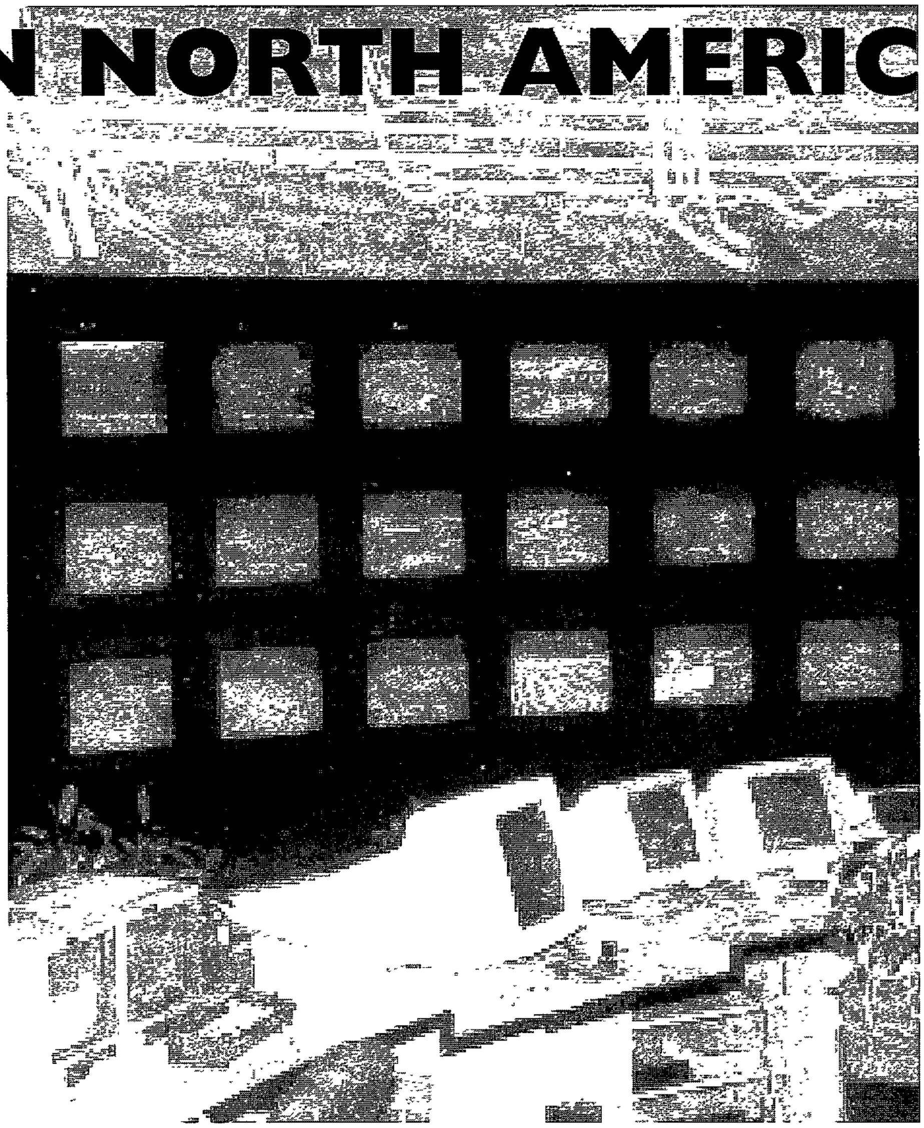
ITS

IN NORTH AMERICA



A REPORT PREPARED BY PARTICIPANTS OF THE
ITS IN NORTH AMERICA '94 STUDY TOUR

ite
Institute of Transportation Engineers

Standard ITE Metric Conversions

During the service life of this document, use of the metric system in the United States is expected to expand. The following common factors represent the appropriate magnitude of conversion. The quantities given in U.S. customary units in the text, tables or figures, represent a precision level that, in practice, typically does not exceed two significant figures. In making conversions, it is important to not falsely imply a greater accuracy in the product than existed in the original dimension or quantity. However, certain applications such as surveying, structures, curve offset calculations, etc. may require great precision. Conversions for such purposes are given in parentheses.

Length

1 inch	=	25 mm (millimeters — 25.4)
1 inch	=	2.5 cm (centimeters — 2.54)
1 foot	=	0.3 m (meters — 0.3048)
1 yard	=	0.91 m (0.914)
1 mile	=	1.6 km (kilometers — 1.61)

Volume

1 cubic inch	=	16 cm^3 (16.39)
1 cubic foot	=	0.028 m^3 (0.02831)
1 cubic yard	=	0.77 m^3 (0.7645)
1 quart	=	0.95 L (liter — 0.9463)
1 gallon	=	3.8 **L (3.785)**

Speed

foot/sec.	=	0.3 m/s (0.3048)
miles/hour	=	1.6 km/h (1.609)

Temperature

To convert ° F (Fahrenheit) to ° C (Celsius), subtract 32, then divide by 1.8.

Area

1 square inch	=	6.5 cm^2 (6.452)
1 square foot	=	0.09 m^2 (0.0929)
1 square yard	=	0.84 m^2 (0.836)
1 acre	=	0.4 ha (hectares — 0.405)

Mass

1 ounce	=	0.03 kg (kilograms — 0.028)
1 pound	=	0.45 kg (kilograms — 0.454)
1 ton	=	900 kg (907)

Light

1 footcandle	=	11 lux (lumens per m^2 — 10.8)
1 footlambert	=	3.4 cd/m^2 (candelas per m^2 — 3.426)

For other units refer to the American Society of Testing Materials (1916 Race Street, Philadelphia, PA 19 103) Standard for Metric Practice E 380.

ITS

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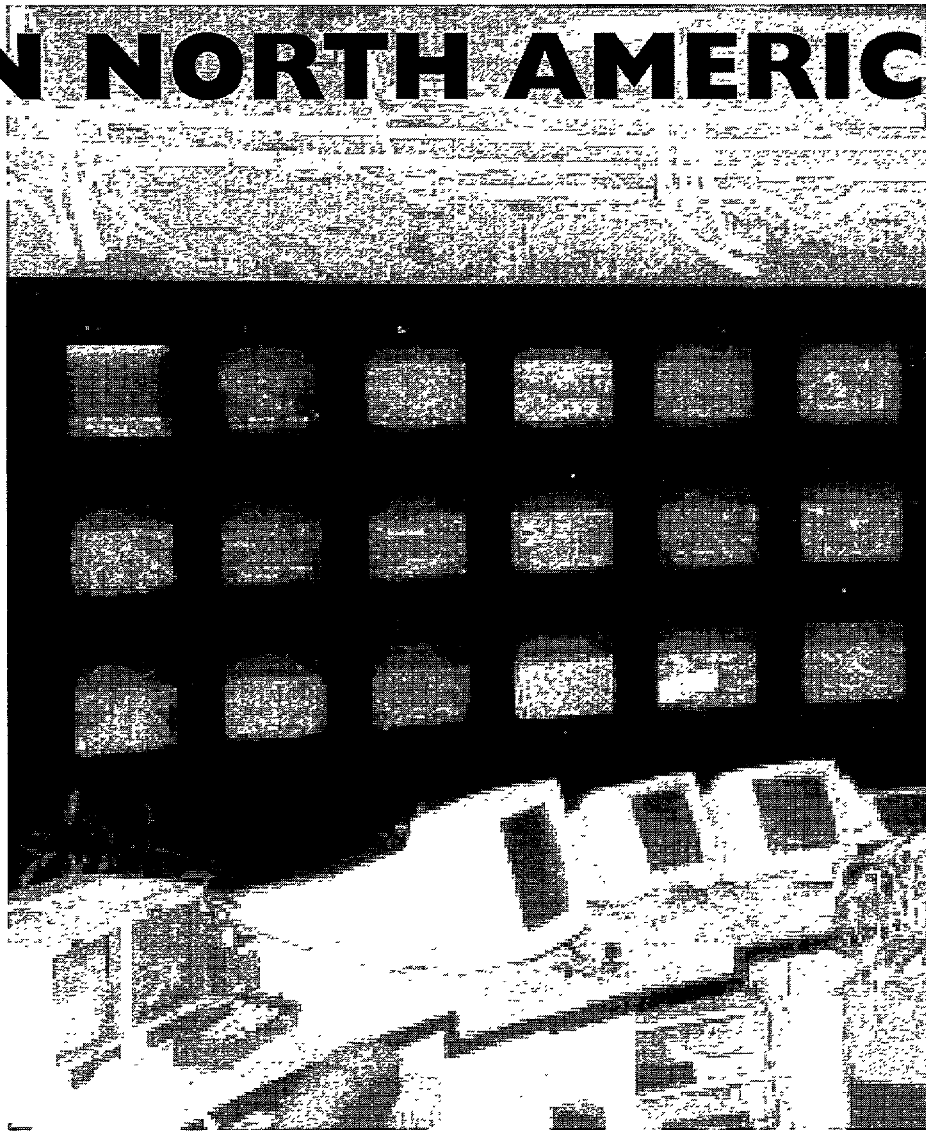

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The Institute of Transportation Engineers (ITE) is a professional society of more than 12,000 transportation engineers and planners, who are responsible for the safe and efficient movement of people and goods on streets, highways and transit systems. ITE members are engaged in planning, designing, operating, managing and maintaining surface transportation systems in 70 countries. Since 1930 the institute has been providing transportation professionals with programs and resources to help them meet those responsibilities. Institute programs and resources include professional development seminars, technical reports, a monthly journal, local. regional and international meetings, and other forums for the exchange of opinion, ideas, techniques and research.

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Preface and Acknowledgments

This report documents the site visits, technical summaries, tour notes and other information gathered during the *ITS North America '94 Study Tour*, a study tour on Intelligent Transportation Systems (ITS), conducted August 7- 13, 1994. and sponsored by the Federal Highway Administration (FHWA) and the Institute of Transportation Engineers (ITE). Twenty-nine tour participants, including ten public sector scholarship winners and participants from Belgium, France, Germany. Ireland, and the United Kingdom visited ITS sites in Minnesota, Illinois, Michigan, and Ontario. Canada.

This report contains the personal observations and perspectives of the ten scholarship winners.

The authors of this report wish to thank FHWA and ITE for sponsoring this very successful study tour, particularly for establishing the scholarship program that made it possible for ten public sector professionals to participate. A special word of thanks goes to Dennis C. Judycki and Sheldon G. Strickland of FHWA; to Thomas W. Brahms, Mark R. Norman. and Juan M. Morales of ITE; to the ITE ITS Council; and finally, to all the hosts and contacts in the sites visited, without whom the tour would not have been possible.

Dennis L. Foderberg, P.E.
Coordinator, ITS North America ‘94 Study Tour, and
Director, ITS Institute
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Minneapolis, Minnesota

Study Tour Itinerary

Sunday, August 7, 1994

FHWA Status of ITS Report
ITS AMERICA Report

Monday, August 8,1994

Human Factors Research Laboratories (HFRL) at the University of Minnesota
Bus Tour of I-394 and Team Transit
Metro Traffic Management Center (TMC) Presentation and Minnesota DOT/Guidestar Presentation

Tuesday, August 9, 1994

ADVANCE Presentation of Chicago area

Wednesday, August 10, 1994

Illinois DOT for Minuteman and Traffic Control Center Presentations
Smart Bus Presentation in Ann Arbor

Thursday, August 11,1994

Michigan's Intelligent Transportation Systems Center (MTIS) in Detroit
General Motor's ITS Research Projects Presentation and Tour in Warren
FAST-TRAC Presentation in Troy, Mich.

Friday, August 12,1994

COMPASS Presentation at the Ontario Ministry of Transportation (MTO)
Toronto Signal System Presentation and Tour

Saturday, August 13,1994

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ITS North America '94 Study Tour

Overview By
Dennis L. Foderberg, P.E.
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On Sunday, August 7, 1994. at 3:00 p.m., 26 people gathered in the Coffman Room of the Radisson Hotel Metrodome in Minneapolis, MN. All but one were signed up to spend the next five and one-half days "on the road." This was the start of the ITE Intelligent Transportation Systems (ITS) North American '94 Seminar Tour. This is the fourth tour in a series and follows successful tours of Europe and Japan. The pace for the tour was hectic and virtually non-stop until the farewell dinner on Friday evening, August 12 at the Toronto Airport Hilton.

This opening session lasted about three hours. Juan Morales of ITE. who served as staff tour coordinator, welcomed everyone on behalf of ITE. Dennis Foderberg of the University of Minnesota, tour coordinator. briefed the participants on the tour schedule and gave an overview of what was in store. Following a round of self-introductions, Mike Soboleuski, Minnesota Department of Transportation. presented an ITS AMERICA report. (Mike was the only one at the briefing not going on the tour.) Wayne Berman, Denise Bednar and George Beronio. FHWA, welcomed everyone on behalf of FHWA and presented an ITS report from the FHWA perspective. Wayne talked about FHWA's overall ITS program. Denise highlighted ongoing operational tests. and George described the current process for the development of an ITS Architecture.

Following a short break, we were whisked away in three very long limousines compliments of 3M, St. Paul. MN. Bob Johnson and George Palm were our hosts for the evening, which included a demonstration of some of the latest 3M technology and a sponsored dinner. The group saw 3M's new smart loop vehicle detection technology and their latest innovations relative to optically programmed signal heads at 3M's Cottage Grove, MN facility. After the demonstration we were able to get better acquainted over a splendid dinner.

The last two full-tour participants joined us at breakfast on Monday, August 8 for the first full day of tour activities. Following breakfast, we visited the Human Factors Research Laboratory (HFRL) on the campus of the University of Minnesota. Peter Hancock, HFRL director. and Mike Wade, head of the Department of Kinesiology. welcomed us and introduced staff and students who conducted the tour.

The following projects were included in the HFRL tour: Work zone safety - The objective of this project is to examine ways of reducing motorists' speed through work zones using lights flashing in sequence. *Flight simulator* - This project evaluates the degradation of navigation performance when a pilot is subjected to an overload of competing work tasks. *Vision impairment* - This test is set up to determine visually impaired (due to cataracts) drivers' ability to divert their attention from the roadway for brief periods of time while driving a simulator. *Virtual reality simulator* - Virtual reality simulation is designed to test drivers' reactions to extreme situations in a virtual reality environment. *Variable message dispalys* - This test is designed to evaluate the effectiveness of various messages on simulated signs.

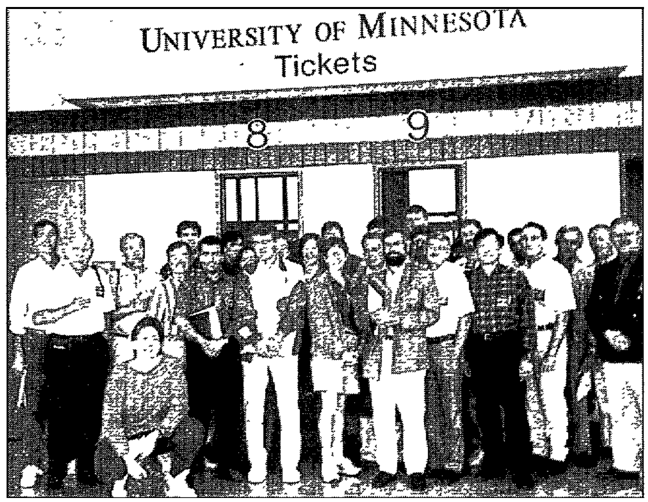

Figure 1. ITE ITS North American Seminar Tour Group at the University of Minnesota, Minneapolis, Minnesota

Next came a windshield survey of the I-394 ITS research corridor, a stretch of highly instrumented interstate running from downtown Minneapolis to the western suburbs. The corridor features include barrier-separated, reversible High Occupancy Vehicle (HOV) lanes with exclusive ramps, park-and-ride facilities, bus transfer stations, bicycle lockers. and special ramp meter bypasses for HOV vehicles.

That afternoon Glen Carlson, manager of the Traffic Management Center (TMC), and Cathy Clark, manager of the Motorist Information Program, both with the Minnesota Department of Transportation (Mn/DOT), were our hosts for a slide presentation and tour of the TMC facility in downtown Minneapolis. The TMC manages 330 miles of freeways, 353 ramp meters, 142 closed-circuit television (CCTV) cameras for surveillance, 45 changeable message signs (CMS). and two portable variable message signs (VMS). The system size is projected to grow to 476 ramp meters, 274 CCTV cameras

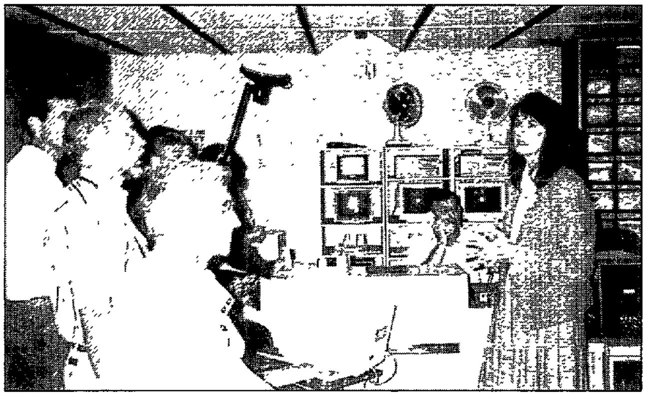

Figure 2. Mn/DOT's Cathy Clark explains the operation of the Traffic Management Center control room.

(old black-and-white cameras are systematically being replaced with color cameras and all new installations receive color cameras), 78 CMS's, and 4 portable VMS's by the year 1999. The TMC also transmits live traffic video to local cable companies who provide a free dedicated traffic cable channel to all their subscribers. In addition. peak hour traffic information is broadcast live on KBEM-FM. a station owned and operated by the Minneapolis school board. The TMC also functions as dispatch for Mn/DOT's "Highway Helpers."

The final scheduled event of the day was a series of presentation< by Minnesota Department of Transportation Guidestar staff. Jim Wright, Minnesota Guidestar program director. welcomed us. explained the organizational structure and described the operation of Minnesota Guidestar, and introduced each staff person and project presentation. Minnesota Guidestar is Minnesota's statewide intelligent transportation system (ITS) program. This program is dedicated to providing leadership in innovative partnerships and institutional progressiveness. The ultimate goal of Minnesota Guidestar is better transportation.

The following presentations were made: *Rural ITS Scoping Study* - Mike Sobolewski described this study conducted to identify the need\ and conderns of actual users. drivers or passengers, in rural Minnesota. *Mn/DOT Communication Plan* - Melanie Braun explained Minnesota Guidestar's current effort to develop a program public relation\ plan. *Genesis* - Ray Starr outlined this operational test which will utilize portable, personal, two-way, wireless communication devices to provide real-time traveler information. *Travlink* - Marilyn Remers and Bill Gardner (Stgar-Roscoe-Fausch, Inc.. Engineers and Planners) explained that this project is designed to deliver up-to-the-minute information on bus service on the I-394 corridor. Travelers will receive information through computer terminals installed at home, software in computers at work, message signs. and terminals in park-and-ride lots and touch screen kiosks. The project also includes a trip planning feature. *Commercial Vehicle Operations* - Cathy Erickson discussed current activities in Minnesota dealing with the operation of commercial vehicles. including a system of automatic real-time verification of out-of-service vehicles.

Back at the hotel. everyone was on their own for the evening. Four members of the group took in a Minnesota Twins baseball game at the Hubert H. Humphrey Metrodome (the Twins beat the Red Sox. 5 to 2). Thanks to a cooperative bus driver another 15 people decided to check out the Mall of America. Of the 15 that went to the Mall on the bus. only 10 returned on the bus later that evening. The other 5 decided to check out Planet Hollywood.

The wake-up call came at S:30 a.m. - yes. that is 5:30 in the morning. By 7:00 a.m. the bus was rolling down Interstate-94 headed for Chicago. IL. On the trip several ITS video\ were shown on the bus's VCR system and oral presentations were made by tour participants James Dale. City of Austin. TX: John Hibbard, Cobb County. GA: and Harriet Smith, Metropolitan Atlanta Rapid Transit Authority (MARTA).

At 2:00 p.m. the bus arrived at the offices of the Illinois Department of Transportation (IDOT), District 1 Headquarters in Schaumburg, IL. Joe McDermott, district traffic engineer, Joe Ligas. ADVANCE program manager, along with Syd Bowcott. DeLeuw Cather, and Paul Dowell, Motorola, welcomed and briefed everyone. Following the briefing, the group divided into three smaller groups and toured the Traffic Communications Center (TCC), were given a ride and demonstration in one of the ADVANCE vehicles, and toured the ADVANCE project's Transportation Information Center (TIC) _

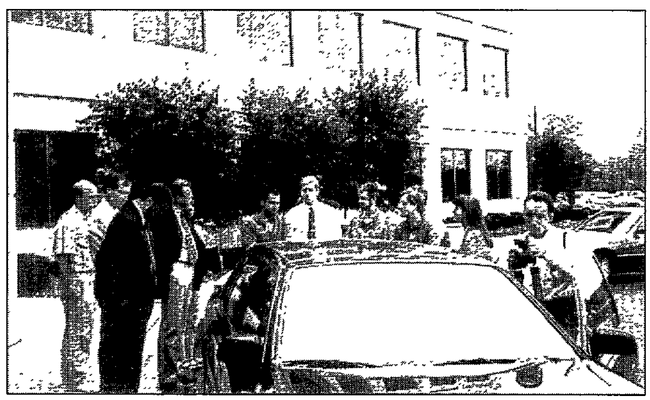

Figure 3. Members of the Tour Group examine one of the ADVANCE vehicles.

IDOT's TCC (also known as the Corn Center) is one of the many important links which make up the chain of operating units. The Corn Center coordinates the assignment of emergency and maintenance vehicles and specialized crews to areas throughout the District. The lines of communication are always kept open and accessible, 24 hours per day, year round.

ADVANCE is IDOT's dynamic route guidance demonstration project being conducted in partnership with the Federal Highway Administration (FHWA), Motorola, Inc., Illinois Universities Transportation Research Consortium (IUTRC) and the American Automobile Association (AAA). DeLeuw Cather and Company. in conjunction with the IBI Group and Castle Rock Consultants. are providing technical assistance for the project.

The TIC is the *ADVANCE* project's nerve center. Real-time traffic information from loop detectors and from the *ADVANCE* vehicles with on-board navigation and route guidance systems (probes) comes into the TIC as well as from various other outside information sources. This information is then fused and processed and real-time traffic reports are provided back to the *ADVANCE* vehicles.

On Wednesday morning, we arrived at IDOT's Traffic Systems Center (TSC) in Oak Park, IL. Joe McDermott again greeted the group and introduced Tony Cioffi operations section chief, and Arland (Ted) Smith, emergency patrol manager. our presenters for the morning. Following an initial briefing. we toured the TSC and had an opportunity to see two "Minuteman" (emergency patrol) units.

For more than 34 years, the IDOT has conducted an active freeway traffic management program in the Chicago area. For nearly 32 years, the first "smart" freeway section has continuously been operated and expanded. The real-time instrumented network operated by the IDOT TSC now covers 136 centerline miles with 2000 loop detectors. The system includes a total of 109 centrally controlled ramp metering stations, 24 remote dial-up Cl3 radio monitoring sites for incident verification, and 18 on-line changeable message signs.

IDOT's emergency traffic control "Minutemen" provide surveillance and respond to freeway incidents on 79 centerline miles or 7 18 lane miles, including ramps of the Chicago-area expressway system 24 hours a day. 7 days a week. The primary objective of the emergency traffic patrol is prompt detection of any disruptive incident on the Chicago expressway system and restoration of the normal flow. Expressway incidents in the Chicago area can range from major truck accidents to spilled loads or disabled motor vehicles. Presently the unit handles over 100.000 incidents per year.

On the road again, we viewed video5 and heard oral presentations from several tour participants, namely: Pamela Hutton. CO DOT; James Pond. Monroe County (NY) DOT: Brendan Finn. European Transport & Telematics Systems, Inc.. Dublin, Ireland: and Andre Lauer, CERTU. Lyon, France.

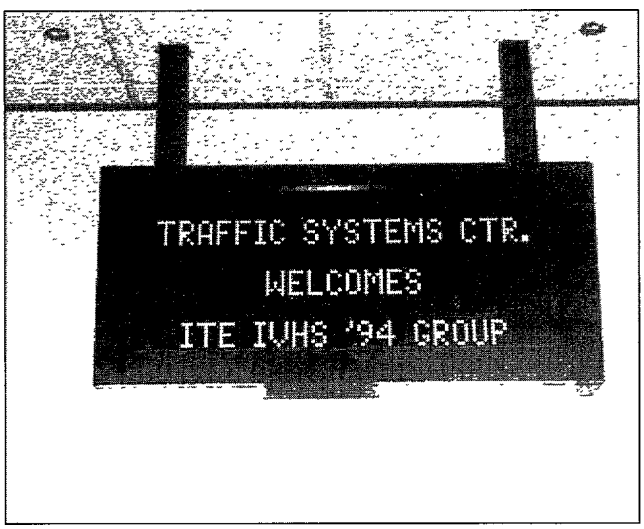

Figure 4. Changeable message sign in the IDOT's Traffic Systems Center in Oak Park, IL welcomes the Tour Group.

Figure 5. Ted Smith talks about the role of IDOT's emergency highway patrol, the "Minutemen."

Our next official tour stop was the Ann Arbor Transportation Authority (AATA) in Ann Arbor, MI. Bill Hiller, manager of information systems for the authority, talked to us about their "Smart Bus" program and responded to numerous questions from the floor. After the briefing, we were given a tour of the facility (bus garage) and walked through one of the busses currently being retrofitted with the "Smart Bus" technology.

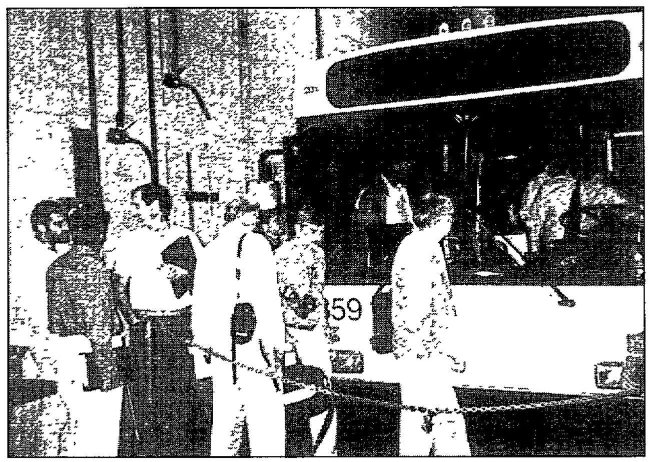

Figure 6. Tour Group member inspect a typical "Smart Bus" installation at the Ann Arbor Transportation Authority maintenance shop in Ann Arbor, MI.

We spent Thursday in the Detroit area where we were joined by two "one-day" tour participants. The day started with a presentation and tour of the Michigan Department of Transportation's (MDOT) Intelligent Transportation Systems Center (MITS) in downtown Detroit. Bob Maki, engineer of transportation systems, Kunwar Rajendra. engineer of transportation systems. and Tom Mullin, ITS engineer. presented an overview of the MDOT's ITS program in the Detroit area followed by a tour of the facility.

The Michigan Intelligent Transportation Systems Center handles a number of ITS programs in Michigan. One of the current operational tests is called DIRECT, which stands for Driver Information Radio using Experimental Communica-

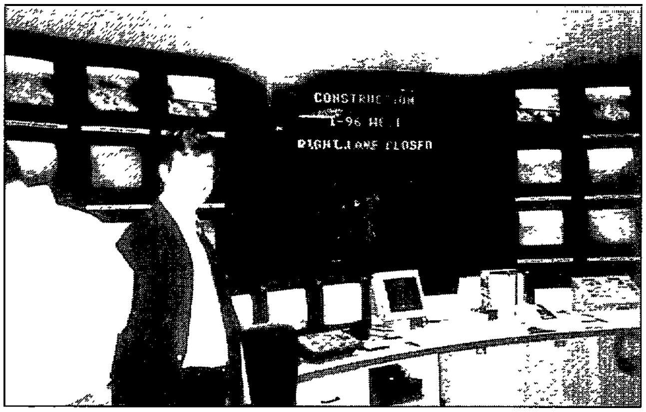

Figure 7. The Michigan Intelligent Transportation Systern Center control room.

tion Techniques. This project is looking at ways to effectively communicate real-time traffic information to the driver. Automatic Highway Advisory Radio (AHAR) and Low Power Highway Advisory Radio (LPHAR) are two of the several methods of communication being tested. Michigan is also one of the states involved in the Advantage I-75 operational test. The Detroit ATMS system currently covers 32.5 miles of the approximately 350-mile Detroit area freeway system. MDOT has currently installed 1352 loop detectors. 14 changeable message signs. IO \ ideo surveillance cameras, and 49 ramp meters.

