Developed For Factors

Of all the parts of the Employer Pass Program Tool, assigning scores to represent various degrees of similarity was the most subjective. With each factor, an input response that was identical to the factor value of the current case was assigned a factor similarity score of 100. With scalar variables, in particular number of employees, ranges was constructed. For example, if the difference between the input employee number and the current case employee number was less than 150, the current case received a score of 100 for this factor. With a difference of 151-250, the current case received a score of 85.

Calculations for Individual Factors in the Employer Pass Program Tool

In the tool, each individual factor score is multiplied by a weight, which, for a perfect match, achieves a score of 100 multiplied by each individual factor weight to yield an overall similarity score of 100.

This appendix explains how scores are allocated for similarities between cases in the case base and the input case. They are broken down by factor below.

Number of Employees Factor

In the tool, this factor accounts for 10 percent of the overall similarity score. Whichever individual similarity score is generated by the input case and a specific case in the case base, that score is multiplied by .10.

Similarity for this factor depends on the absolute value of the difference in the number of employees. The Table B.1 shows the scores.

Table B.1: Scores corresponding to different number of employees

Difference in Number of Employees	Individual Factor Score
Less than 150	100
151-250	85
251-400	70
401-600	55
601-1,000	30
1,001-10,000	15
Over 10,000	0

Walk to Rail Factor

This factor accounts for 15 percent of the overall similarity score. Whichever individual similarity score is generated by the input case and a specific case in the case base, that score is multiplied by .15.

Similarity for this factor depends on the absolute value of the difference in time, in minutes, that it takes to walk from the employer to the nearest rail station. Table B.2 shows the scores.

Table B.2: Scores corresponding to different durations to walk to rail

Difference In Number of Minutes Walking to Rail	Individual Factor Score
Less than 3	100
3-6	85
7-10	60
11-15	45
More than 15 minutes	0

Parking Situation Factor

This factor accounts for 35 percent of the overall similarity score. Whichever individual similarity score is generated by the input case and a specific case in the case base, that score is multiplied by .35.

Similarity for this factor depends on the similarity of two dimensions in one factor. One dimension is parking price, and the other is parking supply or availability. For a match on either dimension, the individual similarity score receives 50 points.

For example, if both the input case and the current employer in the case base have free parking, but a low supply of parking, the similarity score for the individual factor is 100. However, if both have a low supply of parking, but one of the two charges for parking and the other does not, then the individual factor score is only 50, because the pair only matches up on one of the two dimensions. (supply and cost) If the input case and a case base employer are complete opposites, such as a suburban office park employer with abundant free parking and a central city business district firm which has limited park and charges employees to park, then the pair are dissimilar on both dimensions, and the individual factor score is 0.

Urban Form Factor and Premium Transit Factor

The final two factors fluctuate in weight based on whether or not the most premium form of transit near the employer is some type of heavy rail- metro, subway, or commuter rail. Heavy rail is most likely to be completely grade separated and offer significant time travel premiums. If heavy rail exists, the premium mode factor is weighted at 25 percent of the overall score while urban form is 15 percent. If there is no heavy rail, the premium mode factor is weighted at 18 percent while urban form is weighted at 22 percent of the overall score. For greater discussion of why this was done, please see section 4.5 of the paper.

The urban form factor scores are listed in the table below. The relationships between the urban forms and their scores are reciprocal. It does not matter whether the input case or the case base employer is considered as Case1 or Case 2.

Table B.3: Individual Factor scores for different urban forms

Case 1 Urban Form	Case 2 Urban Form	Individual Factor Score
Identical (any urban form)	Identical (any urban form)	100
Urban, Non-Downtown	Urban, Downtown	65
Suburban	Office Park	40

Any relationship not listed in this table, such as Rural/Downtown or Suburban/Urban, Non-Downtown receives a score of 0. The premium transit mode factor scores are listed in the table below. The relationships between the modes and their scores are reciprocal. It does not matter whether the input case or the case base employer is considered as Case1 or Case 2.

Table B.4: Individual Factor scores for different premium transit

Case 1 Premium Transit	Case 2 Premium Transit	Individual Factor Score
Identical (any mode)	Identical (any mode)	100
Metro	Commuter Rail	70
Light Rail	Express Bus	50
Light Rail	Bus Rapid Transit	50

All other pairings, such as case 1 having a subway and case 2 having only express buses, produce a score of 0.

In the case where there are premium modes from both the heavy rail and non-heavy rail groups, the weights for the heavy rail groups and scores take precedence.

How Weights were Chosen for Factors

Once the scores were constructed for each factor, it then became critical to decide which factors would carry the most weight in calculating the similarity of the user input scenario to individual cases in the case base. Since there were not enough cases to run linear regression analysis, expert judgment was used to determine how factors would be weighted, somewhat like the process described by Redmond and Baveja for the police department CBR system. Impacts of the programs were not included as factors, nor were they included as factor weights.

Expert Panel Results

Several transportation experts were contacted and asked to participate in an Expert Panel over email, where they were presented with 10 factors that may or may not lead to increased participation in employer-based pass programs at an individual worksite. The panel was asked to rank the factors in order of most influential to least influential. The results of the Expert panel are shown below, with lower numbers indicating a higher level of influence on employer pass program participation. In Table B.5, scores closer to zero (0) indicate a greater influence on employee participation in a pass program according to the expert panel. Scores closer to one (1) indicate a weaker of influence.

Table B.5. Expert Panel Factor Rankings

Factor	Expert Rankings
parking cost	.28
express bus availability	.34
parking supply	.34
transit cost	.38
walk time to rail	.42

urban form (CBD, urban, suburban, rural)	.50
physical distance to rail	.54
walk time to bus	.56
employer type (private sector, government, college, etc)	.86
# employees at worksite	.94
Expert Group Participants: N = 5	

Correlation Results

In addition to the Expert Panel, 2-tailed correlations were also run for all the major variables in the survey. Of the correlations, the presence of a subway or commuter line had a significant positive correlation with participation in pass programs, as did passes that could be used with more than one transit agency. These insights also informed the values assigned to the factor weights.

Insight about Employer Size from Survey Data

While neither the Expert Panel nor the correlations emphasized employer size as a significant variable related to participation, the findings in the literature that cite administrative hassle as a chief barrier to program implementation, which is strongly echoed in the responses in this study. Therefore, it seems reasonable to place some weight on employer size that will help account for the relative similarity of bureaucracy that needs to be penetrated at a workplace to set up a pass program.

Rationale for Final Factor Weights

The final weights chosen for the factors are shown below in Table B.6.

Table B.6. Final Factor Weights.

Factor	Premium Rail	No Premium Rail
Parking Situation	0.35	0.35
Premium Mode Availability	0.25	0.18
Walk time to nearest rail	0.15	0.15
Urban Form	0.15	0.22
Number of employees	0.1	0.1
	1	1

In addition to strong consideration from the Expert Panel, literature supported the ranking. Michael Meyer found in a TDM literature review in 1999 that parking pricing was one of the most effective TDM strategies for reducing single occupant vehicle trips (Meyer 1999). It is also the principal financial variable among the commuting environmental factors associated with a workplace. Therefore, the parking situation, encompassing both parking supply and parking cost was weighted as the most important factor with a 35 percent factor weight.

The Expert Panel, the correlations, and common sense dictate that premium travel modes such as high-speed rail and express buses should also have higher weights. This weight was set up in a two-tiered process. If there is a commuter rail or metro station within walking distance, the premium mode factor gets assigned a 25 percent weight. As express buses are less attractive than these 2 forms of rail, and light rail often moves at lower speeds, sometimes sharing right-of-way with regular traffic, these premium modes were assigned a factor weight of 18 percent in the absence of the two top rail modes.

The next factors had similar scores in the Expert Panel: walk time to rail and urban form. Walk time to rail was used instead of physical distance to rail because more people answered the walk time question than the mileage question in the survey- it is a more human-oriented metric, and people sometimes have trouble judging the difference between a quarter-mile and a half-mile. When neither of the top 2 rail modes is available, the urban form variable picks up extra weight in light of the fact that light rail stations were found to be correlated with greater distance from employers.

Finally, the employer size variable is included to help adjust the similarity scores for the likely barrier of administrative hassles of implementing the pass program. It will be more beneficial to present results that all other things being equal, will have a similar-sized bureaucracy as the input scenario.

Program Impacts- Reported and Calculated

To keep the survey brief, the survey asked for only three pieces of information that tracked impacts: the number of people who switched from driving alone in the past 2 years, the number of people who participated 5 days per week, and the total number of people enrolled in the pass program. Only 13 respondents answered the first question. 18 answered the second. However, 28 out of 30 respondents knew the full number of participants in the program. This is the number on which all the calculated impacts are built in the tool.

