Title
Intelligent Transportation Systems: A Compendium of Technology Summaries

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A Compendium of Technology Summaries

By
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Overview of the Summaries

Many sources provide good information on Intelligent Transportation Systems concepts and applications. However, some of these sources are highly technical and others are lengthy treatments of the subject. The summaries presented here are designed for the busy, non-technical reader who:

- wants to find out what a particular ITS application is intended for - ramp metering, for example

- is looking for ways to address a particular problem - e.g., how to improve pedestrian safety

- wants to find examples of ITS implementation

- simply wants an update on what changes are taking place in transportation technology.

Each summary is short - 1-3 pages. The summaries provide background on each application, discuss its benefits and costs or limitations, and provides examples of implemented projects, and lists references - to web pages, papers and reports, and in some instances, contact persons.

The summaries were prepared in 2001 and 2002 and were up to date then, but technologies are advancing rapidly, so they will need to be updated in a year or two. Sites where readers can get started on their own updates include:

- www.its.dot.gov - the US DOT website
- www.itsa.org - the website of ITS America, a professional / trade group
- www.path.berkeley.edu - the website of the University of California Program on Advanced Transit and Highways

Most State DOTs, Metropolitan Planning Organizations, and professional organizations for transportation engineers and planners also have extensive information available on new technologies and intelligent transportation applications.

On-Board Vehicle Safety Systems

Description

A variety of on-board technologies are being added to motor vehicles - cars, trucks, and buses - to improve safety. These technologies help make the vehicle "intelligent" by sensing the environment and producing a driver warning or automatic action such as braking or warnings to other drivers. These on-board technologies include:

- Collision warning systems for detecting objects in the path of the vehicle (front or rear) that might not be visible to the driver, warning the driver and in some cases oncoming drivers (e.g., by flashing warning lights)

- Lane warning systems (lateral collision warning systems) that alert the driver of a vehicle or object approaching from the side, e.g., a vehicle that is attempting to change lanes in close proximity to the operator's vehicle

- Minimum Headway Advisory systems that tell the driver that he or she is following too closely

- Lane sensors that determine the position and heading of the vehicle in its lane (e.g., by reading magnetic pavement markings)

- Lane centering systems that help a vehicle stay centered in its lane

- Night vision systems that detectors to aid drivers to stay in lane and detect objects when visibility is extremely low

- Adaptive cruise control that automatically adjusts speed to maintain safe spacing to the vehicle directly in front.

- Skid control that helps the vehicle automatically regain traction when a skid occurs

- Rollover control systems that automatically brake to help the vehicle automatically regain stability when tipping is detected.

- Cooperative headway control that helps vehicles in convoys maintain close spacing and warns of attempts to pass or cut in by other vehicles

- Automatic collision notification system with manual reporting options that detect any crash and report type, severity of crash and vehicle’s final resting position

- Safety equipment condition monitors and notifications (usually through dashboard lights) for wipers, brakes, tires, etc.

- May Day systems that call for police, fire, or emergency vehicle assistance at the push of a button and automatically provide vehicle location information

- Speed and acceleration systems that can be used to train drivers and to keep records of driver habits, for review by supervisors of commercial vehicle operators, and parents of teenagers.

Many of these features are joining air bags, security systems, and advanced lighting technologies as standard safety and security equipment on many vehicles (especially luxury makes such as Lexus and Cadillac), available as options on others,. The rest of the technologies are as options, some on heavy duty vehicles and others on all types of vehicles. The sophistication of various applications differs greatly, as does price; for example, collision warning systems range from about $250 for a simple back-up sensor and warning system to over $2500 for a system with multi-directional capabilities and warnings. The cost is typically over $5000 for heavy vehicle systems with lateral and headway warning features. (A 1) Audio warnings can be chimes, flashing lights, tactile warnings (e.g., brake pulse, or voice warnings (Brake! Brake! Brake!) Some applications also use head-up displays, which project images on the vehicle's windshield

Benefits

On-board safety systems have considerable potential for reducing crashes, avoiding run-off-the-road incidents, and generally improving driving performance. They also can help obtain faster emergency responses.

Limitations

Many of these systems are still undergoing development and have limitations. For example, many collision detection systems have difficulty detecting actual road hazards (vs. off-road objects) when roads are sharply curved, and may not be able to detect objects blocked by hills or large buildings. Work also continues on what kinds of displays and warnings are most effective and useful for drivers.

References and Websites

www.itsa.org/ivi

www.computer.org

www.dotrs.gov.au, Oct. 9, 2000

http://www.manufacturing.net/magazine/dn/supplements/automotive/cars.htm, January 19, 1998

Changeable Message Signs or Variable Message Signs

Description of Technology

"Changeable Message Signs (CMS) or Variable Message Signs (VMS) are programmable traffic control devices that display messages composed of letters, symbols or both. They are used to provide information about changing conditions in order to improve operations, reduce accidents, and inform travelers. They may ask drivers to change travel speed, change lanes, divert to a different route, or simply to be aware of a change in current or future traffic conditions.

Generally, VMS units consist of four components:

1) display board
2) control center
3) monitoring equipment
4) communication network.

The information for the VMS can come from any source that provides traffic information. Some systems have detectors tied directly to the VMSs themselves, while other systems have linked the VMS to a central control center (which could provide information to Highway Advisory Radio as well).

Benefits

The PATH website (1) reports:

> "VMSs provide information about: 1) recurring congestion, 2) non-recurrent congestion, 3) weather-related problems, 4) congestion due to special events, 5) routes, 6) speed restrictions, and 7) other changing conditions or requirements. The information displayed on VMSs can be classified as advice, warnings, and requirements."
>
> "The benefits of VMS system can be 1) a general improvement in routing choice, saving vehicle traveled miles and hours; 2) congestion reduced during peak hour; 3) improved routing during incidents and reduced accident costs; 4) travel time savings; 5) reduced environment effects: reduction in air pollution and 6) energy reductions. "

Applications to Date – Examples

Coordinated VMS systems have been implemented all over the world. The PATH web site, www.path.berkeley.edu/~leap/travelerinfo/Driver_Info/message.html), lists over two dozen examples.

Limitations

There are no particular barriers to implementing variable message signs, but there are a number of issues that can undermine their effectiveness. Variable message signs can have very specific applications, so it is important to consider both the objective and the contextual situation for the sign. For example, a system that is meant to reroute traffic in case of an accident must take into account the network of both highways and surface streets; otherwise it could reroute traffic into a worse situation. It is easy to lose user confidence, so the information displayed on the sign must be accurate. It is better to provide no information than incomplete or inaccurate information. Also there are safety and human factor concerns in sizing and spacing the signs and composing the message.

References

Partnership for Advanced Highways (PATH) web site accessed at www.path.berkeley.edu/~leap/travelerinfo/Driver_Info/message.html

Highway Advisory Radio

Background

Highway Advisory Radio (HAR) is a system of providing real-time traffic information to travelers by broadcasting on an AM frequency. Signs, such as seen in Figure 1, alert the motorist that he is entering a HAR zone. The HAR system can be permanent and located in high-congestion areas, or can be temporary and used in construction zones, during traffic incidents, or during special high-traffic events.

Figure 1. Typical HAR sign.

Source: Interwest Safety Supply, Inc., web site (www.iwsafety.com). Accessed 18 Mar 01

A HAR system comprises a network of low-power radio transmitters. Each transmitter typically broadcasts over a radius of 5 to 10 miles. The transmitters can be fixed or mobile, depending on the application. The information that is broadcast is stored in the transmitter, and can be updated either directly into the transmitter through a microphone --usually done for temporary HAR applications--or remotely via telephone.

Benefits

Highway Advisory Radio is intended to give travelers accurate, up-to-date information so they can tailor their travel plans accordingly. If an accident has closed a lane up ahead, for example, the motorist will learn this from the radio and perhaps take a different route. This benefits both the motorists who choose a different route, and the motorists who are already "caught in the jam" by preventing the jam from building up due to the arrival of more unwary motorists.

Applications to Date – Examples

Highway Advisory Radio systems are in wide deployment all over the country. CalTrans currently maintains 84 permanent HAR locations [1].

Limitations

Smith, et al. have listed many problems with HAR in their home state of Virginia [2].

> "Proper HAR operation is personnel-intensive. At present, VDOT operates HAR transmitters as isolated units. Linking them into a coherent traveler information system requires a concerted effort to consolidate information between multiple agencies. Moreover, updating broadcasts with information of value to motorists takes time. Updating HAR messages cannot be a secondary responsibility, yet field personnel generally have other, high-priority duties, especially in an incident.
>
> Presently, information provided on HAR stations is of limited value to motorists. Motorists want specific, up-to-date information on congestion and incidents that affect their travel. Situations that can be communicated with other traffic control devices or that do not affect motorists do not warrant HAR broadcasts.
>
> Motorists are not turning to HAR broadcasts. Many motorists do not understand when they are in an HAR broadcast area, and what information HAR offers them.
>
> Motorists currently get most of their traffic information from commercial radio station traffic reports. Commercial traffic reports have decades of experience effectively providing regional traffic information in urban areas throughout the country. VDOT does not have the resources to provide this level of information, and should not attempt to compete in this market.
>
> CMSs [changeable message signs] offer considerable advantage as advisory signing for HAR. Static HAR advisory signs offer a single, inflexible attention statement to drivers. Flashing beacon signs face the same problem, and are confusing to some motorists. CMSs can alleviate these problems, directing the message to the appropriate audience."

References

Database provided by Caltrans Transportation Systems Management Program.

Smith, Brian et al. "An Investigation of Operational Procedures for Highway Advisory Radio System." Virginia Transportation Research Council, Sept 95. Accessed on-line at www.azfms.com/DocReviews/Jan96/art13.html

511 Traveler Information

Description

511 is a new, nationwide number that can be used to obtain toll-fee road reports and traffic incident information, plus information on transportation services offered in the area. States and metropolitan areas can develop the specific applications that will be made available on their 511 sites. Usually information is provided on weather advisories, construction, traffic congestion, and incidents or other special conditions. In addition, information on transit services, fares, schedules, and route information usually is available, along with information on ridesharing and bicycling. Some sites also provide point to point travel times by various modes (e.g.., San Francisco Bay Area.) The information may be obtained by phone or from a 5411 website..

The 511 number was designated for traffic use in 2000. Sites are being added nationwide; active sites currently include:

- Arizona 511
- ARTIMIS - Northern Kentucky - Cincinnati
- Iowa 511
- Kentucky 511
- Minnesota 511
- Montana 511
- Nebraska 511
- Orlando / I-4, Florida
- South Dakota 511
- South Florida - Miami-Dade area
- TravInfo® - San Francisco Bay area
- Utah CommuterLink
- Virginia 511 Travel Information - I-81

Detailed case studies for several of these sites are available at the US DOT website, http://www.fhwa.dot.gov/trafficinfo/511.htm

Road Weather Information Systems

Description

A Road Weather Information System (RWIS) consists of sensors installed in the travel lanes of the highway that measure the temperature of the pavement. Atmospheric sensors are placed adjacent to the pavement and measure air temperature, relative humidity, wind speed and direction, precipitation type, intensity and rate, and the driver's perception of visibility [1]. Often, the sensors are bundled together into a remote processing unit, which also sends the data to a central server. By applying models based on current and historical climatological data, technicians can determine the weather conditions at that road location and, more importantly, to determine the likelihood of ice forming on the road and the need to plow snow.

There are a myriad of technologies used in the actual sensors themselves, ranging from infrared spectral cameras to electric thermostats.

Benefits

This information can be used two ways. First, it lets roadway operators better manage snow removal and de-icing operations. For example, Nevada DOT was able to reduce road salting by 73%, which is important in environmentally-sensitive regions like Lake Tahoe [2]. It also lets road maintenance managers more effectively utilize manpower and equipment, especially during periods of harsh weather [3]. Conditions are monitored remotely, so a snowplow team based in, say, Placerville need not drive up to South Lake Tahoe to plow if there is no snow.

Second, motorists can use the information to plan routes. The information can be broadcast on Highway Advisory Radio, displayed on Changeable Message Signs, or be available at telephone hotlines. Also, many agencies operate web sites with the information. Caltrans includes it with its road reports. A company called Surface Systems, Inc. has a web site with links to RWIS information in all states that have them (www.roadweather.com).

Applications to Date – Examples

At least 27 states have implemented RWIS in some form [1].

Caltrans maintains 63 RWIS locations throughout the state [4]. Figure 1 shows the locations.

Limitations

A Road Weather Information System is rather limited in application. It is best in climates that get a lot of snow. Also, current technology is very expensive. The remote processing units mentioned above cost on average $40,000 per unit, with a life span of 5 to 6 years [5]. Each individual RWIS location can have more than one remote processing unit, so it is easy to see how the costs can mount up. One problem with implementing RWIS at a new location is the development and fine-tuning of the climatological models [5]. These models also require a lot of computing power to run, which drives up the cost. The Washington State DOT model, for example, required $700,000 of computer hardware [6]

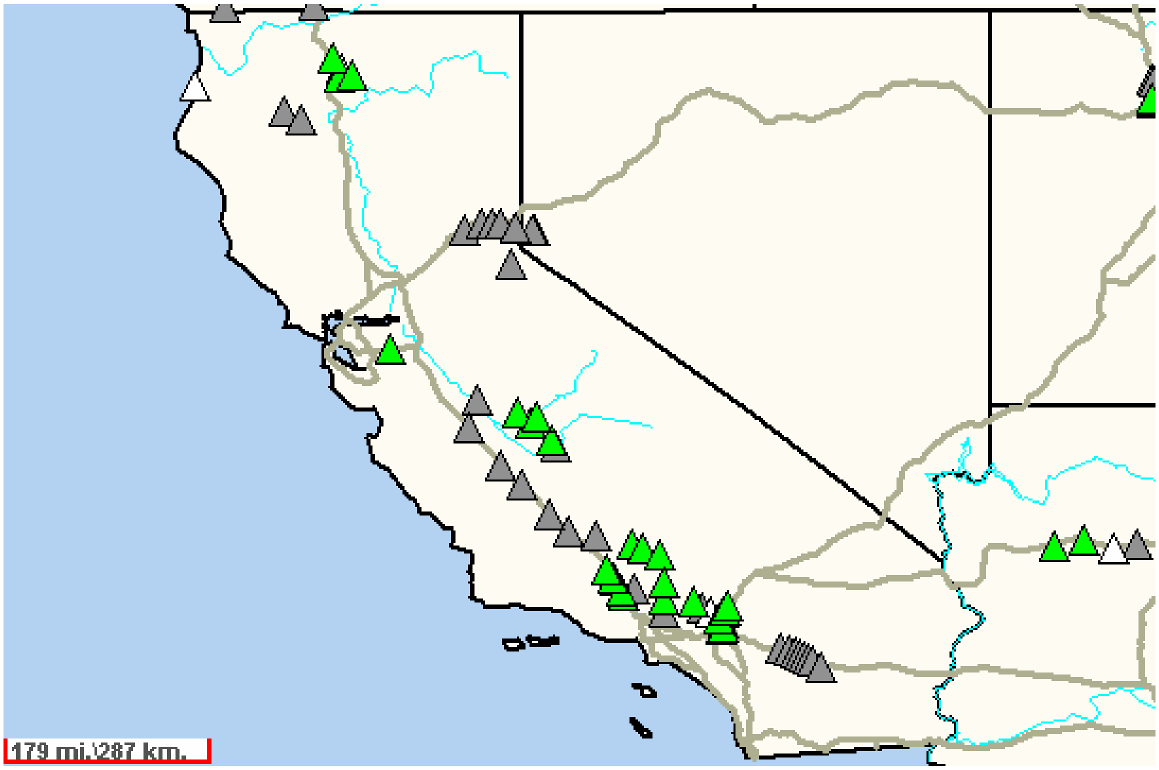

Figure 1. RWIS Locations in California

References

www.roadweather.com/wbpublic/RWISOverview.htm

Nevada DOT news release access on-line at www.nevadadot.com/about/news/news_00045.html

Northwest Weathernet. Accessed on-line at www.nw-weathernet.com/RWISA.htm.

Database provided by Caltrans Transportation Systems Management Program

Aurora—International Program for RWIS. Accessed on-line at www.aurora-program.org
"Lessons Learned in Providing Road Weather Information to Travelers."

