

**Support Initiatives to Enhance the Effectiveness  
of Enforcement on HOV and HOT Facilities**

**A White Paper**

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Enforcement is a critical element to the successful operation of high-occupancy vehicle (HOV) and high-occupancy toll (HOT) facilities. The purpose of an HOV enforcement program is to ensure that operating requirements, including vehicle-occupancy levels, are maintained to protect HOV travel-time savings, to discourage unauthorized vehicles, and to maintain a safe operating environment. Visible and effective enforcement promotes fairness and maintains the integrity of the HOV facility to help gain acceptance of the project among users and non-users.

The growing need for effective HOV and HOT lane enforcement has been spurred by both long-term and more recent transportation developments. As the nation's highways become increasingly congested, the temptation for non-eligible drivers to cheat and make use of an HOV lane becomes larger. In the most congested metropolitan areas, this problem is acute, with documented violation rates on some facilities running well into the double-digits. Enforcement in such heavily congested corridors becomes problematic, as heightened police activity on the HOV lanes can often exacerbate slowdowns by inducing "rubbernecking." More recently, congestion pricing projects, including HOT lanes, have been implemented. In addition, some states are allowing other forms of exemptions, namely low-emission vehicles, which add a new dimension to the enforcement process.

Most enforcement techniques for HOV and HOT facilities have been adapted from longstanding traffic enforcement practices. One drawback of this developmental lineage is that some of these practices are relatively inefficient in the context of a preferential facility. Deficiencies in geometric design, facility operation, or institutional relationships can exacerbate the problem. Enforcement agencies and facility operators increasingly recognize the need for smarter, more efficient strategies to combat violators. New policies and technologies are also needed to support the greatly increased complexity of the enforcement task in the face of an increasingly diverse user base.

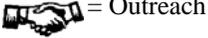
Most of the support initiatives suggested in this white paper reflect the above concerns. Greater efficiencies, whether accomplished through technology or improved practices, can yield more enforcement for equivalent money spent, and more importantly, have a greater positive effect on compliance. The support initiatives presented in this document are summarized in Table 1. The entries in the table indicate the researcher's assessment of 1) type of support initiative, 2) priority, 3) cost, and 4) time frame. Following the table are summaries of each initiative that describe the purpose, applicable facility type, principal stakeholders and sponsors, and anticipated product for each. Additionally, each initiative is evaluated according to its relative safety priority, time frame for completion, and cost. Initiatives are presented in a standardized format to facilitate comparisons and assist agencies in determining how to best leverage available resources to achieve desired safety goals. They are classified according to their applicability to one or more of the following areas:

- Research
- Public/Institutional outreach and awareness
- Personnel training

The Federal Highway Administration (FHWA), in conjunction with the HOV Pooled Fund Study Group, recently sponsored development of a *HOV-Lane Enforcement Handbook*. This handbook

provides guidance for preferential facility enforcement, drawn from extensive review of current and prior HOV enforcement practice and research. The topics addressed in this white paper have been identified over the course of research on the handbook as either gaps in the current body of knowledge on HOV enforcement, or important guidance which has had insufficient promulgation to its intended audience.

**Table 1. Enforcement Support Initiatives.**

<b>Support Initiatives to Enhance HOV-HOT Safety</b>	<b>Focus Area</b>  = Research  = Training  = Outreach	<b>Priority</b> ★ = Low ★★ = Medium ★★★ = High	<b>Cost</b> \$ = Low \$\$ = Moderate \$\$\$ = High	<b>Time Frame</b>  = Short  = Medium  = Long
1. Automated Enforcement Methods for Buffer Violations		★★	\$\$ - \$\$\$	
2. Quantifying and Targeting Persistent HOV Violators		★★	\$\$ - \$\$\$	
3. Enforcement-Friendly Toll Technologies		★★★	\$\$\$	
4. Image Processing Methods for Automated Vehicle Occupancy Detection		★★	\$\$	 - 
5. Methods to Improve Efficiency in HOV Enforcement	 	★★	\$\$	
6. Best Practices and Suggested Improvements for Self-Enforcement Programs	  	★★	\$\$ - \$\$\$	 - 
7. Judicial Awareness of HOV Enforcement Issues	 	★★	\$ - \$\$	
8. Responsibly Exercising Police HOV Privileges	 	★★	\$	
9. Minimally Intrusive Enforcement Practices for HOV Facilities	 	★★★	\$\$	

## 1. Automated Enforcement Methods for Buffer Violations

**Purpose:** Investigate automated methods and technologies for combating buffer violations on concurrent-flow HOV and HOT facilities

**Area(s) of Focus:** Research

**Facility Type(s):** Concurrent-flow HOV lanes

**Enforcement Priority:** Moderate

**Cost:** Moderate-High

**Time Frame:** Medium

**Product(s):** Research Reports, Pilot Implementation Projects

**Influence on Current Practice:** Successful implementation of Video Enforcement Systems (VES) for buffer violations could radically reduce violation rates and greatly simplify enforcement tasks. An effective VES approach has the potential to create a “virtual” barrier-separated facility, increasing safety on buffer facilities.