Using the total number of participants, several other impacts were calculated. First, the participation in each pass program was normalized by dividing the number of participants at the employer by the number of employees at the employer. Then, the resulting fraction was multiplied by 1000 to yield a “participants per 1000 employees” figure. In cases where the employer provided every employee with a pass, this figure was not calculated because the math yields a 100 percent result, even though it is impossible to determine how many people *use* the pass as opposed to simply *possessing* the pass. The participants per 1000 employees ranged from a low of 4 at the City of Santa Rosa to 811 at the Federal Transit Administration. The average number of employees participating per 1000 was 190.

Next, impacts on Vehicle Miles Traveled (VMT) and air quality were calculated using data from other sources, including the EPA, the 1995 National Personal Transportation Survey (NPTS), and the 2000 Census. Using the data localization tool from the 1995 NPTS, total daily VMT was calculated for each of the Metropolitan Statistical Areas (MSA) where the employers were located. To determine the average VMT per person in the MSA, the VMT from the MSAs was divided by the population above age 18 in each MSA. This produced a top value of 29.52 miles per person per day in Tulsa, OK MSA, and a low value of 22.14 miles in the San Francisco

MSA. The total number of participants at each worksite was multiplied by the average VMT per person in the MSA to determine daily and annual VMT reduced at the employer. These employer-wide VMT numbers were then multiplied by the average hydrocarbon, carbon monoxide, nitrogen oxide, and carbon dioxide emissions for cars and light trucks according to the EPA(EPA 2000).

Systematic Error in Calculations

The calculated impacts are subject to some degree of systematic error. First, since the VMTs are calculated using numbers from 1995, and the population is from 2000, the larger populations of 2000 are likely to artificially lower the daily VMT per person number. There is also error in the opposite direction, as the NPTS black-box style spreadsheet used to calculate the VMT in MSAs uses *total* daily travel, not commuting travel. This error is likely to artificially raise the daily miles assigned to commuting, which the tool tries to examine. These errors demonstrate the need for more direct information on the length of commutes at individual employers, which will greatly improve the ability of planners and researchers to quantify impacts.

How the Results Are Presented

After the similarity calculations are performed and sorted, they are output to the screen in order of overall similarity, with hyperlinks from the names of the employers to detail pages about the individual employer. Data from the input categories for each returned case is displayed to the right of the similarity score. In the future, the tool will be enhanced to allow sorting by similarity on individual factors, or by limiting the response set to only certain cases, such as “only colleges and universities.”

APPENDIX C

Caltrans presentation

ITS Decision Website: TOOLS

www.calccit.org/itsdecision

Presentation to Caltrans

Asad Khattak
Ashkan Sharafsaleh



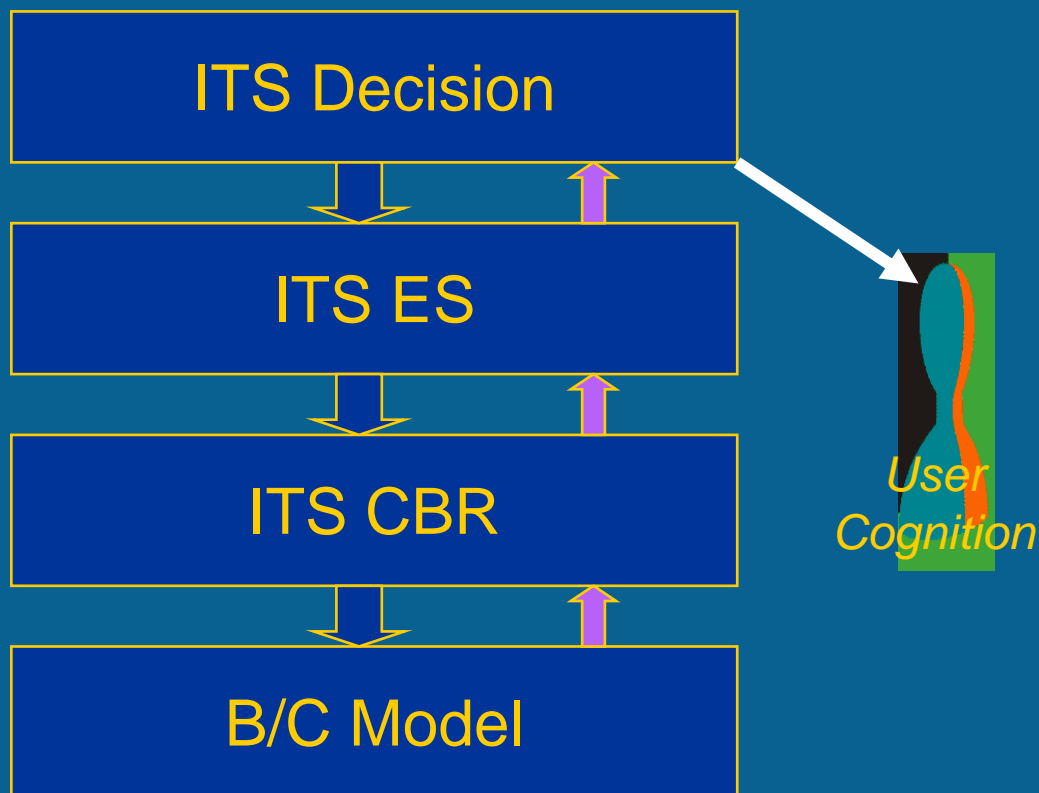
California Center for Innovative Transportation

What is ITS Decision?

- Web-based support for ITS decision making & implementation
- ITS Mainstreaming
- Designed for:
 - Professionals, planners, & engineers
 - Researchers & the public
- Tools to help potential implementers determine:
 - How well it worked elsewhere
 - What will work in their area



What is the ITS Decision Process?



Intelligent Transportation Systems - Home - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address <http://www.path.berkeley.edu/itsdecision/>

ITS Decision

A Gateway to Understanding and Applying Intelligent Transportation Systems

- Home
- Services & Technologies
- Match ITS to Your Needs
- Reports & Articles
- ITS Architecture
- Links
- About Us
- Site Map
- Search

Welcome to the ITS Decision Website.

What are Intelligent Transportation Systems (ITS)?
They are systems that utilize electronics, communications and information processing to improve the efficiency and safety of surface transportation.

What can you learn from this website?
The site provides objective information about **ITS Services and Technologies** and their performance, presented at varying levels of detail, from brief summaries to detailed reports to the online library of published **Reports and Articles**.

What is new at ITS Decision?
Two new features have been added: a section to help you **Match ITS to your Needs** and search engine for the online library. The **ITS Architecture** section has been expanded and the **Links** section updated.