Newsletter of the ITS Cooperative Deployment Network, accessed on-line at www.nawgits.com/icdn/rweather.html.

Advanced Traffic Signal Timing

Background

Advanced traffic signal timing programs can reduce delay, cut congestion, improve pedestrian safety, and lower emissions and energy consumption on signalized streets, which carry about one third of the traffic in most metropolitan areas. These signal timing programs use current, or "real-time", information to update signal timing.

Traffic signals have three important parameters:

Phasing--the various traffic movements allowed by a signal and the amount of green time given to each of those movements. A two-phase signal has two periods of green, one for the main street and one for the cross street. Other signal phases include left-turn-only arrows, or green lights for only one direction at a time. Pedestrian crossing time is also considered a phase. The exact phasing depends on both the volume and the characteristics of traffic, and the physical configuration of the intersection.

Cycle length--cycle length is the time that elapses for the signal to service all the signal phases between the beginning of green for the main street to the return of the beginning of green for the main street; that is, a complete sequence of signal indications. This time is usually expressed in seconds, and is dependent on the traffic volume at the intersection.

Offset--the difference in time between the start of the cycle for adjacent traffic signals. In a travel corridor such as a main arterial, it is a good idea to have all the traffic signals coordinated to produce what is called a progression. This means that traffic traveling down the arterial will hit all green lights. Having a progression increases the capacity of the arterial. The offset is used to create progression, and the length of the offset is a function of traffic volumes, posted speed limit, and distance between adjacent signals

Traffic signal timing controls these three parameters. There are two basic methods for controlling signal timing:

Fixed timing or pretimed--as the name suggests, all the signal parameters are fixed, and the signal controller drives a predetermined, regularly repeated signal sequence. Fixed timings are best for intersections with predictable, stable, fairly constant traffic volumes.

Traffic-actuated--actually senses traffic and changes its parameters accordingly. Most people are familiar with the intersection that will give a green left-turn arrow only when a car is in the left-hand turn lane. This is an example of an actuated signal. Actuated signals range in complexity. Advanced signal timing programs work for actuated signals.

Basically, advanced signal timing programs work by recording traffic volumes and densities of traffic at each approach to an intersection, for all the intersections in an area or "system" to be coordinated. The programs use this information to calculate the optimum signal timing at any given time. The most advanced systems read traffic on a second-by-second basis and adjust accordingly. Some signals can actually anticipate traffic by using the data detected at upstream signals.

The key to implementing an advanced traffic signal program is in the actual traffic signal controller itself. This is a unit that sits near the individual traffic signal and controls its operation. In older signals, the signal controller is essentially a mechanical clock; these signals cannot make use of "real-time" data but must be timed based on "typical" data. Newer controllers are sophisticated solid-state computers.

While even signal systems with old electromechanical equipment will perform better with advanced signal timing plans, older signal controllers, including older electronic controllers, cannot support the most advanced control programs. Therefore, implementing the most advanced traffic signal programs usually means updating or replacing the controllers. Costs depend on the complexity of the intersection, e.g, whether there are special turn lanes, bus actuation, or other special features, and whether the equipment at the intersection (controller, detectors if any, signal heads) can be upgraded or need to be fully replaced.

Advantages:

The Federal Highway Administration (FHWA) and the Institute of Transportation Engineers (ITE) both report that adjusting signal timing is the easiest and cheapest way to improve the operation of traffic facilities. About a third of the vehicle miles traveled in urban areas is on signalized streets and arterials, so traffic signal improvements can reap large dividends.

Signal retiming alone often can achieve important results. Benefits depend in part on how frequently signal timing plans have been updated, but it is common to achieve reductions in delay, emissions and energy use of five percent or more. FHWA found that some cities haven't adjusted their signal timings in 20 years. In such cases updating signal timing can produce large improvements - for example, Seattle retimed their signals in 2001 and found efficiency increases of 20-26% on three major arterials. ITE estimates that optimizing signals costs about $400 per signal per year. Interconnecting signals, which increases efficiency, costs about $2700 per signal per year.

Changing the physical configuration of certain intersections also can be an effective and relatively low cost way to improve traffic flows - especially when this can be done by restriping or redesignating lanes. A 2002 study, for example, found that by changing the way left-hand-turn traffic moves at certain intersections, travel time could be reduced by 40%.

Installing advanced signal systems allows operation from a signal control center or traffic center and permits far more sophisticated timing plans. Not only can signals automatically adjust to the traffic pattern in "real time", managers can rapidly change timing plans to move traffic generated by special events, reroute traffic efficiently in cases of emergency, etc.

Disadvantages:

While signal timing alone is relatively inexpensive, upgrading signal systems for advanced applications can be costly. The San Francisco Department of Parking and Traffic estimates that it will cost around $50,000 per signal to update the control system on Market Street. Beyond the cost of the new controllers themselves, costs include replacing the signal foundation and installing more cable conduit to accommodate the greater number of data cables running to the controller.

Use of advanced traffic modeling software requires advanced training. Some cities prefer to contract for signal timing services. In addition, advanced signal systems require maintenance skills by electronics technicians that not all cities have on staff. Again, contracting may be the way to handle this.

Conclusions

Advanced traffic signal systems hold great potential to increase the performance of streets and arterials without having to increase their physical capacity. However, these systems come at a relatively high price, and substantial gains can often be made by implementing simpler, cheaper timing changes in control programs for existing systems. The FHWA recommends retiming signals every two or three years; most cities do it much less frequently. Furthermore, other intersection changes are also available that could improve intersection performance without changing signal characteristics.

References

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Pedestrian Detection Systems and Other Pedestrian Safety Measures

Pedestrians account for a significant share of motor vehicle-related fatalities and serious injuries in the United States. New technologies offer several ways to improve pedestrian safety at both signalized intersections and other crossings.

At signalized intersections, pedestrian crossing signals are the norm today. Some of these pedestrian signals are pushbutton activated; others run on fixed, preset timing plans. In either case, new technologies can make crossing the street safer and less confusing.

Current pedestrian crossing equipment is known to have limitations. Pedestrians with limited vision may not be able to read crossing light displays. Pedestrians with limited mobility may not be able to cross in the time allocated. Many pedestrians also are unsure of what to do when the pedestrian light starts flashing, and may turn back, run to cross, or even stop mid-street. At pushbutton actuated systems, some pedestrians simply wait for the light to turn, experiencing long delays and confusion. Others do push the button but don't understand why the signal doesn't always turn green immediately. (The pushbutton notification is treated as by the signal controller device as a request for green time for pedestrians, which is scheduled consistent with traffic clearance needs.) In either case, the resulting wait may seem inordinately long, and pedestrians sometimes assume the pedestrian signal is malfunctioning and cross against the light. Finally, pedestrians may have disabilities that make it hard to find the pushbutton or push it once found.

A variety of technologies can address these concerns. Auditory signals and special large-print and symbol-based warning signs can be used to help those who cannot read crossing light displays. Auditory signals are varied to let the pedestrian know when it is safe to cross, when the light is changing, etc. For those able to read the displays, a countdown display, which shows the number of seconds remaining before the signal turns, can help the pedestrian decide whether there is time to cross. A combination of auditory and visual displays reinforces the message as well as helping people with different limitations.

A relatively new solution is to install a pedestrian detection system. Pedestrian detection systems can work with signals or at unsignalized intersections and can be matched with other technologies such as crossing displays and motorist warnings to increase overall effectiveness.The detection systems are based on microwave, infrared or video image processing capabilities. For example, a microwave beam emitter is aimed at a pedestrian walk and emits a beam of energy at a particular frequency. The emitter is coupled with a receptor for the return beam. Detection is based on a difference between the outgoing and incoming beams, indicating the presence of an object (pedestrian) in or at the crossing. When a pedestrian is detected, action can be taken to warn motorists (e.g., activate a flashing yellow light, turn on pavement lights in the crosswalk) or to alter the signal timing to extend the pedestrian crossing time.

Examples

- Microwave based detection technology has been used in the UK under the name Puffin (Pedestrian User Friendly Intelligent). Puffin works with a combination of remote sensor technology and pressure sensitive mats on both sides of the crosswalk. (Fig. 1). The sensors must be installed where there will be no obstacles for the beams and the pressure mats are indeed where pedestrians are likely to stand. Wider streets (fig. 2) are designed to have central refuge sections so that "last minute runs" can be accommodated.

- An evaluation study for the Federal Highway Administration (August 2001) used automatic detection technologies at crossings with pre-existing pushbutton crosswalks. Automated pedestrian detection systems were installed at sites in Los Angeles, CA (infrared and microwave), Phoenix, AZ, (microwave) and Rochester, NY (microwave). If an object was detected, the "don't walk" sign was delayed till that object (pedestrian) was clear of the street. Results show that the capability of extending the crossing time resulted in increased protection for pedestrians; most fewer than before got stuck in the crosswalk after the light had turned.

- In Orlando, Florida, automatic pedestrian detection is being used together with lighted sidewalks to provide increased safety for pedestrians.

Additionally, new technologies can provide special help to the disabled in finding their way through urban environments. For example, the Japanese Ministry of Land, Infrastructure and Transport conducted an experiment in 2001 in which PDA devices helped the physically disabled find the shortest distance barrier-free routes to their destinations.

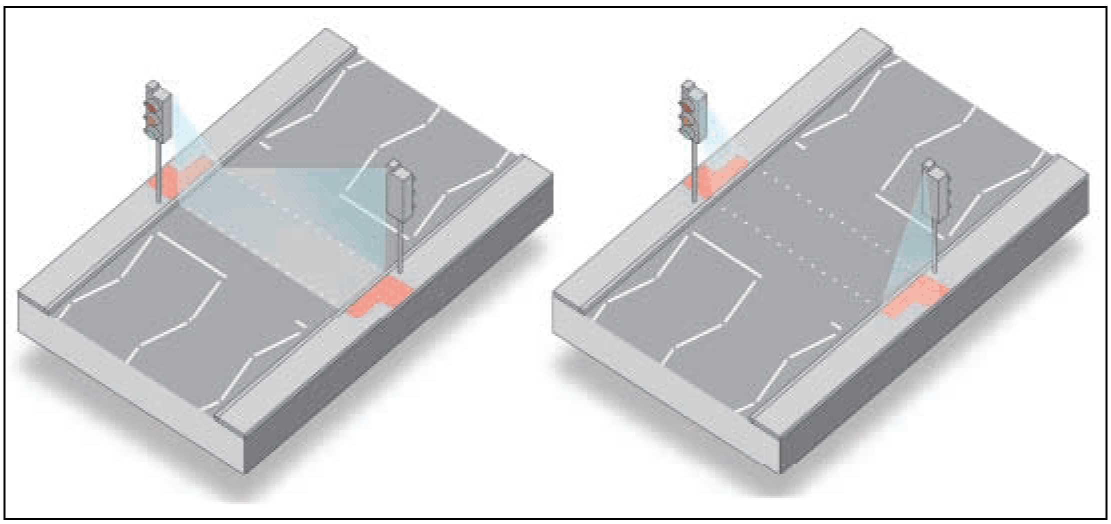

Fig. 1. On Crossing Pedestrian Detection (Left) and Curbside Pedestrian Detection (Right)
Red denotes pressure sensitive mats.

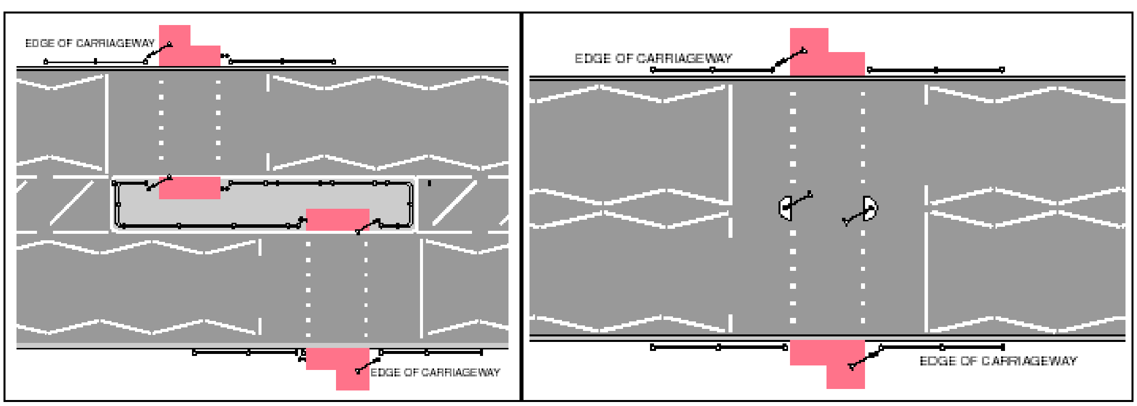

Fig 2. Double carriageway crossing for a wide street condition (left) and with a central refuge (right)

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Hopkinson, P. G., Development of traffic calming in a heavily-trafficked shopping street, Traffic engineering & control, Vol. 30, no. 10, Oct.1989, p. 482-486.

Tolley, Rodney (Editor), The greening of urban transport: planning for walking and cycling in western cities, Rodney, Chichester ; New York : Wiley, 1997.

Web resources

The UK Dept. of Transportation's "Puffin pedestrian crossings" - http://www.roads.dft.gov.uk/roadnetwork/ditm/tal/signs/01_02/index.htm

Recent research on traffic calming practices - http://www.tfhrc.gov/safety/pedbike/pedbike.htm

A walking lobby group website - http://www.walkinginfo.org/

Contacts

The Department for Transport, Local Government and the Regions, Traffic Management Division, Zone 3/25, Great Minster House, 76 Marsham Street, London SW1P 4DR, Tel: 020 7944 2599

The Highways Agency, QS TSS (TCSL) Traffic Control Systems and Lighting, Temple Quay House, 2 The Square, Temple Quay, Bristol, BS1 6HA

Federal Highway Administration, Turner-Fairbank Highway Research Center, 6300 Georgetown Pike, McLean, VA 22101-2296, (Authors of quoted study – Ronald Hughes, Herman Huang, Charles Zegeer, and Michael Cynecki)

Signal Detectors and Signal Timing for Bicycles

Background

Many traffic signals are designed to detect vehicles and change signal timing to accommodate desired traffic movements. Detector technology also can be used to recognize bike presence on approaches and in intersections, allowing light changes and timing adjustments that result in safer, easier bicycling. Advanced signal timing plans also can give bikes priority treatment.

Bike detection can be used to give cyclists an advantage in making left turns or proceeding through a large, complex intersection. These are movements that can be hard for cyclists to make in heavy, fast moving traffic. On streets with heavy bike use, a left turn lane for bikes can be installed and equipped with detectors that identify the presence of bicycles and adjust signal timing accordingly - allowing enough time for bikes to clear the intersection. Alternatively, a bike stop line can be established in front of the motor vehicle stop line, with detectors installed to trigger special bike signals that allow cyclists to get a head start. In addition, where bike use is high, signals can be timed so that bikes can keep up with the general flow of traffic.

At lower-volume intersections, traffic-actuated (sometimes called demand-actuated) signals may be set to remain green in the primary traffic direction until a vehicle arrives at the cross street and is identified by a detector in the pavement, triggering the light to change. When detectors are not set to recognize bikes, a cyclist approaching a red light at such an intersection must either wait for a motor vehicle to appear and actuate the signal change, or dismount and press the pedestrian button to trigger a signal change. Setting detectors to recognize bikes - or using a detector technology that does so - will solve this problem.

Loop detectors, the most often used detector technology, are designed to work primarily as metal detectors. Several "wraps" of wire are set in sawcut grooves into the street and are connected to the traffic signal controller cabinet on the sidewalk. When any metallic object – steel, aluminum, or an alloy - within the field of these loops is detected, the signal turns green. As the system is not designed to work by pressure, the weight of the vehicle has little bearing on detection. However, some detectors require the metal to cross two wires, and in general, the closer to the "wires" the metal is, the greater the likelihood of its detection. Bikes may not trigger a loop detector unless the bike is positioned carefully and the detector is set to be sensitive to a bike-quantity of metal. To help make the system work for bikes, the street is stenciled with the picture of bicycle and a line that demarks where the bicycle should be positioned to be detected. Bike positioning varies with the type of loop detector used - see Fig. 1.