**Participant(s):** Facility Planners, Design Engineers, Enforcement Agencies, Technology Vendors, Judges and Legislators

**Potential Sponsor(s):** Federal Highway Administration, State Department of Transportation, Facility Operators

**Description:** Buffer-separated concurrent-flow facilities are prone to the highest violation rates of all types of HOV facilities. Non-barrier-separated facilities offer unlimited opportunity for unauthorized access; in addition, even authorized vehicles commit a violation when they cross the buffer to enter or leave the HOV lane. The general consensus is that buffer crossing violations occur at even higher frequency than occupancy violations (which themselves average 20% or more nationwide). Buffer violations are more serious than occupancy violations, since they present safety concerns. Buffer violators increase the risk of accidents along HOV facilities and impair the capacity and flow characteristics of the lanes. These dangers are magnified in congested corridors, where large speed differentials between the HOV and general-use lanes can induce hazardous weaving maneuvers (I-10 El Monte HOV lane).

In theory, VES systems can be readily adapted for use in detecting buffer violations. Legally, unauthorized crossing of a buffer can be proven by visual observation alone and does not require close visual inspection of stopped vehicles (like occupancy violations). In practice, several hurdles must be overcome:

- Few states allow photo or video evidence of traffic infractions, except in the case of toll violations. Unlike the case of toll roads, which require permission (in the form of

payment) to access the facilities, there is an expectation of privacy when driving on non-toll public roadways. Changes to legislation would be required to grant admissibility of photo evidence, which may be a non-trivial undertaking (case in point: red-light cameras).

- Buffer-separated facilities offer few areas for camera mounting, and cameras must be placed at many locations along a facility to offer complete coverage.
- Advances in high-speed wireless data transmission, data compression and storage, imaging technology, and improved photovoltaic efficiency may render a freestanding, wirelessly networked VES feasible, but no such system has been implemented yet.

## 2. Quantifying and Targeting Persistent Violators

**Purpose:** Investigate the scope of persistent HOV lane violators and identify effective techniques for targeting these repeat offenders

**Area(s) of Focus:** Research

**Facility Type(s):** All HOV, HOT Facilities

**Enforcement Priority:** Moderate

**Cost:** Moderate-High

**Time Frame:** Medium

**Product(s):** Research Reports, Pilot Implementation Projects

**Influence on Current Practice:** Classification of violators by degree of persistence can be a valuable tool in planning HOT facilities. This data can be used to more accurately estimate the potential customer base, by identifying groups which can be “converted” to HOT use. It can also greatly assist enforcement planning, by identifying the “hard core” of violators (people who are relatively immune to outreach efforts) and the corresponding level of effort needed to address this problem. In continuing practice, it could improve enforcement efficiency by reducing violation rates and motivating enforcement personnel.

**Participant(s):** Enforcement Agencies, Facility Operators, Judges and Legislators

**Potential Sponsor(s):** Federal Highway Administration, State Department of Transportation, Facility Operators, Metropolitan Planning Organizations, Local Governments

**Description:** While data on aggregate violation rates is relatively well known, little information exists on the composition of the class of HOV violators. Specifically, what proportion of HOV violators are “occasional” and what proportion are “regular” or persistent. It is general public and policy perspective that persistent violators should suffer higher penalties than infrequent

violators, as the motives between the two groups may be different. One may argue that occasional violators trespass on the HOV only when they are under substantial time constraints (late for work, etc.), while persistent violators are perhaps motivated by an antipathy to HOV lanes or general disrespect for traffic regulations. Police view persistent violators as more likely to commit other traffic infractions such as aggressive driving (tailgating, speeding, etc.) A chief rationalization for continuing to violate is the perception that the odds are in one's favor. In other words, a persistent violator has the same chance as any other violator to be apprehended. This perception needs to be changed, and targeting *individual* persistent violators is one way to do this. Such targeting goes beyond existing measures – license points and successive fines only target persistent violators *in general*, and then only after they are apprehended. Targeting individual persistent violators, and letting them know that they are being targeted, has the potential to reduce violations. For example, the HERO program in Seattle reports that only 2-3 percent of persistent violators are seen to continue violating after receiving a letter from the State Patrol. The HERO program provides monthly reports to Washington State Patrol (WSP) on violator sightings, which are used to better deploy enforcement resources. Another example is SR-91, where a “top ten” list of violators is distributed to enforcement and roadside assistance personnel.