The next stop was the General Motors (GM) North American Technical Center in Warren. MI. Bill Spreitzer, director, ITS Program Office, provided an overview of the many activities of GM in the area of ITS-related programs. projects and technologies. Following a question-and-answer period, we went to one of the facility's garages and were given hands-on demonstrations of the Oldsmobile Guidestar. Delco Electronics Telepath 100 and Trav Tek. Although not officially part of the program, we were also able to look over several of GM's new electric vehicles (Impacts). GM most graciously provided us with an excellent lunch where we were joined by the GM and Delco people who had conducted the demonstrations.

After lunch and another short bus ride, we arrived at the Road Commission for Oakland County's FAST-TRAC Traffic Operations Center (TOC) in Troy. MI. Our hosts included Brent Bair, managing director, Jim Barbaresso. director of planning, and Les Akey, head of the TOC. Again splitting into three smaller groups, we were given presentations on the Autoscope™ system. a tour of the TOC control room and demonstration rides in Ali-Scout equipped vehicles. The Ali-Scout demonstrations rides were conducted by Melvin Rode. Peter Luchinski. and Benny Reed of Seimens Automotive L.P.

FAST-TRAC, which stands for Faster And Safer Travel through Traffic Routing and Advanced Controls. is the Road Commission's operational test project. This project has several basic components. One is an application of SCATS, the traffic control software package developed in Sydney, Australia; another is machine vision (AUTOSCOPE™) for detection, and another is an application of Seimen's Ali-Scout vehicle navigation system.

Friday dawned the last day of our tour and we were off to Toronto. Crossing the border into Canada proved to be a minor delay. On the "401" we dispensed with the videos, with one exception, and settled in for a series of oral presentations. Presenters included: Jano Baghdanian, City of Glendale. CA: Joachim Boecenfeldt, Heusch/Boesefeldt Consulting Engineers, Aachen, Germany; Detlef Gerhardt. European Commission. Brussels. Belgium; Lee Home, The Port Authority of New York and New Jersey ITD; Arvind Kumbhojkar. Florida DOT: Klaus Mller. PTV Planungsburo Transport und Vekehr Gmbh, Karlsruhe. Baden-Wurttemberg. Germany: Dietrich Reister. Consultancy, Gauting. Germany: and Robert Williams. Dade County Public Works. Miami. FL.

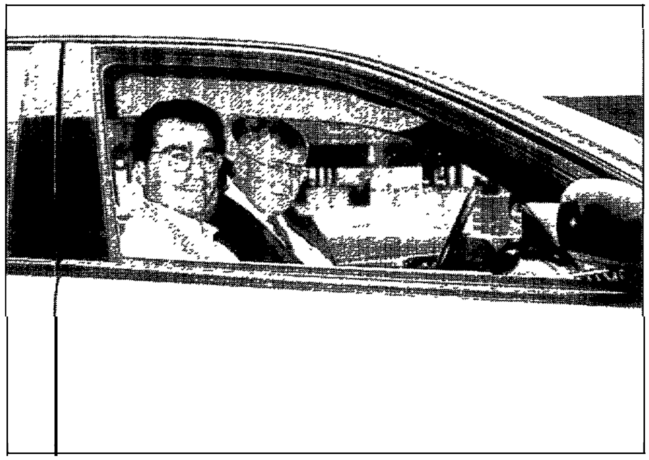

Figure 8. Juan Morales of ITE takes a test ride in an Ali-Scout equipped vehicle in Troy, MI.

Just prior to arriving at the Ontario Ministry of Transportation's COMPASS Operations Centre in Downsview, Ontario we viewed a video outlining the development and operation of that system. COMPASS is a state-of-the-art system introduced by the MTO to manage traffic on their urban freeways by helping to detect incidents and breakdowns, to give drivers more accurate information and to ease traffic flow during peak hours. On arrival, Phil Masters. head of the Advanced Traffic Management Section, personally presented an overview of the systems functionality and capabilities and then escorted the group on a guided tour of the control room.

The trip to the last — but definitely not the least — stop on the technical tour took our group across Metropolitan Toronto to North York. To get there. we were given a taste of Toronto congestion on the "401". North America's busiest freeway with an estimated 350.000-plus vehicles per day. We arrived at the Municipality of Metropolitan Toronto - Integrated Traffic Control Centre (ITCC) and were greeted by Richard Noehammer. traffic engineer. This is a new facility (operation started here in March 1994) and it is well on the way to being the primary control centre for the approximately 1700-signal system located throughout the Toronto metropolitan area. This facility also contains their Traffic Situation Room (TSR), which serves as the clearinghouse for traffic information throughout metropolitan Toronto. Following a

Figure 9. The Ontario Ministry of Transportation's COMPASS control room in Downsview, Ontario, Canada

welcome by Les Kelman. assistant director for traffic. we heard from John Greenough. traffic branch manager. who provided an overview of the Traffic Signal Control System (TSCS) and discussed the highlights of the recently completed SCOOT demonstration project. In addition. Bruce Zvaniga. a manager in the Traffic Signal Control Section. and Kari Fellows. traffic engineer. presented the Gardiner-Lake Shore Corridor Traffic Management System (CTMS) and conducted a walking tour of the ITCC control room.

To conclude the technical tour we took a driving tour of the Gardiner-Lake Shore Corridor through downtown Toronto on our way to the hotel. Following check-in at the hotel, the entire group gathered for a farewell dinner. The next moming participants were on their own, most heading for home and a much deserved rest.

The author wishes to acknowledge the contribution and support of the Federal Highway Administration (FHWA) and the Institute of Transportation Engineers (ITE). In particular, thanks are due Dennis C. Judycki and Sheldon (Bo) Strickland of FHWA: Thomas W. Brahms and Mark Norman of ITE: and Walter H. Kraft of the ITE ITS Council for making the tour possible and for establishing the scholarship program that made it possible for ten (10) public sector professionals to participate. I wish to publically thank all the "hosts" who

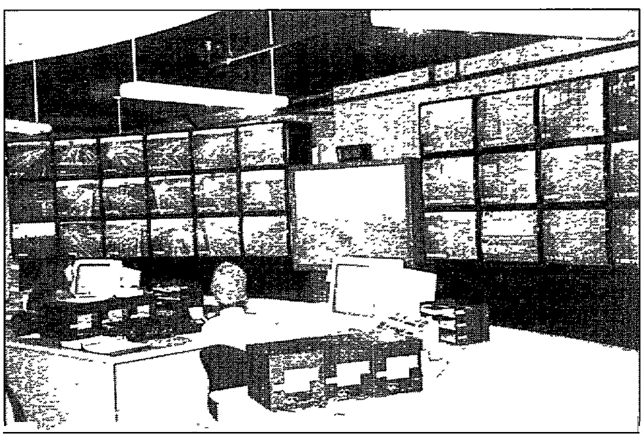

Figure 10: The Municipality of Metropolitan Toronto Integrated Traffic Control Centre in North York, Ontario, Canada.

most graciously gave of their time and talents to make each and every tour visit exceptional. I also wish to thank James R. Pond of the Monroe County (New York) DOT, tour participant, for his assistance in documenting the tour and providing his "unofficial" notes to the author for a reality check. Finally, a very special thank you to Juan Morales of ITE whose tireless efforts to help set up the tour and whose positive attitude, unfailing enthusiasm, and exceptional sense of humor kept the tour on an even keel.

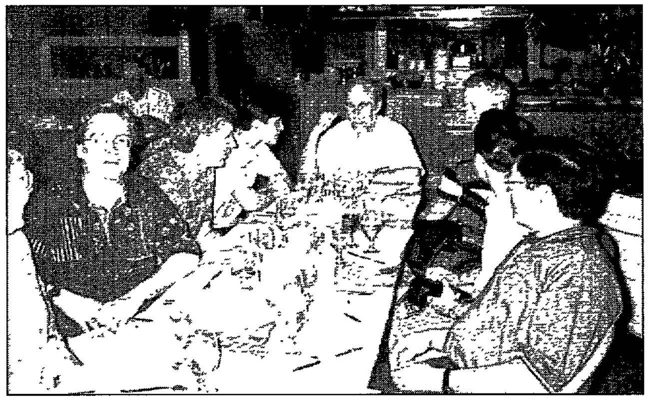

Figure 11. The farewell dinner in Toronto, Ontario, Canada.

ITS North America '94 Study Tour
Technical Notes

By James R. Pond
Monroe County (New York) Department of Transportation
Rochester, New York

Author's Note: The purpose of these notes is to record the verbal and observational information that supplemented the tour handouts. Since they cannot cover everything that was said or seen. I have included the name and phone number (whenever possible) of the person that presented the material. Accuracy has been attempted to the extent that notetaking allows.

Sunday, August 7 · Minneapolis, MN

ITS AMERICA

Contact: Mike Sobolewski 612/296-4935

Mike offered a history of ITS America, together with current and future activities. He discussed Intra-Modal Surface Transportation Efficiency Act (ISTEA) funding, public-private partnerships. and ITS architectural development.

A complete copy of Mike's presentation overheads on ITS America was provided to all attendees.

FHWA PERSPECTIVE

Contact: Wayne Berman 202/366-4069

The Federal Highway Administration (FHWA) is the agency that is responsible for the national ITS program. Wayne described the overall program and highlighted areas where ITS project\ are currently deployed. George Beronio discussed the development of a standard ITS architecture through four independent contractor team\. Denise Bednar highlighted ongoing operational tests. All current and planned ITS projects are listed in the ITS Projects publication from the United States Department Of Transportation (USDOT) dated March 1994. which was provided to all attender\.

3M FACILITY TOUR
Cottage Grove MN

Contact: Bob Johnson 612/733-4693

Minnesota Mining and Manufacturing (3M) offered a tour of their traffic control device testing laboratory. The facility is used to test signs, signal heads, and equipment. A full intersection for testing purposes is under construciton. and the lab will be doubled in size. Bob demonstrated various loop layouts, including 3M;s new smart loop detector\. Of special note is the observation that circular loop layout\ perform poorer than the more traditional square loops. Other equipment such as the optically programmed heads were also demonstrated.

Monday, August 8 · Minneapolis, MN

UNIVERSITY OF MINNESOTA HUMAN RESOURCES LABORATORY

Contact: Dennis Foderberg 6 12/626-8285

The human resources lab tests the interaction between the driver and his environment (primarily the vehicle). How many different tasks can a driver handle in addition to driving? As technology imposes itself (i.e., cellular phones in cars, route guidance systems) on drivers, how much information is needed? Too much information can overload the driver, while too little information denies the driver of important safety data.

Ongoing tests include:

- Variable flashing lights for construction zones. Objective is to reduce motorist speed through work zones. A series of

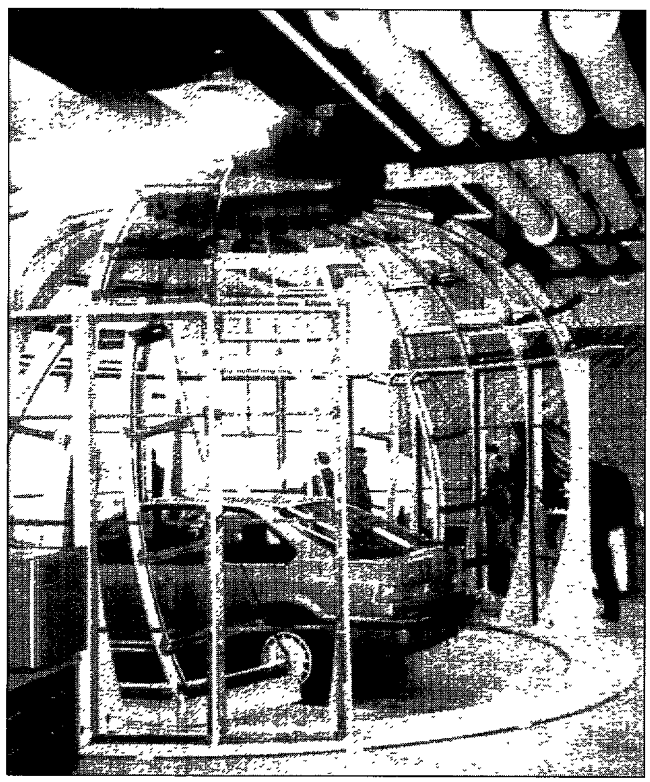

Figure 12. A view of the driving simulator (under construction) at the University of Minnesota's Human Resources Laboratory.

lights is placed on edge of the travel lane. Lights are flashed in a sequence that is slightly different than the motorist's speed. Motorist then perceives a speed relative to the light sequence. Some flash rates give an uneasy feel of going backwards.

- Flight simulator. Idea is to keep inside a box that appears on the screen. This is relatively easy by itself. Pilot can then be given other tasks that compete with navigational skills. Degradation of navigation is checked to determine when pilot is overloaded with tasks.
- Cataract research. This test determines the driver's ability to divert attention from the roadway for brief periods of time while driving. Slides showing various objects are projected outside the driver's side window. Driver must glance at objects and identify them. while also trying to stay on a simulated road.
- Virtual reality simulator. The simulator is made as realistic as possible to test driver's reactions to extreme situations that could be fatal if encountered in an actual driving situation.
- Variable message displays. Drivers are shown various messages on simulated signs along the road and must interpret the results. Sign sizes, fonts, and word choices are tested.

I-394 CORRIDOR

Features seen along the road include reversible High Occupancy Vehicle (HOV) lanes with exclusive ramps and barriers, park and ride facilities with generous parking, bicycle lockers, comfortable and informative bus transfer stations. and special ramp meter bypasses for HOV vehicles. HOV vehicles still are controlled by a ramp meter, but they are in their own lane and get preferential treatment such as faster meter rates and preemption over the adjacent lanes.

HOV lanes feed directly into downtown garages, where car poolers pay $20 per month. Others pay $90 per month.

TRAFFIC MANAGEMENT CENTER

Contact: Glen Carlson 612/34l-7500

Overview

The Traffic Management Center (TMC) covers 330 miles of freeways in an area with 2,400,000 population. Some basic system facts and projections:

- System size is growing as follows:

Item	1994	1999
Ramp Meters	353	476
Closed Circuit TV Cameras	142	274
Changeable Message Signs	45	78
Portable Variable Message Signs	2	4

- The building cost $275.000 in 1972.
- $4 million to $7million will cover 12 to 16 miles of freeway. This includes detectors. cameras, communications, and changeable message signs.
- Annual operating budget is $3million per year, including highway helpers. $800.000 of this is used for maintenance.
- There are 65 total employees.

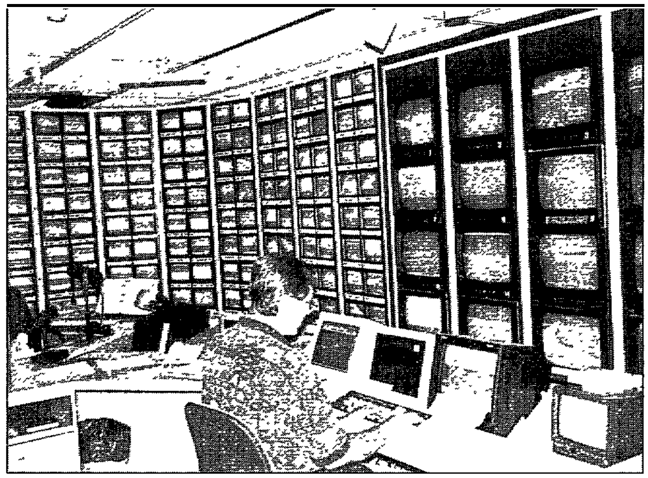

Figure 13. The Minneapolis Traffic Management Center.

- 15 different operators are used, paid $8.00 to $9.00 per hour. Most are undergraduate co-op student workers, typically working 3 years (sophomore to senior). One common trainer ensures consistency. At least one month is required to train an operator.

Originally, the TMC detected many incidents in-house through the camera scans. Now, incidents are detected primarily by cellular phone calls, which typically begin only 30 seconds after the incident occurs. Cameras are used to verify incidents and obtain details, as well as monitor progress. Police scanners are monitored for additional details.

Cameras are placed one mile apart. Communications is changing from coaxial cable to fiber optic cable for economic reasons, and is currently about 50% converted. Microwave is also used in places.

Peak hour staffing includes 2 operators, 1 person sending data to the Trilogy system, 1 motorist information person, and a KBEM radio station disc jockey. Off-peak hour staffing is 1 or 2 people. There are 6 to 8 technicians as well.

TMC is staffed 6 a.m. to 6:30 p.m. (sometimes until 7 p.m.) Monday through Friday. Staffing is also provided for special events upon request. The TMC controls camera movements during working hours, and police control them after working hours. In a few cases. software holes have allowed police to control them during working hours as well.

The monitors appear as banks organized by sequence along the road. There are 128 (8 high by 16 wide) small monitors for the radio station traffic person. Two banks of 24 (4 high by 6 wide) larger monitors surround a single oversized screen in the center. These two banks are used by the operator. This layout was devised by the operators themselves.

The control room is small and tends to be hot and stuffy. If the facility was rebuilt, it would be larger and more open, and key players would be added such as highway maintenance, transit personnel. police, and municipality representatives.

Broadcasts

Cable companies receive video transmissions from the TMC, but don't control what they see. They are basically given a rotating tour of the cameras. A free dedicated traffic cable channel is provided to all cable subscribers. Local private traffic broadcasters work in partnership: it was somewhat of a "shotgun wedding" that they had to go along with.

The radio station KBEM was formerly a school station that had exhausted its funds. $305,000 per year is paid to keep KBEM on the air. Jazz music is played when traffic information is not being broadcast.

Changeable Message Signs

The changeable message sign system includes 45 six-sided rotating drums costing about $70,000 each. (By contrast, a variable message sign costs on the order of $260,000 to $280,000). Five different messages can be displayed on each line, and essentially they cannot be changed. An interesting sign located outside the TMC displays "traffic grades" A through F to motorists about to enter the freeway. This indicates the Level of Service in real-time to motorists. Not only do they get a feel for traffic conditions, they also get a lesson in Level of Service!

Video and Detection Systems

The Minnesota Department of Transportation (MNDOT) is testing Econolite's Autoscope video detection system at 37 installations. Other detection means include 3M visual imaging, 3M point loop, Honeywell visual imaging, AT&T sonic detectors, and conventional loops, which are placed every half mile.

Black and white cameras were originally installed. Color cameras are now being purchased from Panasonic and RCA for all new installations.

Ramp Meters

Ramp meters are very cost effective. They reduce congestion, increase peak volume, smooth out merging, reduce accidents, encourage diversion (especially trips that would only use a short section of freeway). increase ride sharing (through bypass lanes), and manage incidents. Ramp meter rates are not adjusted even if the ramp queue is lengthy. because trip diversion is a desired outcome. Two heads with red. yellow, and green are provided per lane. The top one faces traffic straight on, while the bottom one is turned about 30 degrees toward the driver. Signs on the poles include "this lane" (with arrow) and "1 car per green".

Ramp meters do not detect individual vehicles and cycle whether or not a car is present. Six levels of operation are offered, ranging from 2 to 30 cars per minute. Inactive ramp meters are flashed yellow.

Incident Management

Highway helpers are employed to help clear incidents. Designated accident investigation sites are clearly marked along the freeway. For minor accidents, motorists are supposed to voluntarily move their cars to these sites. Unfortunately, they are not used much. Better laws are needed to encourage their use.

Accidents have decreased due to traffic management, for a rate reduction from 1.35 to 1.00 accidents per million vehicle miles (1200 decreased to 900 accidents per year).

MINNESOTA GUIDESTAR
St. Paul. MN

Contact: Jim Wright 612/296-8567

Minnesota Guidestar is the overall flagship name for the ITS activities throughout Minnesota. Public recognition for ITS is enhanced by assigning a common name to all ITS activities.

The following budget figures for the entire program are approximate:

$18.600,000	in Federal funds
$ 4,700,000	in MNDOT funds
$ 7,000,000	from other sources
$30,000,000	total funds

There are three organizational levels:

- The Executive Committee oversees the program, with a private sector advisory group.
- The Steering Committee guides the program, with the Guidestar Forum series for public input.
- Working Committees work out all the details, including architecture, planning, research, freeway and arterial management, transit, and rural aspects.

Deadlines for moving this program along are in days and weeks rather than months. The 1994 work plan is available for the asking.

Staff turnover has been a problem, with a recent 2/3 turnover of staff (only a few people). The lost experience in negotiation has been the hardest to overcome. The project development process is well documented.

Partnerships have been negotiated with Westinghouse and IBM. Earlier talks with Motorola did not result in an agreement because the old process was followed: start with casual discussions. continue with serious discussions, then include contracts people. This all assumed that the company is truly committed to the venture. A procedure was developed known as the Request For Proposal for Partners (RFPP) which required new legislation. Rather than having to seek out potentially interested partners, this allowed interested partners to step forward. It identifies the truly committed companies and shortens the procedure from one year to a few months.

Rut-al ITS Study

Contact: Mike Sobolewski 612/296-4935

Minnesota would like to deploy ITS statewide, including its widespread rural areas. A study was conducted to examine potential rural ITS applications. Mike gave a full copy of this study to each attendee, so he highlighted the findings.

The study found that people want simple, low technology, cost effective, inexpensive, and reliable information delivery systems. They prefer pre-trip planning data to information provided during the trip. In order of preference, the in-trip information would be given best by radio (FM preferred to AM), Changeable Message Signs, Pagers. and least desirably. cellular phones. Transit was considered to be a good altemative...for someone else.

To get a true statewide system. public meetings were held throughout the state. The public was introduced to the concept of ITS first to avoid the "technology looking for a problem" syndrome.

MNDOT Communications Plan

Contact: Melanie Braun 612/282-2474

Three steps were included in the public relations plan:

(1) External to Minnesota
- Get Federal Funding
- Work with ITS America
- Government Support
- Establish National and International Leadership Position

(2) Internal to Minnesota
- Bring in General Public
- Involve MNDOT Employees

(3) General Traveling Public (Education and Outreach)

There are four obstacles to making this happen:

1. The public doesn't know about IVHS or ITS;
2. Industry is not clear on where we are going with it:
3. Public funds are needed, and it sounds expensive; and
4. Not high on political agenda.

Trust. confidence, awareness, and acceptance are needed to create the public demand that is needed to fuel further ITS development.

Genesis

Contact: Ray Starr 612/296-7596

Genesis is a portable, personal, two-way. wireless communications device. People would generally not buy it just for traffic. it needs another use such as regular paging functions. Information on incidents, travel duration times, routes, alternate modes. and transit schedules are possible uses. Hopefully, individual travel decisions would be influenced, with an emphasis on increased transit usage.

Early tests will use one-way pagers. where user information preferences will be pre-determined. Later. two-way communications will allow users to change their information requirements whenever they wish. Time is calculated as follows: (Distance/Speed) + (Queue Delays). This isn't a problem on expressways, but arterial travel times would require some 5,000 probes to get sufficiently accurate information.

The pilot study will begin in March 1995 with the deployment by September 1995 of 350 alphanumeric pagers and 50 Apple Newtons. Ultimately. the study will expand to 600 pagers. 600 notebooks, and 600 two-way devices similar to the Apple Newton. The costs are $8,000,000 from public funds plus an additional $2.500.000 contribution.

Travlink

Contact: Bill Gardner, SRF 612/475-0010

Surveys showed that the primary reason people do not take the bus is due to lack of route and schedule information. Travlink will provide this data real-time by collecting and distributing transit and traffic information through dedicated and strategically placed kiosks, electronic signs, and display monitors. Touch screens have been developed to make user input easy.

Note that the Genesis project has a related purpose but uses portable, personal devices which are tailored to an individual's needs. Travlink will deploy more complex and specialized fixed interface devices located both in private homes and public places, where anyone can access it. Both rely on a database at the Traffic Management Center.

Travlink primarily uses GPS (Global Positioning by Satellite), with AVL (Automatic Vehicle Location) as a backup, to track actual bus positions at any given time. 80 buses will be equipped initially. With this data. a host of information can be provided. Examples include:

- Suggest the best way to get somewhere (area to area);
- Specific bus schedules and route maps:
- Data on whether the bus is late;
- Bus fares for the specific trip; and
- Park and Ride facilities that can be utilized.

In addition, a traffic information component will offer information on incidents, delays, and construction and maintenance activities expected along the route. A hard copy of all information will be provided in a printout.

Research showed that intersection listings, not maps, were the most useful way to specify desired destination. The number of selections needed to get information should be kept as few as possible. When a bus is late, it will offer a range indicating approximately how late the bus might be.

Since the project required a number of separate procurements, an overall preliminary design was developed first under a single contract to ensure component compatibility. The operational test will be from November 1994 to November 1995, with up to 800 deployed units in offices and homes. The units will be loaned free of charge initially. One big question which has yet to be answered is the ultimate extent of private participation and funding.

Commercial Vehicle Operations

Contact: Cathy Erickson 61 X82-9827

The primary customers are motor carriers, which deal with as many as 20 agencies and suffer delays at each weigh and inspection station. With Commercial Vehicle Operations (CVO), all credentials can be pre-approved with one application. License plate readers on weigh station approaches can match approaching truck drivers to a database that checks for unresolved violations. These trucks can then be inspected for each specific infraction to see if remedial action has been taken. Fuel usage could also be tracked automatically.

Of the five nationwide CVO studies, two are in Minnesota. Cooperative agreements and shared databases with adjacent states enhance the benefits of CVO applications. Video cameras can be placed on parallel routes across state lines to monitor vehicles that might be avoiding the weigh station due to known violations.

Tuesday, August 9 - Schaumburg, IL

ADVANCE

Contact: Joe McDermott 708/705-4141

The Advanced Driver and Vehicle Advisory Navigation Concept (ADVANCE) system has been developed by the Illinois Department of Transportation (IDOT) in conjunction with Motorola. The test service area is the northwest suburbs of Chicago. where explosive growth has overwhelmed the road system. In fact, congestion now occurs in both the inbound and outbound directions (relative to Chicago) during peak periods.

A key player in this process is the American Automobile Association (AAA). It has helped connect IDOT with individual motorist needs. One feature added especially for AAA was a push button that will summon help.

In the ADVANCE system, vehicles act as probes. The highway system is divided into a series of links using a Geographical Information System (GIS) database which is about 98% accurate. Each time a vehicle completes a link, travel time data is returned to the central computer for an update. Closed-loop signal systems provide five minute travel time updates.

Other data that is collected and used includes 911 calls (screened for incidents that would impact travel time), toll-free cellular phone calls, and weather stations (for road surface conditions). All travel time data is stored every five minutes for all links for a 32 day period, basically to include the last month of data. Future enhancements are planned to decrease the five minute update period.

Map matching is used to locate vehicles. with differential Global Positioning by Satellite (GPS) and dead reckoning used as backups. The GPS satellite transmission is often intermittent due to trees, buildings. and other physical obstructions. However, a very short reception is all that is needed for a positional update.

Navigation is provided using a computer located in the car's trunk. A compact disk (CD) is used to store information in the operating area. This disk contains historical travel times, driver behavior, and turn movement combinations. Dynamic, real-time travel time changes are transmitted from the central computer on an exception (deviation from normal travel time) basis. These are only used for travel time decisions for the next five minutes.

Using the travel time data, the on-board computer selects the fastest route to the desired destination. Navigational instructions are provided through simple arrows indicating the direction of the next turn, even if it is still a mile away. A set of triangular arrows begin disappearing one by one as the turn is approached. An audio message is given shortly before the turn is reached, usually upon approach of the appropriate turn bay. (In operation, the audio message was observed to be occasionally untimely or inappropriate for the current circumstances, especially with very short links or when starting a new trip.)

If the route travel time increases due to congestion and another route becomes more desirable, the system will prompt the user, who either approves or rejects the request to change the route. The user is also notified if the route has been abandoned, with a prompt recommending the calculation of a revised route.