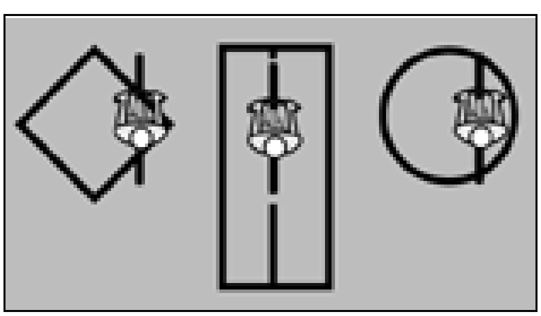

Figure 1. Common Loop Detector Configurations and Bicycle Positioning for Detection

An alternative approach is to replace loop detectors with infrared or video systems for vehicle detection, since bikes are readily detected by these technologies.

Advantages

- The use of bike-sensitive detectors and signal timings can give priority treatment to cyclists where bike use is high, supporting and promoting this mode of travel and increasing its safety and comfort.
- Bike-sensitive detectors can make intersections with traffic-actuated signals far easier and more comfortable for bicyclists to go through.
- Cyclists sometimes run a red light if the light does not change in a reasonable amount of time. This is dangerous and can lead to accidents. Therefore, providing bike actuation at traffic-actuated signals can reduce illegal maneuvers and improve safety.

Limitations

- Loop detectors need to be "set to" detect bicycles. Detectors need to be sensitive enough to pick up bikes in their lane, but not sensitive enough to pick up traffic in adjacent lanes. This is not always easy to do. Sometimes tilting the bike nearly flat on the loops works because it gets the metal portion closer to the wire. Some bikers hang a magnet to the bottom bracket of the bicycle frame to increase detection
- Loop detectors must be maintained and sometimes must be retuned. 3-15% of detector loops fail annually.[1] In addition, maintenance practices should check sensitivity to bicycles, not just to motor vehicles.
- While infrared or video systems detect bikes under normal circumstances, they can be blocked by parked cars, overhanging trees, etc.

Examples

- The City of Berkeley, CA uses bike-sensitive loop detectors on side streets along several arterials where isolated actuated signals are installed at intersections with local streets. The bike-sensitive detectors improve safety and convenience for cylists as well as motorists using the side streets, while maintaining traffic flow on the arterials. Berkeley also has developed a series of "Bike Boulevards" where bike use is facilitated through systematic, route-long application of clear bike pavement marking and signage, replacement of stop signs with yield signs, signal placement to allow easy visibility by cyclists, and use of bike detectors and signal timing that allow bikes to clear intersections safely.

- The City of Portland, OR uses bike detectors and bike priority treatments on numerous signalized streets in its downtown. Signals are timed for speeds of 12-16 mph, allowing bikes to move at the speed of traffic.

[1] Howe-Steiger, Linda, *Staying in the Loop*, ITS. Univ. of California Berkeley Newsletter, Fall 2001.

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DeRobertis, Michelle, Wachtel, Alan, **Traffic calming: do's and don'ts to encourage bicycling**, Institute of Transportation Engineers, Compendium of technical papers for the 66th ITE annual meeting, Minneapolis, 1996, p. 498-503. [Washington, DC: Institute of Transportation Engineers]

Manual on Uniform Traffic Control Devices, Part 9, Traffic Controls for Bicycle Facilities. 2000 Ed.

Federal Highway Administration, Implementing Bicycle Improvements at the Local Level, Publication No. FHWA-98-105.

Web resources

A bicycle lobby website - http://www.bicyclinginfo.org/

A bike advocacy group talking about loop detectors - http://www.bikealameda.org/

An overview of bicycle loop detection in Santa Cruz, CA - http://www.ci.santa-cruz.ca.us/pw/trafeng/bikedet.pdf

Contacts

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Transportation Management Systems

According to the Intelligent Transportation Systems National Architecture developed by the US Department of Transportation [1], Travel and Traffic Management Systems encompass.

- Pre Trip Travel Information
- En Route Driver Information
- Traveler Services Information
- Route Guidance
- Ride Matching and Reservation
- Incident Management
- Travel Demand Management
- Traffic Control

This section looks at the five tools used to implement these principles in California :

- Highway Advisory Radio
- Changeable Message Signs
- Ramp Meters
- Road Weather Information Systems
- Transportation Control Centers

Reference:

1. “The National Architecture for ITS: A Framework for Integrated Transportation into the 21st Century.” US DOT, April 96. Accessed on-line at www.its.dot.gov/arch/brochure.htm

Ramp Meters

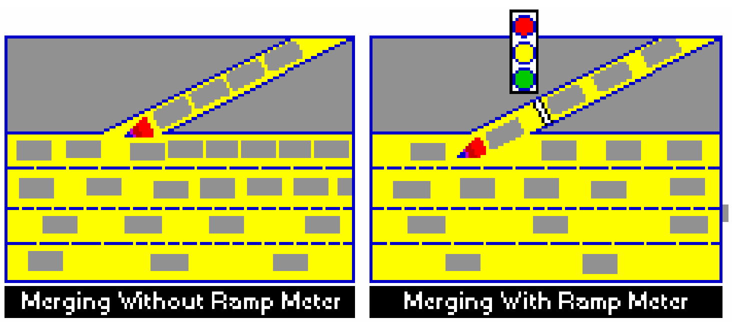
Description

Ramp meters are devices to control traffic entering a limited-access freeway. In almost all cases, they are red-green (no yellow phase) traffic lights, with one light for each lane on the entrance ramp. Ramp meters have varying degrees of responsiveness to mainline (freeway) traffic conditions. At the simplest, a ramp meter can be programmed to turn on and off at a certain time and discharge vehicles at a fixed rate, while the most sophisticated meter completely tunes itself to the traffic over the whole network by varying its discharge rate and when it turns on and off.

The basic set of technologies needed for ramp meters includes a vehicle detection system and a microcomputer to control the process. Several different technologies can be used. Table 1, presented at the end of this summary, describes these technologies.

Ramp meters operate under the principle that by requiring vehicles to enter a crowded freeway in a controlled manner, less disruption to traffic flow will occur. traffic. Figure 1 demonstrates how, without ramp meters, cars will try to merge all at once, forcing mainline traffic to slow. Ramp meters carefully space the traffic entering the highway, allowing them to merge more smoothly with less disruption to mainline traffic.

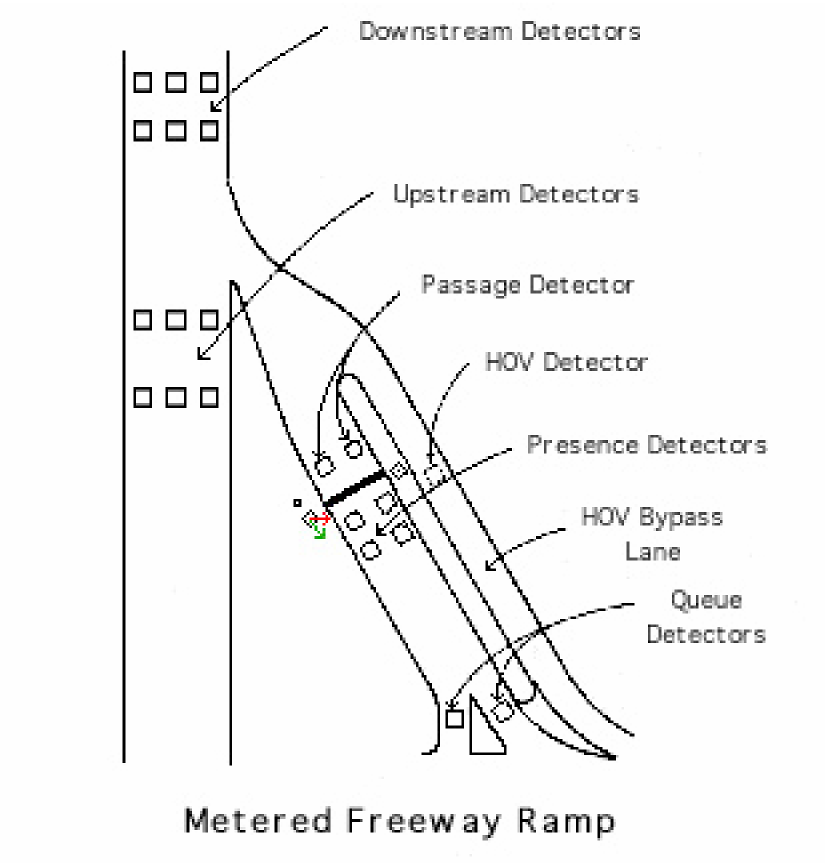
Figure 1. Merging with and without ramp meters



Source: Washington State DOT
(www.wsdot.wa.gov/regions/Northwest)

Figure 2 shows a typical layout for the various components used in a ramp metering application. Note that detectors can be used to identify a queue that threatens to back up from the ramp onto the access street. This allows the metering rate to be adjusted, or the meters to be turned off, if necessary, to avoid creating a problem on the access street. Also note that a bypass lane can be provided for high occupancy vehicles, giving them a time advantage.

Figure 2 Ramp Meter Layout



Source: PATH web site
www.path.berkeley.edu/~leap/TTM/Traffic_Control/control.html#On-Ramp

Benefits

Ramp meters are based on a simple trade-off: a short wait on the ramp allows drivers to save time overall while driving on the freeway. Ramp meters smooth the traffic flow, decreasing congestion and increasing the throughput of the system by increasing average speeds. Travel time reliability is also increased.

> “In practice metering shortens the duration of congestion and improves overall traffic conditions. There is evidence that metering increases throughput, as many metered highways sustain peak volumes well in excess of 2,100 vph (flows up to 2450 vph have been achieved). By eliminating the stop-and-go behavior associated with congestion, metering can also result in up to 50% increases in speed and up to a 30% reduction in accidents. While diversion is an important metering concern, empirical results suggest no more than 5-10% of vehicles will be diverted” [1].

Cambridge Systematics, Inc, recently concluded a detailed study of the effectiveness of ramp meters in the Minneapolis/St Paul region. This study suggested the average travel times are reduced by 12-20% with ramp meters, that throughput increases by 20%, and that accidents are 26% higher without ramp meters [2].

Applications to Date – Examples

Ramp meters are in wide deployment all over the country. California has well over 1000 ramp meters in operation [3].

Limitations

The following chart, from the PATH web site [1], provides a good summary of ramp metering potential limitations.

Potential Cost	Description
Diversion	Diversion involves the diversion of trips from the freeway to alternate surface network routes. Factors which influence diversion include O-D patterns, trip length, ramp delays, and the quality of alternate routes. Conceptually, freeways were not designed for short trips, so diversion may be desirable if surface streets are under utilized. Even if alternate routes do not exist, experiences in Virginia, Chicago, and Denver indicate that metering can still be effective.
Equity	Because ramp metering favors through traffic, metering benefits longer trips at the expense of "local" motorists. Trips may be diverted to local surface streets, and residents close to the CBD may be deprived of access given to suburban dwellers. In Milwaukee, where equity proved to be a delicate subject, metering rates were adjusted so that delay to the average motorist was the same on close-in ramps and on outlying ramps.
Installation and Maintenance Costs	Depending on existing ramp configuration and the size of the system, capital and maintenance costs can be sizable. Ramp metering systems typically have high costs associated with the communication medium connecting the ramps to the control center.
On-Ramp Emissions	Local emissions near the ramp may increase from stop-and-go conditions and vehicle queuing on the ramp.
Promotes Longer Trips	There is evidence that metering results in longer trips replacing shorter trips, as those trips taking up critical bottleneck capacity are also likely to use the long uncongested upstream or downstream freeway sections. Such catering to longer trips can have negative feedback effects, encouraging rather than discouraging commutes from further out.
Ramp Delay and Spill Back	Queues which back up onto adjacent arterial streets can adversely affect the surface network. Those vehicles which use the ramp are delayed as they pass through the meter.
Public Opposition	In addition to physical requirements of the ramp, the feasibility of implementing ramp metering control is dependent on public acceptance of ramp metering. The issue of public acceptance is critical, as the public is bound to be critical of a new installation.
Transfer of Land Values	Users who have been accustomed to ready freeway access may be rerouted in favor of new users, which can cause land values to change.

Table 1. Detector Technologies

Technology	One-lane ($)	Four-lane ($)	Pluses	Minuses
Radar	1500	4000	Good performance in inclement weather Direct measurement of speed	Requires narrow-beam antenna to confine footprint to single lane in forward-looking mode
Acoustic	3500	14000	Potential for identifying specific vehicle types by their acoustic signature	Signal processing of energy received by the array is required to remove extraneous background sounds and to identify vehicles
Laser				
VIP	17000-25000	26000-75000	Provides visible imagery with potential for incident management Single camera and processor can service multiple lanes Rich array of traffic data available	Large vehicles can mask trailing smaller vehicles Shadows, reflections from wet pavement, and day/night transitions can result in missed or false detections
Microwave	700		Good performance in inclement weather Direct measurement of speed	Requires narrow-beam antenna to confine footprint to single lane in forward-looking mode
Ultrasonic	2500	8500	Compact size, ease of installation	Performance may be degraded by variations in temperature and air turbulence
Magnetic	1500	3500	Can detect small vehicles, including bicycles Useful where loops cannot be installed	Difficulty in discriminating longitudinal separation between closely spaced vehicles
Loop	1000	3000	Standardization of loop amplifier electronics Excellent counting accuracy Mature, well understood technology	Reliability and useful life are a strong function of installation procedures Traffic interrupted for repair and installation Decreases life of pavement Susceptible to damage by heavy vehicles, road repair, and utilities
Infrared	7200	16000	Greater viewing distance in fog than with visible-wavelength sensors	Performance potentially degraded by heavy rain or snow
Peizo-electric	17500	40000	NA	NA
Bending plate	33000	75000	NA	NA

Source: New Mexico State University Vehicle Detector Clearinghouse (ww.nmsu.edu/~traffic

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www.path.berkeley.edu/~leap/TTM/Traffic_Control/control.html#On-Ramp
"Twin Cities Ramp Meter Evaluation. Executive Summary." Cambridge Systematics, Inc. Feb, 2001; ww.dot.state.mn.us/rampmeterstudy/pdf/execsummary/executivesummary.pdf
Database provided by Caltrans Transportation Systems Management Program

Transportation Management Centers

Description

"The Traffic or Transportation Management Center (TMC) is the hub of a transportation management system, where information about the transportation network is collected and combined with other operational and control data to manage the transportation network and to produce traveler information.

It is the focal point for communicating transportation-related information to the media and the motoring public, a place where agencies can coordinate their responses to transportation situations and conditions.

The TMC links various elements of Intelligent Transportation Systems such as variable message signs, closed circuit video equipment, roadside count stations, enabling decision makers to identify and react to an incident in a timely manner based on real-time data" [1].

The TMC is itself not a technology but rather a place for managing all other components of a transportation management system. In one sense, it is a building, housing all the computers, monitors, and communications equipment. In another sense, it is the various personnel from different agencies who operate in the TMC.

Benefits

"TMCs can help reduce incident response times, lower incident rates (mainly secondary incidents), disseminate traveler information and hence reduce congestion and enhance safety. To date there is little data quantifying the exact benefits resulting from TMCs. One study conducted by MnDOT reported decrease in accident rates by 25 percent, 20-minute reduction in response time, 35% increase in average speeds (34 mph to 46 mph) during rush hours and 22% increase in capacity of freeways, after the implementation of their TMC." [1].

The PATH web site lists the following benefits.

- Faster incident response and reduction in incident rates.
- By broadcasting traveler information and coordinating their activities with the State Patrol, etc, TMCs have been successful in reducing congestion in freeways and arterials.
- Increases traffic safety by effective incident response and clearance techniques. By providing traveler information regarding incidents it minimizes the likelihood of secondary incidents.
- Enhanced communication in all aspects of transportation management (planning, design, implementation, operation, maintenance).
- Monetary savings by sharing responsibilities between fewer staff, achieved by co-location of participating agencies at the center.
- Agencies working closely together in a TMC typically produce a more consistent, unified response to a situation, increasing the overall effectiveness of the transportation resources.