The targeting of persistent violators may also be important from the standpoint of public perception. Persistent violators who act with impunity may be the “seed” from which a larger violation problem grows, as other motorists become disaffected and are perhaps encouraged to violate the HOV lanes as well.

The identification of persistent violators depends on the effectiveness of existing enforcement efforts. For well-run enforcement programs, an initial review of citations (as well as warnings) and judicial records should identify a subset of frequent violators. This initial review can also serve to quantify the number of repeat violators. A “Top 10” list can be compiled, including license and vehicle description, along with the most likely route these violators use (obtained from warnings and citations). Implementation aspects would include distribution of the list to enforcement, and a 6-12 month monitoring period in which violation rates would be tracked, and the “top ten” list updated on a biweekly or monthly basis.

### **3. Enforcement-Friendly Toll Technologies**

**Purpose/Need:** Identify available options for integrated tolling and enforcement systems and develop guidelines for applicability with respect to different facility designs

**Area(s) of Focus:** Research

**Facility Type(s):** All HOV, HOT Facilities

**Enforcement Priority:** High

**Cost:** High

**Time Frame:** Medium

**Product(s):** Research Reports, Pilot Implementation Projects

**Influence on Current Practice:** This research may encourage vendors to develop integrated toll/monitoring systems, by emphasizing the need and potential market for these systems. If an effective technology is available, this research can create greater awareness on the part of state agencies, planners, and designers and indirectly encourage the growth of managed lanes.

**Participant(s):** Enforcement Agencies, Facility Operators, HOT planners and designers, Toll System Vendors

**Potential Sponsor(s):** Federal Highway Administration, State Department of Transportation, Facility Operators

**Description:** As increasing numbers of HOV facilities are converted to HOT facilities, the choice of tolling technology assumes critical importance for enforcement efforts. In the absence of universal transponder requirements, officers must be able to verify whether single-occupancy vehicle (SOV) users have paid the required toll. The recent opening of the I-394 Express Lanes illustrates a promising trend in toll systems technology. The toll transponders employed on this facility are encoded with recent transaction information, which can be verified by specialized equipment in enforcement vehicles. New technologies have been proposed for the I-15 Express Lanes, in which enforcement officers would have wireless access to the billing system for purposes of verifying tolls.

Research is necessary to identify available options for integrated tolling and enforcement systems and develop guidelines for applicability with respect to different facility designs. Such research should survey available technologies and any successful implementation case studies, and provide guidance for choosing and/or specifying facility-specific operational requirements.

#### **4. Image Processing Methods for Automated Vehicle Occupancy Detection**

**Purpose:** Assess general categories of image processing and facial recognition methods that may be adapted for vehicle occupancy detection

**Area(s) of Focus:** Research

**Facility Type(s):** All HOV, HOT Facilities

**Enforcement Priority:** High

**Cost:** Moderate

**Time Frame:** Short-Medium

**Product(s):** Research Reports

**Influence on Current Practice:** This research would serve to better direct efforts in vehicle occupancy detection, by identifying functional prerequisites for recognition heuristics. Such objective criteria can assist in proactively evaluating the merits of emerging detection technologies.

**Participant(s):** Enforcement Agencies, Facility Operators

**Potential Sponsor(s):** Federal Highway Administration, State Department of Transportation

**Description:** In the last decade, research in the area of near-infrared imaging has identified technologies for isolating the “signature” of human skin. Declining hardware costs for infrared and near-infrared imaging equipment are another promising development, as such equipment has traditionally been prohibitively expensive. The remaining component required for developing a fully automated system of infrared vehicle occupancy detection is the heuristics or algorithms for efficiently and accurately “counting” occupants.

Any imaging system can be viewed as having essentially two components – the eyes and brain. Continuing advances in sensing technologies, such as high-speed near-infrared systems, have greatly increased the sensitivity, quality, and resolution of the “eyes.” However, this increase in the volume of information is not being matched by a corresponding increased ability to process the information other than by brute force computation. Recent research in both image processing and neuroscience indicate that biological visual processing employs radical data reduction and image re-synthesis. In effect, the image received by the eye is converted into a highly compact set of key features; this feature set is then passed to the brain, where it is used by the visual cortex to create a representation of what has been “seen.” In other words, vision works less like a television and more like an abstract painting.