The navigational directions can be toggled to a map displaying the user's current location. This map scrolls as the user drives near the edge of the screen area (rather than continuous scrolling). The area shown is selectable by the user through a zoom in/out feature.

Some safeguards have been included in the system. A liability limitation screen precedes the program, as is often found in computer programs. While common addresses can be selected with the vehicle in motion, a more complicated screen for entering new addresses requires that the operator stop the vehicle before it can be accessed.

The communications medium is a Motorola radio modem operating at 4800 bits per second (bps). This only allows 100 to 110 total cars on the system at any given time. Following the test period, a 64000 bps modem will be used.

The system deployment will begin in Spring 1995, with wide deployment by July 1996. A one year test period will follow. Users will be recruited on a rolling (wait until unit is ready) basis, rather than an up-front recruitment, to avoid lengthy gaps between recruitment and deployment. To date, older people have tended to indicate the strongest interest. This is surprising given the advanced technology.

Although the system will be very complicated, it actually is a downscaled version of what was originally envisioned.

The heart of the system is the Traffic Information Computer (TIC), which gathers information from various sources, including the freeway management network, probe vehicles, and pre-calculated free-flow travel times. The position of each vehicle can be shown on a monitoring screen.

WIN-WIN PARTNERSHIPS

Contact: Paul Dowell, Motorola

The ADVANCE project funding flows through a number of links, as follows:

Taxpayers → U.S. Congress → USDOT/FHWA → IDOT → Motorola

The local Motorola business unit was not experienced in federal contract work. Thus, considerable effort was required to develop a win-win partnership with IDOT. Seven basic rules of thumb that can help develop such partnerships are:

1. Agree on a common understanding of overhead, burden, costs, price, and other accounting terms.
2. Identify those areas that cannot be changed and the areas that have room for negotiation.
3. Do not change the players during the negotiation process.
4. Be creative and flexible: ask "what would happen if we did it this way?'
5. Develop a consensus with all players feeling ownership.
6. Keep the lawyers involved throughout the process.
7. Develop goals, with some conflicts that do not all have to be resolved.

Above all else, solid and absolute commitments are needed to make the partnership work.

IDOT COMMUNICATIONS CENTER

Contact: Joe McDermott 708/705-4141

The Communications (Comm) Center is located at the regional IDOT office in Schaumburg, which is central to the six-county region but outside of the expressway surveillance area. This allows key players to receive and act on information firsthand. During weekdays, the expressway system is monitored by the Traffic Systems Center (TSC) in Oak Park, with complete expressway information provided to the Comm Center. Overnight and during weekends. the Comm Center handles all of the TSC functions. In addition to the expressway system, the Comm Center monitors some 3000 miles of state roads.

The Comm Center is used to dispatch highway crews and provide travel time data to the ADVANCE system. highway advisory radio, and telephone hotlines. There are no video cameras. A map of the Chicago area expressways shows the status of each travel segment using the following color scheme:

COLOR	MEANING
Flashing Red	Occupancy over 50%
Red	Occupancy between 30% and 50%
Yellow	Occupancy between 20% and 30%
Green	Occupancy less than 20%
Blue	Data not available

The staffing is 6 people during weekday peak periods, 2-3 people on weekends, and 1 person overnight.

The Comm Center also controls all Chicago area expressway lights from a central computer. All lights are monitored, and any section can be turned on or off with a simple mouse command.

Wednesday, August 10 - Oak Park, IL

TRAFFIC SYSTEMS CENTER

Contact: Tony Cioffi 708/524-2145

The Traffic Systems Center (TSC) is located near the Illinois Bell telephone hub and is in its fifth facility. It monitors 136 centerline miles of freeway but does not (yet) include the Illinois Tollway system. The 80 miles closest to the central core of Chicago are instrumented. Future plans call for integrating the Illinois Tollway highways into the system. This could even include reading electronic toll tags to track vehicle movements on both the Tollway and expressways.

The center is staffed for 14 hours each weekday. The staffing is primarily done using students through cooperative agreements.

Ramp Meters

Chicago's ramp meters were first installed in 1961-1962. Ramp meters are centrally controlled and operated from the **TSC.** with no controllers in the field. Loops are placed to detect individual cars. Five levels can be selected, ranging from immediate green upon detection (effectively 30 cars per minute) to 6 cars per minute. Some ramps have such high volumes that little or no delays can be placed on the meters. No detection is provided to check if cars have queued beyond the ramp onto the arterial; this is considered to be an allowable situation.

Two color signal indications are provided, red and green. Only one lane ramps are metered, and two heads are provided (one to the left and one to the right). The signals are turned off when inactive.

Variable Message Signs

Chicago uses a disk system with fiber optic light segments in the center of the disk. The display is three lines at 20 characters per line. Congestion messages are sent automatically by a traffic flow monitoring computer. Operators can intervene and override the computer's decisions. Operators can also type in messages by hand. An example custom message was "ACCIDENT AHEAD...NEAR OHIO STREET...USE CAUTION".

Expressway Loop Detectors

Round detector loops are used because they are cheaper and faster to install. Detector outputs are sent back to the TSC building, where all detector modules are centrally located. There are no field controller units.

Speed and travel times are calculated from the loop detector outputs. These estimated travel times assume that the point speed can be applied for a distance halfway to the adjacent upstream and downstream loop stations. The estimated travel times are issued to travellers through a digitized telephone call-in service. They will also provide data to the ADVANCE system.

MINUTEMAN INCIDENT MANAGEMENT TEAM

Contact: Ted Smith 3 12/624-0470

Incident management is especially critical in Chicago because the traffic stream contains 30% trucks. This requires specialized equipment to get incidents cleared as quickly as possible.

The Minutemen have been operating for some 25 years and have a very aggressive incident management program. From seven to twelve trucks are actively patrolling the expressway system at a given time. 60% of the incidents handled are detected by the Minutemen first hand. This means they are already on the scene, can assess the situation accurately, and begin recovery efforts immediately.

The legal authority given to snow plow crews to move blocking vehicles was applied to allow Minutemen to move vehicles as necessary. The general policy is to push. drag, or pull vehicles out of the way, get lanes open quickly, and ask questions later. If the vehicle can be made driveable through a quick fix, it will be attempted. Major incidents may require waiting on accident investigator teams, which the Minutemen will assist to expedite matters.

Police, fire, and ambulance responders still have the primary authority during incident recoveries. Working relationships developed over years have helped these authorities to trust the judgment and recommendations of Minutemen regarding lane closures and the timely removal of vehicles and debris.

Minutemen are trained in CPR, situation assessment. towing procedures, basic car repairs, and anything else that expedites incident management. There is no charge to the motorist for the service. If gasoline is provided, a mail-in form is used for reimbursement by the motorist. Trucks are fully equipped to be self-sufficient. All crew garments are reflective to maximize night visibility.

A handout on the Minuteman service was provided to all attendees. It is especially thorough and includes information on operating procedures, equipment used, recent incidents handled, and photographs.

SMART BUS

Ann Arbor, MI

Contact: Bill Hiller 313/677-3944

The SMART card is an example of an ITS application for a transit system. It is being developed and tested by Ann Arbor Area Transit (AAAT) in Michigan.

AAAT operates a fleet of 60 buses, of which 48 typically are on the road during peak times. The SMART card system will track these buses using GPS, with dead reckoning as a backup. A computer calculates how far ahead or behind schedule the bus is, and this information will be provided to waiting users at bus stops.

This system assists the driver by automating certain tasks. The next bus stop will be displayed, with an audio announcement prior to the stop. The driver also gets data on schedule compliance and vehicle performance, and does not have to contact the dispatcher to report progress. Other record keeping requirements would be handled automatically.

The system has other benefits. A transfer to a connecting bus can be ensured if the originating bus is slightly late by holding the connecting bus for a few minutes. If a schedule is consistently difficult to maintain. or appears to have excessive slack time, this will become apparent. Passenger origin destination data will be recorded.

A host of user services become available. Prepaid fares eliminate the need for exact change. Discounts can be offered for preferred combinations, such as off-peak ridership. frequency of use, or sponsored bus stops. The latter feature would offer free rides for anyone exiting the bus at a given stop. The rides could be paid for by employers or retailers located near that bus stop. Other financial transactions such as parking garage fees. highway tolls. or telephone call charges could potentially be added to the card.

The technology uses a proximity reader that requires the user to wave the card 3 to 4 inches from the reader. This was selected so that coin paying riders would have the perception that a transaction took place, rather than seeing someone apparently riding for free. Users are expected to show the card upon exiting. Although there is no penalty if they don't, they could miss out on fare pricing opportunities.

Thursday, August 11 - Detroit, MI

MICHIGAN INTELLIGENT TRANSPORTATION SYSTEMS CENTER

Contact: Kunwar Rajendra 517/373-2247

The Michigan Intelligent Transportation Systems (MITS) Center handles a number of ITS programs in Michigan. Two current ITS projects that are being operationally tested include:

- Driver Information Radio using Experimental Communication Techniques (DIRECT), which examines ways to communicate with the driver. One method is the Automatic Highway Advisory Radio (AHAR), which automatically preempts your car radio for a traffic bulletin. Another is the Low Power Highway Advisory Radio (LPHAR), which can only he received over a two to three mile stretch, and therefore can provide highly customized messages. Several other methods are also being tested.
- The Faster And Safer Travel through Traffic Routing and Advanced Controls (FAST-TRAC) program in neighboring Oakland County. This program is covered in detail later in the notes. Project evaluation is often the weak point in an operational test. To properly evaluate each of these tests. an independent third party is used. typically from the academic community. It's also important to test a variety of systems before settling on only a few choices for the sake of compatibility.

In the future, additional projects envisioned include HOV validation (check for abusers who should not be in HOV Lane), adaptive signal timing for transit, and dynamic vehicle routing.

Commercial Vehicle Operations

A commercial vehicle operation (CVO) system is being developed for I-75 from Florida to Detroit (and ultimately on to Sault Ste. Marie). International connections across the Detroit River to Ontario Route 401 would be included. Trucking firms are willing to spend money if it will save them time. The goal is to enroll 4000 trucks, which would only have to stop if something is not in order. This will reduce congestion at truck weigh/inspection stations, increase efficiency, and enhance safety.

Both of the international river crossings at Detroit are run privately. CVO features would include automatic toll collection and an "honor lane" for pre-cleared frequent crossers. The desired outcome is an international border that is as transparent as a state border. This involves both customs and immigration. Both must fully satisfy their many requirements.

DETROIT ATMS

Contact: Tom Mullin 3 13/256-9800

The Detroit ATMS system covers 32.5 miles today but will soon be expanded to 250 miles of freeway. The system includes 1352 detector loops, 14 changeable message signs, 10 cameras, and 49 ramp meters. The center is staffed 13 hours a day during weekdays. The video cameras that are used to monitor the freeway are dual lens cameras, with black and white for night and color for day.

MAn Advanced Public Transportation System (APTS) is provided to show the condition of Detroit area freeways. Contrast this data to that used in the Chicago area, where a 50% occupancy is needed to get to the highest level.

COLOR	MEANING
Red	Occupancy over 20%
Yellow	Occupancy between 15% and 20%
Orange	Occupancy between 10% and 14%
Green	Occupancy less than 10%

The operator can add annotations such as accident or construction locations to the screen. This information goes to Greyhound bus, UPS, Detroit DOT, the Smart Bus program, and the Commuter Shuttle airport service through telephone lines.

The state police are relocating into the same building as the MITS center. This will optimize communications between MITS and the police. A partnership exists with Metro Traffic to exchange traffic information.

Ramp Meters

Ramp meters are used primarily to space traffic for adequate gaps between vehicles, rather than to limit volumes entering the mainline from expressway ramps in the Detroit area. As such, metering rates are relatively unrestrictive. ranging from 10 to 15 cars per minute. Ramp meters are not operated during snow and ice conditions (they are all on downgrades. and cause more problems than they solve). They remain off (blank display) until mainline occupancy reaches 10%. When operating, warning beacons are activated at the ramp entrance to warn motorists to prepare to stop.

All loops come to a central computer. which communicates 100 times per second with each loop. Ramp detector loops are placed both upstream and downstream of ramp meters, as well as on the mainline and off-ramps. Occupancy, volume. and speed is calculated from this data. A computer screen in the control center shows real-time detector actuations, as well as the accompanying ramp signal displays. Thus. ramp signal violations are easy to spot.

Variable Message Signs

The variable message sign system uses a pre-specified standard library with about 2,000 messages. The choices are limited to those messages that the sign is authorized to display. A code is entered to select the desired message. Operators cannot create custom messages.

GENERAL MOTORS RESEARCH LAB

Warren, Ml

Contact: Bill Spreitzer 313/986-2816

GM has been in the ITS business since the early 1950's. Electronic route guidance was being developed in the late 1960's. Navigational, headway, and lane control has been worked on throughout the 1980' s, while operational field tests have been ongoing for at least five years. Heads-up displays have been available as a $250 option in some models for the past four years.

The major focus of current research is in the areas of obstacle detection, collision avoidance, communications control. advanced traffic management systems, and commercial vehicle operations. Both vehicle to vehicle and vehicle to highway interactions are being considered. Typical research partnerships involve providing test cars in exchange for access to ongoing test results.

Driver overload research is ongoing. It is estimated that the driver only spends 35% of the time looking at the road, so there is room for additional loading. Information must be managed to give only clear, pertinent, and timely data to the driver. Data management systems should allow the driver to indicate preferences and customize the information accordingly.

One looming issue is the division of Automated Highway System (AHS) tasks between the vehicle and the highway. Most of the tasks will likely be handled by the vehicle. The highway portion might include electronic tags on each traffic signal, showing longitude, latitude, elevation, and status. Other highway features might allow electronic toll collection and dynamic traffic control. The public sector will be responsible for defining the highway portion of the tasks.

Liability is also an issue. Laws are needed to provide some protection through shared liability and limited maximum awards. "Bet your company" situations should be avoided. Most places in the world have not seen the lawsuit escalation that is prevalent in the United States.

Public acceptance has been the subject of numerous studies. An approximate threshold that users would be willing to pay to add in-vehicle features is $1000. If there were a number of separate components to buy, this would be quickly exceeded. Therefore. a system would need to consist of as few as possible integrated components. An interesting example is a wristwatch based travel information system being developed jointly by GM and Seiko.

To market for the general public, navigational instructions are kept simple, such as showing the direction and distance to the location, allowing the driver to determine the route taken. User instructions are polite, such as "you may be off your intended route".

Public expectations differ in other parts of the world. In Japan, for example, intersection improvements are considered successful if they reduce ten cycle delays to four cycle delays.

In the future, holograms will likely replace the traditional windshield view. Signs or signals would not be needed, since the vehicle would receive all the information they would normally convey electronically. Obstacles would be edited out of view, and night vision would be enhanced. The car could totally drive itself, or the occupant could choose to perform portions of the driving task. Car performance would be monitored to spot impending problems before they occur.

Similar to air traffic control. all vehicle movements would be tracked to avoid collisions and improve efficiency. Congestion problems would be avoided through route adjustment. Any needed traveller information would be readily available.

This brings up some interesting issues. A fail safe provision should restore the windshield view and check if the driver is in a condition to take over, in case of system problems. Since this would develop gradually, interim measures are needed during the transition to this future scenario. At some point, a mixture of equipped and unequipped vehicles will be on the road together, especially if retrofits for used cars are not possible. During this transition, benefits are provided both to drivers of equipped vehicles and to the other users of the highway.

The issue of self-incrimination and privacy also has to be considered. Past experience has shown that when people compare the trade-off of lost privacy to the benefits provided, reason prevails and they are willing to go along.

The expected transition to fully automated highways would begin with in-vehicle features alone and then add simple highway modifications. A likely scenario might proceed as follows:

- In-vehicle signing would be employed first, allowing traditional signs to be removed;
- Advanced traveller information would follow;
- Automatic cruise control would come next;
- Obstacle detection and avoidance would be added; and finally
- Fully automated highways (around year 2040).

Trav-Tek

This is the experimental guidance system offered in rental cars in the Orlando area. It primarily gives navigational directions to hotels, restaurants, and tourist attractions. Routes are selected on historical route guidance, so that recurrent trafftc problem spots are known. However. any congestion related to incidents would not be known.

Trav-Tek uses a television screen combined with an audio voice. It is very similar to the ADVANCE system used in Illinois. It is a test system and will not be commercially available.

Telepath 1000

Telepath 1000 is a simple. low cost system that will retail for about $800. It replaces a traditional car radio with a combination car radio and navigation system. The navigation system indicates the direction (through a simulated compass) and distance to a selected destination. All other routing decisions are left to the driver. A memory card is needed for each metropolitan area that could be bought or rented. This system will be commercially available in selected locations this year.

Guidestar

Guidestar is a high end system that will retail for about $2000. Basically, Guidestar is the commercial version of TravTek. It includes a television screen and full route guidance. Other than historical travel times, there is no provision for adjusting the route to avoid congestion. This system will be commercially available at selected locations this year. (Note: This is a General Motors brand name, and is not part of Minnesota Guidestar).

FAST-TRAC

Troy, MI

Contact: Jim Barbarossa 810/645-6277

The Faster And Safer Travel through Traffic Routing and Advanced Controls (FAST-TRAC) program has two basic components. One is an application of the SCATS traffic signal control strategy, while the other is an application of the Ali-Scout vehicle navigation system. The key to the FAST-TRAC program is to merge the traffic signal operation and vehicle navigation data together. Some $52 million is invested in this field test, which is located in suburban Oakland County (near Detroit).

Traffuc Signal Control Using SCATS

SCATS is operated from a control center which is manned by 7 people (4 engineers and 3 technicians) during weekdays. The traffic conditions and signal status for each intersection are shown on a screen in a color coded format. Vehicle actuations can be displayed by individual lane. Even bulb burnouts can be detected.

The SCATS algorithm counts cars and measures the gap between them, and then adjusts the trafftc lights according to the observed current traffic data. The system is very data intensive. All data is processed by a separate computer, which delays the information displayed on the screen by about one second.

The SCATS system allows adjacent intersections to be “married” for coordination purposes. The system decides which signals should be grouped together, and this can be forced through parameter adjustment. SCATS can also be overridden to provide extra green time. Helicopters are used to determine where signal timing adjustments are needed. The adjustments can be done anywhere using a laptop computer. Typical SCATS parameters include cycle lengths from 40 to **160** seconds.

Although it is not required for SCATS, all intersections were converted to protected only left turns. This is a safer but less efficient operation than protected/permissive lefts. It does allow for lead/lag left turn phasing possibilities. Australian manufactured AWA Delta 3 NEMA type controllers are used to operate each signal. Pedestrian phases are actuated by button, although the cameras could detect pedestrians in the future.

For the Oakland County SCATS application, video detection is used exclusively. One camera is usually placed for each intersection leg. with four cameras being a typical number. Unsignalized mid-block turnarounds are also detected. A total of 800 to 1000 cameras cover 200 intersections and turnarounds Cameras which are used for counting are stationary and cannot be used to monitor traffic conditions. Four video cameras are deployed for this function.

Each camera is placed on a pole approximately 35 feet in the air, with some on mast arms 6 to 8 feet out from the pole. Cameras were chosen because there were few loops existing, weather limits loop installations, and maintenance is easy. Pole vibration is not a problem.

Econolite's Autoscope software is used to process the video into vehicle actuations. Simulated loops (or any other shape) are drawn on the screen, and any object within the drawn area causes an actuation. Small detection zones minimize false calls. Directional detection can be specified. so that only movement in a given direction will create a call. This is useful where left turning traffic cuts into the cross street detection zone.

The calibration process involves painting markings on the pavement where traditional loops would be placed. looking through the camera. and drawing outlines of the painted area on the screen. Two or three short loops can be logically connected, allowing for "trap" loops to cover cars slightly out of position. Each camera can handle up to 64 actuation points.

A background adjustment cycle is used to transition from day to night and from dry pavement to snow cover. Compensating for shadows is difficult. In the winter, the sun may cast long shadows, which disappear and reappear suddenly as clouds move through. Street lighting is needed at night to provide a proper background.

The first 28 intersections cost about $45,000 each, but advances and simplification in production have brought the cost down to $25.000 per intersection. This includes cameras and the signal controller.

Ali-Scout

The Ali-Scout navigation system is commercially available in Germany. It uses a series of infrared beacons placed approximately every two miles to communicate with the central computer through telephone lines. The beacons are mounted on traffic signal poles about twelve feet above the ground and resembles a pedestrian signal head. One beacon is placed on each approach, aimed at the oncoming traffic. Two-way data is communicated between the car and the central computer through the beacons; each vehicle acts as a probe.

To select a desired location, either coordinates are entered from a system manual or a place is selected from a scrolling list. The list is alphabetical and gets fairly lengthy as destinations are added. You can remove the display panel and take it with you outside the vehicle.

A compass and distance measurement are always available for a selected location. To get a route plan, you must first drive to a beacon. After that. the system considers current traffic conditions. calculates the best route, and begins screen and audio instructions. It notifies you of upcoming turns and even recommends which lane to be in. If you leave the route. it will give you instructions on how to get back onto it.

The Ali-Scout's performance was impressive. The user instructions were clear and timely. Difficult situations such as two consecutive, closely spaced turns were handled well. The only system limitation is finding the nearest beacon to get the instructions started. The in-vehicle portion of the system would cost about $500.

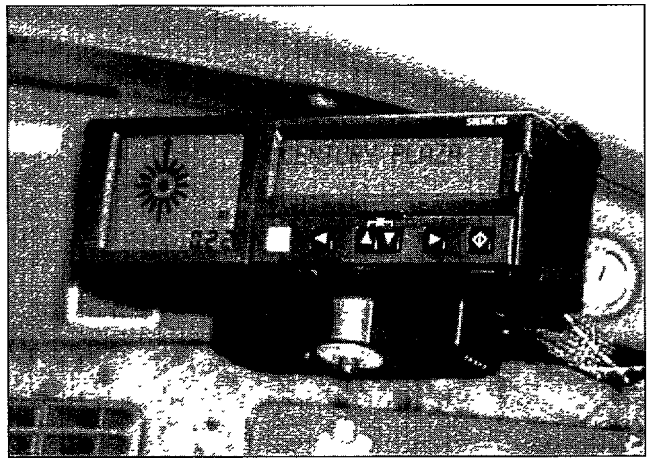

Figure 14. An AL-Scout System display.

Friday, August 12 - Toronto, ON

COMPASS

Contact: Phillip Masters 416/235-3798

The COMPASS system oversees traffic operations on Ontario Provincial Highway 401. In the study area. Route 401 is the busiest highway in North America. with an AADT of 352,000 vehicles per day. It has a cross section of 12 to 17 lanes and includes parallel collector and express roadways, and no alternate routes are available. The system's primary purpose is to manage the distribution of traffic between the collector and express lanes. COMPASS has been operational since January 1991.

Color televisions are used to monitor freeway conditions. The cameras' night visibility is considered to be adequate. The cameras can see everything within the 45 kilometer (27 mile) area covered by the system. There are 220 detector stations containing a total of 1000 detector loops. Spread spectrum cameras with leased microwave transmission systems are mounted on high rise buildings. Permanent licensing for microwave channels has been difficult to obtain.

The detectors are used to identify potential incidents. Cameras are used to confirm the problem, evaluate the incident, and determine the type of help that will be needed. They also bring back video confirmation of the variable message signs.

Cameras are placed on top of 50 foot concrete poles located on the south side of the freeway. This gives a consistent orientation to the operator and minimizes sun glare problems.

Additional systems in the greater Toronto area include the Queen Elizabeth Way (QEW) system in Mississauga, which has 10 ramps meters, the QEW Burlington Skyway system near Hamilton, and the Gardiner Expressway-Lake Shore system. The latter system is operated by the metropolitan Toronto government.

System costs in Canadian dollars (now worth about 70 U.S. cents) include $8.000 to $10,000 per camera installed (including housing), with $1,000,000 for the software and

$800,000 for the monitoring computer system. The incident detection software developed for COMPASS is being used in Korea and Atlanta.

The actual incident management fleet is a relatively modest three or four vehicles on the road at a given time. Surprisingly. there are about the same number of accidents in the express lanes as there are in the collector lanes, even though the latter have more merges and weaves. Areas near the crossover lanes between the express and collector lanes have the highest concentration of incidents.

Variable Message Signs

Thirteen variable message signs are used along Route 401. Each one is placed near a ramp connecting the collector and express lanes. Default information is always displayed, such as safety slogans or upcoming exit information. Several of the signs replaced pre-advance static signs: these display the static message until a special message is needed. Each sign costs about $300,000 in Canadian dollars.

Messages concerning traffic flow imbalances between the collector and express lanes are automatically issued by the computer. Incident messages require operator confirmation of a computer recommended message. An example of an imbalance message is: “Express Moving Slowly...Collector Moving Slowly...Beyond Next Transfer”. This measure has resulted in 7% to 19% higher average speeds.

Upon determining that an incident has occurred, operators specify the location and number of lanes blocked. Based on this, the computer recommends a preprogrammed incident message. Customized messages cannot be created by the operator. This avoids spelling errors, deliberate troublemaking, and message inconsistencies. An example preprogrammed message is “2 Left Lanes Blocked...In Express Lanes...Ahead”. A person seeing this message is beyond the last opportunity to cross over to the collector lanes.

An interesting problem in Canada is the bilingual requirement. Changing the signs to include both French and English has been investigated and would require a $17 million (Canadian) investment. Thus, progress toward compliance is hindered by the cost. Emerging ITS technology such as electronic signing might make this conversion unnecessary.

Ramp Meters

The Queen Elizabeth Way (QEW) has ten ramp meters. These display three colors (red. yellow, green) with a brief yellow. The ramp meters display green when not metering traffic. A flashing yellow beacon warns traffic when the meters are active.

A series of time windows are employed which either allow the meter to come on, force the meter to come on. or force the meter to turn off. Ramp meter rates range from 3 to 9 cars per minute, depending on the mainline volume.

A queueing loop is placed at the top of each ramp. When the queue reaches this point, the timing is adjusted to increase flow rates and shorten the queue. Only single lane meters are used; multiple lane meters were tried but were unsuccessful in controlling traffic.

METRO TORONTO INTEGRATED TRAFFIC CONTROL CENTER

Contact: Les Kelman 416/392-5348

The Metro Toronto Integrated Traffic Control Center is strategically located in the 9 I 1 center for Toronto. Both the traffic signal control system and the Gardiner-Lakeshore management system are located in this new facility. Traffic signal control is being shifted from the former facility; the move is currently about one-third complete.

All traffic signals in the Metropolitan Toronto area are run by the same agency. The system is well integrated. and all functions are located in the same building, including signals, freeways, road crew dispatch, and all emergency services.

The control center is staffed by contractor personnel 24 hours a day. This arrangement has worked out well. Both contractors and consultants participated in tight bidding. The contractor developed a standard test which all operators must pass before they can serve on a shift.

The traffic signal branch is divided into four groups:

- The computer systems group concentrates on computer operations:
- The electronics and communications group performs field work;
- The traffic operations group concentrates on day to day operations; and
- The traffic engineering group focuses on longer term projects.

This avoids the problem of engineers getting bogged down in daily details. About 5 people staff each of the four groups.

New technology is installed gradually. Although this precludes a leadership role, you don’t end up ahead of technology changes and getting committed to technology outside of the mainstream. By making smaller. easier to keep promises to your customers and making good on each promise, greater trust and confidence is built up over the long term.

The SCOOT Traffic Signal System

The traffic signal center is responsible for 1682 signals. Currently, 85 of these traffic signals are operating under a Split Cycle length Offset Optimization Technique (SCOOT) system. Contmued growth of the SCOOT system is planned. A “Swiss cheese” implementation approach will place SCOOT at the most beneficial locations first (as opposed to a single concentrated area).

Telephone lines connect individual controllers to a central node. From there. high speed dedicated links bring data back to the control center. This has saved 70% in communications cost compared to bringing all data directly to the control center from each controller. Telephone costs in Canada are very high.

There are no inherent timing plans for SCOOT. The central computer continually optimizes on a network-wide basis. Flow profiles and vehicle queues are used as optimizing parameters. Green start times and splits are changed incrementally in response to changing traffic demand. The TRANSYT-7F algorithm is employed for the real-time optimization, which is calculated in just a few seconds. The needs of the entire network is considered in addition each intersection's local needs.