Applications to Date – Examples

The TMC concept has been implemented at various scales and levels of government. The Borough of Queens (New York City) TMC monitors 6,000 computerized signal lights, 58 traffic video surveillance cameras, and 7 variable message signs [2]. The Central Valley TMC in

California monitors 2030 miles of highway in a huge area covering Madera, Fresno, Tulare, Kings, and Kern Counties, including Yosemite National Park [3]. TMCs also operate at the citywide scale in large cities such as Seattle, Minneapolis/St Paul, and San Diego, countywide in Bay County, Florida and Montgomery County, Maryland, and region-wide such as the Research Triangle of North Carolina (to provide a few examples). Rhode Island DOT has a TMC for the entire state.

Limitations

Implementing a TMC entails considerable cost. Some costs include conception, design and implementation of the TMC and the capital costs associated with the facility. The Houston TranStar is located in a $11.5 million, 52,000 sq. ft. building [1]. In addition, there are substantial operational costs. For example, the yearly operation budget for the Seattle TMC is in the range of $1.4 million, and that for San Antonio ranges from $700,000 to $1 million [1].

Not surprisingly, an entity touching disparate governmental agencies as well as various areas of the private sector is subject to daunting organizational challenges. Roles must be clear and communication and coordination is vital. Of course, this is easier said than done. The TMC might be seen as a way of optimizing efficiency by the engineering community, but the law enforcement community might see it as using funds that could put an extra patrol car on the road. Further, there are challenges in managing a complex technological environment.

References

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www.ci.nyc.ny.us/html/nypd/html/transportation/traffic.html

Caltrans District 6 Central Valley Transportation Management Center web site.
www.dot.ca.gov/dist6/tmc/tmcresc.htm

Integrated Transportation Management - Traveler Information Systems Centers

Background

Transportation Management - Traveler Information Centers use data from monitoring systems (sensors, monitors, cameras, GPS, etc). to manage a variety of facilities effectively and to provide accurate traveler information. While various applications have incorporated different components, many systems include arterial and freeway monitoring, variable message signs, ramp metering, automated incident response (police, emergency services), arterial signal control, transit vehicle locator systems, and traveler information available on line and by telephone, cell phone and PDA. Centers also may handle planning, design, construction, inspection, operations, and maintenance for the ITS applications run through the Center, and may conduct field tests of new equipment and control strategies.

Benefits

Combined transportation management-traveler information centers provide a one-stop source for travel information. This convenience has been well-received by the public.

When multiple transportation management systems are well integrated, reduced delays, emissions, and fuel use result, since freeways and arterials can be managed together and to reduce the deleterious effects of incidents, construction, and special events. However, center operators have reported that placing cameras on both arterials and freeways is valuable, even if the center is responsible only for managing traffic on freeways; the cameras on arterials can help better anticipate freeway conditions.

Adding planning, design, operations and maintenance of ITS equipment to transportation management - information centers can result in additional efficiencies.

Limitations

The costs of establishing a multipurpose transportation management and information systems center are quite high. Smaller metropolitan areas may lack the level of funding necessary to develop fully integrated centers. (Smaller metropolitan areas may also lack the level of travel delay that provides the impetus for development of such centers.)

In many metropolitan areas, establishing a combined center also requires substantial investment in consensus-building on the mission, vision, and performance objectives of the operation, as the objectives of the various participants may differ in some respects. Incomplete integration of freeways and surface streets management, or the management of an incomplete highway network, results in less effective systems operations.

Local governments and the public may be concerned about integrated freeway-arterial management causing heavy traffic on arterials or excessive delays at on-ramps. However, participatory planning can help develop an acceptable outcome for all concerned, and systems can be operated to produce a more equitable distribution of traffic. For example, Minneapolis is developing a dynamic / real time control system for ramp meters that will prevent traffic back-ups on local streets and more evenly allocate freeway access between suburban and urban core communities

Examples

Houston - TranStar
http://traffic.tamu.edu

Transtar is a multi-agency, multi-jurisdictional enterprise that pools financial resources and brings together personnel and job duties in a single center, creating a seamless transportation management and emergency services system. The system is designed to manage over 300 miles of freeway, more than 100 ramp meters, variable message signs, traffic cameras, traffic signal systems encompassing 2800 signals, emergency response teams, and weather alerts.

The public can get traffic information from the system at a website, with speed maps, real time speed charts along route segments, traffic cameras, and construction and closure information.

Maryland - Coordinated Highways Action Response Team (CHART)
http://www.chart.state.md.us/travinfo/travinfo.asp

CHART is a multi-agency partnership that links state and local transportation agencies with state law enforcement. It combines a centralized statewide operations center with satellite traffic operations centers spread across the state to handle peak-period traffic. The system includes 97 speed detectors, 33 loop detectors, 34 cameras, and 44 weather sensors along 550 miles of the state's busiest highways and arterials.

Montgomery County Maryland – Comprehensive Transportation Management Center with Traffic Responsive Signal System

Montgomery County's Transportation Management Center is linked to the State of Maryland's CHART program. The responsive signal system started with 10 intersections in 1980 and now controls all of the County-maintained traffic signals (700+), The TMC can provide traffic-responsive signal control, special events overrides, and priority treatment for the County's 200-bus flee, which are equipped with GPS-based automatic vehicle location equipment.. The system is capable of monitoring sampling detectors of various types and provides real-time geographic information system and graphical user interfaces. The County reports substantial benefits from its integrated system, including increases in rush hour travel speeds of 14-20%, decreased vehicle delay of 17-37%, and 12-28 % improvements in transit on-time performance. Additionally, on September 11th, the system allowed the County to adjust the signals to account for the unusually heavy traffic flow out of Washington, DC.

References

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IMAJINE - Los Angeles Coordinated Transportation Management

Background

The IMAJINE Project brings together four existing local transportation management facilities in the Los Angeles region:

Caltrans District 7 freeway management system
Los Angeles County Metropolitan Transportation Authority (LAMTA) fixed-route bus operations center and database
Access Service Incorporated (ASI) demand-based paratransit system
City of Los Angeles South Gate arterial traffic signal control system

This project integrates freeway and arterial street operations in the southeast Los Angeles County along with the LAMTA bus operation database. This includes the synchronization of local and state signals, the adjustment of signal coordination to allow minimum delay in transit operations, and coordination of paratransit with fixed route bus operations.

The project successfully completed its final acceptance test in September 2001. This acceptance test incorporated the equipment used to manage system components in each of the agencies, linking already-available ("legacy") systems and the communications network. Also tested was the mechanism for interoperability of systems across modes and jurisdictions in Southern California (an element of the Southern California ITS Priority Corridor).

Benefits

According to participant agencies, IMAJINE has successfully demonstrated that "legacy" systems can be integrated for enhanced system management and service coordination. The interfaces among the systems are in the public domain so that applications can be easily plugged in. Bus priority treatments for the LAMTA's "Rapid Bus" build upon this project, as will future projects. .

Other benefits include the establishment of new organizational relationships, including strengthening ties between ITS planners and implementers. An ongoing Regional ITS Coordinating Committee is overseeing formal evaluation of the system, addressing multiple applications and synergies. The sharing of development efforts among counties and localities has lowered costs and avoided redundancies.

Limitations

Participants report that institutional-organizational issues, not technological issues, are the key limitation. Challenges vary by location and political environment, but include the following:

- The issue of long term technology system operations and maintenance (O&M) funding has not been solved. Technical support resources are limited across the board.
- There is a gap between ITS benefits analysis and common regional performance measures and transportation models

References

Formal evaluation is in progress at the time of this writing and is being carried out by a contractor. Contact Scott Cook at (619) 725 – 6561.

PeMS

Description

PeMS - short for Performance Measurement System - is a software system that collects and stores data from loop detectors on California freeway lanes (including High Occupancy Vehicle lanes) and converts the data into information that can be used by transportation managers. PeMS aggregates flow and occupancy data from the detectors to produce lane speed, flow and occupancy reports and to compute basic performance measures such as congestion delay, vehicle miles traveled, vehicle hours traveled, and travel times between locations. These traffic data can be related to geometrics and other databases for freeway sections to produce a variety of additional analyses.

PeMS data can be used by traffic managers to track trends, identify and analyze bottlenecks, investigate speed-performance relationships, and account for statistical fluctuations in measurements. Studies of the efficacy of measures such as ramp metering can be carried out through simulations with PeMS or by using PeMS data with simulation models like CORSIM or Paramics.

Benefits

PeMS makes detector data useful for a variety of policy, planning, analysis, operations purposes. This in turn makes investments in detectors more cost-effective.,

The PeMS data are far more accurate and reliable than data collected using traditional methods such as floating car studies.

PeMS' ability to produce data in formats needed for required reports should make reporting faster and easier.

Limitations

PeMS is not yet in widespread use and many offices that potentially could benefit from it are not yet trained to use it.

References

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ITS Benefit-Cost Analysis: IDAS

Background and Description

The ITS Deployment Analysis System (IDAS) has been developed as an ITS cost-benefit analysis sketch planning tool. IDAS uses the output from transportation planning models - files that describe the regional transportation network in terms of nodes, links, and trips from each origin to each destination for the forecast year - as the base-case. The user then selects from a list of ITS components and "deploys" one or more by dragging and dropping the ITS components onto a graphical depiction of the network. Over sixty different ITS components such as ramp metering, transit priority treatment, incident management, arterial traffic management, and traveler information can be tested. IDAS determines the new travel patterns that emerge as a result of the ITS additions, using its own travel demand model. Benefits and costs of the ITS additions then are calculated and compared to the base case.

Cost and benefit values built into the model (default values) are based on research studies; the user can change the values to reflect local findings. Travel time, reliability, safety, air quality, energy savings, and noise reductions are among the benefits calculated; costs include the annualized costs of equipment, operation and maintenance. Benefits and costs are all monetized for calculating overall savings. Again, users can adjust the monetary values (e.g., value of time). Sensitivity analyses can be conducted by varying cost and benefit values, deployment levels, etc.

IDAS was developed with federal funds and model maintenance and updates continue to be funded. Training courses are available though the US DOT's National Highway Institute.

Benefits

The software provides a flexible, relatively easy-to-use means of developing cost-benefit information for a specific transportation network.

Limitations

The IDAS software depends on input from a regional or local travel demand model.

Familiarity with travel demand models is needed to set up IDAS, although once set up others with less modeling experience can use the software. Run time can be substantial for complex networks and applications.

References

http://www.fhwa.dot.gov//////environment//cmaqeat/descriptions_idas.htm

The IDAS software can be purchased at the McTrans Software Center at the University of Florida. http://mctrans.ce.ufl.edu

Smart Corridors

Background

The term "smart corridor" refers to the use of a suite of information technologies to enhance performance of existing facilities along a regional transportation corridor. Typical technologies used include advanced traffic signal timing, variable message signs, transit signal preemption, and video incident detection. Coordinated management of freeways and arterials in the corridor can be accomplished by operating ramp meter signals and freeway information systems as part of the overall system management strategy. Where transit is part of the corridor, transit priority treatments and transit information systems at stops and on-line also can be incorporated. Technologies to enhance biking and increase pedestrian safety can be included as well.

Advantages

Smart corridors are designed to increase the overall capacity of the corridor with less capital expenditure than would be needed to add new lanes. Smart corridor applications make use of relatively well established technologies to deliver improvements, so are fairly straightforward to implement from a technology perspective. The technology improvements may appropriately be coupled with physical design changes such as intersection redesign or the addition of median transitways in some cases. Systems operation plans are based on cooperative agreements reached among the owners and operators of the various facilities and ser ices involved in the corridor.

Limitations

Interconnecting many different information technologies presents both administrative and technological challenges. For example, linking traffic signals to transit operations and information requires not only advanced technology but staff in both agencies that can deal with the operation and maintenance of the new technology. In addition, when multiple jurisdictions are involved, there is potential for disagreement over priorities and approaches that can make joint operation difficult to achieve. In addition, while one of the selling points of smart corridors is that they require low capital investments, it may in fact be necessary or desirable to upgrade signal equipment, add new traffic control centers, purchase new transit equipment, and so on in order to capture the full benefits of corridor enhancements.

Examples

Alameda County is currently moving forward on two smart corridors, both expected to be complete in January 2003. The first, the San Pablo Avenue/I-80 corridor, runs from Oakland to Pinole, and is designed to not only improve performance along those notoriously congested routes, but also to minimize the intrusion of freeway traffic onto local streets due to I-80 congestion and incidents, and to proactively manage traffic already diverted from the freeway to minimize its impact on local arterials, and return regional traffic back to the freeway as soon as possible. The San Pablo Avenue corridor involves 15 different local governments, which is one reason why the project has taken almost seven years to reach completion.

The second is the International Boulevard/E. 14th Street/San Leandro Street/Hesperian Boulevard/Union City Boulevard/I-880 corridor, which runs south from Oakland to Union City. Here the smart corridor project is designed to improve traffic signal coordination and reduce delays along the corridor, and to be responsive to fluctuations in travel demand.

Both corridors will have dynamic message signs along the corridor to alert motorists of any changing conditions. Similarly, there is a large administrative or jurisdictional burden.

References

www.smartcorridors.net

Alameda County Congestion Management Agency SMART Corridors Program, at www.accma.ca.gov/pdf/scp_doc.pdf

Electronic Toll Collection

Background

Electronic toll collection is designed to permit tolls to be collected automatically, without the vehicle having to stop. Account information on an electronic tag (transponder) installed in or on the vehicle is read by a receiving antenna at the toll plaza. The toll is electronically deducted from the pass holder's prepaid toll account. The toll tag value can be replenished either by cash payment or automatically from a credit card or bank account.

Benefits

Electronic toll collection is a convenience for motorists, who do not need to carry cash or dig it out for payment at toll booths. Electronic toll collection also greatly increases throughput at toll plazas and thus reduces congestion and its negative effects - wasted time and the heavier pollution and energy consumption that stop and go driving produce. For facility operators, costs of electronic toll collection are lower than that of manned toll booths because equipment and processing costs are less than labor costs for the manned booths approach.

The technologies for electronic toll collection also allow a variety of pricing systems to be deployed, including frequent traveler discounts, off-peak discounts, and credit card payment discounts. Congestion pricing also can be implemented by coupling electronic toll collection technologies with roadway detectors or monitors that measure speeds and flows (the amount of traffic) on the facility.

Limitations

Labor issues have delayed the implementation of electronic toll collection in some states, but those issues have mostly been resolved in the states using ETC. There remains debate over safe speeds for traveling through the toll plaza, particularly in applications where manned toll booths are also present.

Example: E-Z Pass, Seven Northeastern States

E-Z Pass is an electronic toll collection system that has been in operation in the Northeast since 1993. It now extends to seven states - New York, New Jersey, Delaware, Pennsylvania, Maryland, Massachusetts, and West Virginia - and covers 700 toll lanes along 415 miles of toll roads, bridges, and tunnels.

An E-Z Pass transponder can be obtained for a truck or car registered in any state. The tag is associated with a particular vehicle or set of vehicles, not the driver or applicant. The application for the pass is available on line, in hard copy, or by telephone.

The fee for an E-Z Pass is $10 (refundable) for cash/check customers and is waived for credit card customers. The minimum deposit is $25. Balance statements are mailed out monthly for the first six months and bimonthly after that, except when there is no activity. Customers can check their account balances by calling a toll free number or accessing the E-Z Pass website using a Personal Identification Number (PIN). Credit card customers' accounts are automatically replenished; other customers can mail in a check or pay by cash at a service center. Use of a tag to with a negative balance results in an administrative fee of up to $25. Defective tags are replaced without fee and lost or stolen tags are replaced for a fee of $22.50 ($28 for an external tag.)

A variety of discounts are available for E-Z Pass users, as determined by individual participating agencies. Some discounts are applied automatically and others must be applied for. For example, E-Z Pass users of the New York-New Jersey Port Authority bridges and tunnels receive a one dollar discount during peak periods and a two dollar discount off peak. As another example, annual users of the New York State Thruway receive a substantial discount for prepayment.

E-Z Pass has been estimated to increase capacity of the toll lane by 250-300%, according to the website. At some locations this can translate into time savings of 15-20 minutes.

Example: FasTrak, California Toll Facilities

FasTrak is the trademark used to describe the interoperable electronic toll collection systems operated on all toll facilities in California, by Caltrans (seven toll bridges in the Bay Area), the Golden Gate Bridge Authority, the Southern California Transportation Corridor Agencies (Orange County toll roads), and State Route91 and I-15 toll lane operators. FasTrak uses electronic toll collection technology - transponders and receiving antennas- for toll payment, backed up by cameras that record license numbers of violators. Applications can be downloaded from a website or requested by phone or mail.