It is likely that, in order to achieve a sufficiently high level of accuracy, an occupancy detection system will need to incorporate a similar approach of feature extraction and subsequent synthesis. This project would survey applicable research fields, toward the goal of providing a clearer understanding of the benefits and drawbacks to various machine vision processes. Such a survey should be able to provide general estimates as to the time required for processing technologies to sufficiently mature.

## 5. Methods to Improve Efficiency in HOV Enforcement

**Purpose:** Identify best practices in the areas of manpower deployment, court appearance scheduling, and the issuing of citations.

**Area(s) of Focus:** Research, Outreach

**Facility Type(s):** All HOV, HOT Facilities

**Enforcement Priority:** Moderate

**Cost:** Moderate

**Time Frame:** Medium

**Product(s):** Research Reports, Pilot Implementation Projects, Outreach Materials

**Influence on Current Practice:** More efficient use of enforcement manpower can be achieved by the identification and reduction of key bottlenecks and inefficiencies in the enforcement process which are ancillary to the primary duties of enforcement personnel.

**Participant(s):** Enforcement Agencies, Facility Operators, Judicial and Legislative entities, Technology Vendors.

**Potential Sponsor(s):** Federal Highway Administration, State Department of Transportation, Facility Operators

**Description:** Enforcement of occupancy restrictions on HOV facilities is a manpower-intensive task. Many facilities lack the resources to fund enforcement to the levels required for effective enforcement. This project will investigate possible ways to reduce the cost per citation by identifying areas for efficiency gains in the enforcement process. Preliminary areas for improvement include:

- *Judicial Scheduling Support* – Officers must appear as witnesses to support their citations. This typically takes place on the overtime pay scale. Given that occupancy violations are non-criminal, greater allowance for officers' schedules can perhaps be accommodated to reduce the time spent in court. A survey of enforcement agencies and their court hours should be conducted, and suggested ways to reduce these time expenditures shall be proposed.
- *Randomized Enforcement* – Data on violation rates for I-80 in New Jersey indicated that strictly randomized enforcement scheduling was as effective as higher levels of more predictably scheduled enforcement. This result, however, was neither anticipated nor planned for in the study. In fact, no studies have been undertaken to investigate the possible benefits of randomized enforcement scheduling. An implementation study is proposed whereby, for a suitable facility, different levels of randomized enforcement are investigated. Alternatively, a comparison between nonrandom and random enforcement scheduling could be conducted.
- *Streamlining the Citation Process* – Each minute an officer spends on a traffic stop is one less minute spent identifying violators. This lack of an observation presence may have a greater impact on facilities where apprehensions are not visible to other users of the HOV lane. Some states such as Virginia have investigated methods to reduce the time spent issuing citations. Virginia permits enforcement personnel to partially complete the citation (identifying information and violation), and mail the completed citation to the violator. This reduces the time for the traffic stop, in the absence of other violations. Technologies which permit in-vehicle printing of citations may also save time.

## 6. Best Practices and Suggested Improvements for Self-Enforcement Programs

**Purpose/Need:** Research is necessary to identify available options for integrated tolling and enforcement systems and develop guidelines for applicability with respect to different facility designs

**Area(s) of Focus:** Research, Outreach, Training

**Facility Type(s):** All HOV, HOT Facilities

**Enforcement Priority:** Moderate

**Cost:** Moderate-High

**Time Frame:** Medium

**Product(s):** Research Reports, Pilot Implementation Projects, Public Outreach Materials

**Influence on Current Practice:** A better understanding of Seattle’s HERO program and its associated benefits to enforcement could assist other regions in implementing their own programs. Effective self-enforcement has the potential to improve enforcement efficiency, and the benefit of greater public support could be particularly important to value pricing projects.

**Participant(s):** Enforcement Agencies, Facility Operators, Metropolitan Planning Organizations, Local Media Outlets

**Potential Sponsor(s):** Federal Highway Administration, State Department of Transportation, Facility Operators, Metropolitan Planning Organizations

**Description:** Seattle’s HERO program is the original and most successful of its type. It is generally credited with helping to maintain public approval of HOV lanes. The program is notable in that monthly summaries of sighted violations are used by enforcement to identify problem areas, thus improving efficiency. Other programs, such as Virginia’s, have failed because they were not perceived as credible.