A thorough evaluation of SCOOT involved turning the system on and off on alternate days. Three test sites included a CBD area, a commercial arterial. and a commuter arterial route that parallels an expressway. Considerable travel time and stop reductions were observed, with strong benefits in the off-peak hours as well as during peak hours. Rear end accidents were reduced. as well as all-red violations. Details are contained in a series of handouts given to all participants.

One large benefit of SCOOT is a potential reduction in personnel, since timing plans do not have to be developed and updated. Another advantage is automatic adjustment to irregular travel patterns such as incident diversions or sports events.

One observation is that buses do not keep up with the platoon and may not receive any benefits from the system. Currently, there are no preemption provisions for transit vehicles.

SCOOT parameters include allowed transitions of 4 to 16 seconds in cycle length, 1 to 4 seconds in split, and 1 to 4 seconds shift of offset. The maximum cycle length is around 140 seconds. These limits avoid severe transitions and damper the system to respond to longer term trends. It takes several cycles to adjust for quick surges in traffic.

Gardiner-LakeShor e Freeway Monitoring

Contact: Bruce Zvaniga 416/392-9631

The Gardiner Expressway is a mostly elevated 6 lane freeway which is generally without shoulders. Lake Shore Drive is an arterial that runs parallel to the expressway. and frequently directly underneath it. The two highways have a combined AADT of 245,000 vehicles per day. Managing these two highways as a unit provides considerable safety and quality of travel benefits, while avoiding the need to widen the expressway.

Freeway control has been divided into four implementation phases, as follows:

- The detection phase, including loops and cameras:
- The advisory phase, which will show current traffic conditions on a PC-type screen;
- The diversion phase, which will use Variable Message Signs: and
- The control phase, including ramp meters, lane control signs, and traffic signal system integration.

The advisory screen is under development, and includes colors to represent road conditions by speed as follows:

COLOR	MEANING
Red	Speed less than 25 miles per hour
Yellow	Speed between 25 and 40 miles per hour
Green	Speed over 40 miles per hour
White	Data not available

Flags show where an incident is located. This data is available to the media, along with a camera tour. Fax transmissions are sent on a custom schedule for each subscriber. This service is currently free but will have a charge in the future. Cooperation with the local media is strong, and video from a television station owned camera on the CNN tower is provided to the control center.

All detector loops on the expressway are double loop speed traps spaced every half kilometer. The arterial alternates single and double loop arrangements. Cameras are located both above and beneath the expressway (to cover the arterial below). Twisted pair wires bring information back to nodes, where fiber optic cables are used to complete the circuit back to the central facility.

The usefulness of Variable Message Signs has been questioned by the public due to their high cost. While it is true that less expensive means such as highway advisory radio may be available, the message signs guarantee that everyone gets the information. Two telespot fiber optic disk signs are being purchased. Four roll and drum advisory signs containing up to four brief messages each (such as "open" or "closed") are used.

Some interesting issues arise because two different agencies monitor the area freeways. Currently, the operations are completely independent. Overlapping coverage is planned for the future to provide more seamless traffic control. The Variable Message Signs on Route 401 are the LED type. while flip disks are used on the QEW (and soon on the Gardiner). This incompatibility does not seem to cause any difficulties.

ITS North America "94 Study Tour
Personal Observations

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The objective of the ITE ITS North America ‘94 Study Tour was to provide first-hand knowledge of ATMS, ATIS, APTS, AVCS and CVO systems. The tour presented a balanced view of probable solutions to congestion management, safety concerns, and information dissemination needs with respect to the motorist or rider of transit. The emphasis on the importance to integrate ATMS and ATIS was made very clear in several of the systems we visited.

Beginning with a visit to the University of Minnesota’s Human Factors Research Laboratories, the group learned about the work being done to simulate real-world experiences with visually impaired drivers, airplane pilots. signal modality of young versus older drivers and multi-tasking.

The ITS tour was then led to the Minnesota DOT's Metro Division Traffic Management Center which featured a freeway traffic operations center for 250 miles of roadway in the Twin Cities Metro Area. Ramp metering, closed circuit TV. changeable message signs. HOV facilities, ATIS and video image vehicle detection were being used to provide an extensive system of integrated corridor traffic management. The Guidestar project is an ITS program which will use traffic data collection and distribution and Autoscope technology for video imaging.

Genesis and TravLink are two other tests being conducted to determine the impacts for transit and transit information services. Results from these efforts are not yet final.

As the tour progressed to the Chicago area the group learned about the Advance program which features dynamic route guidance, in-vehicle navigation and probe vehicles. It is one of the largest fleets (3,000 vehicles) being tested anywhere. The Advance system will provide real-time traffic information to assist drivers reduce travel time and increase safety.

Michigan offered the opportunity to observe and learn about several ITS programs and projects including the following:

- Faster and Safer Travel through Traffic Routing and Advanced Controls (FAST-TRAC)

  Dynamic route guidance, driver information, beacon technology and advanced traffic management are integrated to provide better traffic management and traveler information. SCATS traffic signal controllers and Autoscope vehicle detectors are being used with Ali-Scout beacons.

- Driver Information Radio using Experimental Communication Technologies (DIRECT)

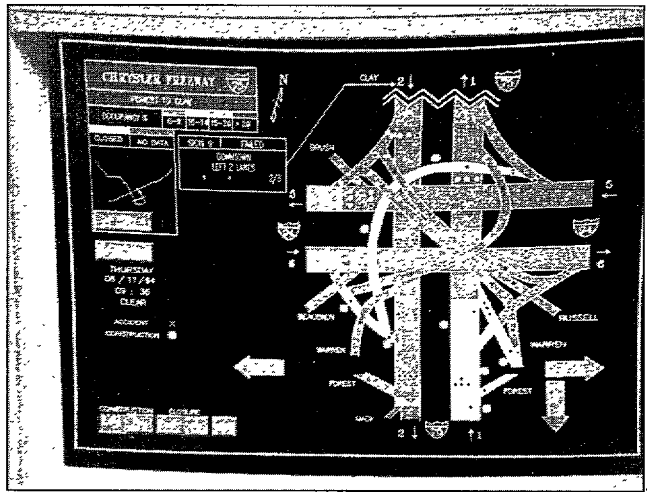

Figure 15. A status display at the Michigan Intelligent Transportation Systems Center.

  A motorist advisory system comprised of low powered HAR and automatic HAR, a radio data system and cellular phones will provide enroute driver advisory and traveler information services.

- Michigan Intelligent Transportation Systems **(MITS)**

  The FAST-TRAC and DIRECT projects are but a couple of the ones being coordinated by MITS. The Advanced Traffic Managment System **(ATMS)** uses an extensive video surveillance system. changeable message signs, highway advisory radios, ramp meters and inductive loops to manage traffic safely and efficiently on Metropolitan Detroit freeways.

The final leg of the ITS tour was in Toronto. The Ontario Ministry of Transportation provided much information on the COMPASS program. The use of inductive loops, closed circuit TV, and changeable message signs to help detect incidents and to provide motorists with accurate information shows many benefits. The traffic monitoring system works very closely with local police, fire and ambulance personnel for incident response activities.

The last stop on the tour was the Toronto Integrated Traffic Control Center for Metro Toronto. The consolidation or integration of various traffic functions has improved the management and effectiveness of the transportation network in Toronto. The traffic signal control system uses standard time of-day computerized operation and has embarked on traffic responsive signal timing through the use of the Split Cycle and Offset Optimization Technique (SCOOT). The center relies heavily on inductive loops, closed circuit TV and changeable message signs in incident detection and modification of traffic signal timing plans.

The importance of traffic surveillance (loop detectors, closed-circuit television and monitors). was prominent in almost all of the tour sites. Only Chicago was not using CCTV at present. Video image processing is gaining in promise, but is mostly being used in field tests.

Traffic adaptive control or traffic rerponsive signal timing plan generation was exhibited in the SCOOT system and others to provide real-time signal response to current traffic condition\. This type of responsiveness all but eliminates the labor-intensive process of developing new timing plans to address traffic peaks.

Traveler information systems are placing greater emphasis on the delivery of real-time traffic information to the motorist before and during trips. The result is to influence driver decision-making to provide a safe and efficient travel choice. Some of the methodologies being used are in-vehicle navigation, heads up display, changeable message signing. highway advisory radio, video and traffic information broadcasts over radio and television. bulletin boards, and kiosks.

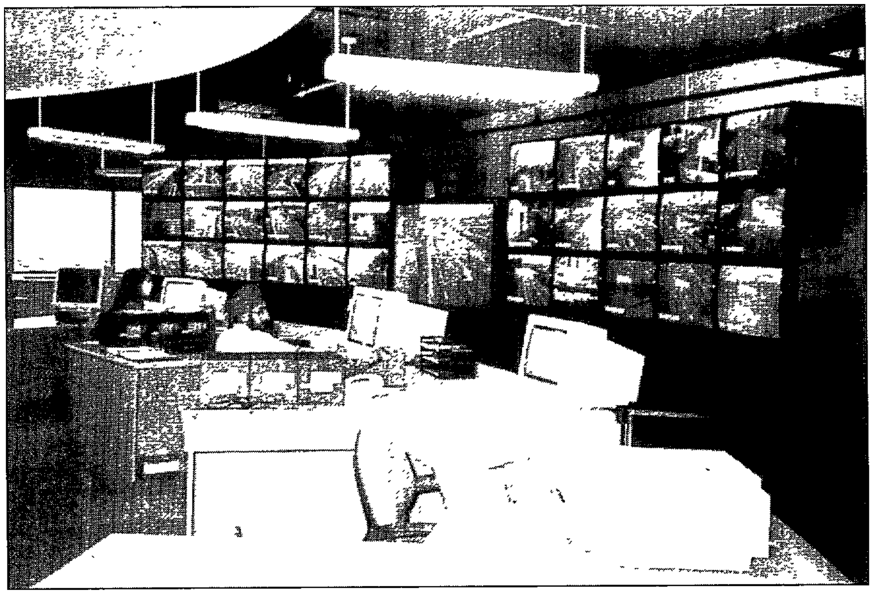

Figure 16. The Toronto Integrated Traffic Control Centre in North York, Ontario, Canada.

The impressive part of the tour. to me, was not so much the technology application, but the cooperative arrangements between public, private. academia, etc. The partnerships which have been cultivated and roles developed have had to address both institutional and technological issues.

The many operational test sites visited exhibited varying levels of innovative institutional arrangements, thus promoting intergovernmental cooperation and privatization opportunities. Within these frameworks, various legal, funding, technical and administrative implications and responsiblities have been determined and roles developed.

The various tour participants and contact persons were very knowledgeable and enthusiastic concerning the ITS strategies being implemented or those planned. The operational test sites visited provided state-of-the-art technologies addressing real-time traffic problems.

The tour was very interesting to me as was the various discussions among tour participants. I developed many friendships and gained insights to what ITS applications are being made, not only in North America, but also in Europe. It was an extremely fast-paced week, but very rewarding.

Where is the Intelligent Highway Taking Us?

By Harriet Robins Smith
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The ITS North America Tour was extremely informative and precipitated a great deal of thought and information exchange among the participants. In exploring ideas with participants from the United States and abroad some questions about long term goals came to my mind. It is through this paper that I would like to consider these ideas with you, the reader.

Webster's *New Collegiate Dictionary* defines engineering as "the application of science and mathematics by which the properties of matter and the sources of energy in nature are made useful to man in structures, machines, products, systems, and processes." Certainly this definition applies to intelligent transportation systems (ITS). Arguably, in the broadest sense, and seeking long range prospective. the overall purpose of ITS is to improve the quality of life. We who are promoting ITS are doing so for the purpose of harnessing nature and energy in a way that is useful and will improve the quality of life for us all.

Keeping our long term goals in mind it behooves us to step back upon occasion and examine whether we are taking a long enough prospective to reach short term goals without sacrificing the future.

One of the immediate goals of ITS is to relieve traffic congestion. In Minneapolis, Chicago, Detroit. and Toronto tremendous effort is going into reaching this goal.

Incident management is prominent in the minds of traffic engineers today. During the tour we heard repeatedly that it is extremely important to identify and respond to incidents quickly to avoid resultant traffic congestion and subsequent collisions. There is a ricocheting effect with traffic congestion and collisions. Because of the violation of driver expectation, traffic congestion causes collisions and collisions interrupt or stop traffic flow causing congestion.

Safety concerns are not the only reason to mitigate traffic congestion. When automobiles are stalled in traffic, precious fuel is wasted and air quality suffers.

We must find ways to reduce traffic congestion.

With the passage of the Intermodal Surface Transportation Efficiency Act the United States took the position that we no longer can afford to solve traffic congestion problems with the addition of roads or lanes and must find more creative solutions. One of those solution is to apply advanced technologies in a way that will enhance the efficiency of the transportation system we have available. One technology that is in various stages of implementation is the provision of driver information through variable message signs which reflect traffic volumes and densities through loops, autoscopes. video monitors, and other traffic detection devices. Either implicitly or explicitly the variable message signs encourage the driver to leave the freeway system and use the arterial highway system to move around the congestion. In none of the four cities mentioned above are there messages on the signs which direct the driver to public transportation.

This detail alone may be insignificant, but it points to a larger issue. That issue is that diverting traffic can only be a short term solution.

In every urban area there is a tolerance level for the amount of time one is willing to spend in commute. If traffic moves smoothly or can be diverted around slow points. then commuting distances can increase without the sacrifice of time. The vehicle miles travelled then increases and traffic again slows. This phenomenon is called as "latent demand". The concern here is that through traffic conversion we may be exacerbating a long term problem by creating latent demand. If this is the case, what is the solution?

It is possible that the only solution is a radical change in behavior-a new way of looking at transportation and the meaning of independence with respect to automobile ownership and use.

What is being done through ITS to change for the long term America's obsession with the automobile? Are any attempts being made to take the driver out of the single occupant vehicle and onto a bicycle, transit vehicle, sidewalk, and so forth?

One of the most encouraging pieces of evidence that attempts are being made to affect long term changes in behavior was seen in Minneapolis. Along highway I-394, which began operation in 1992. a series of park/ride lots have been constructed adjacent to the highway. The park/ride lots are highly visible from the highway which continually reminds drivers of the transit alternative. provides a sense of security and obviously is accessible. The park/ride lots are scheduled locations for information kiosks which will give the traveller real-time data on the arrival times and destinations of buses. This traveller information will not divert the car to another **highway,** but rather the traveller to another mode.

Based on what was seeen in the tour. transit is generally an afterthought or a last resort. In the human factors laboratory at the University of Minnesota research tends toward projects concerning virtual reality with respect to driver training and the human interaction with a vehicle and/or road. The resistance of an American to use available transit may be a human factors issue. Is there a possibility for research into factors that may make humans feel more competent, secure, and comfortable on transit as well as in an automobile?

One of the European participants spoke of the resistance of transportation engineers in Belgium to make improvements to road and traffic signals systems because those improvements encourage more single occupant vehicle (SOV) use. The idea is to promote transit using the "push and pull" technique. The "pull" includes the positive incentives such as frequent transit service, a clean and safe system, etc. The "push" includes the negatives factors such as scarce parking and heavy traffic congestion.

Another European participant mentioned that he received his driver's license in his late 20's and was amazed to hear about the American ritual of taking the driver's test on one's 16th birthday.

The technologies we saw in Ann Arbor which are being installed in the 'Smart Bus" are certainly encouraging. No doubt global positioning, automated stop announcements, kiosks with real-time information, and smart cards will make the transit traveller more comfortable and better informed. Are these technologies enough to draw anyone out of a "smart car" or off a "smart highway"?

It is intuitively apparent that making SOVs more attractive makes alternatives less attractive. Unfortunately, we have no good examples of a thriving community/country in which transit ridership, bicycling, and walking have actually replaced traffic congestion. Therefore, what I am about to suggest will be paving new ground. The suggestion is that in determining which technologies to implement in urban areas, let us consider first whether the technology will encourage or discourage more SOV use. Let us make decisions that will in the long run improve the quality of life for us all.

A Tale of Four Cities:
Applying ITS Technologies Across Many Jurisdictions

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INTRODUCTION

The purpose of this paper is to compare the ITS systems that each of four visited cities has developed from the perspective of both the travelling motorist and transportation officials.

As Intelligent Transportation Systems (ITS) are applied throughout the United States and abroad. the need for establishing standards that can be consistently applied throughout the transportation industry has often been raised. Recently, a visit to four cities on the ITS North America Tour allowed an opportunity to look at the similarities and differences that exist today in applied ITS technology. Many of the factors that have caused variations in how technologies have been deployed will continue to influence future ITS deployments.

THE TRIP

The information for this report was obtained during the 1994 ITS North America Tour. The ITE sponsored trip included stops in Minneapolis. Chicago, Detroit, and Toronto. At each city, official presentations were given, formal tours were conducted, and area highways were driven. In addition, bus transportation was undertaken between the cities. Well over 1,000 miles were logged during the six day trip, offering exposure to a wide variety of ITS applications.

The four cities that were visited have many similarities. All four metropolitan areas are large in terms of both population and land area. Each area features generally flat terrain, a relatively cold winter climate. a steady core city population combined with rapid suburban population growth, and an extensive freeway system.

The major difference between these cities is that each is in a different state or provincial jurisdiction. Thus, differences in funding levels, priorities. policies. and standards exist. Traffic congestion levels also differ. both in terms of what exists and what is considered tolerable. It is these jurisdictional differences that account for much of the variety in local ITS applications.

SYSTEM COMPONENTS

ITS is a collective name for a series of individual components that work together. Those components that were featured on the tour include ramp metering, changeable message signs, incident management, traffic conditions displays, radio/telephone advisories. vehicle navigation systems, commercial vehicle operations, transit system enhancements, video camera monitoring, and advanced traffic signal control technology. Each of these components will be discussed in turn.

RAMP METERING

A prominent ITS measure seen in all four cities is ramp metering. Ramp meters have been in use in the United States for over 30 years. Of the four cities visited, Chicago has the oldest system (in fact, Chicago pioneered their use on a five mile test section in 1962). On the other hand, Minneapolis has a very modem system of ramp meters.

The hardware used to display ramp meter indications to motorists varies considerably. Chicago and Detroit use two color signals (red and green), while Minneapolis and Toronto use three color signals (red, yellow, and green). The accompanying signing and number of heads used also varies from city to city.

If the traffic signal criteria in the *Manual of Uniform Traffic Control Devices* is applied to ramp meters, that would suggest that three color signals are appropriate. However, the safety necessity of the yellow clearance interval for intersections does not apply to ramp metering situations. In addition, the yellow interval duration on ramp meters must be extremely short to ensure that only one car can move at a time.

Operational procedures also differ with ramp metering. When the ramp meters are inactive, Minneapolis flashes them yellow; Toronto displays a steady green; while Chicago and Detroit turn them off altogether. **In** Toronto and Detroit, advance warning flashers are activated when meters are in operation.

Some design differences stem from jurisdictional preferences concerning whether traffic can queue beyond the storage capacity of the freeway ramp. In Toronto. loop detection is provided at the top of each ramp to check if the queue is about to exceed the ramp's storage capacity. Ramp meter rates are increased to empty the queue when this happens, at the expense of the mainline. In Chicago, it is considered acceptable to store ramp traffic on the crossing arterial, as long as adjacent intersections are not adversely affected.

The public would certainly notice the differences in the display mechanisms. However, the differing queue storage philosophies would probably not be noticed. In this case, some ITS application details can be varied. while others should be standardized.

CHANGEABLE MESSAGE SIGNS

All four cities visited use changeable message signs as the primary means of getting information to motorists. The variable message type is clearly preferred to the more limited rotating drum system.

Most cities leave the signs blank when they are not in use. Toronto displays messages continually on their signs. To reduce sign clutter, some of their signs replaced static signs that listed upcoming exit information. These normally show the message that was formerly displayed on the static sign. When an incident occurs, the message changes to an advisory.

The procedure for selecting the wording on the sign varied. In Chicago, custom messages can be created at any time by the operator. Minneapolis uses a rotating drum that does not allow custom messages. Operators in Detroit and Toronto must select from a library and cannot create custom messages.

From the motorist standpoint, the wording on the sign is critical. The complex decisions that are needed when incidents affect the desired route require accurate information, yet the signs allow only a few words. As more ITS systems include the signs, some standardization between jurisdictions will help deliver a consistent message no matter where the driver goes.

INCIDENT MANAGEMENT

Each of the cities have an incident management program. The extent to which they have been implemented varied widely, depending both on budgetary concerns and perceived need. As might be expected, incident management becomes more aggressive in areas of heavy congestion.

Chicago's incident management program is a highly aggressive program with a "move now and ask questions later" approach. The Chicago area patrol finds 60% of the incidents on their own by maintaining thorough, continuous coverage. This minimizes detection, response, and clearance time. It should be noted that the Chicago vehicle stream includes 30% trucks, which makes every incident critical.

Incident management programs are unique because they are not necessarily seen by the individual travelling motorist on a daily or even weekly basis. These programs are more of a long term effort. Because of this, the emphasis on this aspect of ITS will likely continue to vary widely between cities unless minimal guidelines or mandates are imposed.

TRAFFIC CONDITIONS DISPLAYS

A relatively new addition to the ITS family is the provision of real-time data to motorists through television monitors. This typically includes a map of the expressway system that has been overlaid with colors representing different levels of traffic congestion.

Comparing the displays from different systems said a lot about public expectations. In Detroit, the most congested condition was shown once the occupancies reached 20%. In Chicago, 50% occupancy is needed to reach the most congested condition. Toronto's display is based on speeds rather than occupancy. The color codes also changed from system to system.

It makes sense to use thresholds that are appropriate for a local area. As the systems become more widespread, there may be a need to establish some consistent rules for the sake of the travelling public.

RADIO/TELEPHONE ADVISORIES

Surveys taken by the Minnesota Department of Transportation indicate that the public most prefers travel data that is offered before the trip even begins. A telephone advisory system is one method to provide detailed travel condition information to anyone who is near a telephone, including motorists who are out of town.

In Chicago, a telephone call-in system gives estimated travel times between locations that have been calculated from system sensor loop information. This is especially important in an area where travel times are less predictable because of recurring congestion. In the future, a telephone service could offer a 900 number which provides traffic data for any selected city (similar to weather information hotlines).

Radio advisories continue to be an effective way to deliver a detailed message to motorists. A flashing beacon is typically mounted on a static sign to advise motorists of a pertinent message. The traveling motorist will find a variety of frequencies. operating ranges, and message contents during the trip. In the future, the trend appears to be headed toward dedicated. full time traffic stations (on both cable TV and radio). Highway advisory radio will still remain useful because messages can be highly customized to a particular location. Compatibility in these cases is more a hardware issue than the specific contents of the message.

VEHICLE NAVIGATION SYSTEMS

Vehicle navigation systems are being tested in Minneapolis, Chicago, and the Detroit area. These represent the most advanced ITS technologies that were observed during the tour.

Because this technology is still in the early stages of development, it is not clear what the final system will look like, or whether there will be multiple systems that are compatible with each other. To impose standardization now would limit the diversity in research that is needed at this point.

One of the biggest questions that has yet to be answered is how much of the navigation system will be in the vehicle, and how much will be inherent in the road or centrally operated. While in-vehicle configurations can be developed privately, the road and central data portions will rely on government support for development.

Some systems that are entering the market now need little information outside the vehicle other than a position confirmation. These cannot adjust for changing traffic conditions. Others require periodic beacons along the roadside. As central data systems are developed. more sophisticated navigation devices will take advantage of the information. Ultimately, supporting features located on the highway itself will take on an increasing role. but these will probably be the last to develop.

On the lighter side, a calculator that is now being sold through a products catalog features pre-stored freeway exit information concerning hotels, restaurants, and tourist attractions. By entering the interstate number and the exit number, it lists selected services that are available and offers simple directions. This is a good example of the private sector contributing on its own. Like the cellular phone. the products can begin to dictate the rules.

In the future, compatibility issues for vehicle navigation systems will be vital both with the public and for system operators. These systems rely on two-way data exchanges, with vehicles providing the travel times needed to update the central database. Incompatible vehicles from other areas would cause a number of problems, including the inability to get information either to or from the vehicle.

COMMERCIAL VEHICLE OPERATIONS

Minnesota and Michigan are very active players in the development of commercial vehicle operation systems. These systems will help trucks move from state to state and even internationally without the need to stop frequently for safety, weight, and agricultural inspections.

Much compatibility is already built into the design of commercial vehicle operations due to their nature. Multiple state agreements are common and necessary for their success. These agreements can serve as a model for compatibility as other ITS system components need to become more and more integrated.

TRANSIT SYSTEMS

Since transit systems rely on complex schedules and fixed routes, traveller information is critical, especially at the onset of the trip. Several cities are developing systems that gather and disseminate information on schedule performance and progress along the route. From the rider's perspective, compatibility from one city to the next is not especially critical for these systems.

On the other hand, the ability to pay fares electronically will need compatibility with other systems. For example. Ann Arbor's Smart Card program may ultimately include bank services, highway tolls, telephone call charges, and parking garage fees in addition to bus fares.

VIDEO CAMERA MONITORING

Video cameras are becoming more and more predominant along the highway in urban areas. All of the installations that were visited are positioned on top of a pole, with the camera so high above the highway that it is almost unnoticeable to the average traveler.

Camera coverage ranges from intermittent views to complete coverage. Intermittent cameras allow for confirmation that a traffic problem exists but may not provide much detail as to the exact nature of the problem. Complete coverage guarantees that the incident can be verified in detail and that recovery efforts can be monitored as well.

Current camera technology standards make it unlikely that a compatibility problem will arise. Assuming that cameras continue to be installed in an unobtrusive manner, the physical appearance to the public is not important. The only standardization issue might be which images are shown on the video image that is supplied to the public through cable television or video monitors located in public places. Along these ends. Toronto uses a standard orientation by locating all cameras on the south side of the highway.

ADVANCED TRAFFIC SIGNAL CONTROL

Two systems that were visited include the SCATS based system in Oakland County. Michigan and the SCOOT based system in Toronto. Both systems use adaptive traffic control strategies, an extension of the traffic responsive mode that is currently used in closed loop systems.

These systems are generally transparent to the public, other than a somewhat smoother traffic flow. Existing traffic signal controllers typically need to be modified to operate these systems, if they are compatible at all. Oakland County must use Australian manufactured NEMA based controllers due to compatibility problems.

In the future, these systems must be able to operate with standard controllers. In addition, systems of adjacent jurisdictions must be fully compatible so that the necessary communication of data can be accomplished. Currently, jurisdictional lines with regard to traffic signals are all too often very obvious.

PUTTING IT ALL TOGETHER

The systems that have been seen during the trip are at various stages of development, and many are still experimental. Ultimately. all of these components will have to work together, and the more compatible the components are, the more seamless the system will be.

One group that is working on this problem now is four teams that are independently developing a standard ITS architecture. Ultimately, one of the conceptual designs will become the standard means of integrating all of the components together.

Updates to standard publications such as the *Manual on Uniform Traffic Control Devices* will be needed as new technologies are developed and applied. Even older technologies such as ramp meters still do not appear to be standardized in appearance or operation.

Other components need to be standardized to allow the complete communication of data. The prime example is the traffic signal controller. After all these years, complete traffic signal controller compatibility still seems to be far in the future.

Of even more concern is a potential proliferation of privately developed devices that are not compatible with anything else. For example, we must overcome the tendency of some private industries to develop captive markets by deliberately avoiding compatibility with competitors.

CONCLUSIONS

ITS has the potential to draw us closer as a nation through reduced travel times and by making real time data concerning distant destinations readily available. The physical appearance of our message signs, signals, information screens, and in-vehicle devices should be as uniform as possible for the sake of the public. The jurisdictional lines should ultimately be as transparent as possible. Based on this trip through four cities, the jurisdictional lines remain strong.

If history repeats itself, we have a hard task ahead. Computers, video recorders, music recording formats, and even traffic signal controllers are examples where insufficient standardization attempts have led to obsolete eight inch floppy disk drives, 8-track tape decks, and other victims of incompatibility. Standardization guidelines for ITS are clearly needed as early and as thoroughly as possible, within the need for diversity that research requires.

ACKNOWLEDGMENTS

The author expresses appreciation to the Federal Highway Administration for their scholarship support and to the Institute of Transportation Engineers for organizing a highly effective and educational tour. In addition, appreciation is expressed to the agencies that devoted much time and energy demonstrating the various system components, answering questions. and offering hands-on experiences.