Click here for **Latest Updates**

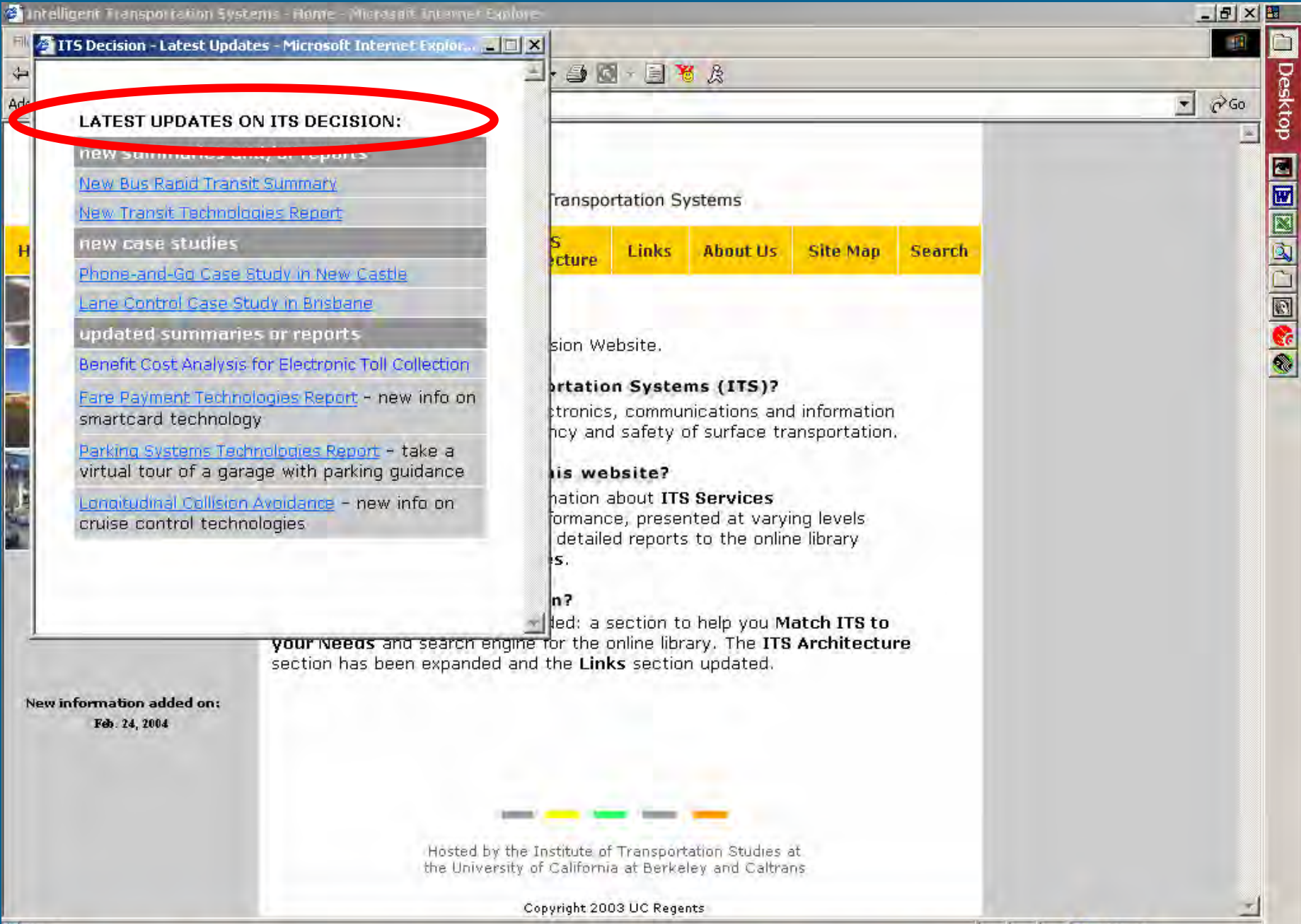
New information added on:
Feb. 24, 2004

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Done Internet

Start Cal... http... Inte... ITS... scre... ICD... 11:18 PM



LATEST UPDATES ON ITS DECISION:

- new summaries and reports
 - [New Bus Rapid Transit Summary](#)
 - [New Transit Technologies Report](#)
- new case studies
 - [Phone-and-Go Case Study in New Castle](#)
 - [Lane Control Case Study in Brisbane](#)
- updated summaries or reports
 - [Benefit Cost Analysis for Electronic Toll Collection](#)
 - [Fare Payment Technologies Report](#) - new info on smartcard technology
 - [Parking Systems Technologies Report](#) - take a virtual tour of a garage with parking guidance
 - [Longitudinal Collision Avoidance](#) - new info on cruise control technologies

Intelligent Transportation Systems

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Intelligent Transportation Systems Website.

What are Intelligent Transportation Systems (ITS)?

Intelligent Transportation Systems (ITS) are the application of electronics, communications and information technologies to improve the efficiency and safety of surface transportation.

What is this website?

This website provides information about ITS Services, ITS Performance, presented at varying levels of detail, and detailed reports to the online library.

What's new?

Added: a section to help you Match ITS to your needs and search engine for the online library. The ITS Architecture section has been expanded and the Links section updated.

New information added on:

Feb. 24, 2004

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- Archived Data
- Automatic Vehicle Location
- Carsharing
- Congestion Pricing
- Electronic Toll Collection
- Fare Payment Technologies
- Freeway Service Patrol
- Freight Operations
- Incident Management
- Intelligent Vehicles
- Parking Systems Technologies
- Public Transit Technologies
- Ramp Metering
- Remote Emissions Sensing
- Ridematching
- Rural ITS
- Safety
- Telecommunications
- Telecommuting
- Traffic Management
- Traffic Signal Control
- Traffic Surveillance
- Travel Demand Management

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The PATH ITS Gateway

to understanding and applying Intelligent Transportation Systems

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- Match ITS to Your Needs
- Reports & Articles
- ITS Architecture
- Links
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Reports & Articles

Reports and articles from:

- Professional Journals
- Technical and Trade Magazines
- Academic Publications
- Federal and State Agencies
- The California Partners for Advanced Transit and Highways Program
- ITS Decision

You may search by just one field or any combination:

- **Topic**
- **Title** (as many or as few words as you like)
- **Author** (as many or as few names as you like)
- **Year of Publication**
- **Recent additions**
- **Source/Publisher**

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ITS Architecture

What is the National ITS Architecture?

It is a common framework for planning, defining and integrating intelligent transportation systems and their technologies. It defines:

- Tasks and functions, such as gathering traffic information or requesting a route;
- the physical devices that carry them out, such as loop detectors or telecommunications links; and
- the paths and connections by which data flows among the various physical devices to accomplish the task or fulfill the function.

MENU

What is the National ITS Architecture?

How can I find where my project belongs in the architecture?

Why was the architecture developed?

What are ITS standards?

What does it mean to be in conformity with the National ITS Architecture?

How can I find out more about the National ITS Architecture and ITS

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Links

General information

[ITS Cooperative Deployment Network](#)

A shared Internet resource containing up-to-date news and resources. Members of the cooperative include most leading organizations and associations concerned with deploying ITS in the U.S. Features include free monthly email newsletter, access to online discussions, a shared calendar of ITS-related events and a resources. Sponsored by the National Associations Working Group for ITS (NAWGITS) and the ITS Cooperative Deployment Network (ICDN).

[USDOT Intelligent Transportation Systems](#)

Comprehensive federal site with links to all USDOT ITS programs. Includes a hotline, links to major USDOT ITS initiatives and on-line documents and links Sponsored by the USDOT ITS Joint Program Office.

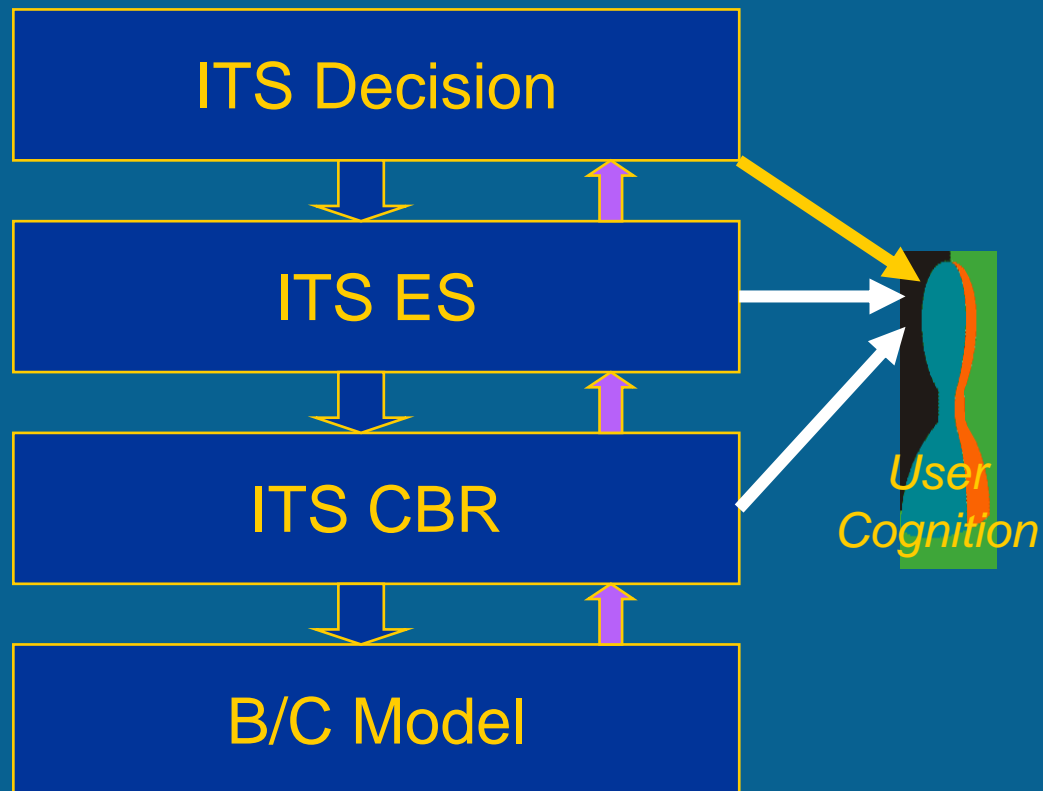
MENU

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Tools...