FasTrak requires a deposit of $20 per transponder for cash/check accounts but waives the deposit for the first three transponders for credit accounts. The minimum opening balance is $30. The account is replenished automatically for credit card users and is billed for cash/check users, with the biling amounts based on average use records.

References

www.ezpass.com

www.caltrans.dot.gov/fastrak

Example: I-15 Congestion Pricing and Managed Lane Concepts, San Diego

Congestion pricing is helping to manage commuter traffic flow on an eight-mile stretch of Interstate Highway 15 (I-15) in northern San Diego County. Since 1988, this highway has contained two express lanes that can be used, free of charge, by high occupancy vehicles (HOVs) - vehicles with two or more occupants. The express lanes are accessible at their termini only, with no intermediate access points. Because the lanes were underutilized while adjacent lanes remained congested, since December 1996 single-occupancy vehicles (SOVs) have been allowed to use the express lanes for a fee (toll.). HOVs continue to travel free.

In the first six months of the project, SOVs were allowed to purchase a monthly permit, priced at a fixed $50/month, to use the express lanes. Electronic toll technology (ETC) was introduced in June 1997. About a year into the project, the electronic toll technology was used together with traffic sensor technologies to vary the toll depending on the time of day, the level of congestion, and travel time saved. Solo drivers must have a FasTrak electronic toll collection account and transponder to take advantage of the toll lane.

The tolling system is a variation on congestion pricing called "discount pricing". A toll schedule is established to reflect the typical amount of traffic at different times of day; tolls can vary every 15 minutes from 5:45 am to 7 pm as well as by day of week. The minimum toll is 50 cents and under normal conditions the most that a motorist would pay is $4.00. The toll could be as high as $8.00, however, if the road sensors detect extremely heavy traffic. If traffic is lighter than usual a discount off the typical toll is given. An electronic sign located before the entrance to the I-15 Express Lanes gives motorists advance notice of the current toll as they approach the lanes. Revenues from the tolls are targeted for mass transit and car pool service improvements along the I-15 corridor.

Recognizing that traffic continues to grow rapidly in the I-15 corridor and that it is highly directional, southbound in the morning and northbound in the evening, San Diego transportation officials are currently developing a broader concept of Managed Lanes that would take a flexible view of roadway configurations. The median express lanes would be expanded to four. Then, in addition to using congestion pricing and the latest technologies to maintain traffic flow, identify and clear accidents, etc., I-15 managers would make adjustments to the road configuration using movable concrete barriers to make additional lanes available in the peak direction as needed. The approach also could be used in case of special events or emergencies.

References

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Managed Lanes: www.dot.ca.gov/dist11/I15managed/news/manlanes.htm; www.dot.ca.gov/dist11/I15managed/15home.htm

Contact Persons

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I-15 Managed Lanes Project:Project Contact: Olga Estrada, (619) 688-2556, Olga_Gonzalez-Estrada@dot.ca.gov (Caltrans District 11)

Example: SR-91 Congestion Pricing

California State Route (SR) 91 (Figure 1) is a twelve-lane freeway connecting the employment centers of Orange County to the residential developments of Riverside County. Rapid growth in commuting in this corridor during the last two decades has put a severe strain on SR-91; no alternate routes are available through the mountainous terrain [Kazuya, 1999] By the mid-1990s the average commuting time on SR-91 had grown to over an hour a day each way, almost three times the national average [Sullivan, 1996].

Figure 1. Regional Location, SR91

Congestion and the lack of an alternative route created the context for the SR 91 expansion project: On December 27, 1995, four 10-mile toll lanes in the median of the existing freeway were opened (Figure 2).

Figure 2. New lanes on SR-91

Advantages

SR 91 has a number of innovative features:

- Tolls vary by time of day based on expected congestion in the corridor.
- The facility is fully automated: all users must be registered customers and carry FasTrak transponders (FasTrak) that identify them
- Camera enforcement is used to identify and ticket violators
- Discounts are used as an incentive for high occupancy vehicles (HOV).
- The facility was developed and is being operated by a private company for profit, in partnersip with Caltrans.

Surveys of users of the toll facility indicate that people from a variety of walks of life make use of the toll road for its fast service, at least on occasion.

Limitations

The SR 91 toll road has raised concerns among some political and community leaders about the equity of tolls.

Contact

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References

SR-91 website: www.91expresslanes.com
ITS America website (search for SR-91): www.itsa.org

Road Weather Information Systems

Description

A Road Weather Information System (RWIS) consists of sensors installed in the travel lanes of the highway that measure the temperature of the pavement. Atmospheric sensors are placed adjacent to the pavement and measure air temperature, relative humidity, wind speed and direction, precipitation type, intensity and rate, and the driver's perception of visibility [1]. Often, the sensors are bundled together into a remote processing unit, which also sends the data to a central server. By applying models based on current and historical climatological data, technicians can determine the weather conditions at that road location and, more importantly, to determine the likelihood of ice forming on the road and the need to plow snow.

There are a myriad of technologies used in the actual sensors themselves, ranging from infrared spectral cameras to electric thermostats.

Benefits

This information can be used two ways. First, it lets roadway operators better manage snow removal and de-icing operations. For example, Nevada DOT was able to reduce road salting by 73%, which is important in environmentally-sensitive regions like Lake Tahoe [2]. It also lets road maintenance managers more effectively utilize manpower and equipment, especially during periods of harsh weather [3]. Conditions are monitored remotely, so a snowplow team based in, say, Placerville need not drive up to South Lake Tahoe to plow if there is no snow.

Second, motorists can use the information to plan routes. The information can be broadcast on Highway Advisory Radio, displayed on Changeable Message Signs, or be available at telephone hotlines. Also, many agencies operate web sites with the information. Caltrans includes it with its road reports. A company called Surface Systems, Inc. has a web site with links to RWIS information in all states that have them (www.roadweather.com).

Applications to Date – Examples

At least 27 states have implemented RWIS in some form [1].

Caltrans maintains 63 RWIS locations throughout the state [4]. Figure 1 shows the locations.

Limitations

A Road Weather Information System is rather limited in application. It is best in climates that get a lot of snow. Also, current technology is very expensive. The remote processing units mentioned above cost on average $40,000 per unit, with a life span of 5 to 6 years [5]. Each individual RWIS location can have more than one remote processing unit, so it is easy to see how the costs can mount up. One problem with implementing RWIS at a new location is the development and fine-tuning of the climatological models [5]. These models also require a lot of computing power to run, which drives up the cost. The Washington State DOT model, for example, required $700,000 of computer hardware [6]

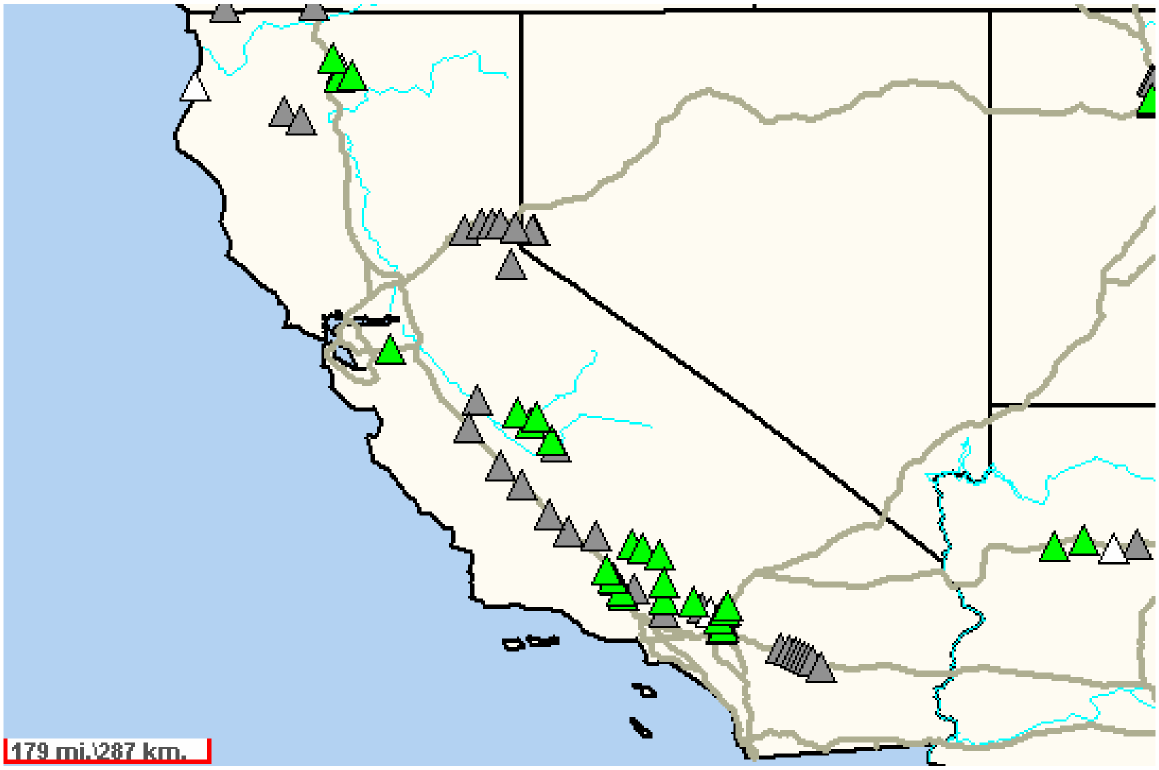

Figure 1. RWIS Locations in California

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www.nawgits.com/icdn/rweather.html.

Smart Snowplowing

New technologies are being used to help snowplow operators locate road boundaries and obstacles in blizzards, when visibility is almost zero. Several technologies are being tested ; some are installed in the vehicle, others in the road. The technologies include:

- GPS that provides accurate information on the road centerlane and edge
- Forward, rear, and side radar systems that identify objects and provide visual and audible alerts (collision warnings)
- Magnetic "nails" that mark the edge and center of pavements
- Smart Tape: magnetized lane-marking tape that can be sensed by vehicles
- Displays that project a representation of lane boundaries on the front window.

Minnesota DOT has been conducting a multiyear test of these technologies on several state highways and interstates. Caltrans is also a partner in these tests.

Smart Emergency Vehicles

Many of the technologies used for lane centering and visibility aids are now being tested in Minnesota. Lateral guidance and collision warnings equipment has been installed on several ambulances and State Patrol squad vehicles. The technology employed includes DGPS, magnetic pavement marking tape, radar detection, a windshield heads-up display, and several types of warning devices. The evaluation was to have been completed by March 2002 but is being extended because it didn't snow much during the scheduled period.

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www.its.umn.edu

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Smart Cards for Automatic Transit Fare Collection

Background

A number of transit operators have used magnetic stripe paper tickets for many years. These tickets typically can be purchased for varying amounts, from a single fare to as much as $50 or $100. Most applications also allow additional cash value to be added, up to a maximum. The user inserts the ticket into a reader at the entry gate, and inserts it again to exit and pay the fare. The readers record the time of entry and exit from the system and deduct a distance-based (sometimes also a time of day-basd) fare from the stored cash value.

While these paper tickets have worked well, there are drawbacks. For example, if the ticket gets wet or torn it can jam or be misread. Thus, credit card-like plastic Smart Cards are being implemented by a growing number of transit agencies as a superior technology for ticketing and fare payment.

Plastic Smart Cards' larger memory allow for flexible data processing and security features. For example, it is possible not only to record cash values and calculate and deduct fares, but to do so for multiple applications - several different transport systems, parking, etc. Other information, such as user identification, also can be stored on the card, adding to its security.

Example: Translink - San Francisco Bay Area, California

TransLink is a multi-operator Smart Card transit fare program in San Francisco Bay Area. Because the region is served by many transit agencies, most operating in only one or two counties, many riders routinely transfer from one transit system to another. These riders have long expressed a desire for a single transit card to smooth their transfers and to eliminate the need to carry exact change or multiple tickets. In response, The Metropolitan Transportation Commission (MTC) worked with transit operators to develop a universal fare card. TransLink is the product of that effort.

TransLink uses a "multiple-interface" card. Users can load cash value onto the card by inserting it into a value -adding machine or can have funds provided automatically through a secure transfer from a bank account or credit card. However, the card is contactless when it comes to being read by a fare machine: the cards can be read when they are waved within 5~6 inches of a reader on a bus or at a gate. The transaction happens in a fraction of a second, allowing fast passenger boarding and alighting.

TransLink is being introduced in two phases. Under a pilot program started in early 2002, TransLink has been made available to a panel of volunteers who can use the smart card on selected routes of the region's largest transit operators (AC Transit, BART, Caltrain, Golden Gate Bus and Ferry Transit, San Fransciso Muni , and Santa Clara County VTA.) In 2003, TransLink equipment will be installed on transit vehicles and at transit stations throughout the Bay Area and will be available to the general public. When fully implemented, the TransLink Smart Card will work on all of the 26 participating transit systems region-wide.

User surveys and focus groups conducted during the pilot program found a high level of satisfaction with the new cards, especially their convenience, automatic value (debit card) features, and plastic medium. On the other hand, concerns were expressed about the ability of the card to be used by others if lost or stolen, and their inability to verify the reliability of the technology. The need for a deposit on first buying a Smart Card also was seen as an irritation and probable impediment to use, especially if regular fare cards not requiring a deposit also remained available.

One objective of the Smart Card plan is service/fare integration. However, debates over how to allocate costs and revenues - "fare share" issues - slowed the implementation of a unified fare policy and continue to be matters of contention. . Staff believe that this fare share issue and related matters of coordination among participating transportation operators are substantially bigger implementation barriers than any of the technololgy issues.

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Contact Persons

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Mr. Jacob Avidon: javidon@mtc.ca.gov [Transportation Analyst/Planner]
General Questions: service@translink.org [Customer Service]

Further Reading/References

Charles River Associates, "Final Report on the TransLink Demonstration"; 2002
TransLink program home website: www.translink.org
TransLink project in MTC: www.mtc.ca.gov/projects/translink/translnk.htm

Example: The Taipei Smart Card, Taipei, Taiwan

The Taipei Smart Card project was initiated by the city's mayor in 1997 to serve the metropolitan area of about six million people. The design concept was derived from the Hong Kong Octopus system: integration of both fares and services by means of a contactless ticketing system for buses, metro,and public off-road car parks. The project began as a city-led effort but has been carried out since March 2000 under the auspices of The Taipei Smart Card Corporation, a public-private partnership involving the number of banks, smart card and software providers, consultants, and transit and ferry companies as well as city government., The City of Taipei, Taipei Rapid Transit Corporation, 13 private bus companies, Taipei Bank, Taishin International Bank, United World Chinese Commercial Bank, Chinatrust Commercial Bank, Mitac Inc., Seaward Leasing Co., Mercuries Data System Ltd., China Engineering Consultants, Inc. and Solomon Smartnet Corp. are partners.

The Taipei Smart card is a contactless type with data storage capacity of 256K. (The magnetic card used before has only 100 bytes of storage.). The large data storage capacity was needed to allow fare integration across the large number of providers in the region. In addition, the card was designed to allow later additions of other services such as cash card applications or possibly an all-in-one ID card/cash card/transit card.

A pilot program started in February 1 2001 (one year before TransLink.) Full implementation was scheduled for June 2002, but only the Taipei subway system, 15 parking lots and 1 bus line were ready for Smart Card operation at that time. The rest of the system came on line during the fall of 2002, with 62 subway stations, 4000 buses, 33 parking lots, 900 posts (locations for adding cash value to cards) and 157 value-adding machines (for cash or credit/bank auto-load) in operation.

Marketing the Smart Card was recognized as a key issue, as staff expected travelers to be somewhat reluctant to try the new technology. The marketing staff therefore tried to make the Smart Card a sensation. The idea was to link the Smart Card with pop culture, giving it a "cool" image. The card's debut was on Christmas 2001 and the Smart Card was sold not only as an integrated transit ticket but also as the ticket for a Coca Cola -sponsored Christmas concert. The ticket itself was a special holiday version designed to be eye-catching. Corporate sponsors helped underwrite the ticket production costs and rock stars promoted it at the concert.