ITS North America '94 Study Tour
Personal Observations

By Jano Baghdanian
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The ITS North America 94 Seminar Tour was organized by ITE to provide transportation professionals employed by public and private agencies with an interest in ITS the opportunity to visit ITS facilities in North America. Four cities were visited by the seminar tour: Minneapolis. Chicago. Detroit, and Toronto.

The seminar tour group was comprised of twenty-nine participants from California, Colorado. Florida, Georgia, Kentucky, Minnesota, New York, Texas, Washington, D.C., Belgium, France, Germany, Ireland. and the United Kingdom.

Author's main reasons for attending this seminar tour were: (1) to study the ITS technologies and projects in the research, testing, and deployment phases in North America and investigate their potential application in urban areas; and (2) considering that the City of Glendale, California is in the process of designing a state-of-the-art Transportation Management Center this seminar tour provided an excellent opportunity to visit systems for freeway traffic management, computerized signal control, traveler information, route guidance, changeable message signs, automatic toll collection, and public transportation.

The following report discusses the various ITS projects visited by the tour and is not intended to be a detailed description of each project or site visited. but represent the personal observations of the report's author.

DAY1

3M CORPORATION TRANSPORTATION SAFETY CENTER

Cottage Grove, Minnesota

The tour participants were invited to visit the 3M Transportation Safety Center. 3M's representatives provided a tour of the 3M Outdoor Lab for R&D of Traffic Management Systems and 3M's 20/20 Microplexer System for Real-Time Traffic Management.

With the expansion of the Center which is currently underway, a diverse number of traffic safety and traffic management systems can be tested. A paved area of the outdoor lab was used for installation of loop detectors in various shapes and configurations for traffic signal detection systems. 3M's technical lab can provide excellent opportunities in testing various ITS products in cooperation with urban traffic engineers.

DAY 2

UNIVERSITY OF MINNESOTA - HUMAN FACTORS RESEARCH LAB (HFRL)

The University of Minnesota (UM) is one of the participants in the Minnesota Guidestar program. The UM is extensively working on a number of ITS projects. HFRL lab was established by Dr. Peter Hancock, Director, and Dr. Michael Wade, Professor, School of Kinesiology in 1989. Graduate students involved in various projects made presentations on:

Cataracts:

Measurement of driving performance of visually-impaired drivers.

Front-to-Rear-End Collision Warning System (Signal Modality):

Use of auditory and visual warnings in emergency braking responses.

Lighted Guidance:

Study of using lights on either side of a road in a work construction zone to reduce speed of traffic.

Traffic Advisories:

Effect of traffic messages structure on driver behavior.

Virtual Reality:

HFRL is investigating issues of perception/detection of obstacles in a 3-D environment.

From the author's standpoint, the most interesting aspect of the UM HFRL was the involvement of graduate students from different disciplines. Student from Psychology, Kinesiology, Computer Science, Industrial Engineering space were each responsible in the research and testing of projects outlined above. Thus example demonstrates the unlimited potential for educational institutions to become involved in the R&D of ITS technologies.

BUS TOUR OF I-394 MINNEAPOLIS

The I-394 between the cities of Wayzata and Minneapolis is a six lane radial freeway with I5 HOV-only access ramps, three miles of reversible HOV lanes, and eight miles of HOV lanes. This facility provides a number of incentives for commuters (Carpool, vanpool. transit) to use the facility such as the HOV-only access ramps, meter by pass ramps. park-n-ride lots conveniently located along the freeway with timed transfer stations for public transportation, and three parking garages with direct access from l-394 with a capacity of 6,000 spaces and reduced parking rates. The success of this facility is demonstrated by the fact that over 1,600 vehicles using the HOV lanes during the A.M. peak hour carry between 43 and

47 percent of the inbound people. In addition, in the same A.M. peak period. there are 84 inbound buses carrying over 2,600 passengers. The I-394 can be described as a complete model of a successful intermodal HOV facility.

MINNESOTA DEPARTMENT OF TRANSPORTATION (MN/DOT)

TRAFFIC MANAGEMENT CENTER (TMC) - MINNEAPOLIS

The Mn/DOT TMC was constructed in 1972 as part of I-35W Urban Corridor Demonstration Project. The TMC is the communications and computer center for managing traffic on Twin Cities Metropolitan Area Freeways. Together with Minnesota Guidestar, the TMC brings the ITS technologies to Minnesota.

The TMC operates 320 ramp meters, 142 CCTV cameras, 46 CMSs, 34 HOV ramp meter bypasses, motorist information radio, highway helper program, and 39 Autoscope cameras. The TMC manages ATMS and ATIS projects as part of the Minnesota Guidestar program. The TMC is also involved in Integrated Corridor Traffic Management along a 5.3 mile segment of I-394 which will integrate freeway and local arterial systems to improve the efficiency of traffic movement throughout a corridor.

From the au ' s standpoin t facil is a excellent example of integratio of surveillance. CMS's . travelr information. and communications for effective incident management and motorist information.

MINNESOTA (MN) GUIDESTAR

Minnesota DOT

James L. Wright, Director of Minnesota Guidestar and five project managers presented an overview of the Guidestar Program to the ITS tour participants.

The Mn Guidestar is a public, private and academic partnership with a mission to introduce advanced transportation technologies and strategies throughout all of Minnesota.

The key partners of this program are Minnesota DOT. University of Minnesota, Federal Highway Administration, private sector (automobile, communications, and mapping industries, suppliers) and ITS industry investors.

The following Guidestar projects were presented to the ITS Tour participants:

Rural ITS Scoping Study:
: A study to determine which ITS user services. technologies and products might be appropriate for a rural environment.

Travelink:
: Tests the impacts of enhanced transit and highway information on commuter willingness to use car, or Vanpool, or ride the bus.

Genesis:
: Tests the effectiveness of an advanced portable traveler information service to provide real time travel data.

An additional twenty ITS projects were also mentioned in the presentation, however, the details of each project is beyond the limits of this paper.

From the Author's perspective, the key the success of the Mn Guidestar Program is the coalition of the public and private sector entities that have formed the Guidestar program. Tremendous amount of effort has been expended to develop the Mn Guidestar program. The five- and 10-year project goals developed in th Guidestare Strtegic Plan can be used by similar- coalitions to implement intelligent Transportation system (ITS projects. The Cities of Glendale, Pasadena, Burbank. So. Pasadena, and La Canada Flintridge in Southern California. form Arroyo Verdugo Transportation Coalition (AVTC) that can be used as the foundation for the formation of a similar program at a smaller scale. Interestingly, thi s coalition has included the development of ITS projects in its 20-year Inter-modal Plan. The author will present the MN Guidestar program to this coalition and pursue the potential for the establishment of a similar program by developing a strategic plan.

DAY 3

ILLINOIS DEPARTMENT OF TRANSPORTATION (IDOT) COMMUNICATIONS CENTER (DISTRICT ONE)

The IDOT Communications Center (Com Center) is located in the District One Department of Transportation building in Schaumburg. Ill. Its primary responsibility is to call out appropriate personnel and coordinate their actions in response to incidents and inquiries such as emergency medical evacuations, ambulance calls, hazardous materials, snow and icing hazards. The CornCenter's telecommunications media consists of direct lines to various agencies such as the Chicago Police, State Police, MINUTEMEN Headquarters in Chicago, and DOT Traffic System Center in Oak Park. The CornCenter also controls storm water pump stations. highway lighting. highway advisory radio network, CMS. and reversible lane controls for Kennedy Expressway.

THE ADVANCE PROJECT

The ITS Tour visited the first Advanced Driver and Vehicle Advisory Navigation concept (ADVANCE) being tested in the northwest portion of Chicago and its suburbs. The tour participants were taken on demonstration rides in an ADVANCE vehicle equipped with a Mobile Navigation Assistant (MNA) unit, an in-vehicle display screen mounted in front of the dashboard. Each driver planned a route using the MNA unit. A comprehensive map with audio instructions guided the driver to the designated destination while communicating with a centralized Traffic Information Center via a two-way high speed data radio. The MNA unit gave the driver the best route information to avoid congestion and enhance safety. The on-board navigation system also contained an electronic directory to help the driver locate businesses such as restaurants. hotels, or points of interests.

ADVANCE project will involve volunteer drivers in at least 3,000 private automobiles, transit, and commercial vehicles.

Advance project test is scheduled to last through 1997. The evaluation of this system will be very valuable in the advancement of in-vehicle navigation systems.

From the author' s perspective, this project is another ex citing ITS technology that combines communication, electronics, and information processing to increase mobility and inprove convenience and comfort for all surfac transporta- e tion facilities.

DAY4

ILLINOIS IDOT TRAFFIC SYSTEMS CENTER - OAK PARK, ILL.

The ITS Tour visited the second Freeway Management Center on the tour. The IDOT Traffic Systems Center (TSC) Managers and monitors 136 Freeway centerline miles with 2,000 loop detectors, 109 ramp metering stations. and 18 on-line changeable message signs. The TSC also receives more than 18,000 calls per month regarding incidents through its 999 Cellular Express Lines.

One of the interesting aspect of this visit was the IDOT Emergency Traffic Patrol (MINUTEMEN) presentation at the TMC. A fleet of 35 basic patrol units and 9 special units are responsible for handling more than 123,000 incidents in 1993. On Chicago-Area Expressways, MINUTEMEN operates 24 hours a day, 7 days a week on 7 18 lane miles of the Chicago Area Expressway Systems. The MINUTEMEN program has proved that the key to a successful freeway incident management system is a complete freeway patrol program to respond quickly and initiate clearance procedures to restore normal traffic flow.

Overall, the IDOT's Freeway Traffic Management Program which includes the CornCenter in Schaumburg. TMC in Oak Park, and the Emergency Traffic Patrol (MINUTEMEN) in Chicago. demonstrated IDOT's extensive involvement in all aspects of ITS applications and its great potential for future expansion.

ANN ARBOR SMART BUS PROGRAM -ANN ARBOR, MICHIGAN

The ITS tour visited the Ann Arbor Transit Authority (AATA) transit facility. The AATA is conducting an operational test of Smart Bus concept. Each bus is being equipped with an on-board communication and navigation system, a central control system, and a "SMART CARD" fare collection system. The on-board system monitors the actual performance of transit bus in regard to route, location, speed and its mechanical systems. It also controls the fare collection system and destination sign.

The most interesting aspect of the SMART Bus Program was the SMART CARD fare system which can also be used as a parking pass to encourage commuters to ride transit with convenient method of fare payment at a lower cost.

DAY5

MICHIGAN INTELLIGENT TRANSPORTATION SYSTEM CENTER (MITS) - DETROIT, MICHIGAN

The ITS tour visited Michigan's Intelligent Transportation System Center (MITS). In this visit the tour was presented with current and proposed ATMS and ATIS operations, Michigan DIRECT (Communication Driver Information Radio Experimenting with Technology) and other ITS projects in Michigan. The MITS Center in Detroit is the hub of ITS technology in Michigan. Its Control Room manages 32 miles of Detroit's freeways using CCTV cameras, CMSs, ramp meters, inductive loops and communication systems.

One of the interesting applications of ITS technology in Michigan is a study for the development of Electronic Automation for border crossings between United States and Canada to expedite the movement of both commercial and private vehicle travel between the two countries. This is a joint study between United States and Canada.

GENERAL MOTORS (GM) ITS RESEARCH CENTER -WARREN, MICHIGAN

The tour of GM's ITS Research Center provided another insight in the automotive industries' commitment to the development of vehicles that can be integrated in the current and future ITS technologies. GM representatives demonstrated Collision Avoidance Systems and Integrated Cruise Control, night vision enhancement technologies, and automatic vehicle tracking technologies, Oldsmobile Guidestar, Delco Electronics Telepatch 100, and Trav Tek.

From the author's perspective. the auto industry can play a key role in the future of ITS by testing new ITS products in automobiles andmarket these products us appropriate.

FAST TRAC PROJECT - TROY, MICHIGAN

Fast-Trac which stands for Faster and Safer Travel through Traffic Routing and Advanced Controls is managed by **the** Road Commission of Oakland County (RCOC). Fast-Trac is the first in the world ITS project to integrate ATMS and ATIS. The principal technologies in Fast-Trac include:

- The Sydney Coordinated Adoptive Traffic System (SCATS) for area-wide traffic signal control.
- The Autoscope Video Image processing system for traffic detection.
- The Siemens Automotive Ali-Scout System for dynamic route guidance.

This project demonstrates the advantages offorming a partnership of Federal (FHWA). State (MDOT), Local (RCOC), and the private sector (Siemens Automotive, GM, Ford, Chrysler) in the development of ITS technologies with a common goal of providing, safe, efficient and environmentally friendly transportation systems. The success of these types of project will he extremely beneficial in the advancement of ITS technologies and their acceptance by the motoring public.

DAY6

COMPASS PRESENTATION - ONTARIO MINISTRY OF TRANSPORTATION (MTO), TORONTO, CANADA

The ITS tour visited the MTO's COMPASS project which is a new high-tech tool for managing traffic on urban freeways, for incident management and driver travel information. The initial phase of COMPASS project includes a segment of HWY 40 1. An advanced control center managed traffic flow using a combination of monitors, CCTV cameras, detector loops, CMSs and emergency patrol vehicles.

From the author- ' s perspective. the MTO Control Center was the most impressive andfunctional of the other Freeway Control Centers visited on the ITS tow.

TORONTO INTEGRATED TRAFFIC CONTROL CENTER

The Toronto Integrated Traffic Control Center is a new state-of-the-art communications and computer center which houses both corridor traffic control and urban traffic signals. The Center currently manages 600 signals which will be expanded by 1,100 signals that are currently managed from another control center.

The most interesting feature of this Center. compared to the other centers visited on the tour, was the integration of the Fire Department, roadway dispatch, and Police with the Metro Traffic Control System by providing separate work stations for each entity for better coordination and control in incident management.

From the author's perspective, although such integration may not be possible when expanding large control systems in metropolitan areas, it does make sense to design new freeway or w-ban traffic control center to accommodate ATMS, dispatch for-fire. police and roadway patrol, incident management, and HAR.

The presentation of Toronto's Scoot System Performance Report in Metropolitan Toronto was also very informative in terms of evaluating the extent to which traffic operations can be improved through the introduction of enhanced traffic control systems.

SUMMARY

The ITS North America '94 Tour provided the author an opportunity to gain first hand experience of ITS technologies and projects in North America. This study tour was worth a thousand reviews of technical papers, reports or studies on the subject of ITS. Live and video presentations from experts and tour participants and the interaction between them gave another dimension to the tour.

The following are the author's key observation from the ITS Tour:

- There is a need for transportation engineers employed by State and Local governments to be involved in ITS. As ITS technologies develop, these professionals will be required to evaluate, test, and implement ITS projects.
- ITS affects all modes of land transportation, namely, pedestrians, bicycles. motorcycles, automobiles, trucks, and trains. Therefore, transportation professionals especially at local level (cities) need to keep up with ITS developments in order to provide technical input to the public and elected officials on ITS technologies and issues.
- ITS projects requires a partnership of Public (Federal, State, Local) governments, Private (automotive industries, communications and mapping industries and product manufacturers) and Academia (universities and research laboratories) to ensure its success.
- Smaller scale ITS projects can be deployed at local level (cities) by building a coalition of local governments with a strategic plan with well defined long-term goals, objectives, and actions. This concept can be pursued by the Arroyo Verdugo Transportation Coalition in California (Glendale. Burbank, Pasadena. So. Pasadena, La Canada Flintridge).
- With the advancement of ITS technologies, there is a greater need for cooperation between State and Local transportation engineers for the implementation of ATMS on freeways and arterial traffic signal systems so that both freeway operation and arterial operations are fully integrated.
- The success of ITS will depend on public acceptance of the technologies being developed. An extensive public education and marketing program is required for ITS project regardless of its scale.
- ITS presents a new and exciting era in transportation for transportation professionals. The unlimited application of ITS technologies will present new career opportunities for engineers in the transportation field as well as students in engineering disciplines.

In conclusion, the author wishes to thank the Institute of Transportation Engineers and Federal Highway Administration for selecting the author as one of the scholarship recipients to participate in the ITE ITS North America '94 Tour. In addition, the author wishes to thank the City of Glendale for providing the time and incurring part of the expenses for attending the seminar tour. And, special thanks to Dennis L. Foderberg, Director, Institute of ITS. and Juan M. Morales, ITE Director of Technical Programs for an extremely informative and well organized tour.

ITS North America '94 Study Tour
Personal Observations

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By James J. Dale
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City of Austin, Texas

INTRODUCTION

The ITE ITS North America '94 Study Tour was exactly what was promised: an informative and exciting trip. In addition to the knowledge acquired from the hosts at each facility, the discussions with the tour escorts and other participants also provided a wealth of information. I am assured that the experiences and contacts made during the tour will prove extremely valuable in our efforts to develop an ITS in Austin. Although all the information acquired during the tour cannot be discussed here, I will try to touch on some of the key elements that I felt were unique to each facility that we visited.

MINNESOTA

While in Minnesota. our tour primarily centered around the Minneapolis/St. Paul region. Four sites were visited: 3M's research facility, University of Minnesota Human Factors Research Laboratory. Minnesota Department of Transportation (MN/DOT) Traffic Management Center (TMC). and the Guidestar Program.

Within the transportation profession, 3M is probably best known for their sign products. Unknown to me. however. was their involvement with traffic detector systems. Two products that interested me were: (1) the 2020 detector card and (2) the microloop. The 2020 detector card can be used to determine traffic volumes and speeds from one loop. Using this detector card in conjunction with our existing loops at signalized intersections could provide an important ingredient, traffic speeds, needed to better manage our existing arterial street system. Arterial street traffic speeds could be used to identify congestion, to determine which alternate routes would be best suited to accommodate incident diverted traffic. and to identify when signal timing improvements may be nccdcd. Microloops can replace the standard wire loop used for detection. They are roughly four inches (in) in height and are placed about 18 in below the pavement surface. Unlike the standard loop installation that requires a saw cut to place the wire in the pavement, microloops require a vertical shaft to be drilled. Drilling a shaft when compared to cutting the pavement may reduce overall installation time and costs.

The University of Minnesota Human Factors Research Laboratory demonstrated the important role research plays to ensure motorists can interact with the technologies that will one day be available in automobiles and along the roadside. One of many research projects under way is the study of driver performance engaged in secondary tasks which require increased attention. Inferences from the results of this study will be made in relation to the impact future in-vehicle, navigation, and collision avoidance technologies will have on motorists.

MN/DOT's TMC in Minneapolis is using a variety of technologies to improve traffic flow on the freeway system and to inform travelers about freeway traffic conditions. Some examples include: metering freeway to freeway ramps, displaying freeway level-of-service (LOS) information at ramp entrances, partnering with Minneapolis Public Schools (MPS) to operate a radio station, and training TMC operators. MN/DOT has been metering freeway-to-freeway ramp traffic for more than 20 years. Their experience has shown that heavy traffic volumes from unmetered ramps can cause congestion and accidents downstream. Freeway to freeway ramp metering, however, has shown a net reduction in accidents and congestion. On the approach to a number of freeway entrance ramps, signs are placed that display the downstream freeway LOS. A letter "A" indicates the best traffic conditions and a letter "F" indicates the poorest traffic conditions. This signing system is linked to downstream freeway detectors that allows real-time LOS information to be displayed on the signs. This information allows motorists to decide whether they would be best served by taking the freeway or an alternate route. MN/DOT has entered into a unique partnership with the MPS to use MPS's radio station, KBEM, 88.5 FM. This partnership allows live traffic reports to be broadcast throughout the entire metropolitan area every 10 minutes during the morning and evening rush hours, and continuously during major freeway incidents. MPS agreed to this partnership in exchange for funding participation for its broadcast expenses. MPS operates KBEM as part of its communication program at a local high school. The cost to Mn/DOT for this partnership was $242,000 per year. Staff at the TMC recommended having one operator train new TMC operators. The reasoning is to ensure all operators are consistent in their response to similar incidents and the information they provide to the traveling public.

MN/DOT's Minnesota Guidestar is introducing and managing the deployment of advanced transportation technologies across Minnesota. During our visit, they discussed a number of projects. One such project was a "Rural ITS Scoping Study."This study identified the needs and concerns of travelers in rural Minnesota by directly asking the users. Based on the users' needs, ITS projects **were** identified that would improve the quality of life of rural Minnesotans. The lessons learned from this study could assist in future efforts to identify the needs of rural Texans. Although Texas has a number of urbanized areas, the state is predominantly rural.

Travlink is another project managed by Minnesota Guidestar that is testing advanced travel information technologies and their impacts on transit ridership and travel behavior. Real-time transit schedule information will be provided at transit stations and major activity centers. A concern is displaying the word "LATE" for a bus that is behind schedule. If travelers see the word "LATE." they may choose an alternate travel mode to the bus. A number of events, however, may occur that would cause the bus to arrive on time. In the meantime, potential bus riders may have opted for a different travel mode.

ILLINOIS

Our visit to Illinois focused on the ITS efforts within the Chicago metropolitan area. We were fortunate to visit the Illinois Department of Transportation (IDOT) Communication Center and Traffic Systems Center (TSC). to listen to a presentation about the IDOT emergency traffic patrol "Minutemen," and to learn about the project ADVANCE (Advanced Driver and Vehicle Advisory Navigation Concept).

The IDOT Communications Center is charged with coordinating the assignment of emergency and maintenance vehicles throughout the Chicago area and disseminating real-time freeway travel information. Besides providing up-to-the-minute traffic information to the news media, operating changeable message signs (CMSs). and programming messages on their Highway Advisory Network (1610 AM and 530 AM), the Communications Center also operates a telephone answering system. This system provides prerecorded information about freeway construction projects (1-800/352-IDOT). freeway congestion limits (1-708/705-4618). and freeway travel times (1-708/705-4620).

A couple of interesting points about IDOT's TSC are (1) the links between the freeway surveillance system and the traveler information system and (2) their primary means to verify incidents. The TSC currently monitors traffic operations on 136 centerline miles of freeway. Information from the TSC is translated from computer output to speech to automatically update the messages on the telephone answering system. The TSC information is also used to update real-time color-coded maps of the freeway system. The colors vary for different freeway segments depending on the amount of congestion. The primary methods used to verify incidents by the TMC in Minneapolis and the TSC are different. The Minneapolis TMC uses surveillance cameras as their primary source for incident verification. The TSC. on the other hand. primarily relies on the emergency traffic patrol "Minutemen" to verify incidents. At this time, however. TSC staff are planning to use surveillance cameras in the future.

IDOT's emergency traffic patrol "Minutemen" are known around the world for their aggressive attitude towards clearing the freeway of incidents and restoring capacity. The pride the "Minutemen" staff take in their job was obvious during the presentation and demonstration. At this time, freeway service patrols do not operate in Austin. Discussions, however, have occurred about using service patrols to monitor sections of freeways that are undergoing reconstruction. Once the motoring public is exposed to service patrols and realize

Figure 17. Equipment used by the Minuteman Emergency Traffic Patrol.

the benefits, there will a greater chance to build the support needed to establish a permanent service patrol in Austin.

The ADVANCE presentation and demonstration was my first exposure to in-vehicle route guidance. Having the opportunity to ride in an ADVANCE vehicle clearly demonstrated the benefits in-vehicle route guidance could provide to a motorist that is either unfamiliar or familiar with the surface street system. Unfamiliar motorists would benefit from the navigation component and the ability to have their route reprogrammed if an incident occurs on their originally planned route. Familiar drivers would probably not receive as much benefit from the navigation component as the unfamiliar driver. The benefit to the familiar driver, however, would be the travel time savings associated with having their original route reprogrammed to avoid an incident.

MICHIGAN

A variety of organizations were visited in Michigan that were involved in different ITS efforts. The tour stopped at four sites: Ann Arbor Smart Bus Project, Michigan Intelligent Transportation System (MITS) in Detroit, General Motors North American Operations Technical Center (NAO) in Warren, and the FAST-TRAC (Faster and Safer Travel through Traffic Routing and Advanced Controls) Project in Troy.

Ann Arbor Transportation Authority (AATA) presented its project to test the Smart Bus concept and provided some advice and insight to tour participants considering similar projects. Elements of the Smart Bus project include: an on-board system, a central control system. and a “Smart Card” fare collection system. The on-board system (1) monitors route performance, location, speed and mechanical systems, (2) controls the fare collection system, destination sign, and enunciator, and (3) enables buses to communicate with traffic signal preemption devices and the central control system. The central control system monitors the overall performance of the bus fleet and provides real-time transit information (e.g., arrival times) to the public. “Smart Cards” will play a dual role as a farecard to board the bus and as a parking pass. A piece of advice offered by AATA staff was to only monitor functions that are truly important to operating the system. As the number of monitored functions increase so does the potential for false indications that these functions are not operating correctly (that is, a false positive). Each reported malfunction, whether positive or false, needs to be investigated. Therefore, as the frequency of false positives increase. so does the unnecessary time a bus is taken out of service and the amount of staff needed to inspect the alleged malfunction. Insight provided by AATA staff was in regard to bus preemption at signalized intersections. Based on their transit fleet’s history of on-time performance. staff at AATA reported that traffic signals would not need to be preempted 92 percent to 95 percent of the time to keep buses on schedule. Although bus signal preemption systems can increase the people moving capacity of a roadway, its impact on both transit and signal performance needs to be assessed prior to widespread deployment.

MITS is the name for the Michigan Department of Transportation’s (MDOT) approach to making ITS a reality. While visiting MITS headquarters in Detroit. we learned about a number of initiatives under way in the Detroit area and across the state. One MITS effort in Detroit is to expand the existing traffic surveillance system from 32 to 250 miles of freeway. Installing CMSs, highway advisory radio, ramp meters, surveillance cameras, and traffic detectors will part of this expansion. Staff at MITS headquarters indicated that approximately 75 percent of US-Canadian trade occurs through Michigan. To expedite boarder crossings, MDOT in cooperation with the Ontario Ministry of Transportation is investigating automated electronic systems for toll collection, customs clearance of commercial vehicles and commuters. and immigration clearance for pre-screened truck drivers and commuters. “TALLY-HO” is another MITS initiative which is designed to deploy a statewide traveler information system. Travelers would be able to locate traffic congestion, construction and maintenance projects. and severe weather through kiosks located at welcome centers and rest areas across the state.

General Motors Corporation (GMC) currently is developing several on-board systems to improve the safety and efficiency of automobile travel. Options that will be available in future GMC models include: automated cruise control, collision avoidance systems, in-vehicle signing, traveler information, lane tracking and vision enhancement systems. In 1996, automated cruise control is scheduled to be available on GMC’s luxury vehicles.

FAST-TRAC is applying ITS technologies to improve the operation of traffic signal systems and to provide in-vehicle information about arterial street traffic conditions. Three principal technologies are part of the FAST-TRAC project: Autoscope cameras for traffic detection: Sydney Coordinated Adaptive Traffic System (SCATS) for area-wide traffic signal control, and Siemens Automotive Ali-Scout System for dynamic in-vehicle route guidance. First, Autoscope cameras are used to monitor traffic volumes and transmit that information to a SCATS controller at each signalized intersection. Next, SCATS automatically adjusts the signal timing to accommodate the traffic flows. Traffic flow information is also transmitted to a central computer at the traffic operations center. The central computer monitors traffic flows across the network and balances traffic flow when needed. Roadside beacons then communicate with vehicles equipped with Siemens’ Ali-Scout System to provide in-vehicle traffic congestion and alternate route information. Besides providing traffic congestion and alternate route information, the Ali-Scout system is used for trip planning and route guidance. Preliminary benefits have been a 19 percent increase in peak hour travel speeds. FAST-TRAC staff uses the example, that if the average commute to work is 24 minutes, FAST-TRAC could provide a travel time savings of 43 hours per year to the average commuter.

CANADA

Toronto, Canada was the final stop of the week. The Ontario Ministry of Transportation and the Metropolitan Toronto Integrated Traffic Control Centre were the last facilities visited.