Matching ITS to Users' Needs: ES & CBR

- **Expert System**

- Problem: Itchy skin, hives
- Context: Have others at your work experienced this? How long has this been going on? Family history?... + Tests
- Diagnosis: Allergy
- Prescription: Take antihistamines twice a day

- **Case-Based Reasoning**

- Studies: (1) on 25-55 age group (2) on 65 and above age group (3) on females only



Match ITS to Your Needs

This page offers links to **three tools** to help you to determine which intelligent transportation systems are appropriate for your needs. They all use data that you supply to generate responses tailored to your needs.

The **expert-system tool** asks you to describe your local transportation system and guides you to potential ITS solutions located on this site. You can use this tool if you have information about **any** of the following:

- population of the project area;
- type of transportation system proposed;
- type of agency implementing the project;
- and type of problem to be solved.

[Go to Expert-System Tool](#)

The **case-based reasoning tool** automatically finds case studies of transportation programs from around the country that are most similar to your setting and speeds up the time needed to research programs by providing quantitative data as well as comments from those who implemented the programs in the case studies. Currently, the case-based reasoning tool analyzes Employer-Based Transit Pass Programs, Automatic Vehicle Locations systems for transit, and Freeway Service Patrols.

[Go to Case-Based Reasoning Tool](#)

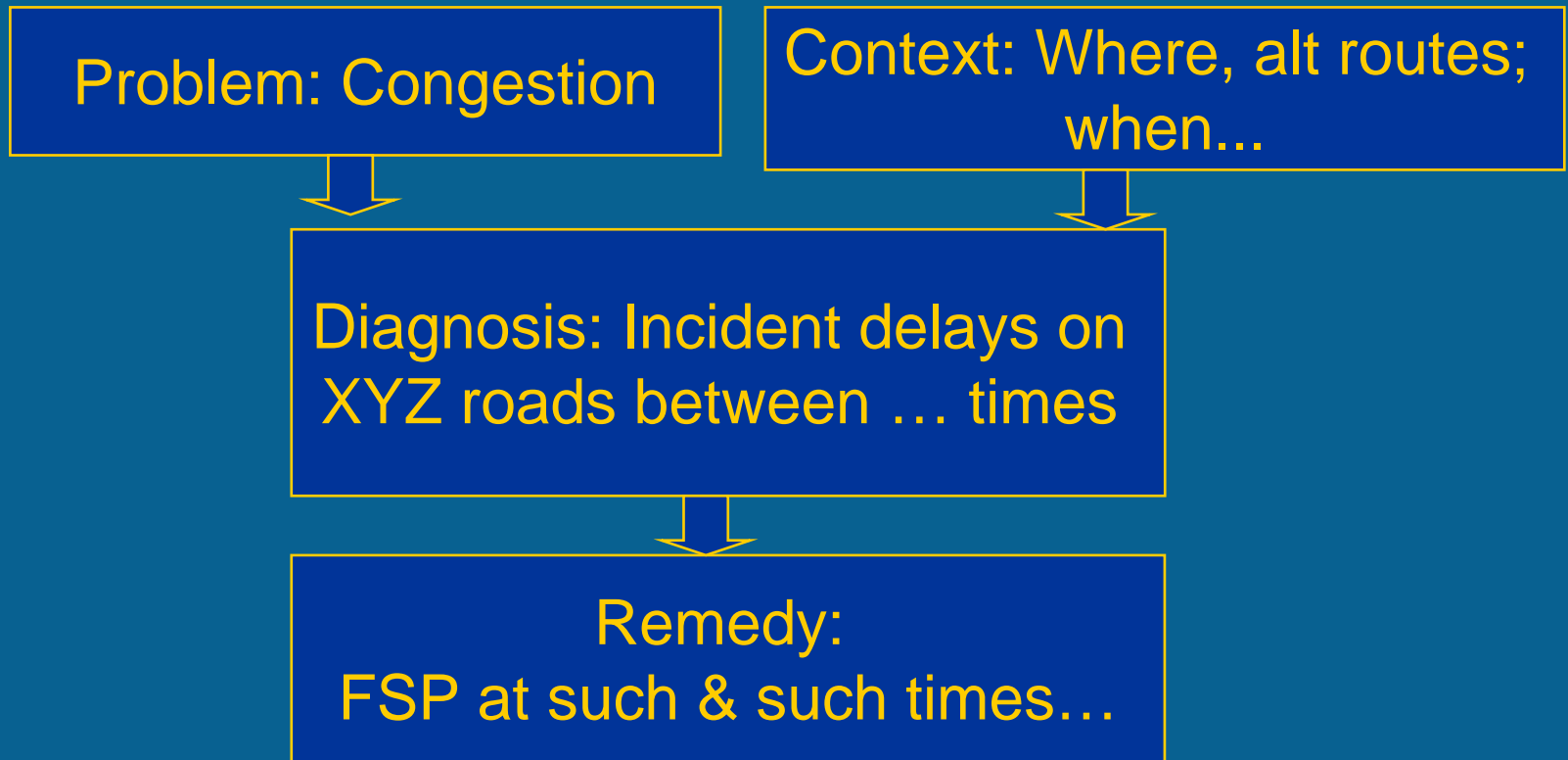
The **Caltrans Transportation Planning Program** has developed the **Life-Cycle/Benefit-Cost Analysis Model**, which is an Excel spreadsheet that provides a method for preparing economic analysis. The user of this tool must be aware that it is to be used in conjunction with other planning analysis practices and that Caltrans cannot be held liable for the information derived from its use.

[Download the Life-Cycle/Benefit-Cost Analysis Model](#) (Cal-BC.xls)

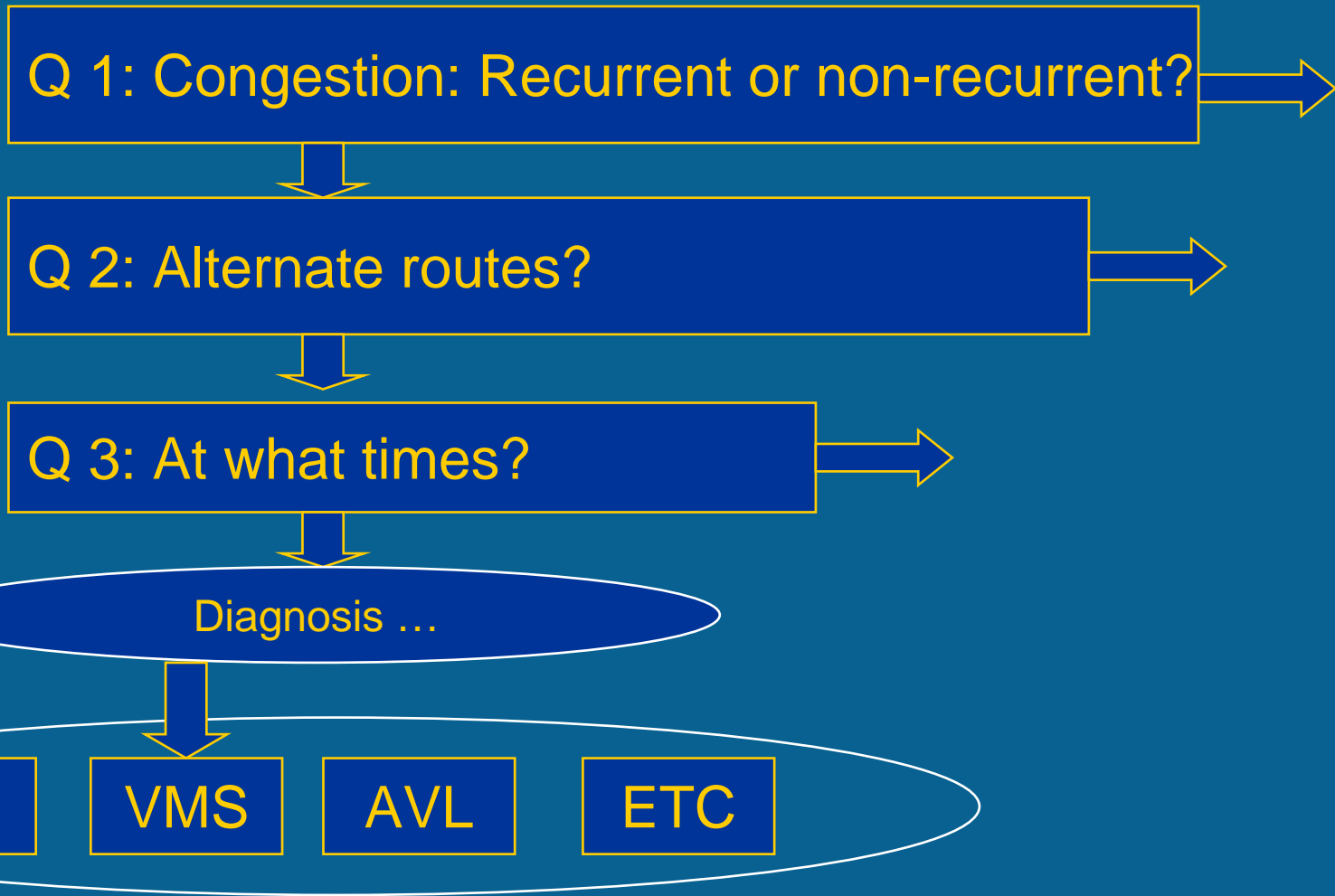


Last updated June 10, 2004

Expert System process



Tree structure



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Services and Technologies

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FREEWAY SERVICE PATROLS

The most visible components of an incident clearance program are the service patrols. These operate in most major metropolitan areas of the United States (see the tables below). These programs usually consist of a fleet of light-duty trucks, equipped with two-way radio communication to a traffic control center. Often times the local transportation authorities will contract with private tow truck companies to provide incident clearance services, instead of operating a fleet of vehicles themselves.