Subsequent marketing events, supported by a budget of about $600,000 a year, included high school dance parties where a Smart Card provided free entry, promotions at shopping centers and subway stations, and one day discounts.. In the first few months, however, Smart Card sales remained sluggish, with about 600 sales a day compared to over 10,000 for the old magnetic tickets. Studies indicated that the requirement for a cash deposit for the initial smart card (about $18) made it less competitive with the still-available magnetic card system. Nevertheless, by October 2002, the daily sales had climbed to about 13,000 a day.

A new promotion, "30 Cents Easy Go!", was initiated on October 10, 2002 (the National Day of Taiwan.) On that date and several other dates in Fall 2002, travelers could ride the subway system as far as they want for a flat 30 cent fare if the Smart Card was used.[1] In addition, the deposit policy was modified, so that the cardholder can borrow against the deposit for one ticket if the card balance is exhausted. The promotion led sales to jump to about 20,000 a day on discount days. As of November 2002, total sales exceeded 300,000.

Two major problems have emerged during implementation. One is a faster than expected error rate and down time for readers mounted on buses. Vibrations and heavy use apparently combine to lead to more failures than had been anticipated. In turn, this led to two other problems. One is a shortage of spare readers for bus use. Operators who cannot get a spare have allowed Smart Card holders to travel free, but are attempting to recover the lost revenue from the City of Taipei. A second problem has been how to handle cases when customers contend that there is money on the card but the reader does not register it. At the moment there isn't a standard procedure for dealing with such problems between cardholders and bus drivers.

[1] There are other payment options such as magnetic card, coin etc.

While sales data show growing consumer acceptance and marketing studies report customer satisfaction with the Smart Card's convenience and ease of use, no detailed large scale evaluation is yet available on the Taipei system. Operators expect that , in the long run, the Smart Card system should reduce costs, improve efficiency, and allow the public transport system to provide better service, but they likewise lack specific data on these matters. The operators do report that the Smart Card speeds boarding and alighting, reduces the cost of cash handling, and greatly improved the quality of ridership data.

Contact Persons

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Further Reading/References

Taipei Smart Card project website: www.tscc.com.tw
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Transit Information Systems

Transit Information Systems are designed to provide real-time information on routes and schedules, fares, any delays that may be occurring, and, in some cases, actual locations of individual vehicles and expected arrival times at particular stations and stops. Transit information is often provided by individual transit operators but increasingly is being integrated into multi-modal traveler information systems.

Advanced transit information such as vehicle locations is usually gathered by using automated vehicle locator (AVL) systems on buses and trains. These systems transmit vehicle location data to a central data processor that then can provide the information to system managers, and to transit users through website displays and by telephone.

Benefits

Difficulties in obtaining and interpreting printed transit route and schedule information has been identified as a barrier to more widespread transit use. By reducing this information barrier, transit information systems make transit more convenient and attractive. In addition, lack of certainty about when the next vehicle will arrive, and irritation about unexplained delays, are common complaints about transit. Transit information systems that provide real-time information can help reduce uncertainties for customers.

Limitations

Transit agencies often lack capital to invest in new technologies. Some agencies question the wisdom of spending significant funds on real time information systems rather than on basic vehicles and services. Some also question the value of on-line or via wireless Internet applications when the many of their patrons lack access to such technology.

Site operators have learned that fancy graphics, animations, music, etc. can seem attractive to web designers but slow down customer access to information, reducing the value of the site. Also, like any information system, accurate information is critical, and requires an ongoing budget for operation and maintenance. Finally, the site must be designed to handle peak period demand.

Examples

Seattle Metro Bus View

The Seattle Metro Bus System has several routes for which the real time location of individual vehicles is made available on the Internet. The system provides real-time bus location information, building upon Metro's existing AVL system.

Washington Metro (WMATA) RideGuide

http://rideguide.wmata.com/

This on-line transit information system provides users with the ability to receive a trip itinerary. The user inputs a location of departure, destination, time, date and selection criteria (minimize - time, walking or transfers and mode – rail only, bus only or either).

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Nextbus: A Real-Time Transit Information System

Background

Nextbus is a real-time transit information system that notifies public transit users of the next vehicles' actual arrival times. The GPS-based technology was invented in 1999 by NextBus Information Systems, a company based in Emeryville, CA.

To provide real-time transit information, NextBus uses satellite technology and advanced computer modeling:

- Vehicle locations along their routes are tracked by an automatic vehicle location (AVL) system that includes global position determining devices installed in each vehicle. Using wireless communication systems, the device sends vehicle location information every 90 seconds to a central processor, which computes and updates the present location of the vehicles.

- The central processor electronically stores vehicle location information in a data table that also contains the location of scheduled stops, the connections to other transit vehicles at the stops, and the arrival times of vehicles at their stops.

- Vehicle status information, including predicted arrival time, can be accessed by the general public via the internet or by using portable access devices such as cell phones or Personal Digital Assistants (PDAs).

Advantages

- Transit users obtain accurate information on when the next vehicle is going to arrive. They can then decide to just wait for the vehicle, to make use of extra time to do something else - perhaps place a call or make a purchase, or to switch to another transit option or another mode.

- Fleet managers and operators obtain detailed information on vehicle headways, schedule adherence, and missed runs. This information should be of use in improving schedules and service quality.

- Initial responses indicate that NextBus is popular with riders and makes transit more attractive. So far there are only limited data on possible ridership effects, however.

Limitations

Computers, cell phones, and handheld electronics are increasingly available to US households, but many low income households still lack these devices. Transit users who do not have internet connections will be able to obtain NextBus information at display-equipped stops and stations, but will have less convenient access to information than those who have the requisite technologies at hand.

Examples

More than twenty cities are using the NextBus technology. Among them are the following:

- San Francisco MUNI has installed NextBus on all five Muni Metro lines and on one bus line (the 22 Fillmore). Real-time arrival information fis available overf the internet and at rail stops and bus shelters.
- Muni plans to install the system on all lines over the next five years, with 430 information across the city.
- AC Transit is providing the real-time transit information for three bus routes along the San Pablo corridor, with displays installed at the El Cerrito and El Cerrito del Norte BART Stations.
- The Washington DC suburb of Fairfax, Virginia has installed NextBus on its entire system which serves the city, a nearby Metrorail station, and George Mason University.
- The Emeryville (CA) Go Round Shuttle provides NextBus displays at bus shelters, business lobbies, restaurants and shops.
- The Massachusetts Bay Transportation Authority (MBTA) has outdoor displays for real-time transit information at five major stations along the Haverhill Commuter Rail Line.
- Vail (CO) Transit has NextBus information available on its busiest transit route, which connects visitors to three major ski portals.

A NextBus display is shown in Figure 1.

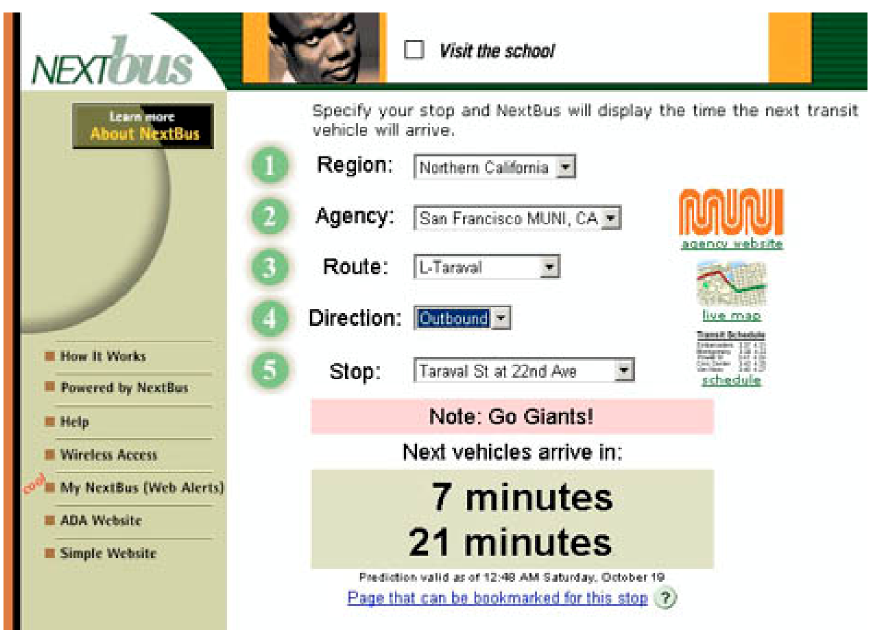

Figure 1. NextBus Display

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Web Resources

NextBus Information Systems, Inc.
http://www.nextbus.com/

Nextbus in AC Transit
http://www.actransit.org/riderinfo/nextbus.wu

Nextbus in Fairfax CUE
http://www.ci.fairfax.va.us/Services/CueBus/NextBus.htm

Vail Transit
http://ci.vail.co.us/transit/default.htm

Emery-Go-Round
http://www.transitinfo.org/EmeryGoRound/

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Bus Rapid Transit

Bus Rapid Transit (BRT) provides the characteristics of rail transit together with the flexibility and lower costs of buses. A BRT system typically uses a variety of intelligent transportation systems and technologies to improve transit reliability and performance. Priority treatment for transit vehicles, smart cards for fast boarding and fare payment, and real-time traveler information are key elements. Many applications also use low emission, low noise buses and some use wide-door, low floor designs.

Bus rapid transit may operate on freeways on high occupancy vehicle lanes, on separate transitways, or on local streets and arterials with designated bus lanes and/or traffic priority treatment or signal overrides. Some applications also reduce the number of stops or provide limited stop service on BRT lines.

Operators can apply automatic vehicle location to manage the services and connect the bus location to signal override requests and to transit information systems. User-friendly features such as real-time transit information available on line, by phone, and at major stops are provided using AVL data along with schedule and route information.

Benefits

BRT technologies and operating strategies can reduce both in-vehicle and boarding time and can improve the reliability of service, which in turn can reduce waiting time. High quality service can be provided at far less cost than that of rail transit.

Limitations

Designs that reduce the number of stops or provide limited-stop service have the disadvantage of increasing walk time, which can be a serious penalty in some situations. The more sophisticated applications using exclusive rights of way and extensive technology applications can be costly.

Examples

Line 22 Rapid Transit Corridor, Santa Clara Valley Transportation Authority (Santa Clara Co., CA)

The Santa Clara Valley Transportation Authority (VTA) plans to develop this 27 mile long route as a Bus Rapid Transit Corridor. Currently, service is offered on 10-minute headways during weekday peak hours and operates near capacity, with 28,000 riders daily. BRT service will operate in mixed traffic but will use queue jump lanes and traffic signal priority treatment to reduce bus travel time. In addition, low floor articulated buses and bus bulbs at station areas will be used to reduce passenger boarding time. An AVL system will be used to manage the line and to provide bus arrival time information to travelers.

:

Bus Rapid Transit Project, San Pablo Avenue and Telegraph/International Blvd./E. 14th Corridors, AC Transit (Oakland, Berkeley, and other communities, CA)

AC Transit currently is implementing the 72 San Pablo Rapid Bus as the first of several planned BRT projects. The 72 route will extend 16 miles throughout seven cities and two counties. The project will speed travel times by reducing the number of stops and using low floor, multi-door buses, stops located at the far side of the intersection, signal priority based on bus headways and bus detectors, and queue bypass lanes. Stops will be equipped with bus arrival information systems.

AC Transit is also moving ahead on Bus Rapid Transit (BRT) for the Telegraph/International/E. 14th corridor, connecting Downtown Berkeley, the University of California, Downtown Oakland, Downtown San Leandro and Bayfair Mall. Existing bus lines in the corridor carry about 40,000 passengers per day. The plan calls for BRT capital improvements that would reduce travel times by up to one third and improve service reliability. The project will use dedicated bus lanes along arterial streets, priority treatment at signals, specially designed stations and boarding platforms, and proof of payment fare verification. Alameda County sales tax funds for transportation will be used to complete portions of the study and some elements of the project such as signal priority and stop relocation.. To permit the quick implementation of traffic signal priority and stop relocations, a Categorical Exclusion (CE) will be sought from EIS/EIR requirements.

Metro Rapid, Whittier-Wilshire Blvd. (Line 720) and Ventura Blvd. (Line 750), Los Angeles
.
The Los Angeles County Metropolitan Transportation Authority (MTA) and the City of Los Angeles Department of Transportation (LADOT) have implemented a Metro Rapid demonstration program on these two heavily traveled routes. Eventually the project may be extended to 15-20 routes.

The Metro Rapid services replace existing limited-stop service; local bus service is not affected. Metro Rapid stop spacing has been lengthened to about .85 mile, a little shorter than Los Angeles' light rail transit stop spacing. Service is provided on low floor natural gas-powered buses with a distinct red color and logo, operating between stations located at large trip generators. About half the stops will be provided with real-time passenger information.

Total time to travel each Metro Rapid route has dropped by 25% compared to the local service, with thirty to forty percent of the drop attributed to a new signal priority system installed in the City of Los Angeles portions of the routes. With this system, a bus approaching an intersection may automatically trigger the signal to remain green for 10 extra seconds. Buses arriving at an intersection on or ahead of schedule are not given priority. Also, at major intersections, the transit extension can be triggered every other cycle only, to balance transit and auto needs.

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See http://www.fta.dot.gov for extensive information on Bus Rapid Transit

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Smart Taxis

Description

Taxis are an important mode of transportation in many communities, serving both visitors and residents who cannot drive, don't have a car, or need a ride for a particular trip. Many taxi companies work on a cash basis and collect fees based on distance traveled, with the driver usually choosing the route. Route information has not been available to the passenger once in the taxi (though sometimes the passenger can get it through a personal cell phone or PDA.) The need to carry cash for cabs can be troublesome and the lack of route information can be a worry for the taxi passenger who is unfamiliar with the area.

While in many communities, an increasing number of taxi companies will now accept credit cards, new technologies are appearing that both increase payment options and to provide other services including maps and directions. Taxis are being equipped with multi-purpose touchpad displays that allow the passenger to pull up maps and typical fares as well as pay by sliding a credit card or debit card through the machine, which is mounted flush with the back of the front seat. In some cases the machines also provide information on events, allow reservations to be made, and present short film clips on tourist attractions and the history of the area.

Example

New York City recently initiated a pilot project in which the makers of several in-taxi video systems are testing their products. (Passengers may mute the system if they want a silent ride.) All of the systems offer news and entertainment, along with information on fares, surcharges, and typical distances to key destinations such as airports. Most also carry advertising on theater, movies, and other entertainment as well as lists of hotels and restaurants. The advertising is expected to generate revenues for the providers of these systems. One product, which will have no advertising, will instead provide a touchpad for a variety of services, including use of an on-board phone, hotel and restaurant reservations, ticket purchasing, and airline information. The system also will have touchpad options for music, sports, news and entertainment and information on shopping, night life, and special events. In this system passengers will pay for most of the services they use (and for their ride, if they wish) using the system's swipe card feature with a credit or debit card. The provider expects to earn revenues from service charges and placement fees.

While initial feedback indicates that consumers like the systems, they are too new for any conclusions to be drawn about their profitability or the durability of the equipment in heavy use.

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Car Sharing

Description and Background

Car sharing is a membership program that provides short-term, hourly use of vehicles located in multiple parking sites close to the members' households or workplaces. Members pay membership fees that cover insurance, gasoline, and maintenance, as well as use charges for both miles driven and driving time. Key differences between car sharing and car rentals are the use of multiple parking instead of centralized lots, and pricing structures favorable for frequent use for an hour or two rather than rates set for daily and weekly use.

Car sharing members can be individuals or companies who need a vehicle for occasional use. Individuals who do not own a car may join a car sharing program to have use of a vehicle for grocery shopping or a trip to the garden center - trips that involve carrying purchases not easily transported on foot, bike or transit. Households may also use car sharing to obtain an extra car for occasional short trips when the cars owned by household members are not available. Businesses can use car sharing instead of having their own company cars, giving employees access to a pool of vehicles for going to a meeting or running an errand.

Car sharing also can be used as a means of access to transit stations or stops that are beyond walking distance. In these applications the term "station car" is often applied to the vehicles. Such vehicles may also be used by transit riders in case of an emergency; use of these cars could also be an alternative to a taxi ride in employer-sponsored "Guaranteed Ride Home" programs.