The Ontario Ministry of Transportation operates the Highway 401 COMPASS system to improve the mobility of Highway 401 users within Toronto. Elements of the COMPASS system include: CMSs, surveillance cameras, ramp metering, freeway and ramp loop detectors, emergency road patrols, and the Traffic and Road Information System that automatically send traffic information via Fax to the media. Video from the surveillance cameras is also being broadcast to the public by a local television station. An additional source of timely freeway information is a 24-hour hotline which provides lane closure information for freeway maintenance and construction activities. The ramp metering system has increased speeds by 45 percent and reduced travel times by 22 percent. Highway 401 has a unique express/collector configuration with a cross-section not less than 12 lanes. Typically, each section of Highway 401 provides three restricted access express lanes and collector lanes in each direction connected by entrance and exit ramps. Tbe express lanes serve the longer freeway trips while the collector lanes serve the shorter freeway trips. On the busiest days of the year, sections of Highway 401 will exceed 350,000 vehicles per day. CMSs have demonstrated a 7 to 19 percent increase in speeds when used to balance traffic flow between the express and

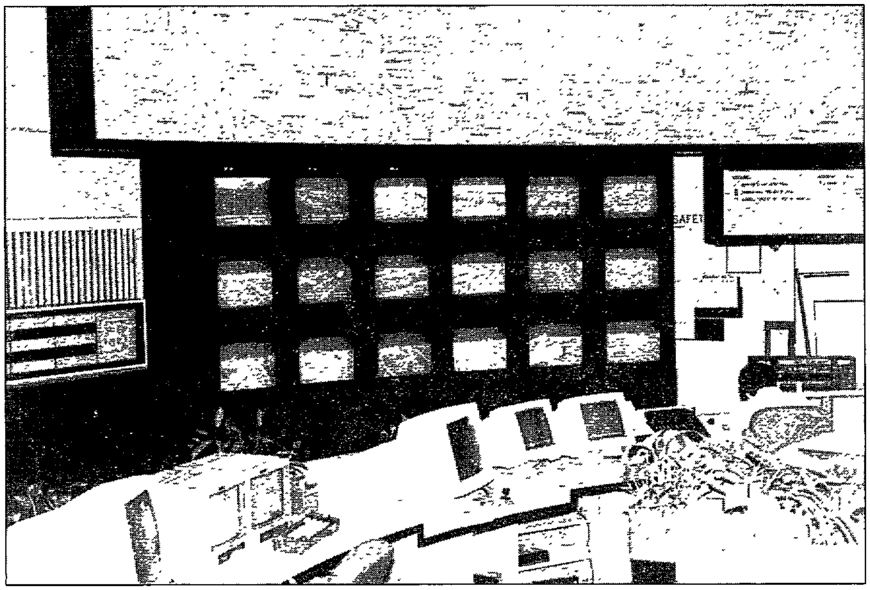

Figure 18. A view of the Ontario Ministry of Transportation's COMPASS control room.

collector lanes. The freeway collector lanes in Toronto are in some ways similar to the frontage roads that run parallel and adjacent to most urban freeways in Texas. Although traffic flow on frontage roads is usually controlled by traffic signals, both freeway collectors and frontage roads provide a parallel alternate route when a incident occurs on the freeway. Furthermore. CMSs and traffic signal control strategies could be used in Texas to make more efficient use of the frontage roads during freeway incidents (similar to how CMSs are used to balance the flow between the express and collector lanes in Toronto).

The Toronto Metropolitan Integrated Traffic Control Centre houses three user groups: (1) the Gardinsr-Lake Shore Corridor Traffic Management System (CTMS) to monitor and manage traffic flow along the Gardiner Expressway and along Lake Shore Boulevard, a parallel signalized arterial: the Traffic Signal Control System which operates approximately 1700 traffic signals: and. the Traffic Situation Room which is the clearinghouse for traffic information throughout metropolitan Toronto. The Gardiner-Lake Shore CTMS provides coordinated traffic management between the Gardiner Expressway and Lahe Shore Boulevard. Once an incident is detected and confirmed on the expressway. CMSs are activated to divert traffic to the parallel arterial street. SCOOT (Split, Cycle. and Offset Optimization Technique) is then used to automatically adjust the signal timing in frequent. small increments to best accommodate the freeway diverted traffic. One day, this same scenario will occur on urban freeway corridors throughout Texas with parallel signalized frontage roads and arterial streets.

CONCLUSION

The ITE ITS North America '94 Study Tour was a success. I believe there were 3 primary reasons for its success. First, the people who organized the tour: Dennis Foderberg and Juan Morales. The technical expertise, logistical effort. and sincere friendliness of these two gentlemen were an integral part of making the tour a valuable and memorable experience. Second, the staff at each facility that hosted our visit. Besides presenting their projects and lessons learned, the hosts were extremely knowledgeable and genuinely enthusiastic about the work they do. The hosts answered all questions. And, if any questions could not be answered, they were willing to follow-up over the phone or in writing. Third, the tour participants. The diverse background of tour participants was another source of information that added to the success of the tour. Tour participants were from across the United States and Europe. The experience of the tour participants with ITS varied from those who were just becoming involved with ITS to those who had several years of experience. If similar tours are available in the future, I would strongly recommend it to anyone involved with planning, designing, or operating any part of an intelligent transportation system.

A Brief Discussion of:

Non-Technical Issues Related to ITS Design and Implementation

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Introduction

This report addresses issues observed on the tour.

Thanks

No paper resulting from the ITE ITS North American tour would be complete without acknowledging the people who made the tour possible. The efforts of Juan Morales of ITE, and Dennis Foderberg of the Minnesota Transportation Research Center made the tour a success. Such a tour cannot succeed without significant planning. evident by our accommodations and the systems which we visited. Once a tour such as this starts, it does not simply "take care of itself." It was due to Dennis' and Juan's efforts that this tour was the success it was.

Thanks are also in order to those representing the systems we visited. As we are all "doing more with less," their enthusiasm and willingness to take time from an already-full schedule were much appreciated. Also, thanks from me to the other participants in the tour. Their insights into what we were observing, as well as information about their day-to-day situations, is of immense value to me in terms of where my agency is and where it should be heading.

And, thanks is in order to my management and our Board of Commissioners. in allowing me the opportunity to take this tour. It is certainly my intent that the financial investment made by Cobb County in this tour should be returned many times over as we head down the path towards implementation of our own ITS element.

Why this topic?

Why this topic? We spent a week on this tour looking at very impressive examples of high technology implemented to manage traffic. Many papers could be written to address different aspects of technologies observed and their effectiveness. However, it is becoming more apparent to me that there are non-technical issues, such as these discussed, that may preclude or have influence over the technology implemented.

At the first meeting of the tour group, we were asked what interested us most about these places we were to visit-or, perhaps. what we most hoped to get out of the tour. My response concerned the non-technical issues; policies, politics, relationships between agencies, etc. I was concerned that I might be perceived a skeptic: however other tour participants echoed this response. I regarded this as a confirmation that non-technical issues may be more significant than technical ones. These issues appear to fall into several categories: policy/political, societal acceptance, fiscal, those I call "just 'cause that's how we want to do it," and issues of trust between agencies.

Policy or Political Issues: What are CCTV cameras for?

A nearly-standard part of new ATMS installations is closed-circuit television (CCTV). Whether used for incident detection, or vehicular detection through a machine-vision technology, CCTV can do a remarkable job of adding "eyes" to an ATMS. A good example of this is Minnesota DOT's system in the Minneapolis/St. Paul area. Their widespread installation of CCTV cameras, a mix of fixed-mount and pan, tilt, and zoom cameras, have given them an incident detection/confirmation/response capability perhaps second to none nationally.

Minnesota' s CCTV cameras aren' t for Law Enforcement

Minnesota's Traffic Management Center is staffed exclusively by MnDOT employees, with the exception of the peak-hour radio announcer. No law enforcement personnel have, until recently. had regular access to any MnDOT CCTV images. This has changed, though, due to the provision of a CCTV feed to the Minnesota State Police office. With this has emerged a problem: the police have, on several occasions, used these cameras to observe suspicious activities at locations adjacent to the freeway. This concerns MnDOT staff. as the concept of their CCTV surveillance being used for Law Enforcement purposes is new to them, and apparently goes against what MnDOT has espoused as the purpose for CCTV surveillance.

But, Richardson, TX, encourages police to look

While in previous employment, I worked with the city of Richardson, Texas, part of the Dallas metropolitan area. Due to its franchising arrangement with the City's cable TV provider, they had access to cable TV as a means of communicating with traffic signals and with CCTV cameras. The City installed CCTV cameras at several locations to allow them video surveillance of congested intersections. After installation, the City Police Department observed the CCTV monitors at their traffic control center. Subsequently, the Police Department uses the cameras as surveillance needs dictate. to the extent that the Police Department stations personnel at the City's traffic control center to accomplish this.

Societal Acceptance Issues

Cameras peering into cars

One comment which I've heard previously, and heard during the tour, concerned the "invasion of privacy" issue involving CCTV cameras. The concern is that cameras can "peer into" vehicles-beyond the reasonable limits of freeway surveillance for incident management. My observation of CCTV operations in Minneapolis and Toronto indicates that this concern, while well-founded, may not be realistic. Despite very capably-equipped CCTV cameras, equipped with pan/tilt and a large-range zoom lens. operators may simply not be able to zoom and focus tightly enough to discern anything significant inside a vehicle.

However, it is not necessary for my or other professional observations be taken as "gospel." The wide availability of camcorders with zoom lenses similar in capability to field CCTV cameras allows agencies contemplating CCTV surveillance to perform trial videotaping, at various heights (using existing buildings), and with various zoom settings. The resulting tape can be reviewed by agency officials to determine if there may be issues involving inappropriate CCTV surveillance.

ADVANCE relationship between information and the user

The ADVANCE program, nearing deployment in Chicago, is certainly exciting in terms of what information "we", the transportation profession, will learn from it. This is similar to the TravTek program conducted in Orlando, certainly, but will involve a regular group of people versus the primarily random group of people from which TravTek. The concept of a regular group of individuals makes for a good situation. in that we can get information about a regular user's use of ADVANCE over a significant duration of time. However, the information we can get is potentially intimate that ADVANCE can know where and when somebody is starting and ending a trip. Tying that to a person's name can easily be construed as an invasion of privacy. Consequently the ADVANCE designers has had to ensure that there will be no name relationship involving the data collected.

I was fortunate enough to rent a TravTek car in 1993. However, it was difficult for me to get beyond the extensive amount of computerization/communications in that vehicle to simply use the tool provided. The ADVANCE program appears to be a much more realistic implementation of technology. The ADVANCE program involves the user in updating the software and database through replacement of a CD-ROM disk. In a full-scale implementation, it is possible that different vendors could provide different versions of software-for different cities, or different types of destinations within a city. In designing ADVANCE in this fashion, consequently, a third-party private-sector industry could be created.

When I completed the survey following the car rental, several questions concerned what cost I would be willing to pay for the TravTek equipment. I arrived at a cost of approximately $1,000; not a large cost increment on a $20,000 cost, and reasonable for the potential value. Apparently, other surveys indicated a similar cost threshold. Consequently General Motors is working with that impact on a car's cost in mind. A new navigational product, not as full-featured as TravTek or ADVANCE, is under development. being designed to cost no more than an additional $1,000 per vehicle.

Ramp metering

During the course of the tour, we visited several freeway management systems that used ramp metering. A question asked concerned the use of 2- or 3-section signal heads for the ramp meter signals. Minnesota used 3-section heads; Toronto used 2-section. MnDOT acknowledged that the yellow interval displayed is very short, but justified their continued use because, when the meters are not functioning, the signal flashes yellow. Toronto displays nothing when metering is not occurring. I advocated a 2-section head for the Phoenix FMS due to 1) the short yellow interval which would occur during metering and 2) to draw attention to the ramp meter, recognizing its difference from a conventional traffic signal; the flashing yellow, is certainly a worthwhile use of the indication.

Fiscal Issues

Chicago's accomplishments

When visiting Chicago's Traffic System Center, especially after touring MnDOT's Traffic Management Center, the absence of CCTV surveillance and accompanying monitors was very conspicuous. It appeared that Chicago's freeway management capabilities were very restricted due to no CCTV surveillance. Chicago's system, though, is nationally known-especially for its Minutemen and their accomplishments. It appeared that the lack of agency-owned communications infrastructure was a significant factor to their lack of CCTV surveillance. However, the lack of agency-owned communications infrastructure may be attributable to limited capital investment, since the cost of communications infrastructure overwhelms the cost of central equipment and field control hardware. Fortunately, the reconstruction of the Kennedy Freeway includes fiber-optic communications cables, which will allow CCTV surveillance of this heavily-congested freeway.

Consequently. Chicago's program and its success appears all the more significant, given the absence of capital investment. If, somehow, capital investment could be compared to benefit received. Chicago's system would likely have a very large benefit/capital investment ratio. It will be interesting to see how the Chicago system adapts to a corridor which does have CCTV surveillance.

Oakland County' s accomplishments

By way of comparison to Chicago, Oakland County has an attractive situation, financially. Oakland County's FAST-TRAC system implementation is funded by FHWA demonstration funding. As part of this installation, Oakland County is accomplishing several innovative technologies, including implementation of the Autoscope "machine vision" vehicle detection system at many intersections. Additionally, as part of the SCATS system, Oakland County installed the actual traffic controllers used in Australia with the SCATS package. Implementation of this system is a wonderful opportunity to get a good feel for the appropriateness of the SCATS package in a suburban United States setting.

Additionally, implementation of this system blazes new ground in using the SCATS controllers in an American system. simplifying the implementation of further SCATS systems. This system should also result in 1ower Autoscope costs, due to its rather large purchase of Autoscope equipment. Consequently, more Autoscope installations nationwide may occur, resulting in its increased exposure.

"Just 'Cause That's How We Want to Do It"

Minnesota many C monitors

Minnesota DOT's Traffic Management Center in Minneapolis is very impressive. The control room looks very thoughtfully laid-out-possibly due to their extensive experience in its operation. The more you live with something, the more you know how you want it to be. It could be said, though. that they have too many CCTV monitors-and that some of them are too small to be useful. This plethora of small monitors may, however, predate more recent studies which evaluate appropriate sizes and numbers of CCTV monitors for different system situations.

MnDOT uses the TMC as part of their public relations/ information program. Given that, the large number of monitors certainly creates an impressive view for a visitor. Additionally, these smaller monitors are connected directly to their associated camera, which can facilitate troubleshooting.

Oakland County trànsition to protected-only left turn phasing

While visiting Oakland County's traffic control center, several of the tour participants (including myself) erroneously concluded that installation of the SCATS signal system forced the county to convert all locations with protected-permissive left-turn phasing to protected-only left-turn phasing. Ultimately, through clarification provided by the SCATS vendor, it was realized that SCATS can operate with protected-permissive left-turn phasing. The county had used the installation of SCATS as an opportunity to make this phasing change. Perhaps this gave the county an opportunity to implement something unpopular (protected-only left-turn phasing) while making a change to the signal system which should have a positive impact. From a "purely" engineering perspective. protected-only left-turn phasing has its advantages: accident rates typically go down after its implementation, and it also gives flexibility in signal phase sequencing.

Chicago 's Separate CommCenter and Traffic Systems Centers

One apparent advantage of the MnDOT TMC was the fact that everything was in a single room: operations and dispatch. From the perspective of an observer, this certainly looked like a good approach. When we arrived at IDOT's CommCenter, it took me a while to realize that this was only the dispatch aspect of what we had seen in Minneapolis. The fact that freeway operations were being managed from a different site some twelve miles away was hard to comprehend. My "knee-jerk" response to this situation was that overall operations would benefit from being housed at the same site. However, the scope of the dispatching operation, especially when compared with what we observed at the other centers visited, puts the concept of combining operations in a very different light. Given the size of both the dispatch and operations rooms, even if located at the same site, they would continue to be housed in separate rooms. While same-site locations of the rooms could foster some coordination of activities, and could result in elimination of some external phone lines, the benefits attributable to such a combination of facilities would have to be carefully evaluated in light of the scope of both operations especially when compared with the capital cost of such a combination.

Chicago 's Minutemen vs. What We Observed in Toronto

While at Chicago's Traffic System Center, we were shown two examples of IDOT's emergency response vehicles: a typical EPV, and "Sweet P," a 50-ton rotator crane. Frankly, both vehicles appeared somewhat extreme to me-overkill, despite the fact that Chicago's Minutemen are known virtually nationwide-and are well received in Chicago. Nonetheless, I maintained my cynical attitude. Later on the trip, while at Toronto's traffic management center, we observed CCTV coverage of a vehicle stalled on the Gardner expressway. The Gardner expressway has very narrow shoulders, and this vehicle was unable to fully clear the right lane. It seemed like an eternity before a service vehicle arrived at the disabled vehicle. Then, for reasons unknown to us, the service vehicle left, with the disabled vehicle remaining. I'm not sure how many "near misses" we observed. I don't know the ultimate outcome of the disabled vehicle, but I certainly wished Minutemen had been present to get the vehicle out of the way. Whether with Minutemen or a privately-sponsored response force, some patrol or assistance means appears to be a necessary part of freeway management.

Issues of Trust

While visiting facility. their staff described a recent major incident which required their detouring traffic off the impacted freeway. The conversation ran to the issue of how they informed the local agencies on the detour route, and their response. MnDOT staff indicated that they simply called the impacted agencies, and received a favorable response from all agencies except one, who apparently "threw up his hands," as he didn't know how to respond.

This scenario they laid out raised, to me, issues of trust.

The impacted local agencies, when contacted by MnDOT, likely knew of the magnitude of the incident and its impact on their streets. This knowledge could have been confirmed or otherwise substantiated due to the trust which apparently exists between MnDOT and the local agencies. Since MnDOT has been actively managing for more than twenty years. they are well able to estimate the impact of an incident and to either respond appropriately or advise others of an appropriate response. This trust, built on experience, is essential to developing the interjurisdictional cooperation necessary as traffic management leaves the freeways and reaches the surface streets.

Conclusion

My purpose in this paper is to indicate to those reading that the non-technical issues may loom larger than most any technical issue anticipated during the design of an ITS installation. Additionally, it would appear foolish to presume that the non-technical issues could be resolved during a single meeting. In many of the systems we observed, it appeared that many of the non-technical decisions that we asked about were either dictated by a limitation, or not explicitly made. but simply arrived at over time. Given the age of the Minneapolis, Chicago, and Detroit systems, the starting size and when they started their system implementation, the questions regarded as critical today were simply not considered.

Additionally, the age of these systems allows trust to be built up between the agency operating the system and the adjacent local agencies. There appears to be little substitute for time in the establishing of this trust, which appears to be a necessary building block for the extension of these systems from the freeways to surface streets.

Traffic Management Systems in North America

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ITE's ITS North America Tour '94 included seminars and visits to highway traffic management/operations centers in four major urbanized cities; Minneapolis. Chicago, Detroit and Toronto. Several of these systems have been in operation for many years, one relatively new but all with an on-going commitment to reducing congestion, improving travel and providing the latest travel information to the transportation user.

Observations/Trends of Traffic Management Systems

ITS incorporates a wide range of user services and deals with a lot of new and emerging technology which may be intimidating to some. However, the traffic management systems in Minneapolis, Chicago and Detroit have been in existence for an average of nearly 2.5 years.

As operating costs continue to rise, agencies are looking to new approaches to staff their operations and control centers. The use of cooperative (co-op) students from local area universities is a relatively inexpensive way to increase and supplement existing staff as well as provide a training ground for future transportation professionals. Some agencies prefer to hire college sophomores since they know that these students will be available for at least three years. Other agencies, such as Metro Transportation in Toronto have privatized and contracted out the staffing and operation of the control center; while others such as the TMC at Mn/DOT have staff from a commercial radio station assigned to the center.

Most operating agencies have realized significant user benefits and plan to expand and/or upgrade their traffic management system. This requires a vision, plan and commitment.

Loop detectors remain the backbone for sensor technology. However, many agencies including Mn/DOT and MDOT are testing machine vision sensor technology.

As more and more traffic management systems become operational, there is a clear need to integrate the management systems and/or operations centers to provide the maximum benefit to the transportation user. In Michigan, Detroit is planning to establish an electronic linkage with nearby Oakland County's operations center in Troy; while Metro Transportation in Toronto will eventually share live video and emergency response plans with Ontario.

Many methods are employed to get traffic and travel information to the user so that the user can make informed mode and route choices. These methods include direct hook-ups or terminals to the central computer, autofax messages, use of the educational television network as well as the traditional HAR, CMS, cellular telephones and cable television.

Mn/DOT's Traffic Management Center

The Minnesota Department of Transportation's Traffic Management Center (TMC) manages the freeway system in the greater Minneapolis-Saint Paul area. The TMC opened in 1972 and covers 200 of the 330 total highway miles. The TMC is in operation Monday through Friday from 6 a.m. to 6:30 p.m. or later, if there are special events. The center includes 142 CCTVs generally spaced one mile apart, loop detectors placed every one half mile in each lane. 353 ramps meters, 45 changeable message signs, 6 highway helper vehicles, and a total staff of 65. The cost of implementing the traffic management system is roughly estimated at $4 million to $7 million for 12 to 15 miles of highway with detectors, CCTV, fiber optic communications and CMS.

The CCTV's (all but six) are capable of rotating 355 degrees and are connected to the TMC via fiber optic cable, microwave and coaxial cable. Fifteen addition cameras are planned to be installed this year and a total of 180 cameras by 1995. In addition, the coaxial cable will be upgraded to fiber optic technology in the next five years.

Each ramp meter location includes loops on the main line of the highway that enables each ramp meter to operate automatically locally. 322 of the ramp meters are capable of being centrally controlled at the TMC and can be manually overridden based upon known traffic conditions. The goal is to add 40 more ramp metering sites this year and to ultimately have a system of 490 locations. Ramp metering is a major focus of the traffic management strategy.

The changeable message signs are drum type signs with three lines for displays. Each line has a six sided drum that enables the TMC to display a variety of messages. Mn/DOT plans to add 10 CMSs by the end of 1995. While Mn/DOT has found this sign technology to be very dependable, they recognize the need for greater message flexibility and is currently analyzing newer technology.

The highway helper program began in 1987 to provide free assistance to motorists and aid the State Police with incident management. The 6 highway helper pick-up trucks patrol 6 routes on 70 miles of the most congested highways from 5:30 a.m. to 8:30 p.m.. Monday through Friday. Last year, the program provided over 16,000 assists. It is estimated that the annual benefit of the program is $250,000 per route; while the cost is approximately only $92,000 per route per year. This fall. Mn/DOT plans to equip the highway helper vehicles with AVL to improve dispatching.

Traffic advisories are issued by the TMC. Through an arrangement with the Minnesota Public Television Network (KBEM), Mn/DOT provides live traffic reports during weekday peak periods over the network. Mn/DOT pays KBEM $305,000 to support this activity. The TMC also provides images and maps to cable television and hopes to add construction and road closure information in the future.

The TMC has a total staff of 65 people. This includes 15 co-op students from the local universities who are paid $8 to $9 an hour to assist in the center. 15 highway helpers, 15 TMC operators, 6 to 8 maintenance personnel and other supervisory and support staff. The TMC is generally staffed with 5 operators during peak periods and 1 or 2 staff off-peak. The center has an annual operating and maintenance budget of $3 million.

The TMC is located at 1101 Fourth Ave. South, Minneapolis, MN 55432 and can be reached at 612/341-7500. Glen Carlson is the manager of the center.

Illinois DOT Traffic Systems and Communications Centers

IDOT's real-time freeway traffic management system in Chicago has been operating "smart" highways for 32 years. The IDOT Traffic Systems Center (TSC) operates 136 centerline miles of instrumented freeways with over 2,000 loop detectors, 109 centrally controlled ramp meters. 18 CMS. 11 HAR and an emergency traffic patrol. The system does not include the tollways in and around Chicago.

Data from the loop detector system is brought back the TSC via leased telephone lines. Loops are installed in the center lane at one half mile intervals and are used to determine real-time expressways condition information. Another source of incident detection is the *999 Cellular Express Line that receives more than 18,000 incoming call a month. More than 95% of these calls are "Good Samaritan" calls reporting incidents. breakdowns, congestion and possible roadway hazards such as debris in the roadway.

The CMS were added to the management system in 1988. To date, there are a total of 18 signs; 9 disk matrix, 2 fiber-disk retrofits and 7 fiber-disk matrix installations. The CMS are remotely controlled from the TSC via leased telephone lines. Loop data is used to determine congestion and is tied into the CMS system to provide traffic conditions to motorists automatically. Incident information is not automatically displayed on the signs. The CMS are used to display incident information, construction related information and during quieter times the signs are blank or display site specific messages such as lane drop ahead or reduced speed zone. IDOT's policy is to use the CMS only for messages of a traffic related nature.

IDOT's Emergency Traffic Patrol or "Minutemen" provide surveillance and response to incidents on 79 centerline miles of expressway in Chicago. The Minutemen service operates 24 hours a day, 7 days a week. Minutemen provide over 110,000 assists each year with 58 Minutemen and support staff with a budget of approximately $4 million. The type of assists include disabled vehicles, abandoned vehicles, accidents, debris and pedestrians in roadway, and fires. The patrol fleet includes 35 emergency patrol vehicles that are capable of relocating a loaded tractor trailer, 9 4x4 vehicles, 3 heavy duty tow trucks and 1 crash crane.

The 11 highway advisory radio stations operate in a real time mode. Messages are updated by digitized voice based upon traffic information collected through roadway sensors. Expressway congestion is broadcast on 1610 AM and estimated travel times on 530 AM. Trafftc information is also provided to the public through a comprehensive network of radio and television stations, a telephone hotline, a commercial * 123 cellular telephone service and direct hook-ups to the TSC central computer. Rail transit and suburban bus information is also provided.

The TSC operates 14 hours a day, 5 days a week. Half of the staff are co-op students. The TSC has an annual budget of $1.2M for operations and maintenance. The TSC is located at 445 Harrison St., Oak Park. IL 60304- 1499; Anthony Cioffi is the Operation Section Chief for IDOT.

When the TSC is not in operation, the duties are shifted to IDOT's District 1 Communications Center in Schaumberg, IL. The Communication Center operates 24 hours a day, 7 days a week with the primary responsibility as the operations hub for the district. In addition, the center provides up-to-the-minute information regarding accidents and congestion to the networks and radio and television. The assignment of emergency and maintenance vehicles and specialized crews is coordinated through the center. The center is staffed by 10 full time and 10 part time staff with 5 supervisors. Typically, 2 to 6 communications specialists are on duty during the week from 6 a.m. to 7 p.m. and one specialist on the midnight shift. The Communications Center is located at District 1 Headquarters, 201 West Center Court, Schaumburg, IL 60196-1096. Joseph McDermott is the Traffic Bureau Chief.

Michigan DOT's Intelligent Transportation Systems (MITS) Center

The current freeway traffic management system in Detroit has been in operation for over 20 years. The system covers 32 miles in metropolitan Detroit and future plans call for the expansion of the system in stages to 250 miles over five years. A request for bid to expand the system has been issued and selection of a system integrator is in progress at this time. This phase will add 60 freeway miles in Detroit and nearby Oakland County to the system.

The system has 1,240 inductive loops that are used to incident detection based on lane occupancy. Typically, when the system detects an incident, the exact nature of the incident is verified through the 10 CCTVs or the State Police who may be dispatched to the scene. Once verified, the MITS Center staff manually selects an appropriate message to display on any of the existing 14 CMS. The system is then updated through a terminal and a red X is placed on a map. This information is then available to other terminals on the system. More

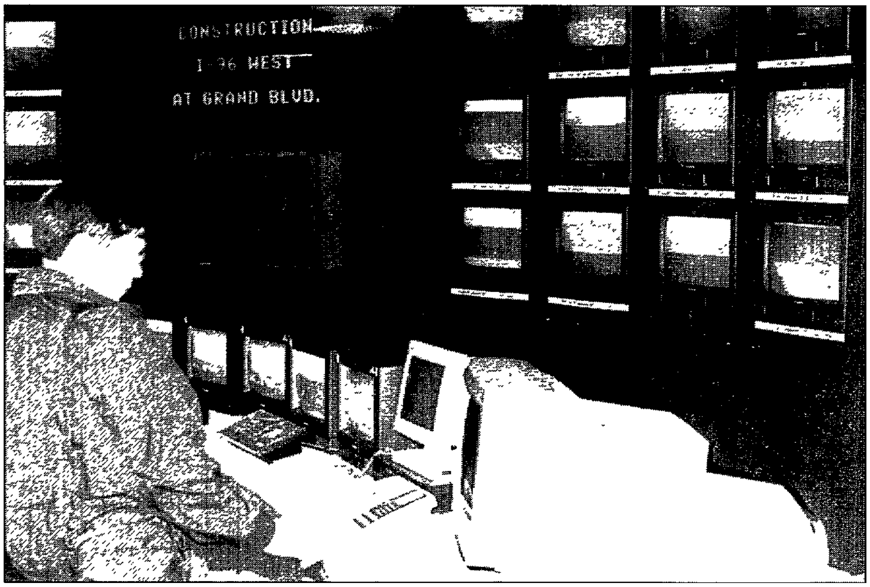

Figure 19. Tour participant Lee Home examines the Michigan ITS Center control room.

specific information on the incident is available to terminals users by calling the MITS Center. MDOT also has under way, a federally funded project to provide the real-time traffic conditions information to dispatch centers of public transit agencies in the Detroit area.