Patrols usually operate on "beats" along a pre-defined stretch of highway, although sometimes they are dispatched on demand. The hours of operation vary with locality and with the specific purpose of the clearance effort: most operate only during peak hours on weekdays only, while a few work around the clock every day of the year. Trucks carry emergency and traffic control signs, gasoline and other materials and tools to assist disabled cars, and first aid kits. Usually these trucks are equipped with tows or push bumpers, which allow them to move vehicles off the road.

FSP programs vary in size from two vehicle operations to programs with as many as 150 tow trucks, as is the case in the Los Angeles Metropolitan Area. Correspondingly, coverage varies from just a single bridge or tunnel, to several

MENU

← FULL REPORT

CASE BASED REASONING

Related Topics

Done

Start



Inbox - Outlook Express

Intelligent Transporta...

Microsoft PowerPoint - [I...

Moving on to case-based reasoning...

- Answer to “Who else has tried it?”
- Focuses on similarity
- Qualitative and quantitative information combined
- User may not be familiar with the context



Should my city implement freeway service patrol?



Need to weigh:

- how many travelers might use it?
- costs of administering program
- benefits of program & techs
- what operational problems have others (in similar situations) encountered?

Example: Do Your Own Research

- **Attend Conference:**
 - hear about other implementations
 - talk to those who already run FSP programs

Expensive



- **Read documents:**

- study results of projects
- review cost/benefit analyses

Time consuming



Match ITS to Your Needs

This page offers links to **three tools** to help you to determine which intelligent transportation systems are appropriate for your needs. They all use data that you supply to generate responses tailored to your needs.

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[Go to Case-Based Reasoning Tool](#)

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[Download the Life-Cycle/Benefit-Cost Analysis Model](#) (Cal-BC.xls)



Last updated June 10, 2004

Our CBR Tool: Tech Overview

ITS Decision

A Gateway to Understanding and Applying Intelligent Transportation Systems

Case Based Reasoning: Freeway Service Patrol Tool

INTRODUCTION TO FREEWAY SERVICE PATROL TOOL

Welcome to the Decision Support Tool for Freeway Service Patrols!

Freeway Service Patrols (FSPs) are services run by cities, state DOTs, and other highway maintenance organizations that provide vehicles to shorten the time that traffic becomes congested after crashes, breakdowns and other delay-causing incidents on America's highways. Usually, this service takes the form of a pickup truck or tow truck with signage that can direct motorists approaching the incident scene to merge or move on, as well as provide assistance to those motorists involved in the incident itself.

By effectively clearing road incidents, Freeway Service Patrols reduce delays and congestion, and help improve overall urban mobility and air quality.

Some topics you can learn about by using the tool include:

- ◆ How many vehicles would be needed to patrol our metro area?
- ◆ What cost:benefit ratios have other FSP programs achieved?
- ◆ How many motorists are served by FSP programs in different metro areas?

[Click Here to use the Freeway Service Patrol Tool](#)



California Center for Innovative Transportation

Our CBR Tool: Input For FSP



A Gateway to Understanding and Applying Intelligent Transportation Systems

Freeway Service Patrols

Case-based reasoning tool to recommend FSP Strategies

Enter your city's population

Enter Your Number of Incidents Per Year

Enter the Number of Miles of Road Served by Your FSP Program

Enter the Number of Routes you Serve with your FSP Program

Enter the Number of FSP Vehicles in your FSP Program

Submit

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ITS Decision

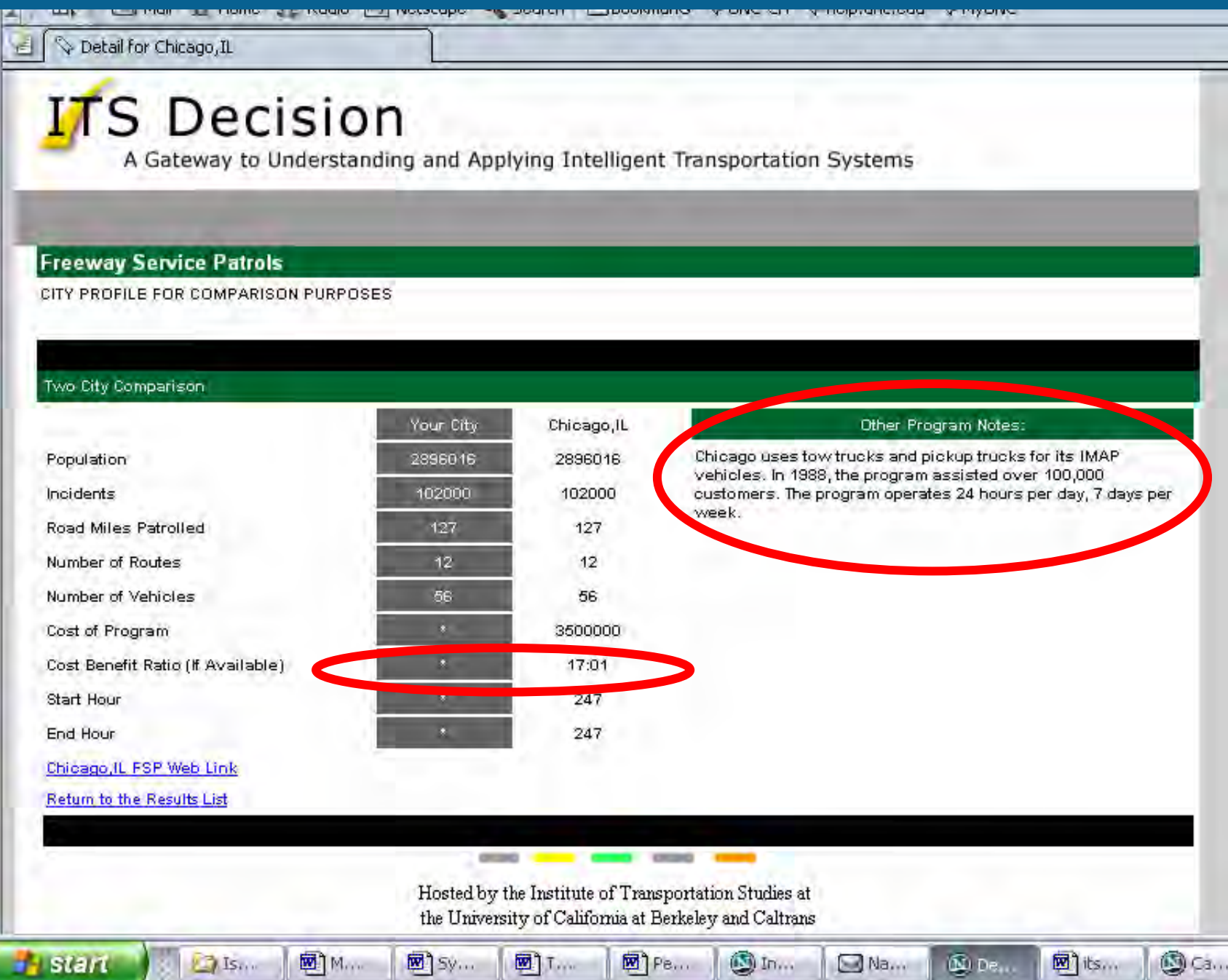
A Gateway to Understanding and Applying Intelligent Transportation Systems

Freeway Service Patrols

CITY SIMILARITY SCORES

Before implementing your FSP Program, you should examine what has been done in these cities:

City	Similarity Score	Population	Incidents	Road Miles Patrolled	Number of Roadways	Number of Vehicles
Your City	NA	2896016	102000	127	12	56
Chicago,IL	48.5	2896016	102000	127	12	56
Orange Co.,CA	48	2846289	80000	145	10	50
Cincinnati,OH	40.5	331285	18200	88	2	5
Ft.Lauderdale,FL	40.5	182397	24000	81	6	7
Kansas City,MO	40.5	146866	40000	97	2	4
Sacramento,CA	40.5	407018	11700	90	4	17
Winston-Salem,NC	40.5	185776	13200	143	4	6
St.Louis,MO	40	348189	99999999	161	10	14
Atlanta,GA	39	416474	16900	105	5	12
New York,NY	38.5	8008278	23570	217	7	21
Oakland,CA	38.5	399484	97000	362	20	57
Albany,NY	37.5	95658	8200	35	2	2
Columbia,SC	37.5	116278	4200	32	2	3
Denver,CO	37.5	554636	18000	61	5	10
Detroit,MI	37.5	951270	7080	68	4	5
El Paso,TX	37.5	563662	18000	31	2	6



ITS Decision

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Freeway Service Patrols

CITY PROFILE FOR COMPARISON PURPOSES

Two City Comparison

	Your City	Chicago,IL
Population	2896016	2896016
Incidents	102000	102000
Road Miles Patrolled	127	127
Number of Routes	12	12
Number of Vehicles	56	56
Cost of Program	*	3500000
Cost Benefit Ratio (If Available)	*	17:01
Start Hour	*	247
End Hour	*	247

Other Program Notes:
 Chicago uses tow trucks and pickup trucks for its IMAP vehicles. In 1988, the program assisted over 100,000 customers. The program operates 24 hours per day, 7 days per week.

[Chicago,IL FSP Web Link](#)

[Return to the Results List](#)

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AVL/CAD Systems

 ITS Decision

AVL/CAD Systems

SIMILARITY SCORES

Before implementing an AVL/CAD System, you should examine what has been done in these cities:

AVL Implementation	Similarity Score	# Buses in Local Service	Urban Form	Size of Entire Fleet
Your Existing Conditions	NA	20	Small Urban	Less than 50
City of Napa	100	15	Small Urban	Less than 50
City of Albuquerque	86.5	72	Small Urban	101 to 200
San Joaquin Regional Transit	51	49	Large Urban	101 to 200
Hamilton Street Railway	37.5	142	Large Urban	201 to 500
Maryland Mass Transit Administration	13.5	642	Large Urban	More than 800

[Run This Tool Again](#)



California Center for Innovative Transportation

Our CBR Tool: Planner Input For Employer-Based Pass Programs

The number of records is 30

JTS Decision

Employer-Based Transit Pass Programs

Case-based reasoning tool to recommend Employer-Based Transit Pass Programs

Enter the number of employees onsite

What Best Describes the Urban Form of Your Area?

Are there express bus routes near the worksite?

How close is the nearest rail station to the worksite?

What type of workplace is this?

Submit

Urban: Central Business District

No

No Rail

Private Sector



Results with Similarity Scores

TDM Similarity Results - Mozilla

File Edit View Go Bookmarks Tools Window Help

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Bookmarks Planning Links Search News WFU Hoop Weather Employer Pass Progra... HouseHunt HAWAII INFO

ITS Decision

Employer-Based Transit Pass Programs

CITY SIMILARITY SCORES

Before implementing your Employer Pass Program, you should examine what has been done in these cities:

Employer	Similarity Score	Employees	Urban Form	Express Bus	Employer Type	Attr.
Input Employer	NA	1700	Central Business District	No	Private Sector	
Thrivent Financial for Lutherans	68	1500	Central Business District	yes		
Yahoo Inc.	62.5	1800	Office Park	yes		
University Village	58	1500	Urban; Non-CBD	no		
coffee company	53.5	2300	Urban; Non-CBD	no		
Downtown Denver Partnership	51.5	20	Central Business District	yes		
Catholic Charities	51.5	400	Central Business District	no		
Software Developer/Service Provider	51.5	600	Central Business District	no		
Health Care	51.5	500	Central Business District	yes		
Transit Agency	47	1700	Urban; Non-CBD	no		
Router manufacturer	46	800	Office Park	yes		
City of Berkeley	43.5	1313	Central Business District	yes		
Pacific Science Center	41.5	155	Urban; Non-CBD	no		
Cambridge Systematics, Inc.	41.5	100	Office Park	no		
Bank	37	999999999	Urban; Non-CBD	yes		
Target	34.5	10000	Central Business District	yes		

Done



Qualitative info

TDM Employer Case Profile - Mozilla

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Bookmarks Planning Links Search News WFU Hoop Weather Employer Pass Progra... HouseHunt HAWAII INFO

Employer Pass Program Profile

Yahoo Inc.
Sunnyvale, CA

General Employer Information:		Comments From Elizabeth Williams
Type of Employer:	Private Sector	"Yahoo provides a 25 percent transit subsidy for employees. Growth in the overall rideshare program is tracked annually via an on line survey. All components in the rideshare program are being promoted and growth is evident in transit and carpool uses. Impacts are shown to employees as costs savings and stress reduction options. A company-wide Rideshare database has been developed to track daily efforts and to help with internal ridematching with other employees. The database also allows the program to target market to specific transit or carpool groups. Commuter Checks are provided to employees either in a pre-tax payroll deduction or on site for transit and vanpool fare purchases. More transit ridership could be generated if acutal transit passes were sold directly on site to enhance convenience for employees."
Total Number of Employees at Worksite	1800	
Number of Employees Participating in Program	82	
Year Program Started	1999	
Description of Surrounding Area	Office Park	
Other TDM Strategies At This Location		"Ranked from survey includes first, stress reduction; second, save costs, wear and tear on personal vehicle; third, length of commute; fourth, time savings."
Is the program mandated locally or regionally?	yes	
Is there a guaranteed ride home program?	Yes	
Is there a Ridesharing/Carpool program available?	Yes	
Do Employees Have a Telecommuting Option?	No	"In survey order, irregular work schedule, anything else takes too much time, prefer to drive myself, do not like to depend on others"
The Following Bicycle Facities are Available:		
Bike Racks	yes	
Showers	yes	
Lockers (for clothing)	yes	

Done



Data collection instrument

Employer Pass Program Survey - Mozilla

File Edit View Go Bookmarks Tools Window Help

Back Reload Stop http://www.unc.edu/~patrick1/mp/ Search Print

Employer Worksite Basic Information

Name of Employer:	<input type="text"/>	
Employer Location:	City: <input type="text"/>	State: <input type="text" value="Choose a State"/>
Approximate Number of Employees At Location:	<input type="text"/>	
Which of the following best describes the location of the employer?	<input type="radio"/> Urban <input type="radio"/> Business Park <input type="radio"/> Suburban <input type="radio"/> Rural <input type="radio"/> Downtown <input type="radio"/> Other (categorize this better)	
What type of employer is this?	<input type="radio"/> Private Sector Employment Site <input type="radio"/> Government Employment Site <input type="radio"/> University <input type="radio"/> Other: <input type="text"/>	

Pass Program Attributes

Participation Information

Is this employer's participation in a transit pass program mandated or voluntary? Mandated Voluntary

Employee Participation: Please be as specific as possible. If you do not have a breakdown by days of participation, simply fill in the

Employees Participating: 1 or more days per week



TDM Example

particular worksite.

How supportive are public officials in your area of Transportation Demand Management strategies?

Very Supportive
 Somewhat Supportive
 Indifferent
 Unsupportive
 Very Unsupportive

What do employees like most about this program?

Employees enjoy reading enroute to work, lower stress and

What is the biggest barrier to employee participation in this program?

Getting the word out! You need a strong PR person!

What convinced the employer to implement this program?

This employer was concerned about tax consequences; we

What challenges occurred in implementing this program?

We had trouble meeting with

How were those challenges overcome?

Employer Pass Program Impacts

The following section asks questions about the impacts of the Employer Pass Program at this worksite. We have decided to use a "before" and "after" approach in this section with before denoting data prior to the beginning of the pass program, and after pertaining to the most recent data gathered, regardless of the age of the program. For any unknown data, please enter NA for "Not Available."