Successful car sharing requires high vehicle availability, a variety of vehicles, and short access time and distance to the vehicles. Although car sharing programs usually request reservations 24 hours in advance, many users prefer to make the reservation very close to the time of usage. This may necessitate a relatively large fleet of vehicles.

Many car sharing programs use advanced technologies to reduce labor costs and provide convenient and accurate service. The technologies include internet reservations, automatic vehicle location, a wireless tracking system that transmits the mileage and vehicle-use time directly to a headquarters, and electronic billing systems, plus smart card access to the vehicles. Environmentally-friendly vehicles, such as small electric vehicles, also are used in some applications.

Benefits

Car sharing can save money for participants. Monthly fees and use rates are usually less than the costs of owning a small vehicle. By having a car sharing membership. a household may be able to remain carless or to handle multiple transportation needs while owning only one car. In addition, if an individual uses a shared car for only a few hours, the cost is usually lower than conventional car rental or making the trip using two taxi rides.

A study done in Germany showed a dramatic transit increase and VMT reduction among the members of a car sharing organization: the percentage share of VMT privately-owned vehicles dropped from 60.5% to 13.4% and the VMT by public transportation increased from 35.8% to 57.3%.(Shaheen, 1999.)

In US transit applications, car sharing has the potential to increase ridership by providing needed access to remote sites or by providing reassurance that transit users will be able to have a car should an emergency require it.

To the extent that car sharing reduces household auto ownership, it can reduce parking demand as well. Berkeley, CA has allowed a developer to reduce the amount of parking provided in return for garaging car sharing program vehicles in his downtown apartment complex. .

Limitations

US car sharing programs to date have received subsidies from government grants and in some cases, from property owners (e.g., free use of parking spaces.) So far the programs have not been able to cover costs. In addition, a study of the car sharing program in San Francisco showed that members increased their vehicle miles of travel. While the additional travel may represent trips that were formerly made in far less convenient ways, areas that are concerned about emissions and VMT may not find this increased auto travel desirable.

The concentration of demand for car sharing on evenings and weekends can be a problem when members are mostly individuals and households. Business members using the cars during the weekday can support a larger fleet and help to balance demand.

Examples

Over 100 car sharing programs are in operation, including the following:

- Mobility CarSharing Switzerland opened for operation in 1987. Carsharing has since spread to Germany, Great Britain, Scandinavia, Italy, Canada, and the US, and many organizations are now firmly established .

- In 1997, Boulder CarShare Cooperative, the first American CarSharing organization, was launched.

- The Oregon Department of Environmental Quality and the U.S. Environmental Protection Agency funded a one-year CarSharing pilot project in Portland, Oregon, in 1998; CarSharing Portland, Inc. was subsequently established and aims to operate as a for-profit business , though it has received government start-up subsidies.

- In the San Francisco Bay Area, BART has had a program of station cars at both in-town and suburban locations.

- A City of San Francisco program was established by a group of environmental organizations, planners, and transportation researchers that formed a public-private partnership called City CarShare, which started operation in March 2001.

Car sharing organizations also are operating in Boston, Chicago, Denver, New York , Seattle, and Washington DC.

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City CarShare, San Francisco, California <http://www.citycarshare.org>

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E-Motion Mobility, Atlanta, Georgia <http://www.emotionmobility.com>

Flexcar, Portland, Seattle, Washington D.C. <http://www.flexcar.com>

I-Go, Chicago, Illinois <http://www.i-go-cars.com/>

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Smart Cards

Description

Smart cards are credit card-sized devices that contain microprocessor chips. The chips are the brains of the cards. They are capable of recording ample data to perform a variety of functions such as money transfer and time calculations. The cards can either be contactless (capable of being remotely read) or contact (they have to be inserted or "swiped" at a reader to enable a transaction.)

Smart cards have numerous applications. They are widely used as building security cards, for employee and student IDs, and as library cards. In the last few years they have been used in a variety of transportation applications. Many cards have a large enough memory to permit multiple uses on a single card.

Smart Cards for Parking

Smart cards for parking can be used at meters or in lots and garages. They make paying for parking a really simple task. Both "swipe" cards and "touchless" cards are in use.

Examples

The City of Berkeley, CA has installed parking meters in its commercial districts that permit smart cards to be used for payment. Anyone can buy the cash cards in denominations from $10 to $50. The parking meters are equipped with readers for the cards that deduct the parking fee based on various factors such as length of time parked, time of day and week, parking zone, etc. The cards can be programmed to be accurate to a minute or can charge for increments of "time bundles" such as 15 minutes. The same readers at the parking spots also take coins, which makes the technology adaptable and very user friendly.

According to City staff, implementation of this technology was amazingly simple once the city allocated the funds to buy the meters - in this case, as part of its ongoing meter replacement program. The city installed the smart meters in one area at a time, relocating meter heads that lacked the readers to other districts, so that it would be easy for users to know where the smart meters were available. They then extended the program to other districts. The main difficulty has been getting the word out to travelers that the cards are available. Currently, they are only sold by a city office, and publicity has been largely though brochures and city publications.

Other California cities using smart parking include Monterey and Pasadena. Monterey initiated the program by offering incentives for users by subsidizing the cost of the card. Lower costs of money handling at meters may partially offset this subsidy.

In the Boston area, smart cards used for transit can also be used for parking. According to a Feb. 26, 2002 survey of 275 Massachusetts Bay Transportation Authority riders, 88 percent said they had used smart cards to pay for parking and 87 percent of those said they were satisfied with the system.[1]

Advantages

Smart cards are gaining popularity because they eliminate the need to have cash or exact change, making it simple, convenient and speedy to make payment transactions

The card readers can be programmed and tied into a central maintenance system that tells city personnel when batteries are running low or they need repair, and all this can happen remotely.

The same card can be recharged and used over and over again.

Where "contactless" cards are in use, this ability to be read without contact saves time and effort for users.

Smart card technologies can be standardized region-wide, making them convenient for travelers at any location within the region.

Disadvantages / Potential Barriers

Until such technologies become commonplace, getting the word out to travelers that smart cards are available for parking is likely to require special efforts, such as leafleting cars, posting signs, etc.

Having only one outlet for purchasing and adding funds to the cards probably limits use. Internet sales of cards and upgrades arranged at multiple locations (libraries, banks, grocery stores) could probably overcome this problem, however. .

If the card is lost of stolen, it can be used just like cash.

Conclusions

Smart card use in the U.S. and Canada increased by 79% from the first half of 2001 to the second half.[2] Nevertheless, the use of smart cards to pay for parking is still low.

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Israeli manufacturer of contact less smart cards - http://www.easypark.co.il/index.htm

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Parking Guidance Systems

Background

Intelligent parking guidance systems guide drivers to parking facilities and tell them where spaces are actually available. Variable Message Signs are used together with sensors and software that keep a count of cars entering and exiting each facility (and level of the facility, in structures) and determine whether any spaces remain. This information is then posted on the message signs, usually through a control center where operators also may adjust the information provided (e.g., to allow some spaces to be held for later in the day, account for a certain percentage of spaces being blocked by careless self-parking, etc.

Eventually, parking guidance systems could be tied to parking reservation systems, but this has not yet be implemented.

Benefits

Intelligent parking guidance systems helps motorists locate parking quickly and efficiently. In so doing, they can reduce time spent in hunting for a parking space, and related vehicle travel, congestion, emissions, and energy use. Motorist frustration over having to search for a space also can be reduced. In addition, facility operators can achieve higher levels of occupancy, a potential revenue generator or cost saver depending on whether the parking is offered for a fee or is free of charge.

Limitations

The systems are designed for areas where parking is in heavy demand and not easily located, as is often the case in downtown areas, urban shopping districts, at airports, and at certain transit stations. Clearly the system would be of limited use in cases where the available parking is reserved for employees or monthly renters, or can be plainly seen by motorists, as is the case in many suburban stores, shopping malls, and office parks. Costs of variable message signs, sensors, software, and control centers also must be weighed against the benefits of making parking more easily located.

Example: Helsinki, Finland

Helsinki adopted two different real-time parking guidance systems in 1991 and 1998. The systems inform drivers of the available parking spaces in each parking facility in the city, using 23 parking signs with 50 variable messages. Each sign uses both directional arrows and names to direct motorists to the nearest parking facilities. More distant parking facilities are indicated with arrows only.

Facilities with available spaces are shown with a white figure "P". If the parking facility is full or closed, a red back slash is drawn over the figure P. (See figures.)

Example: Aalborg, Denmark
A parking guidance project implemented in Aalborg, Denmark was studied in detail. Prior to implementing the system 21% of visiting car traffic could not find an unoccupied parking space at a given parking facility. After implementation only 9% could not find a space. A survey of Aalborg resident found that 67% of car users respond favorably to the system. In addition, the study estimated that the system reduced parking-related vehicle-kilometers by 930 km/day, or 232,500 car-km per year, and reduced parking search time by 7,750 hours per year. Fuel and emissions reductions also are believed to have occurred, though the percentages are small.

US Examples

Parking guidance systems are available in the US at many airports, including San Francisco, CA and Manchester, NH.

The City of Nashville, TN began a downtown Traffic and Parking Guidance System in 1998, using a variable sign network together with traffic detectors and parking location information. The system is designed to monitor traffic flow in the downtown area and adjacent freeways, account for parking availability, and relay both traffic and parking information to variable message signs. The system will eventually be connected to Tennessee DOT's incident management system. As of early 2002 the project was under construction with partial operation only. The city expects that the system will make traffic flow more efficient and make downtown parking facilities in Nashville easier to use (US DOT 2002).

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Contact Persons

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Automatic License Plate Reading

Description

Automatic license plate reading uses image-processing technology to automatically identify vehicles by their license plates. The system uses illumination (usually an infrared light) and a camera to take an image of the front or rear of the vehicle. An image-processing software program then automatically extracts the license plate number from the image of the vehicle.

The license plate number can then be utilized in various ways. In a paid parking application, it can be used in place of a paper ticket to keep track of time in the parking area. Similarly, it can be used in place of a vehicle pass to allow entry into a controlled parking area. For law enforcement applications, the license plate number database can be linked to other databases that contain information about the vehicle or vehicle owner.

This technology differs from the License Plate Inventory systems used by some parking operators. With a license plate inventory system, .a parking attendant reads the license plate and manually enters it into the database. In contrast, LPR systems obtain the license plate number and enter the information automatically. LPR is also different from the cameras being used in some cities to enforce red lights. With red-light cameras, a photo of the license plate is taken automatically, but the photo must be interpreted by a human technician. In the LPR system, the photo is interpreted automatically (and immediately) by a computer.

Advantages

- Labor savings. For example, in parking applications, automatic license plate reading reduces the need for parking attendants to read and enter plate numbers, resulting in faster processing of vehicles. In some cases parking staff needs may be reduced and in some cases unattended parking may become feasible.

- Law enforcement. A joint Wisconsin-Minnesota study used LPR systems to track commercial vehicles that were in operation illegally. The license plate readers were placed along the roadside at weigh stations. The study concluded that LPR systems could "multiply" law enforcement power in many applications. In this case, the number of commercial vehicles that were screened increased from 36 percent checking manually to 44 percent using LPR.

Limitations

- Inaccurate. A 1998 Federal Highway Administration study found that LPR systems are not yet very accurate. Of 3,460 attempted reads, 1,413 were successful in correctly interpreting the license plate information, for a success rate of 41 percent. Unsuccessful reads fell into two categories: "no reads" and "bad reads." Reasons cited for "no reads" included missing, damaged, or dirty license plates. "No reads" accounted for 27percent of the unsuccessful attempts. "Bad reads" were attributed to misinterpretation of the license data, often caused by different styles and colors of various state plates. "Bad reads" accounted for 32 percent of the unsuccessful reads. Excluding unreadable plates, the success rate was 56 percent. An FHWA report suggests that manual keyboard entry is about 90 to 94 percent accurate when traffic is at low speeds.

- Immobile. The physical apparatus is large and weighty, so at the current state of technology, LPR systems are not something that can be carried around by a parking control official.

Examples

- The City of San Francisco uses a similar video imaging technology to allow buses to make right turns from the left-most travel lane on busy downtown streets. The cameras are located on street lights, and when a bus is detected, a special signal phase is activated to let the buses make the turns.

- The Cours Mont Royal Hotel in Montreal, Canada uses LPR to manage its parking garage. It replaces a human operator. It has increased the throughput of parking entry and exit transactions. The hotel also reports that LPR has decreased its rate of missed or undercharged parking tickets.

- Alconbury Developments, Limited, is a British company that developed a former Royal Air Force airfield into a freight terminal. To overcome local opposition to the increase in heavy truck traffic, the company uses LPR to inventory the truck traffic, and then reimburses the local road maintenance agency accordingly. License plates in Britain are standardized, so there isn't the "bad read" problem that occurs in the United States.

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Red Light Camera Enforcement

Background and Description

Red light cameras can help communities enforce traffic laws by automatically photographing vehicles whose drivers run red lights. These photographs can be used to issue traffic tickets.

A red light camera system is connected to the traffic signal and to sensors at the crosswalk or stop line. The system continuously monitors the traffic signal, and the camera is triggered by any vehicle passing the sensors a specified time after the signal has turned red. A second photograph is taken that typically shows the red light violator in the intersection. The equipment records the date, time of day, and time elapsed since the beginning of the red signal as well as the speed of the vehicle. Tickets typically are sent by mail to owners of violating vehicles, based on review of photographic evidence by human technicians.

Benefits

The need to reduce red light running is literally a life or death matter: Each year more than 800 people die and an estimated 200,000-plus are injured in crashes that involve red light running. More than half of the deaths are pedestrians and occupants in other vehicles who are hit by the red light runners. According to the Insurance Institute of Highway Safety (IIHS), running red lights is a common behavior; in a study in suburban Fairfax, Virginia, a motorist ran a red light on average every 20 minutes. Another IIHS study found that running traffic controls is the most common type of urban motor accident, accounting for 22 percent of all crashes. The same study showed that motorists are more likely to be injured in crashes involving red light running than in other types of crashes. Occupant injuries occurred in 45 percent of the red light running crashes studied, compared with 30 percent for other crash types.

Studies in two US applications show that red light camera enforcement reduces red light running. An IIHS study in Oxnard, California, showed that red light running violations across the city dropped a total of 42 percent after cameras were introduced at only nine intersections. Injury crashes at intersections with traffic signals in Oxnard were reduced 29 percent after the camera program began. Front-into-side collisions -- the crash type most closely associated with red light running -- were reduced 32 percent overall, and front-into-side crashes involving injuries were reduced 68 percent. Another IIHS study showed violations declined about 40 percent in Fairfax, Virginia, after one year of camera enforcement.

Limitations

The evidence on effectiveness is not unanimous. A 1995 study conducted by the Australian Road Research Board examined red-light-camera intersection accidents for the five years before and after the cameras were installed. The report concluded that "there has been no demonstrated value" of the red-light camera "as an effective countermeasure." Another report suggests that red light cameras are not targeting the real cause of accidents: what are classified as red light violations are more properly speed violations or DUIs; in the case of DUI violations, automating red light enforcement rather than deploying police officers for enforcement could allow a drunk to remain on the road and possibly lead to more accidents.

In addition, rear-end accidents may increase if people stop suddenly for a red light. A study that looked at the data for Oxnard, California, study described earlier found that rear-end crashes at red-light camera intersections increased from 18 (before installation) to 156 over the study period, for a total rear-end accident increase of 767 percent.

Cost also can be an issue, since a red light camera costs about $50,000. Installation and sensors cost about $5,000 per intersection. However, most jurisdictions partially or fully recover those costs through increased ticket revenues. In fact, some cities, such as Washington, DC, have found that red light cameras are net revenue producers.

Finally, some motorists complain about “not facing their accuser” when they receive a traffic ticket in the mail.

Examples

According to the IIHS, as of July 2002, red light cameras are currently in use in just over 70 cities, including New York City, Washington, DC, Baltimore, Phoenix, Los Angeles, San Diego, and San Francisco.

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Commercial Vehicle Operation [CVO]

Description

Commercial Vehicle Operation (CVO) and regulation can reduce costs and increase efficiencies by using intelligent technologies. New technologies can increase safety, simplify credential-checking and tax administration, and lower the costs of freight handling, fleet management, and vehicle operations.