A staff of 2 people assigned to the traffic management system operation. are at the center between 6 a.m. and 7 p.m.. five days a week. The center is located at 1050 Sixth St.. Detroit, MI 48226.

Ontario's Ministry of Transportation Traffic Management Systems

In response to increasing pressures on their urban transportation network. the Ontario Ministry of Transportation has installed an advanced traffic management system, called Compass on Highway 401 through Toronto. Highway 401 was initially designed as a by-pass route through the northem part of the City of Toronto. However, much like our interstate ring roads, as the urbanized areas expanded Highway 401 was used for more localized traffic and is congested throughout much of the day. Highway 401 is already 12 travel lanes wide with a main and collector roadways. In some sections , the roadway is 17 lanes wide. The 40 kilometer system includes 230 detector stations or approximately 1000 induction loops. 19 CCTV spaced one kilometer apart and 13 VMS.

When an incident is detected, the system alerts the operator and tells the operator the nearest CCTV that is available to confirm the incident. The VMS are automatically updated by the system to display the appropriate congestion message such as Congestion Ahead / Usc Service Road. These VMS cost approximately $300.000 Canadian and are capable of displaying graphic symbols at each end of the sign. The system has improved speeds by 7% to 19%. Specific incident information is displayed through operator intervention.

The system is staffed by 20 people in 3 shifts. 24 hours a day, 7 days a week. The central computer system (i.e.. hardware and software) cost approximately $2 million. Annual operating and maintenance cost are 5.5% of total capital costs. The Compass Operations Center is located at 1201 Wilson Ave.. Downsview Ontario M3M 1j8 For more information. contact the Head of Traffic Operation\ for the Ministry District 6 at 416/ 235-777 1.

The Ministry of Transportation's first freeway traffic management system was installed on the Queen Elizabeth Way in Mississauga (just west of Toronto in 1975. this system uses roadw ay detector. CCTV for monitoring and verification, ramp metering. emergency vehicle dispatch and CMS. The system has provided impressive benefits. Improvements include a 22% reduction in collisions. a 45% increase in average speed and a 21% reduction in overall delay.

Other highways in metropolitan Toronto are under the jurisdiction of Metro Transportation, Municipality of Metro Toronto. Metro has installed a traffic management system with Compass software on the Gardiner Expressway. The system includes loop detectors, CCTV. VMS and an automated fax capability to provide traffic information to others.

The operation is staffed around the clock by 2 people. The staffing is provided by contract to an outside, private vendor. Metro is located at 703 Don Mills Road, Fifth Floor, North York, ON M3C 3N3.

Traffic Management Systems in North America

ITE's ITS North America Tour '94 included seminars and visits to highway traffic management/operations centers in four major urbanized cities; Minneapolis, Chicago, Detroit and Toronto. Several of these systems have been in operation for many years. one relatively new but all with an on-going commitment to reducing congestion, improving travel and providing the latest travel information to the transportation user.

Observations/Trends of Traffic Management Systems

ITS incorporates a wide range of user services and deals with a lot of new and emerging technology which may be intimidating to some. However. the traffic management systems in Minneapolis, Chicago and Detroit have been in existence for an average of nearly 25 years.

As operating costs continue to rise, agencies are looking to new approaches to staff their operations and control centers. The use of cooperative (co-op) students from local area universities is a relatively inexpensive way to increase and supplement existing staff as well as provide a training ground for future transportation professionals. Some agencies prefer to hire college sophomores since they know that these students will be available for at least three years. Other agencies, such as Metro Transportation in Toronto have privatized and contracted out the staffing and operation of the control center; while others such as the TMC at Mn/DOT have staff from a commercial radio station assigned to the center.

Most operating agencies have realized significant user benefits and plan to expand and/or upgrade their traffic management system. This requires a vision, plan and commitment.

Loop detectors remain the backbone for sensor technology. However, many agencies includin Mn/DgT and MDOT are testing machine vision sensor technology.

As more and more traffic management systems become operational, there is a clear need to integrate the management systems and/or operations centers to provide the maximum benefit to the transportation user. In Michigan, Detroit is planning to establish an electronic linkage with nearby Oakland County's operations center in Troy; while Metro Transportation in Toronto will eventually share live video and emergency response plans with Ontario.

Many methods are employed to get traffic and travel information to the user so that the user can make informed mode and route choices. These methods include direct hook-ups or terminals to the central computer autofa messages, use of the educational television network as well as the traditional HAR, CMS, cellular telephones and cable television.

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This paper was a brief overview of the traffic management systems in the cities we visited on the tour. My thanks to FHWA for providing the scholarship that enabled me to participate in the tour and gain invaluable insight into ITS activities, to ITE and Juan Morales for coordinating the tour and Dennis Foderberg for leading the group and keeping us on time.

ITSNorthAmerica'94 Study Tour
A Colorado Perspective

By Pamela A. Hutton
Statewide ITS Operations Engineer
Colorado Department of Transportation

Introduction

The ITS North American '94 Seminar Tour included site visits to ITS facilities in the Chicago, Detroit, Minneapolis and Toronto areas, as well as numerous presentations on ITS topics of interest to tour participants. Participants included employees of from public and private agencies representing nine states and the European countries of France, Germany, th eUnited Kmgdom, Ireland, England, and Belgium.

The objective of the seminar tour was to provide transportation professionals with an interest in ITS with first-hand knowledge of ITS systems in North America. Advanced Traffic Management Systems, Advanced Traveler Information Systems, Advanced Public Transportation Systems, Advanced Vehicle Control Systems and Commercial Vehicle Operations were covered. Presentations, dialogue with experts, videos and discussions with others participating in the tour provided attendees with an understanding of research, planning, operations, institutional and funding issues.

The Institute of Transportation Engineers offered a limited number of scholarships to participate in the tour to employees of public agencies in the United States with operational responsibilities for traffic management and control systems. These scholarships were made available by a grant from the U.S. Federal Highway Administration. Those awarded scholarships were asked to make one or more presentations during the tour and to prepare a written report upon completion of the tour describing what was learned. The following report was prepared to satisfy this commitment and completes the agreed to obligation as a scholarship recipient.

University of Minnesota Human Factors Research Laboratories

Observations

Dr. Peter Hancock, Laboratory Director and founder of the Human Factors Research Laboratories (HFRL), welcomed and introduced to the tour attendees his staff of researchers, outlining the three areas of presentation. In the expert hands of this research team tour attendees were givenpresentations in the general areas of motor vehicle simulation, aircraft simulation, and virtual reality.

Ongoing projects in the area of motor vehicle simulation include: Cataracts, Front-to-Rear-End-Collision Warning System. Genesis, Interaction of Non-Driving Tasks With Driving, and Traffic Advisories. Cataracts is a project studying the abilities of drivers, especially older drivers, with visual impairments such as cataracts. HFRL will measure the driving performance of visually impaired drivers and interpret the results in the framework of licensing renewal requirements. Front-to-Rear-End-Collision Warning System is an investigation of the use of auditory and visual warning in eliciting emergency braking responses, as well as measuring the performance differences between young and older drivers. Measurements of reaction time, movement time from the accelerator to the brake pedal, and total response time were taken. The results of this investigation are presently being analyzed. Genesis is a study of human factors evaluation and simulation of two way traffic communication of traffic information. Pagers, laptop computers, and personal/digital assistants will be used to send requests for and receive current traffic information. Interaction of Non-Driving Tasks with Driving (Multitask) is a study of driver performance when engaged in secondary tasks which increase attention and cognitive workload. Results will interpreted in the framework of future in-vehicle, navigation, and collision avoidance technology. Traffic Advisories is a project examining the effect of traffic message structure on driver behavior. It was determined that messages containing qualitative or imperative information increased the likelihood that drivers would act to reduced congestion. Additionally, this study concluded that a history of accurate traffic messages had the same influence on driver behavior.

Topics under study by HFRL in the area of aircraft simulation include: FAA, Navy: Adaptive Automation, and Trilogy. FAA is a three-year research project examining reason making in the cockpit as it relates to the spacing, routing and maneuvering of aircraft in the en-route environment. A specific objective is the specification of safe and effective strategies for allocating control devices between flight decks and air traffic control. Navy: Adaptive Automation is a series of eight studies (over two years) which examined how automated control can be shared between the operator and the system. Specific studies examined interface configuration and automation procedures. Trilogy is an evaluation of the Radio Broadcast System and traffic message channel receivers on human factors and safety issues.

The HFRL is also involved in the following virtual reality projects: Lighted Guidance, and Virtual Reality. The Lighted Guidance project is studying examining the uses of lights on either side of the road in a construction work zone, in order to reduce the speed of traffic. Presently being examined are the effects of lights whose appearance seems to be moving towards the driver, away from the driver. and stationary. The results of this study are currently being analyzed. Virtual Realit - y is a study that investigates the issues of perception/ detection of obstacles in the 3-D environment of virtual reality.

A Colorado Perspective

While human factors research is of most interest to those private agencies whichconcern themselves with design of transportation vehicles, there are projects of notable interest to the Colorado Department of Transportation. For example the Traffic Advisories study which examines the effect of traffic message structure on driver behavior could be a valuable resource for the Department in writing script for the dissemination of congestion traffic data.

As I understand the results of this study, the quantitative or imperative nature of the message structure significantly increases or decreases the likelihood that motorists will react to the warning. Public Information Officer scripts and Variable Message Sign menus should be carefully designed with the results of this study considered. Further, it should be noted that this study documents the importance of establishing a history of accuracy in the dissemination of information. Nothing will limit the effectiveness of warnings issue more than a public perception of inaccuracy.

Minnesota Department of Transportation ' s Traffic Management Center

Observations

The Minnesota Department of Transportation' s Traffic Management Center (TMC) is the communications and computer center for managing traffic on Twin Cities Metropolitan Area freeways. The TMC is equipped with video and radio monitoring and broadcasting equipment, traffic management work stations, and staffed by 37 personnel.

The control room includes two independent operator stations, a radio announcer station. an information officer work station,computer graphics terminals, and a large screen for map displays. Each operator station has 2 17-inch monitors 4 and computer terminals with graphics capabilities to view system-wide status, control on-line ramp meters and changeable message signs. A large computer generated map displays real time traffic conditions on the Metro Area freeway system.

The TMC 's instrumentation includes:

- 354 ramp meters: 322 are centrally controlled by the TMC,
- 142 CCTV cameras,
- 46 changeable message signs.
- 34 HOV ramp meter bypasses, and
- 1 miles of HOV express lanes for carpoolers and buses

Live traffic reports for the entire Metro Area are broadcast from the TMC over Public Radio Station KBEM. 885 FM. Reports of two to three minutes occur every ten minutes on weekdays during peak traffic periods. During a major incident, motorist information is broadcast continuously. Drivers are alerted to tune to KBEM by flashing roadside signs. Twenty-seven strategically located Traffic Radio signs or any on of the CMS's may be activated to alert drivers to tune to 88.5.

A cable TV traffic channel includes a real-time graphics map showing traffic flow condition on all currently instrumented freeways; videotext providing lane control information and other public service announcements; and live video from on-line CCTV cameras. The audio feed is provided by KBEM radio. During peak periods it includes the traffic radio broadcasts.

A Colorado Perspective

Certainly the strengths of this TMC are theincredible roadway instrumentation and the motorist information program.

Colorado, in planning for the new Traffic Information Center (TIC) could learn from both of these Minnesota strengths. To be truly effective Colorado' s TIC must have an extensiv base of accurate traffic data, both from the vehicle detection and video conformation perspectives. The only way to do this is to invest in the infrastructure that will supply the required data. It is this data that will become the base for all that the TIC will accomplish.

Secondly. Colorado' s TIC must have a means to disseminate the data that is collected Mn/DOT's unique concept of broadcasting traffic information directly from the TMC ensures that the information that is disseminated is accurate and timely. The broadcaster literally becomes a vital tool in managing motorist reaction to traffic conditions via this communication medium. Additionally, the broad spectrum of media ensures that a maximum number of motorists are exposed to the disseminated information.

Minnesota Department of Transportation Guidestar (ITS) Program

Observations

The Minnesota Guidestar Program is a program dedicated to developing and providing Minnesota' s statewide intelligent transportation system (ITS). The Minnesota Guidestar Program is comprised of four components: research, demonstration. deployment, and coordination. These activities occurs simultaneously under the Minnesota Guidestar Program "umbrella ". Each Program, purportedly, both stands alone and supports the other Program components.

The Minnesota Guidestar Program mission is to transform the current transportation system into one with increased accessibility. greater productivity, enhanced safety, reduced environmental impacts and broader private sector investments.

The Minnesota Guidestar Program also defines a vision for the transportation system 10 years in the future: goals, objective, and action to work toward their vision; and recognizes need for and importance of a business plan. The Guidestar Strategic Plan outlines all these objectives.

A Colorado Perspective

The similarities of Minnesota' s Guidestar Program and Colorado 's C-Star Strategic Plan are striking andsuspect not accidental. From the concept of an umbrella type approach to the mission, from the goals and objectives to the understanding of a need to develop a business plan, the outline of the programs are practically identical **In** essence both States would like to plan for and provide their citizens with a transportation system that is more accessible. more productive, safer, is environmentally friendly and invites private sector investments for the good of all.

As striking as the similarities are, the differences are equally striking. Minnesota has been extremely successful in securing sustained funding and public acceptance. There must be a reason for this, and I believe the reason comes from a variety of aspects. First the Minnesota Program has wide political and public agency support. Second, in public this organization appears unified and focused, although having some inside knowledge about this program I know that the organization went through many of the growing pains now being experienced by CDOT. Third, Minnesota has been willing to take some calculated risks in introducing this Program, committing state resources to leverage their advantage. Finally, Minnesota bars no expense in public relations and education, the quality of all printed and presented material is testimony to this aspect. It is this professionalism that breeds confidence in the program, and I believe is the key to their successful program.

While I don't believe Colorado's ITS Program should be a copy cat of the Minnesota Program, I do believe there are valuable lessons here to learn. Further, Minnesota has funded an extensive planning and need assessment effort, the results of which could be beneficial to Colorado, without the expense of reinventing the wheel. Let us learn from the findings of Minnesota. and go forward.

Illinois Department of Transportation Freeway Traffic Management

Observations

The Illinois DOT Freeway Traffic Management (FTM) program has operated, impressively, for three decades. The FTM consists of three primary functions: the Traffic Surveillance and Control System. the Communications Center, and the Emergency Traffic Patrol "Minutemen".

The freeway traffic surveillance and control system is a real-time, centrally supervised. operational network of 2000 detectors, 95 ramp controls, and 13 changeable message signs. Surprisingly this operation performs all functions without the luxury of video surveillance cameras. The information collected is used to generate traffic reports for IDOT. and other public agencies, as well as 55 radio and television stations.

The Communications Center coordinates the assignment of emergency and maintenance vehicles, for the Chicago metropolitan area. The moto of this unit is "Service is ehat the customer says it is". Translated, encourages the public to set the limits of the services offered, within budget limits of course.

The Emergency Traffic Patrol "Minutemen" provide surveillance and respond to freeway incidents on 79 centerline miles of the Chicago metropolitan area freeway system, 7 days a week, 24 hours a day. The primary goal of the Emergency Patrol, al IDOT employees, is to provide prompt detection of any disruptive incident on the freeway system and initiate quick clearance procedures to restore the normal traffic flow. The Minutemen often defend the right of the commuters to have all available traffic lanes open for use, reducing the practice of closing several traffic lanes for investigation purposes.

A Colorado Perspective

While the entire IDOT program was extremely interesting. I found myself most impressed with the Minuteman operation. Different than the Colorado Courtesy Patrol in that this tow and recovery service is staffed with IDOT employees. This concept would not be consistent wit Colorado's desire to encourage public and private partnerships nor the FTE capping, but it does offer IDOT some unique advantages.

First, the Minutemen are frontline advocates for the need to provide all available traffic lanes to the traveling public. This ensures the return of normal traffic operations as soon as possible. Our Courtesy Patrol contract personnel have neither the authority nor the incentive to add this valuable aspect to our service.

Second, th IDOT Minutemen are available 7 days a week, 24 hours a day for emergency response. For Colorado this could translate into additional freeway coverage. and additional coverage in rural areas where congestion peaks on weekends rather than during the traditional weekday peak periods.

Third, the **IDOT** Minuteman program enjoys tremendous public acceptance and appreciation. It is perhaps the best public relations program ever established by the Illinois Department of Transportation, testimony to this is the public willingness to allow for almost annual increases in the service. Further, this program lends credibility to all o IDOT's ITS programs. increasing their ability to pursue other technological advancements.

Michigan Intelligent Transportation Systems Center

Observations

The Michigan Intelligent Transportation Systems (MITS) Center is the hub of ITS technologies in Michigan. MITS control 32 miles of the Detroit freeways, currently instrumented for traffic surveillance. The field equipment includes 10 CCTV cameras, 14 changeable message signs, 49 ramp meters, and 1240 inductive loops.

Expansion of the current traffic surveillance system from 32 miles of Metropolitan Detroit freeways to 250 miles is a major thrust of curren MITS efforts. Plans call first expanding traffic surveillance along I-7Detroit north to Pontiac, and I-696 from l-75 to Telegraph Road.

A Colorado Perspective

A common thread among all the trafic management centers is that they are able to collect traffic data (speed, pccipancy and counts). It is essential that this data be gathered without it the computer systems have nothing to base decisions on, have nothing to compare to historical data, and have nothing from which to base recommendations.

CDOT has a beginning, the ramp metering control loop data with modification could be used, but can not supply the quantity of data required because the spacing is much to infrequent. Along the l-25 corridor inductive loops have been placed in the road bed, but have not been connected to the logic and communications devices that could collect, bundle and send the data to a chosen location. It would seem that this should be the first priority for Colorado's TIC.

Ontario Ministry of Transportation Freeway Traffic Management System

Observations

The Ontario Ministry of Transportation has introduced a program to develop and install ITS technologies in major urban areas across the province. This program. titled COMPASS, has begun with an initial project on Highway 4 1, the Queen Elizabeth Way, in the Toronto area. The goal of this endeavor is to help detect accidents and breakdowns. give drivers more accurate information and ease peak hour traffic flow. This project once fully functional claims to represent one of the most advanced traffic systems in North America.

COMPASS uses 1000 vehicle sensors embedded in the pavement connected through 220 detector stations to provide traffic flow information to system operators at the management center. The use of this technology provides the management center with the number of vehicles on the highway and their travelling speed.

Closed circuit television cameras, located approximately 1 kilometer apart along the 19 kilometer highway section, transmit live images to the operations center to confirm information from the vehicle sensors and to identify problems on the highway quickly. Traffic conditions are monitored 24 hours a day, seven days a week. Operators use the vehicle sensors and closed circuit television cameras to respond quickly to traffic congestion and emergencies.

To inform motorists of upcoming highway conditions, operators key in traffic information for display on 13 changeable message signs located along the highway. In this way current traffic information can be displayed, when this information is not required the signs can be easily changed back to indicated the upcoming exits.

The Ontario Ministry of Transportationboosts the following benefits as a result of the implementation of this project:

- Improved emergency assistance for the motorist in the case of an accident or vehicle breakdown.
- Better traffic information available to help motorists anticipate conditions ahead.
- Decreased number and severity of motor vehicle collisions on the highway.
  (22 percent reduction in collisions)
- Increased safety assurance in highway maintenance and construction zones.
- Reductions in congestion - and the associated delay - during rush hour periods and emergency situations.
  (2 1 percent reduction in overall delay)
- Less time spent idling in traffic leads to reduced fuel consumption and vehicle emissions.
  (45 percent increase in average speed)

The COMPASS project also incorporates the use of ramp metering to regulate the demand on the freeway system. The experience of the Ministry of Transportation has proved that ramp metering shortens overall trip times for motorists, even though there are short waits at the ramp signals.

A Colorado Perspective

While this project is very exciting, and walking into the traffic control room is spectacular, it is important to understand that at present the portion of freeway which is controlled in this fashion is relatively minor. This is the beginning of a much larger endeavor for the Ontario Ministry of Transportation. This 19 kilometer section of monitored freeway is their "test bed" for a much larger, more comprehensive program.

Having said that, let me turn my attention to two fascinating aspects of this project, the ramp metering system and the variable messages signs.

Ramp metering along this corridor is not activated on a time based plan, but rather activated on a demand management basis. That is, based on the collected traffic data (volume. speed, lane occupancy) the ramp metering is turned off and on. There are three levels of ramp activation, all using predetermined traffic thresholds. For instance at the start of the morning peak period when the traffic reaches the first threshold the ramp metering system may be turned on. As the volumes increase and the speeds decrease during the moming peak period the second threshold is reached which requires the use of the ramp metering system. Finally. as the morning peak period dissipates the third threshold is reached and the systems allows the ramp meters to be turned off. This approach seems to make so much sense because the ramp metering system is only activated when needed, but is always available for special events, accidents, or any incident that would cause congestion at unexpected times.

The Ministry of Transportation operates both the data collection system and the ramp metering system from one location. Is this a requirement? No. Colorado could. as recently proposed. establish the Traffic Operations Center as a point of data and information, collection and dissemination. The Regions would simply use this data to operate the facilities for which they haveresponsibility.

Finally, the second interesting aspect of the COMPASS project was the choice of variable message signs. These signs are capable of graphic displays, enabling operators to key in messages that include highway number shields, any standard sign symbol, or exit arrows. Further, considerable research was done to ensure that the messages displayed were easily understood and comprehended by the traveling public. The Ministry suggests that the script for all possible messages be carefully planned. referring to Connie Dudek as a leading authority on this subject. Additionally, message types have been given a priority and are displayed as follows (1 being the highest priority message type displayed, 4 being the lowest priority message type):

1. Incident Messages
2. Congestion Messages
3. Safety Messages
4. Default Messages (typically advanced guide signing of exits)

The Municipality of Metropolitan Toronto

Observations

The Gardiner-Lake Shore Corridor Traffic Management System (CTMS) monitors and manages traffic flow along the Gardiner Expressway through metropolitan Toronto, and along Lake Shore Boulevard. a parallel signalized arterial. The CTMS makes extensive use of traffic monitoring equipment and motorist information devices to improve traffic flow within the corridor. All of the CTMS equipment is operated from the "Integrated Traffic Control Center.

The Gardiner Corridor consists of a six lane arterial (Lake Shore Blvd.) and a parallel six lane controlled access expressway. For much of the ten mile section the Gardiner Expressway is elevated with Lake Shore Blvd. operating directly beneath the expressway. The majority of this arterial/expressway facility was designed and constructed without adequate shoulders. which adds to congestion and delay with every breakdown and flat tire. The average daily traffic on this facility is 245,000 vehicles.

Traffic is monitored on this city operated facility using 29 cameras; 500 detection loops measuring volume. speed. and lane occupancy; and fiber optic cable allows for communication to and from the 50 detector stations and the traffic control center. Currently this facility does not include the use of variable message signs. but in cooperation with 13 local radio stations and one cable television station traffic information is updated and disseminated every 10 minutes to the motoring public. The city is planning a project which will install variable message signs in the near future.

A Colorado Perspective

This facility like all others we visited, is now enjoying the benefits associated with the installation of this technology. These include improved emergency response, better dissemination of traffic data, a reduction in collusions, reductions in overal motorist delay, and an increase i oeral travel speed.

What I found unique with this facility is that the city of Toronto investigated the possibility of hiring contracted services for control room operation. This eliminated the need to increase their Full Time Employee level, which is often a problem in staffing a new organization. Further they found that in contracting for this service they were able to provide 24 hour coverage in the control room for the same cost that the city would have expended for 16 hour coverage. This was a cost saving benefit for all I would suggest that Colorado in staffing the Traffic Information Center consider the same type of analysis, the savings or service gains could be substantial.

Conclusion

In conclusion, although the site visists were very thought provoking and educational, the learning experience was greatly enhanced by the interaction of the tour attendees. T share meals with fellow attendees and discuss what had been seen or heard evoked more learning about how ITS technology is being applied in every comer of the United States and in parts of Europe. I would recommend this tour to anyone interested in ITS technology implementation.

It should be noted by the reader that the conclusions drawn in this report are the opinions of the author, and do not necessarily reflect the current direction of the Colorado Department of Transportation.

Observationson Systems and System Architecture

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INTRODUCTION

The intelligent (surface) transportation has come a long way since the early experiments with detectors, telemetry and computer monitoring for traffic surveillance and control. Numerous forces have shaped the development of Intelligent Transportation System (ITS) over the last four decades. ln-creased role of mobility in our lives, changes in our transportation needs and priorities; emergence and rapid growth of advanced technologies and their application to transportation; sheer need of means to efficiently use existing roadway systems and public transportation; congestion caused accidents, delays, pollution. losses, and traveller aggravation; changes in the vision of transportation planners: and above all, economics and the extent of availability of resources. are the major ones. Regardless of the tortuous path of the ITS evolution. "intelligent" technologies have fulfilled the expectations, whether applied to freeways, signals, public transit, or vehicles themselves. However, the mobility woes over the last twenty years have also become chronic and have spread over larger and larger areas. Consequently, the task of meeting surface transportation needs has become too complex to let us focus on advancing any one of its individual subsectors alone. It appears that the strategies of providing multimodal, seamless transportation and moving people rather than vehicles, will provide the best possible solution to our current and future problems. It means that the comprehensive solution sought will have to treat the individual Advanced (Traffic Information, Traffic and Transit Management....) Systems as subsystems. Secondly, the system design will have to consider larger but logical domains, "regions," so that demands are effectively managed, resources are fully utilized and advanced technologies are exploited as they continue to rapidly develop. This has increased the complexity of the system design and has made system architecture more than ever a key tool for planning, designing and managing the ITSs. The ongoing Architecture Development Program to establish a national ITS architecture clearly underscores this fact.

System architecture provides an overall framework: it helps assign the needed executable functions to the components so that a system can achieve its objectives. The complexity of the framework depends on the functions a system needs to perform, and what the domain and constituents of the system are. An essential requirement for a system to succeed as a system, is that components have to be "integrated" framework, i.e., they must be able to "effectively communicate " with each other. The framework of a regional transportation system has two major dimensions: a physical one that renders the user services and an institutional one that is responsible for physical components. Consequently, the communication also needs to be two dimensional. Not only the system components should be able to be interlinked for free information exchange, but also the agencies facilitate such exchange. The task of developing an "integrated" regional system becomes challenging when the component subsystems have been developed without specific considerations of compatibility needs and the organizational philosophy and procedures are prone to creating barriers for concerted actions.

GENERALBACKGROUND

The areas visited during the North American (ITS '9 -Minneapolis/St. Paul, Minn.; Chicago and Schaumburg. 111.; Detroit and Ann Arbor, Mich. and Toronto. Canada- are all major urban areas but with different characteristics. The ITS programs in these regions are well-established and have evolved with time. They together give a historical perspective of ITS and individually present four excellent examples of evolving system architecture; they all are expanding their systems and testing new ITS elements. The tour provided a quick glimpse at these programs. The host organizations provided as much information as they could to expose the tour participants to the broad range of facets and activities. This paper. however. focuses only the systems aspects. **It** makes an honest attempt to describe system components, services they render and the operating and administrative structures, as perceived by the author. Significant factors associated with the development of these programs and enhancement/expansion plans are also described. It is emphasized that the intent of the paper is not to review technical details of hardware. software. operating systems, communication networks. protocols, on and offsit communication, system integration techniques and so forth. It considers the functionality of systems providing the user services.