	Before	After
--	--------	-------

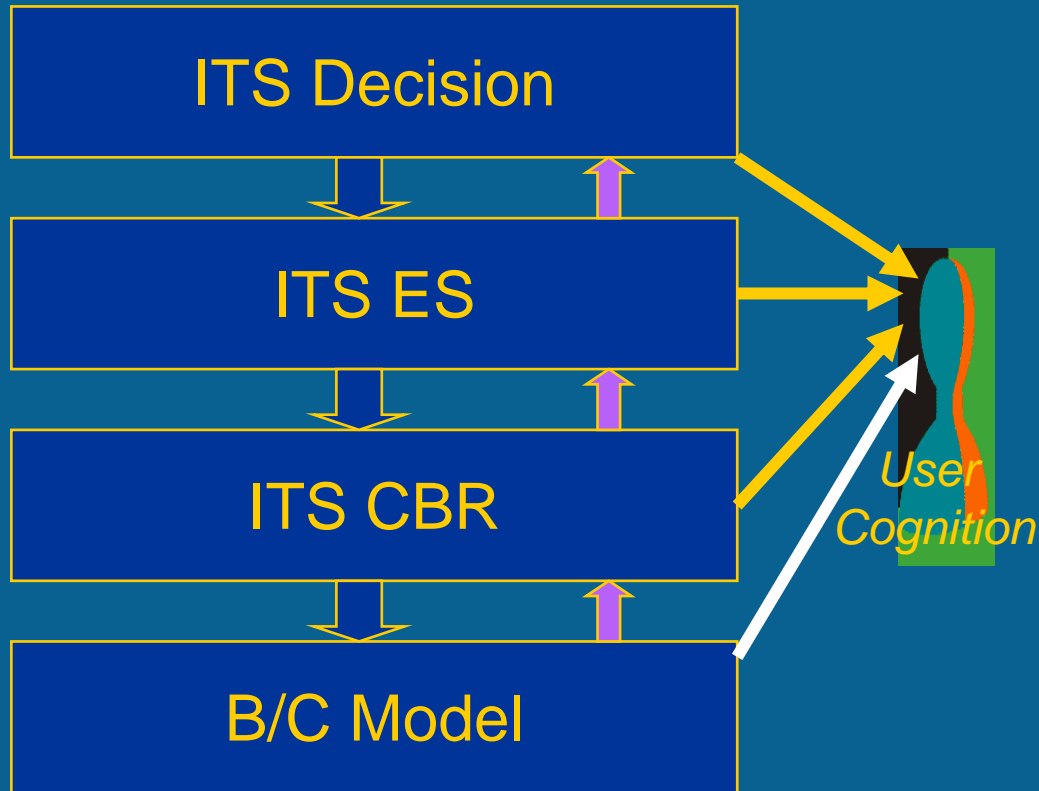


CBR Summary

- CBR: Are there similar cases?
- What have others done in similar situations?
- Quantitative + Qualitative information
- Currently pursuing
 - AVL/CAD
 - FSP
 - TDM (Employee Pass Program)



Cost/Benefit



Welcome to **California**
[Caltrans](#) > [Transportation Planning](#) > Tools

search



My CA



This Site

Transportation Planning Tools

Transportation planners at Caltrans and other agencies use many tools to assist them in making decisions. Some of these tools do calculations based upon input from the planner. Other tools provide data in a format that can be used for analysis.

The following tools are used within the Transportation Planning Program and are available for your download and use. The user of these tools must be aware that these tools are to be used in conjunction with other planning analysis practices and that Caltrans cannot be held liable for the information derived from the use of these tools.

- The [Life-Cycle/Benefit-Cost Analysis Model \(Cal-BC.xls\)](#) is a spreadsheet that provides a method for preparing economic analysis.
- The [Intermodal Transportation Management System \(ITMS\)](#) is a performance-based decision support system operating on a personal computer allowing alternatives analysis using performance measures. It has intermodal system elements for freight and person movements using a spatial and attribute database associating transportation systems under existing and forecasted conditions.
- The [California Transportation Investment System \(CTIS\)](#) is a customized Geographic Information System (GIS) application that runs on ArcView 3.1, or higher. The purpose of this sketch-level Tool is to display transportation projects (including highway, local, rail, aviation, transit, bicycle and pedestrian) programmed and planned statewide over the next 20 years for use in analyzing the multi-modal transportation system throughout California.
- [Intergovernmental Review \(IGR\) Program Guidelines](#) include some of the training materials utilized by [Headquarters IGR](#) managers. These materials, which are often shared with local development agencies and other CEQA lead agencies, include the [Traffic Impact Study Guide \(TIS\)](#) and the [Transportation Mitigation Monitoring Submittal Guidelines \(TMMMSG\)](#).
- The purpose of the [Transportation Trend Analysis and Demographic Projection Study](#) was to analyze past population and travel trends, and project future trends, in order to support the state infrastructure and development planning process.

[Life-Cycle/Benefit-Cost Analysis Mode](#)
[The Intermodal Transportation Management System \(ITMS\)](#)
[The California Transportation Investment System \(CTIS\)](#)
[Intergovernmental Review \(IGR/CEQA\) Program](#)


District: **HQ**

PROJECT: **Hypothetical Project**

EA:
PPNO:

Enter all project costs
Project costs (line items)

1A PROJECT DATA

Type of Project Enter "X"

Highway	HOV Lane	<input type="text"/>	HOV Restrict (Enter 2 or 3)
	Passing Lane	<input type="text"/>	
	Interchange	<input type="text"/>	
	Bypass	<input type="text"/>	
	Other/General	<input type="text"/>	
Transit	Passenger Rail	<input type="text"/>	Exclusive Right-of-Way
	Light-Rail (LRT)	<input type="text"/>	
	Bus	<input type="text"/>	

Project Location (enter 1 for So. Cal., 2 for No. Cal., or 3 for rural)

Length of Construction Period years

Length of Peak Period(s) (up to 8 hrs) Existing 5 hours

1C HIGHWAY ACCIDENT DATA

Actual 3-Year Accident Data for Facility


	Count (No.)	Rate
Fatal Accidents	<input type="text"/>	0.01
Injury Accidents	<input type="text"/>	0.34
Property Damage Only (PDO) Accidents	<input type="text"/>	0.64

Statewide Average for Highway Classification

	Existing	New
Accident Rate (per million vehicle-miles)	<input type="text"/>	<input type="text"/>
Percent Fatal Accidents	<input type="text"/>	<input type="text"/>
Percent Injury Accidents	<input type="text"/>	<input type="text"/>

1E

Year	Project Support	IM
Construction Begins		
0	<input type="text"/>	<input type="text"/>
1	<input type="text"/>	<input type="text"/>
2	<input type="text"/>	<input type="text"/>
3	<input type="text"/>	<input type="text"/>
4	<input type="text"/>	<input type="text"/>
5	<input type="text"/>	<input type="text"/>
6	<input type="text"/>	<input type="text"/>
7	<input type="text"/>	<input type="text"/>
Project Opens		
1	<input type="text"/>	<input type="text"/>
2	<input type="text"/>	<input type="text"/>
3	<input type="text"/>	<input type="text"/>
4	<input type="text"/>	<input type="text"/>
5	<input type="text"/>	<input type="text"/>
6	<input type="text"/>	<input type="text"/>
7	<input type="text"/>	<input type="text"/>
8	<input type="text"/>	<input type="text"/>
9	<input type="text"/>	<input type="text"/>
10	<input type="text"/>	<input type="text"/>
11	<input type="text"/>	<input type="text"/>
12	<input type="text"/>	<input type="text"/>
13	<input type="text"/>	<input type="text"/>
14	<input type="text"/>	<input type="text"/>
15	<input type="text"/>	<input type="text"/>
16	<input type="text"/>	<input type="text"/>
17	<input type="text"/>	<input type="text"/>
18	<input type="text"/>	<input type="text"/>
19	<input type="text"/>	<input type="text"/>
Total	<input type="text"/>	\$0



1B HIGHWAY DESIGN AND TRAFFIC DATA

Highway Design Existing New

Number of General Traffic Lanes	<input type="text"/>	<input type="text"/>
Number of HOV Lanes	<input type="text"/>	<input type="text"/>
Free-Flow Speed	<input type="text"/>	0
Length (in miles)	Highway Segment	0.0
	Affected Area	0.0

Average Daily Traffic

Current	<input type="text"/>	<input type="text"/>	<input type="text"/>
Base (Year 1)	w/o Project	0	0
	w/ Project	<input type="text"/>	<input type="text"/>
Forecast (Year 20)	<input type="text"/>	0	0

Average Hourly HOV Traffic (if HOV project)

Percent Trucks (include RVs, if applicable) Existing 9% New 9%

Truck Speed (if passing lane project)

1D TRANSIT DATA

Annual Person-Trips

	w/o Project	w/ Project
Base (Year 1)	<input type="text"/>	<input type="text"/>
Forecast (Year 20)	<input type="text"/>	<input type="text"/>
Percent Trips during Peak Period	39%	<input type="text"/>
Percent New Trips from Parallel Highway	<input type="text"/>	100%

Annual Vehicle-Miles

	w/o Project	w/ Project
Base (Year 1)	<input type="text"/>	<input type="text"/>
Forecast (Year 20)	<input type="text"/>	<input type="text"/>

Average Vehicles/Train (if rail project)

Reduction in Transit Accidents

Percent Reduction (for safety projects)

Average Transit Travel Time

Including transfers (in minutes)	Existing	New
Non-Peak	<input type="text"/>	0
Peak	<input type="text"/>	0

Model should be run for both roads for intersection or bus sec highway projects

Enter all project costs (in today's dollars) in columns 1 to 7. Costs during construction should be entered in the first eight rows. Project costs (including maintenance and operating costs) should be net of costs without project.