Private sector freight handlers make extensive use of new technologies in logistics systems that have greatly speeded up operations, made more efficient use of vehicles and labor, and reduced losses and delays. Automatic vehicle location and in-vehicle route guidance systems tied to routing and dispatching centers by on-board communications systems are widely used by freight companies.

Public sector applications include automated weigh-station bypasses, electronic credentials, electronic data exchange, electronic funds transfers for payment of fees and taxes, and remote sensing for brake safety, emissions, and speed.

Benefits

Increased competition in the freight industries has pushed companies to invest in technologies that increase efficiency in the use of vehicles, fuel and labor and provide for added safety and security. The industry also has been a strong advocate for technologies that reduce paperwork, a costly and time consuming element when handled by conventional means Government agencies have benefited from vehicle regulation efficiencies as well as from reduced congestion at borders and inspection points.

Limitations

Because of the heavy flows of freight vehicles, containers, etc. interstate and internationally, compatibility and interoperability of management and regulatory equipment and systems are a major concern. Another issue is data management, as vast quantities of data must be linked and stored in ways that allow easy retrieval. High costs of the new systems add another concern; the fully automated systems are most cost-effective where full deployment is expected.

Examples

Several programs are currently under implementation in various states:
:

- COVE project (TX, AR, AZ, CO, LA, NM, OK)
- Electronic One-Stop Shopping Operational Tests (AK, CO, TX, CA, AZ, NM, IA, MN, NE, WI, KS, MO, IL, SD)
- Heavy Vehicle Electronic License Plate [HELP] program (CA, AZ, TX, NM, OR, WA, BC)
- International Border Clearance System (CA, MI, NY, AZ, NM)
- IOU Electronic Clearance Project (ID, OR, UT)
- Commercial Vehicle Electronic Credentialing and Safety Information (CVISN) (MD, VA, CT, KY, OR)

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CVISN - Commercial Vehicle Information Systems and Networks) Program

Background

The Commercial Vehicle Information Systems and Networks (CVISN, pronounced See-Vision) program is intended to make commercial vehicle regulation and monitoring more efficient for both government and the freight industry, and to increase safety. Key elements of CVISN include 1) automated collection of information on safety performance and credentials status, 2) electronic administration of credentials, including application filing and processing, fee collection, distribution of credentials, and tax filing and auditing, and 3) roadside electronic screening, with transponder-based verification of safety and credential information and weigh-in-motion flagging of vehicles that require further inspection.

Benefits

The CVISN program is expected to reduce paperwork for both government and the freight industry, to make tax payments and reporting more efficient, and to reduce errors and speed processing of filings. It also will reduce the number of trucks required to stop to at weigh stations and allow law enforcement to focus on high risk drivers, carriers, and vehicles. Studies reported by FHWA on its website indicate that safety information systems can increase the removal of unsafe commercial drivers and vehicles from the highway by some 50%. In addition, the FHWA site reports benefit-cost studies with ratios of up to 6:1 for electronic credential administration, and savings of at least a dollar a minute for commercial motor vehicle operators that can reduce time spent in weigh and inspection stations.

Limitations

Because of the complexities of the CVISN program and its requirements for organizational change, it is being implemented in a series of steps and phases that include establishment of stakeholder participation and oversight, staff training, and development of a business plan before investments are made in new technologies. Costs are substantial; FHWA estimates that a Level 1 deployment of CVISN will take a state about three years and cost between $6-10 million.

Examples

Ten states were selected as prototype and pilot states for CVISN Phase I implementation: California, Colorado, Connecticut, Kentucky, Maryland, Michigan, Minnesota, Oregon, Virginia and Washington. Early goals included the establishment of:

- Credential Administration Fuel Tax Agreement (IFTA) and International Registration Plan (IRP)
- Processing Connection to IRP and IFTA Clearinghouses
- Safety Information Exchange
- Communication and information standards consistent with federally-sponsored software such as ASPEN and state SafetyNet systems
- Inspection stations connected to national Safety and Fitness Electronic Record (SAFER) and the FMCSA Motor Carrier Management Information System (MCMIS) database

- Development of a state Commercial Vehicle Information Exchange Window (CVIEW) system (or equivalent) to support the exchange of snapshot data within the state or with other states
- Roadside electronic screening
- One or more fixed or mobile sites equipped for electronic screening

In addition, to date 49 states have completed a CVISN business plan, 41 have completed training workshops, and 34 have approved design and program plans, according to the Federal Motor Vehicle Carriers Administration website on CVISN.

References

Federal Highway Administration website, www.fhwa.dot.gov

Federal Motor Vehicle Carriers Administration., CVISN Home Page, http://www.jhuapl.edu/cvisn/

I-95 Corridor Coalition

The I-95 Corridor Coalition was formed in the early 1990s. It began as an informal group of transportation professionals attempting to resolve the operational and institutional barriers to coordination of ITS applications in twelve states - New England, the Middle Atlantic States, and Virginia. Following the passage of ISTEA the Coalition was formalized in 1993.

The twelve states are home to about 25% of the US population and contain 13 major airports, more than two dozen rail stations, 11 major seaports and 30,000 miles of Interstate nd primary highways. Congestion and economic development needs have been key issues motivating the coalition.

The Coalition lists the following as its major accomplishments:

- **Information Exchange Network (IEN) -** A regional network connecting the transportation management centers along the corridor.
- **Traveler Information Dissemination -** Developing an Intermodal Traveler Information System to provide estimated travel time and fare information on any trip, by any combination of modes between major origins and destinations within the Corridor. The Coalition also publishes (available on their website and distributed at rest areas) a bi-annual Traveler Alert Map displaying construction activity, upcoming events, closures and bottlenecks throughout the Northeast.
- **Commercial Vehicle Safety and Productivity** - The Coalition is developing a regional oversize/overweight vehicle permitting system, and working to create a more efficient way for qualified operators to obtain State credentials.
- **Electronic Payment** - The Coalition is continuing to support efforts to develop a convenient and standard system for electronic payment of travel and other services. The goal is to create a system that would accommodate electronic toll payments as well as payments of rail and transit fares using a single set of proximity or smart cards.
- **Training and Information Exchange Among Partners** – Another important contribution of the Coalition was to provide "seed" funding to establish the Consortium for ITS Training and Education (CITE), bringing in 40 partners from around the world to develop and deliver ITS training and education to public agency personnel over the Internet.

The Coalition also reports that a survey of its members indicated that they most valued: "networking and information exchange; coordination and cooperation; training and technical assistance; staff responsiveness with information or help for agency issues; participating face-to-face with colleagues; and the support that [the Coalition] provided for their agency's ITS programs.

Our near-term focus will be in the areas of traveler information, commercial vehicle safety and productivity, and electronic payment. Emphasis will be directed to:

- Allowing the public and shippers to smartly plan trips between major origin and destination points in the Corridor by providing a comprehensive source of information on all modes of travel.

- Achieving the productivity and safety goals associated with implementing FHWA's Commercial Vehicle Information Systems Network (CVISN) throughout the Corridor.

- Allowing travelers to seamlessly make electronic payments throughout the Corridor and supporting achievement of national ITS program goals related to interoperability of electronic toll and commercial vehicle operations applications.

The Coalition is focusing on outcomes rather than outputs. Now and in the future, the success of Coalition activities will be increasingly measured by their impact on the Corridor's transportation system effectiveness. The Coalition will continue to sponsor evaluations of all its major activities that focus on assessing the benefits of potential improvements to regional passenger and freight movements and the regional economy.

References

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European ITS Initiatives with Local Government: ITS City Pioneers Program

Background

The European Commission adopted in September 2001 a new set of common policies address growth challenges, reconciliation of mobility demand with sustainable development, and safety. Major initiatives included: a "rebalancing" of modal shares for both people and goods; congestion and bottleneck reduction; interoperability of transport systems across and within the Member States; focusing on user safety, costs, and intermodal movement; rational energy diversification; and managing the globalization of transport (enhancing EU global role and competitiveness). Pricing and technology strategies have significant roles in these policy initiatives, with Intelligent Transportation Systems (ITS) being highlighted in one of four "annexes" (appendices) to the white paper.

A related initiative – the "e-Europe 2002 Action Plan" – was adopted in June 2000. Among the Plan's stated aims is to facilitate ITS deployment by accelerating research and development and removing barriers to private mobility service provision. Initial implementation targets are set for 2002 with the thinking that EU global competitiveness in transportation technology could be lost if immediate actions were not taken. Specific 2002 targets are:

- 50 percent of Europe's major cities and towns provided with traffic and travel information services;
- 50 percent of Europe's major motorways to be equipped with traffic monitoring and management systems;
- All new vehicles sold in Europe to be equipped with more effective active safety systems;
- All of Europe's mobile phone users to be provided access to location determination for emergency calls and with full multilingual assistance and emergency services; and
- Legislative initiatives to be undertaken to promote the "Single European Sky" (for air traffic control), mobile communications for rail/maritime information and control systems and for Galileo (the EU's planned, high-accuracy global positioning system for civil use, featuring pay-for-service and third generation GPS bandwidth).

An assessment of Europe's progress toward e-Europe strategic goals is ongoing, including "benchmarking" of major IT areas (e.g., internet access in EU households, pupils per PC, etc.). However, it is not clear if there will be a quantitative assessment of progress toward, or achievement of, the specific ITS targets.

Examples

A major effort was undertaken in the 1990s to use ITS as a tool in implementing the EU transport and growth policies. One element of this effort was the ITS City Pioneers Consortium. The Consortium was headed up by ERTICO (ITS America's counterpart in Europe) and included a number of government and industry partners. This EU-funded program promoted ITS technology applications for local government, including outlying areas. ERTICO developed a series of documents, published in 1998, to promote local applications of ITS. The first was a general overview of ITS with a number of ITS "success stories" highlighted, including:

- Residential area access control system, using electronic permits and roadside readers, developed for the 1992 Barcelona Olympics for residents and workers in the city center;

- Central Oslo cordon system for electronic toll collection (priced for transport revenue generation not demand reduction):

- Flexible routing/demand responsive transit, with automated vehicle location (AVL), for suburban/rural service in Flanders;

- Personal security system for Paris metro trains and buses packaging a security control center, emergency response software, bus/train AVL, video surveillance for stations, and alert devices for drivers/agents and users; and

- Real-time traffic and traveler information in the British Midlands.

The second was an ITS Planning Handbook. The handbook included advice on planning issues, including a step-by-step method and checklist for ITS deployment plan development. Individual country planning environments and previous experience were discussed with specific case examples highlighted. Finally, an "ITS Toolbox" document detailed individual ITS technology applications and packages and provided guidance to urban planners on tool selection and integration.

The outreach portion of this initiative was launched at a press conference/executive forum in Stockholm in September 1998. Since then ERTICO has led ITS public awareness efforts in Europe.

Benefits

Setting targets for ITS deployment provides a basis for assessing progress.

Using ITS to implement general transportation policies both helps to mainstream ITS and allows ITS projects to be demonstrated to a wide audience. By providing guidance to local governments and highlighting successes, other localities have a good source of information on how ITS can be helpful to solve their transportation concerns.

Limitations

While European ITS policy, like that in the US, looks for private sector investment and services, most initiatives have required government funding support.

Implementation targets are only useful if attainment is actually tracked and if it falls short of targets, reasons for shortfalls are addressed.

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- *Intelligent City Transport: A Guidebook to Intelligent Transport Systems*
- *Intelligent City Transport: ITS Planning Handbook*
- *Intelligent City Transport: ITS Toolbox*

Rural Applications

Background

Rural areas can benefit from a number of intelligent transportation systems. Weather and pavement sensors can be used to warn motorists of poor driving conditions in time for them to slow down. Advanced transit reservation, tracking and routing systems that can make rural bus and dial-a-ride services more efficient for government providers and more convenient for patrons. On-vehicle safety devices can get help for a driver that has crashed or run off the road. Travel information systems can help tourists find their way with ease. Electronic clearance for trucks can reduce costs of transporting agricultural commodities. Railroad crossing warning systems can increase safety.

Examples

The San Joaquin Valley Intelligent Transportation System Strategic Deployment Plan was developed for the eight counties of the San Joaquin Valley of California, one of the prime agricultural areas of the United States. Cities and counties in the Valley already have implemented a number of ITS technologies, including interconnected traffic signal systems, roadside motorist aid call boxes, closed circuit TV monitors for congested routes and interchanges, weather and changeable message signs for key tourist / mountain routes, and a tourist traveler information system in the Yosemite area. The Deployment Plan identifies a number of additional ITS applications that stakeholders view as high priority for the Valley. These include railroad grade crossing surveillance and traffic control systems, expanded and upgraded road weather information systems, expanded transit user information systems, emergency response and May Day support systems, and animal vehicle collision support systems.

Benefits

Safety can be improved significantly and efficiency of operations can be increased through judicious use of ITS in rural settings.

Limitations

Most rural areas have many miles of road per capita and per vehicle mile traveled and road maintenance can be seriously backlogged. When this is the case it can be hard to find funds to put into new technologies.

References

San Joaquin Valley Intelligent Transportation System Strategic Deployment Plan, April 2001.

FHWA website, www.fhwa.dot.gov

"Intelligent Transportation Systems Improve Travel Safety and Transit Service in Rural Areas," ITS Sheet 4, Produced by the Federal Highway Administration and Federal Transit Administration, Washington, DC, Publication No. FHWA-OP-00-031.

ITS Applications with Security Benefits

Intelligent Transportation Systems are playing an integral role in improving transportation security. Transportation agencies are working closely with public safety and law enforcement agencies, private operators, vehicle manufacturers, shippers, and receivers to develop crisis prevention management and disaster response systems. In the US these security systems have taken on added importance since the terrorist attacks of Sept. 11, 2001. Other countries, including England, France, and Japan, also have dealt with terrorists and have a number of well developed systems.

Examples

Credentials Verification and International Border Crossings: Otay Mesa Border Crossing and the Southern California ITS Priority Corridor - The use of electronic credentials for trucks, drivers, and shipments can greatly speed border crossings. The Otay Mesa border crossing between California and Mexico is being equipped with advanced security systems to effectively manage the heavy truck traffic crossing from Tijuana. Forecasts indicate that over 2 million trucks will carry goods through this border crossing by 2010. The border crossing is part of the federally-funded Southern California ITS Priority Corridor, which runs through all of Orange County and parts of Ventura, Los Angeles, San Bernardino, Riverside and San Diego Counties and provides a multi-year "test bed" for real-world ITS applications and evaluations. Planning, development and deployment of advanced traffic management, traveler information, fleet management, goods movement and intermodal technologies are being deployed along the corridor to manage the flow of travelers and goods in this international crossing.

Bridge Monitoring Systems, Transit Station Monitoring Systems - Caltrans is deploying video camera systems to monitor the bridge security in the state. California transit agencies are among the many transit operators deploying camera systems to monitor station security. New digital video cameras are being used in many of these applications, allowing images to be directly downloaded onto computer systems, where review and processing can be done efficiently, for example, using license plate reader technology. . Some systems are also linked to biometric (face recognition) capabilities.

The Delphi Project - Biological terrorism epidemic simulation is being done in a partnership between the Center for Disease Control and the Los Alamos National Laboratory's TRANSIMS transportation modeling group. The partnership has employed the software EpiSim (disease analysis software) with realistic simulations of people's geographic movement using the TRANSIMS model developed for traffic and travel forecasting to generate predictions of epidemiological consequences.

Container Security: A variety of technologies and materials are being used to seal containers and allow shippers, receivers, and regulatory agencies to determine whether a container has been opened or tampered with. Some of the technologies also allow the container to be monitored on it route. . One technology uses an electric seal (E-seal) to secure containers at point of shipment or inspection at port and can then be used to track container shipments from their point of inspection along trade corridors to their point of clearance at U.S. checkpoints and .land border crossings. At checkpoints and border crossings,

Truck Security: A variety of on-board security systems are becoming available for trucks to help track shipments and improve security. Many trucks are now equipped with GPS or cellular technologies to monitor the truck's location and on-board computers for storing and transmitting vehicle credentials, shipment credentials, and driver credentials. Additional developments include the ability to communicate with "electronic fencing", systems that create boundaries around sensitive areas and only allow the truck to cross the border if it has authorization, and systems that will slowly decelerates the truck to a complete stop if it enters the restricted area.

References

http://www.its.dot.gov
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