SYSTEMS AND PROGRAMS VISITED

Minneapolis/St. Paul, Minn.: The twin city area of Minneapolis/St. Paul is distinctly urban and the rest of the state is primarily rural. The transportation network in the urban area includes freeways and metro bus service. The airport and riverport impact the surface traffic in their vicinity. Minnesota Department of Transportation (Mn/DOT) 's principal involvement with ITS technologies through its Traffic management Center (TMC) is in Traffic Management and Traveler Information Services. These services are provided to the users of about 220 lane miles of freeways, about 66% of the total length. Media and Highway Police are its partners; park-and-ride lots and subsidized parking are used to increase the usage of metropolitan bus service and ride sharing.

The ITS program in Mn/DOT is more than twenty years old. Minnesota Guidestar, now the state's lead ITS agency dedicated to facilitating better transportation throughout the state is a part of Mn/DOT. The Guidestar has brought together public and private agencies and academia to pursue its goal through research, demonstration and deployment of ITS technologies. The agency intends to provide all the 28 user services and has developed a detailed IO-year strategic plan. The most prominent feature of the two-year old Guidestar program is its active, $40 million dollar/year, work plan that includes more than 30 research and development projects, scoping studies and operational tests. Recognizing the quantitative significance of rural area in the state's transportation network and its special needs, the agency is also emphasizing rural ITS. The University of Minnesota is actively involved in almost all ITS activities and conducts research that not only covers technology development but also human factors.

Chicago and Schaumburg, Ill.: The transportation network in Chicago and its suburbs spread across six counties is truly multimodal. A significant portion of commuters patronize the transit, particularly the fixed rail system to travel to downtown Chicago. The airport. known as the nation's busiest. affects the traffic well beyond its vicinity. The X-year old freeway traffic management program initiated by the Illinois Department of Transportation (IDOT) is the forerunner of the ITS program in the state. The current operation emphasizes freeway management and dissemination of near-real time Traveller Information that give incident management a high priority. These two services are coordinated, but operate independently from two separate centers. Accessibility (to the freeways and the telephone exchange respectively) was a criterion in the location selection of the Traffic Systems and Communication Centers (TSC and CornCenters). The TSC is primarily responsible for freeway traffic surveillance, control. data collection and analysis of collected traffic data to create travel advisories. It is linked to all major transportation and communication agencies in the area including rail, bus and airport services. state police. bureau of traffic, and media and emergency traffic patrol. The CornCenter, serving for over 25 years. coordinates the assignment of emergency and maintenance vehicles and response of area agencies. It disseminates up-to-the minute travel information through a variety of media and remotely controls storm water pump stations and communication and freeway lighting systems.

The ongoing ADVANCE (Advanced Driver and Vehicle Advisory Navigation System) program is an operational test for providing in-vehicle dynamic navigation and route guidance to the participating vehicles. The joint public-private partnership program has received support from the high-tech industry and universities in the area. It is managed from an independent Traffic Information Center (TIC) which maintains two-way communication with the instrumented automobiles on the road. The vehicle receives static route guidance from the on-board computer and dynamic traffic information from the TIC. The feedback from the vehicles (vehicle speed) allows the center to assess the travel time and congestion severity. This data is to be integrated with the information from the TSC and CornCenter. The closed loop signal system is also a part of the ADVANCE system architecture.

Detroit and Ann Arbor, Mich: Detroit and cities around Detroit such as Troy and Ann Arbor is the primary area of ITS technology development, deployment and operation testing in the state of Michigan. Universities in the area and auto industry are major partners in this endeavor. The car manufactures cooperate with the public sector and also have their own smart vehicle programs. The freeway operation is controlled from the Michigan ITS (MITS) center. The public transportation and system integration have received special attention in the ongoing ITS activities which appear to have much more diversified. Various state and local government agencies are participating in the ITS projects.

The FAST-TRAC (Faster and Safer Travel through traffic Routing and Advanced Controls) operational test is aimed at integrating ATIS and ATMS. The demonstration program is managed by the Road Commission for Oakland County. It is integrating arterial and freeway as a part of the new system. Real time data sharing among the freeways, signal system, transits, paratransits, police and emergency services is an important objective of the program. The system integration software will play a major role in making this happen. Apart from FAST-TRAC, the projects on smart card by Ann Arbor Transportation Authority (AATA). Automated Vehicle Location (AVL) and real time traffic information system undertaken by consortium of various agencies will help enhance intermodal transportation and seamless travel.

Toronto, Ont.: The COMPASS program, introduced by Ontario Ministry of Transportation (MOT, an agency that appeared to be equivalent to State DOT in the United States) is a typical of urban freeway management program, but implemented on a grander scale. The segregation of freeway traffic using collectors and express lanes makes the traffic more organized and possibly easier for ITS deployment. However, construction and maintenance of the freeways is probably more expensive because of size. Communication with travellers is more challenging because of the requirement to be bilingual (English and French). The program is being expanded to include more freeways around Toronto. The freeway operations are managed through a Freeway Management Center. It did not appear that the program had any major partners. but the universities appear to have some role in research/ technology evaluation type activities.

The Transportation Department of the Municipality of Metropolitan Toronto has been engaged in the congestion management program over the last six years to improve traffic flow conditions on the city streets. The agency chose traffic adaptive signal control as the primary focus of their project. It has successfully completed the first phase of operational testing using SCOOT (Split, Cycle, and Offset Optimization Technique). It now plans to expand the system to the entire city in phases. The signal system. controlled from an independent center, is operated by the municipality staff with little apparent partnership with other non municipal agencies.

OBSERVATIONS

There may be a subtle difference between the perceived role of freeways in the United States and Canada. For example. the Highway-40 I (the first leg of COMPASS program) was not meant to carry urban traffic. On the other hand, U.S. freeways were not only meant for long distance SOV and commercial traffic, but also for rapid movement within urban areas (e.g., Kennedy expressway in Chicago).

Incident management, the idea of providing appropriate advance warning to let the travellers avoid trouble spots and freeway traffic control were the logical early steps in the evolution of the congestion management programs. The necessity to provide faster and more reliable services opened the doors for computerization and advanced communication systems, so began the “development” of ITS technologies that focussed on transportation applications. The initially targeted functions not only dominate the current ITS operations in the four regions visited during the tour, but also everywhere in the North America.

Severity of recurrent and nonrecurrent freeway congestion. size of the transportation system and the leadership appeared to be the major forces initiating ITS deployment in the regions visited. (Adverse ambient conditions causing nonrecurrent congestion-particularly winter freezing, snow, snowstorm-is certainly a common factor to all four urban areas.) Chicago is an excellent example where all the factors conjure. It is therefore not surprising that the existing system in Chicago is closer to providing the envisioned multimodal transportation where all local agencies exchange real time information and participate in providing user services. It has already developed the “two-dimensional” compatibility. The transportation system in Minneapolis/St. Paul is not as large, nor its congestion as severe as in Chicago. Its transportation system is comparable to or smaller than some other urban areas in North America, but not its ITS program. The credit goes to the vision of the leaders and efforts they have continued to put in over the years. Initiating a well-thought-out rural ITS program is another example of their planning for the future.

The visit showed that freeways have dominated the scene of ITS deployment and operation and other urban streets still have largely remained outside the scope of ITS deployment. Many of the arterial roadways were congested at least as much as freeways. The complexity of the grid (against relatively simple linear geometry of the freeways) and lack of resources and technology for the enhancement of such grid are among the reasons why they lagged in deployment. It was despite the advantages they offer: existence of ready alternate routes and their superior proximity to transit operations. These streets go almost to the door steps where people want to go. They therefore can provide a vital link for seamless. multimodal transportation and help managing demand. The FAST-TRAC program appeared to be the only program visited during the trip to address this shortcoming. The use of traffic responsive signal system as an integral part of traffic management, emphasizing autoscope for traffic data collection, development of integration software for assimilating and analyzing the data in real time and optimizing utilization of all modes of travel are indeed cutting edge concepts of ITS architecture. The Road Commission established by a county (the Oakland county) is leading the $50 million +, FAST-TRAC program. It has successfully enlisted the support of all major organizations in the area. The strong support provided by the Michigan DOT to this program shows MDOT’s pragmatism and vision. The author is not aware of any program other than the Southeast Florida Intelligent Corridor System (ICS) program that is developing a system assuring two-dimensional compatibility for seamless multimodal transportation. The segmental developments in Toronto may eventually lead to such a system. Although it was not clear whether the systems in Toronto will be eventually merged to form a cohesive multimodal transportation network. individual freeway and non-freeway enhancement are certainly keeping pace with the times.

Lack of sufficient funding was universally recognized difficulty for ITS development, deployment or operation. The programs are using a wide range of techniques to minimize the severity of the problem. Chicago is using work study students to meet almost 50% of its operational staff needs for the TSC; a media representative is a part of Freeway management Center operation staff in Minneapolis. The ADVANCE concept of using vehicles as probes will continue to provide dynamic data on congestion at a very small operational cost. The willingness of the people to participate in the test and large percentage of rental vehicles running the streets in the area assures sufficiency of this source even in the future. Public-private partnership has become a norm in the U.S; almost every major ITS endeavor has elements of private funding. Exceptional success of Guidestar in forging private-public partnership (more than 24 such partnerships have been established so far) should help the state enormously to carry on its task. The auto industry is certainly a major partner for the state of Michigan. It is also helping other programs outside Michigan. The consultant putting together the system software for the FAST-TRAC program is bearing 20% of the cost of the development. Universities are nonprofit organizations. All the programs visited have the universities as partners. Their participation is not only cost effective, but they often provide services and facilities that no other private or public agency can provide. Participating students is a valuable source of trained and dedicated employees and knowledgeable citizens. It is hoped that a significant number of these programs would generate significant funding revenues and possibly become self sufficient in the long run through public-private partnership.

If it is assumed that the results of ongoing studies and operational tests will be implemented locally, wherever they are undertaken, it is possible to visualize the architectures that may emerge. The physical system in Minnesota may remain dominated by freeways and, if so, will be more centralized. The strength of the system will be a smooth merging of “urban” and “rural” systems. Technologies and density of field devices in the urban and rural freeway segments may be different, but the efficiency and the level of service will be practically identical and users may not find any distinct difference. Although the scope of Guidestar program is the entire state of Minnesota, areas adjacent to the twin cities and other relatively major urban and needy areas across the state are likely to be the nuclei of future deployment. Chicago is already a successful distributed system. It may continue to develop along the same lines. The FAST-TRAC model emphasizes software controlled, automated operation of physical components. The system will probably become more efficient and less operator intensive.

SUMMARY AND CONCLUSIONS

All the programs visited during the tour have succeeded in deploying the ITS technologies successfully and have showed that intelligent transportation is a rational way for attacking the congestion problems. Freeways have been the focus of the ITS enhancements so far and they may continue to be the major component of intelligent surface transportation in the near future. However. the realization that freeways alone cannot meet the future transportation needs has brought to our attention the utility of other modes of travel, demand management and the need to develop system compatibility. The U.S. programs are particularly successful in establishing close coordination among the public agencies in their regions and seeking and receiving cooperation from the private industry. All the programs recognize the need of a seamless multimodal transportation and are working towards achieving them. However, the nature of existing systems and the area specific needs will govern the architecture of the future system. Whether, distributed or centralized; rural or urban; highly automated or human interface dependent, these evolving systems will certainly meet the needs of the user in the region.

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Roger Buckley, 21 s t Century Commuter:

A Futuristic Outlook of How Technologies Developed in the 20th Century in the Great Lakes Area of North America Are Being Used to Move Traffic in the 21st Century in the City of Metropolitania

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The first thing Roger Buckley did when his alarm hummed him awake on Monday morning was to stroll into the bathroom and activate his radio receiver/recorder. As he prepared for the day, his radio advised him of the current and forecast weather for the day. and of the current and projected status of transportation systems in the corridor through which he commuted four mornings per week.

Almost half of Roger's neighbors in Metropolitania worked in their homes by "telecommuting". This trend had begun late in the 20th century when home computers and modems became commonplace. However, Roger worked in the service industry, and his presence was required at his job site, the Metro-Transportation Hub.

The report from his radio receiver/recorder was not actually being transmitted live, as standard radio programs were, but had been transmitted sometime within the previous five minutes and digitally stored in the radio. This enabled Roger to select the time when he wanted to hear the report. The night before, he had programmed the radio to receive and save the specific information which he would need. He also selected the digitized voice tone he wanted to hear it in (which was code-named Brenda).

"Good morning Roger," Brenda began. "The 6 o'clock temperature in Metropolitania is a pleasant 20 degrees with humidity of 35 percent, visibility of 10 kilometers, no clouds. pollution index of 26, and ozone of 82."

Roger worked 40 hours per week, as had been the standard for American workers for decades. But he worked four IO-hour shifts. At the turn of the century, the federal government pressured businesses and other governments to modify the hours that workers commuted to jobs in all major metropolitan areas. Even with the significant increases in telecommuting, and the increase in transportation system capacity which had been achieved in recent decades, delays were still unacceptable on most major corridors. The productivity of the American worker and the quality of life for the average American family were suffering. Switching most workers from five eight-hour shifts to four 10-hour shifts had, in one single act, reduced peak hour volumes by almost 20%.

"Six o'clock traffic is flowing smoothly at level of service (LOS) B, on Interstate 23, your first choice route from your home to the Hub. Travel time is currently 17 minutes. Current travel time on Main Street, your second choice route is currently 33 minutes and is also LOS B."

Cameras and vehicle detection loops had been installed during the past couple decades on expressways and major arterials. They were monitored by computers which could determine exact traffic volumes and travel times through every designated roadway segment. Instantaneous "pictures" of every segment along any specified route could be taken, and travel times calculated and summed to calculate total current travel time for any route used by any motorist.

Cameras were first installed only for observational purposes in many metropolitan areas in the 1970s through the 1990s. Incidents on critical transportation corridors could be identified and a response initiated. However, the cameras were expensive to buy and maintain, and finding human beings who could continuously monitor them without falling asleep or going crazy proved to be a problem. In the 1990s. the price of cameras came down. Also. several companies developed and perfected a technique to digitize the video images from the cameras, run them through a computer, extract specific information, and use it for specific purposes. Particularly noteworthy was the Autoscope system developed at the University of Minnesota. It was first installed by Minnesota DOT on an expressway and used to identify incidents. It was also installed early on in Oakland County Michigan and used in lieu of detection loops to identify vehicles at intersections. Eventually. individual cameras using the Autoscope and similar systems were able to serve those purposes, as well as to feed characteristics of platoons travelling between signalized intersections into programs which optimized traffic signal timing in real time. Furthermore, when incidents were automatically identified, an operator could be advised, and could at his or her option, bring the picture to a work station monitor for analysis. Workers no longer needed to sit and stare at large banks of television screens.

Advanced Traffic Information Systems (ATIS) had their origins in the previous century. From the 1970s through the 1990's commercial radio stations would occasionally broadcast traffic reports mixed in with their traditional entertainment formats. Their efforts met with mixed success. Motorists regularly ridiculed the reports for being completely incorrect, or for hearing them report newsworthy situations only after it was too late to do anything about them. Problems with these information desemination systems were two-fold. They lacked any single reliable highway monitoring technique.

Instead they relied on random reports from police dispatchers. cellular telephone equipped motorists. and a minimum number of airborne reporters. Secondly, they were unable to distribute their information directly to the motorists who needed it when they needed it. Instead, they distributed a generalized report for an entire metropolitan area to all motorists in that area on a periodic basis. It was almost impossible for motorists to pick up information useful to them exactly when they needed it. Nonetheless, the systems managed to be of sufficient help to enough motorists in all major cities to justify their retention. And they served as the forerunner of the far more successful ATIS of the 21 st century.

During the 1990s. many major metropolitan areas began to envision. design, and install a sophisticate ATIS. Minnesota DOT's Genesis, Illinois DOT's ADVANCE, and Michigan DOT's DIRECT projects all began providing motorists of certain corridors or sections of Minneapolis, Chicago, and Detroit with more reliable roadway status information. These test projects expanded in area coverage and in quality of reporting as roadway monitoring systems expanded throughout the metropolitan areas. Eventually the highly reliable and useful system being used by Roger this morning came into being.

This was going to be a hectic day for Roger. It was the start of an International Summit of world leaders to be held right here in his home city of Metropolitania. Each one of the leaders, along with their entourage. would be arriving at the airport and transferring to other modes of transportation to get to their hotels. Roger's job was to facilitate the movement of passengers and cargo through the Metro-Transportation Hub. On good days, this was a stressful job. Today, it might be impossible.

Fortunately, Brenda's information sounded good so far this morning. Of course, he was still in the shower. and there was no guarantee that situations would not change by the time that Roger actually began his trip. but this information would at least start him thinking about his planned route. He could make corrections in real time later as needed.

All transportation systems in the Metropolitania area were closely monitored and controlled by the Metro Transportation Authority (MTA) from their centralized Transportation Control Center. The Center was the brains for all Intelligent Transportation System (ITS) components. Multiple computer systems processed data coming in from monitors all around the area and transmitted control and informational messages back out. By having all ITS components operrated from the Center, operations throughout the metropolitanian area were carried with maximum efficiency and effectiveness. Some incoming communication was handled over radio links, but most was handled over fiber-optic cable. A fiber-optic network fanned out from the Center to traffic signals, ramp metering stations, variable and changeable message signs, vehicle detection loops, observation cameras. and remote radio transmitters and receivers throughout the metropolitan area.

Brenda continued: "However. at 5:55 MTA closed down the primary high-speed rail link between the Hub and downtown due to unconfirmed reports of a terrorist bomb threat. MTA and Police personnel are investigating, but no re-open ing time has been estimated. MTA currently forecasts that as commuters are diverted from rail to busses and cars, your primary route will degrade more quickly than in normal AM peak periods, dropping to LOS C at 6:30 with a 35-minute travel time. LOS D at 6:45 with a 45-minute travel time, and LOS F at 7 o'clock with a 65-minute travel time. Your secondary route will . . ."

Roger didn't want to hear any more bad news and shut it off. Nor could he afford the time. This would be the one morning of the year that he couldn't be late. He hurriedly dressed, and had to skip breakfast to get out of the house fast to beat the other commuters.

In his car, he turned on a radio receiver/recorder similar to that in his bathroom for an update from ATIS. As pre-programmed again, it was Brenda who updated him on travel conditions, current to within the past five minutes. Brenda confirmed that travel characteristics of his primary route were starting to degrade, but that his secondary route had yet to experience the effects of the diverted traffic. Travel times for both routes were still forecast as previously reported.

Roger made an informed decision to start out on his primary route. Since the two routes were somewhat parallel, he could always switch if needed. He drove several blocks to the nearest freeway entrance and found that the ramp metering system was already in operation, an indication that traffic farther in toward town was picking up sooner than expected.

MTA had implemented all of the expressways in Metropolitania with ramp controls during the past couple decades. The theory behind the controls was that an expressway lane of traffic could handle about 3000 vehicles per hour flowing smoothly at about 80 kilometers per hour when the demand on the system was just that. However. if the demand on the system exceeded this capacity, the crowding would force traffic to slow down, and the flow rate would drop below 3000 vehicles per hour per lane, possibly to under 1000 vphpl with average running speeds of under 10 kph. Therefore. to insure that the full capacity of the expressway was utilized during the peak periods, it was critical to not allow the demand on the expressway to exceed the capacity. Regulating the flow of vehicles onto the expressway was the only effective way to do so.

Ramp Metering Systems such as this were first tested in the late 1980s and 1990s in many. but by no means all, American cities. For years, officials in many metropolitan areas were unconvinced of their benefits, or were concerned about the likelihood of convincing their citizens of them. One of the most extensive ramp metering systems installed before the turn of the century was in the progressive Twin Cities area where 400 expressway ramps were controlled. The success of that system helped convince most other American cities to implement this component of ITS during the following decade. Although it took years of public relation campaigns in the 1990s to convince the public that ramp metering was beneficial, today's motorists unanimously understood and accepted it as a part of their daily commutes.

Once Roger got through the ramp metering system, the expressway was flowing quickly and smoothly. Today's motorists were much better trained than their predecessors of just a few decades before. As recently as the turn of the century, citizens were able to obtain their driver licenses by passing simple written and driving tests. They could even renew their licenses indefinitely without retesting. As a result, many collisions occurred when incapable motorists got into situations they weren't experienced to handle. Also, many motorists couldn't use the system efficiently, and caused major capacity reductions. Only in major commuting corridors did expressway lane capacity ever exceed 2000 vph.

Now, motorists were thoroughly practiced and tested in all aspects of driving on a regular basis. To obtain a license, one was required to take a drivers education course that went well beyond the basics and included theories on maximizing the capacity of the roadway system and a minimum of 10 hours in a variety of basic and specialized driver simulators.

In the simulators, candidates were exposed to a variety of typical and emergency driving situations. Their responses to each situation were measured by computers. and their subsequent course work adjusted accordingly. The computer would keep each candidate advised of his or her progress through the course, and would print the license once the course was successfully completed. Final written and driving tests were no longer necessary.

To maintain a drivers license. each motorist was required to take an annual drive in the simulator during which he or she would be subjected to emergency situations. Their reactions would be judged. and their licenses would be hopefully renewed. However, almost half of all drivers were issued licenses with various restrictions, allowing them to use the roadway system. but not on critical corridors at critical times of day. The driver licensing system had become similar to the pilot licensing system in place since the middle of the 20th century. Having only adequately competent drivers on the expressways during peak periods resulted in significantly increased capacity. As a result of this high level of training and the restrictions on less competent drivers, commuters were able to drive safely with a headway of little over one second per vehicle, or about 3000 vehicles per hour per lane.

Driver education course work included a thorough review of Intelligent Transportation Systems (ITS) in use in any modem metropolitan area. Applicants were introduced to all ITS components. They learned what the purpose of each component was, how it worked, and how each motorist could best use it to improve the safety and efficiency of his or her travels throughout the area. The ITS systems were included in the simulators so that license candidates could become experienced in their use before encountering them in the real world.

The driver simulators were originally developed in the 1990s at the Human Factors Research Laboratories (HFRL) at the University of Minnesota. There, engineers, scientists ,and psychologists studied human interactions with rudimentary driving and flight simulators and in virtual reality environments, and laid the groundwork which so contributed to the increase in driver skills in the 21 st century.

Roger was cruising along smoothly, being extremely pleased with his decision to skip breakfast and get out on the road fast when his radio beeped at him. This indicated that a new five-minute report had just been downloaded to his radio, and that it contained significant new information. He lowered the volume of the classical music on his CD player, and pushed the radio button for Brenda to advise him of the news. Simultaneously. he drove under an old, but still operational, variable message sign that said something about an accident ahead.

Variable message signs (VMS) and changeable message signs (CMS) became popular during the last couple decades of the previous century. They were a common means to communicate information to drivers about roadway conditions ahead. One of the more impressive CMS systems was found in Minneapolis where about 55 signs kept motorists advised of special situations which they could expect on the expressways ahead of them.

The use of VMSs and CMSs was warning in the 21st century. The signs were very expensive to procure, usually quite expensive to maintain, and had limited use. They were mostly stationary. Those which were portable were difficult to locate both safely and effectively. And worst of all, they could only convey a small amount of information before motorists passed beneath them. Studies showed that Traffic Engineers were unable to post even half of the information they needed to convey to motorists, and that the average motorist absorbed only half of the information posted.

Nonetheless, there were still many VMSs being used early in the 2 1 st century because only the newer cars were equipped with the latest ATIS. All variable message signs were scheduled to be abandoned within the next decade since all new cars were being equipped with ATIS.

Brenda brought bad news: "An 18-wheeler blew a front tire and rolled over at the Cross Street exit, 2 kilometers west of the Metro-Transportation Hub, blocking the exit lane and one expressway through lane. Your ETA at the Hub just increased from 6:45 to 7: 15 by staying on your primary route. Consider transferring to your alternate route by taking the next exit in one kilometer, turn right two blocks, turn left onto Main Street for an ETA of 7 o'clock." Roger shifted right to prepare to exit and pushed the replay button to make sure that he heard those directions correctly.

Route Guidance Systems (RGS) had been completely incorporated into the ATIS within the past decade. Preliminary systems of this type were developed in the 1990s as part of Illinois DOT's ADVANCE system, General Motors' Trav-Tech and Guidestar systems. and Sieman's Ali-Scout system. Most of these systems not only included route guidance, but motorist information systems. Such systems could advise a motorist of the names and locations of the nearest fast-food restaurants or car repair shops. In the early 2 1 st century, stationary versions of such systems were installed at shopping malls, bus stops, and airports to enable pedestrian travelers to make important decisions about their destinations, directions, and modes of travel.

Roger had lived in the Metropolitania area for all of his adult life, and was familiar enough with the roadway network to rarely rely on the RGS. Others used it constantly. Some residents of Metropolitania who lacked a natural sense of direction had learned to rely on it for almost every trip they took. Since Metropolitania was a popular tourist destination, the RGS. which was in all rental cars, also received considerable use from visitors needing to find their way around. And in unexpected situations like the one that Roger now found himself in, even he was glad to have it. Contrary to earlier models, this RGS was so user friendly that anyone could operate it. However, to reprogram it for a new destination still required a passenger or the driver to pull the vehicle off the road.

Within a couple minutes, Roger was on Main Street. The radio beeped. Roger didn't want to hear any more bad news, but didn't want to miss out on anything he should know either. "Your secondary route is confirmed and your ETA remains 7 o'clock." No problem.

Roger's car was equipped with an Automatic Vehicle Locating (AVL) device, enabling him to be tracked from Central by MTA. Such systems had been developed in the late 1990s and served two purposes. In order for Route Guidance Systems to provide real-time directions to the driver, the system had to know where the vehicle currently was. One system was designed to receive Global Positioning System (GPS) data to determine its location, and then use on-board intelligence to determine optimum routing. Another system design required location information to be radiod back to Central where computers calculated optimum routing and transmitted it to the vehicle. An advantage of the latter technique was that the central site could also use the vehicle positioning data it received to calculate average travel times on roadway segments throughout the metropolitan area which assisted it in calculating recommended routes for other motorists.

Brenda continued: "Travel times on Main Street are increasing as the AM peak develops and as commuters continue to divert from rail and from the I-23 Expressway off-ramp vehicle roll-over. MTA has suspended the real-time development of traffic signal timing patterns and has implemented Heavy Inbound I-23 Blockage Patterns."

Under more normal circumstances, all of Metropolitania's traffic signals were centrally controlled by MTA using the latest Adaptive/Responsive software algorithms. This software relied on the vehicle flow data being constantly retrieved from the cameras and vehicle detection loops and processed through a signal network simulator in a micro-computer. Optimum signal timing was then calculated by the system, and implemented in the street within a few seconds.

Such systems had their origins in software developed in the late 1900s. In the 1990s two such systems were particularly competitive throughout the world. The SCOOT (Splits, Cycle Length, and Offset Optimization Technique) system was developed in Great Britain in the late 1970s and first tested in North America in Toronto and Oxnard CA in the 1990s. The SCATS (Sidney Coordinated Adaptive Traffic System) system was developed in Australia in the 1980s and first tested in North America in Oakland County MI in the 1990s. The two systems used quite different simulation and optimization techniques. Both systems had their supporters and detractors. Many heated debates in the traffic engineering community revolved around which was the superior system. A third contingency maintained that both systems represented interesting and valuable steps in the long range goal of attaining a truly optimal real time traffic signal control system. However they felt that because both systems were based on an extremely limited amount of input data from vehicle detection loops that neither were superior to a standard Time-of-Day scheduling system using pre-calculated timing patterns. The debate between SCOOT and SCATS did not end until the early 21st century when both systems fell out of favor. being replaced by several enhanced systems which could make use of the much greater amount of platoon characteristic data that had become cheaply available with newly developed detection techniques.

Nonetheless, central MTA operations personnel had decided that conditions in the corridor this morning did not warrant letting the usual algorithms optimize the flow for all directions. Instead, they wanted to provide 100% favoritism for inbound trafftc to delay the inevitable inbound traffic flow breakdown as long as possible. Side street traffic and reverse-peak direction traffic would have to be sacrificed.

Once again, Roger was at the right place at the right time. MTA was providing a lengthy green band for traffic traveling inbound on Main Street. Although volumes were picking up fast. he was able to quickly complete the rest of his journey to the Metro-Transportation Hub.

Thanks to Roger's quick departure from home and his ability to make the best route decisions along the way, he was able to beat most of the commuters and get to work by 7 o'clock in a respectable 40 minutes flat.

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