EA:
 PPNO:

T DATA

Count (No.)	Rate
	0.01
	0.34
	0.64

Existing	New

w/o Project	w/ Project
39%	100%

w/o Project	w/ Project

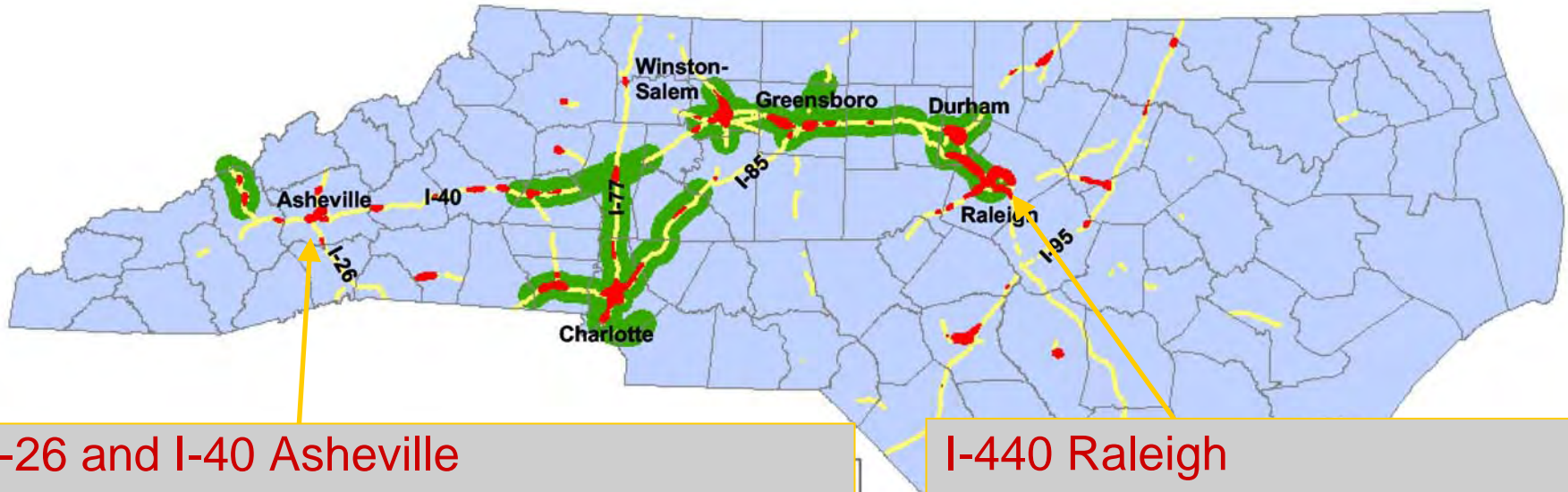
Existing	New
	0
	0

PROJECT COSTS									
Col. no.	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
Year	INITIAL COSTS			SUBSEQUENT COSTS		Mitigation	Other Costs	TOTAL COSTS	
	Project Support	R / V	Construction	Maint./ Op.	Rehab.			Constant Dollars	Present Value
Construction Begins									
0				<-- Must enter a cost -->				\$0	\$0
1								0	0
2								0	0
3								0	0
4								0	0
5								0	0
6								0	0
7								0	0
Project Opens									
1								\$0	\$0
2								0	0
3								0	0
4								0	0
5								0	0
6								0	0
7								0	0
8								0	0
9								0	0
10								0	0
11								0	0
12								0	0
13								0	0
14								0	0
15								0	0
16								0	0
17								0	0
18								0	0
19								0	0
20								0	0
Total	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0



Decision Support Tool Candidate Sites

Crashes per 100 Million Vehicle Miles Density



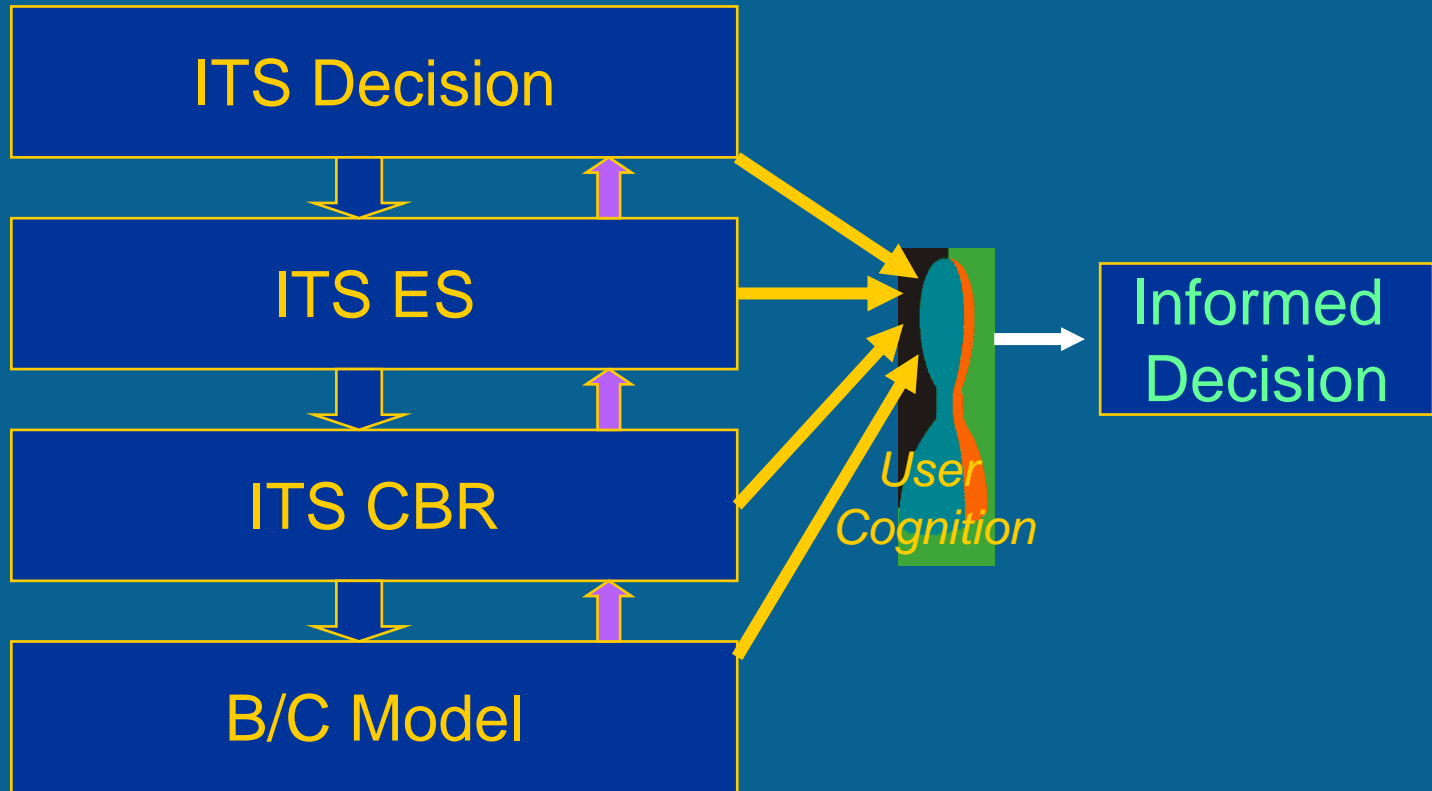
I-26 and I-40 Asheville

- 4-lane facility
- 15 miles in length
- 64000 ADT
- 303 crashes per year
- 4 FSP vehicles (estimated)
- B/C = 2.7 (Net worth \$410K)

I-440 Raleigh

- 6-lane facility
- 12 miles in length
- 82000 ADT
- 712 crashes per year
- 3 FSP vehicles (estimated)
- B/C = 3.3 (Net worth= \$420K)

What is the ITS Decision Process?



What Next?

- Combine Expert System and Case-Based Reasoning with B/C Models
- Expand ES & CBR to 32 ITS services—or at least “high-impact & proven” ITS services
- Explore opportunities to collaborate...