No research has been conducted to quantify the contribution of Seattle’s HERO program to overall enforcement effectiveness. Such an analysis could encourage the growth of these programs, if the benefits to enforcement (lower violation rates, increased fine revenues) can be demonstrated. A second purpose of this project would be to identify and possibly implement improvements to the program, such as:

- More frequent updates (weekly, biweekly) of sighted violation summaries
- Public feedback – information can be provided on the number of sighted violators who have been subsequently apprehended (e.g., “Police have ticketed 30 percent of those you have reported”)
- Better tracking of persistent violators (“most wanted”). Seattle’s program targets problem areas, but what about individual problem drivers?

Seattle's program already tracks suspected violators and provides monthly reports to enforcement agencies. These reports indicate the number of violation sightings at various locations along the HOV network. Combined with citation and adjudication data, this information could be used to estimate the number of citations issued to violators who were also identified by HERO activities, and the fine revenue generated by these citations. This information could be used to provide a cost/benefit analysis of self-enforcement programs.

## 7. Judicial Awareness of HOV Enforcement Issues

**Purpose/Need:** Research is necessary to identify available options for integrated tolling and enforcement systems and develop guidelines for applicability with respect to different facility designs

**Area(s) of Focus:** Outreach, Training

**Facility Type(s):** All HOV, HOT Facilities

**Enforcement Priority:** Moderate

**Cost:** Low-Moderate

**Time Frame:** Short

**Product(s):** Outreach Materials

**Influence on Current Practice:** Greater judicial appreciation for the objectives of HOV and HOT facilities and the enforcement approach needed to achieve the objectives. Outreach efforts are especially timely in the wake of changes in federal law and the likelihood of revisions to state law.

**Participant(s):** Enforcement Agencies, Facility Operators, Members of the Judicial Branch of Local and State Government.

**Potential Sponsor(s):** Federal Highway Administration, State Department of Transportation, Facility Operators

**Description:** A HOV project is susceptible to misinterpretation by the judicial branch. The HOV project oftentimes incorporates a traffic scheme and traffic regulations that are unique to the area. Incomplete judicial understanding of the HOV project could result in judicial overrulings of the HOV citations. Additionally, because of the unique traffic scheme associated with HOV projects, traffic court judges can be more sympathetic to an alleged "confused and unsuspecting" motorist cited for an HOV violation.

A good enforcement program can be undermined by the judicial branch of government if the judicial branch does not uphold the citations issued by the enforcement agency. If police officers

continually find their citations being overturned in traffic court, they may be inclined to issue fewer citations for the offense in question. Knowledgeable motorists may also become aware of certain traffic citations that are not being upheld by the traffic court system, particularly if publicized in the news media.

Judicial support for HOV fines varies across the country. Occupancy violations may often be perceived as a “victimless” infraction. In localities lacking dedicated traffic courts, judges may be unfamiliar with HOV eligibility requirements, and have little understanding of the HOV lane concept and rationale. These problems may be exacerbated in the absence of uniform state minimum fines; in this case, judges may impose only token fines and thus actually encourage violators.

This project would prepare outreach materials for a judicial audience. A partial list of topics could include:

- The objectives of HOV facilities,
- The consequences of excessive HOV violations,
- The traffic regulations applied to achieve the objectives,
- The enforcement approach,
- Previous court rulings, if any, applicable to HOV facilities, and
- The legal basis for the restrictions and enforcement procedure.

## **8. Responsibly Exercising Police HOV Privileges**

**Purpose/Need:** Develop outreach materials for ensuring that current FHWA policies and guidelines on the use of HOV lanes by law enforcement and emergency vehicles are followed

**Area(s) of Focus:** Outreach, Training

**Facility Type(s):** All HOV, HOT Facilities

**Enforcement Priority:** Moderate

**Cost:** Low

**Time Frame:** Short

**Product(s):** Outreach and Training Materials

**Influence on Current Practice:**

**Participant(s):** Enforcement Agencies, Facility Operators, State Department of Transportation

**Potential Sponsor(s):** Federal Highway Administration, State Department of Transportation, Facility Operators

**Description:** Vehicles operated by federal, state, or local law enforcement personnel may be permitted to use HOV lanes as long as they are clearly marked law enforcement vehicles equipped with rooftop emergency lights and a siren. Officially marked emergency services vehicles, such as ambulances, fire, and tow trucks, and emergency medical services vehicles are also allowed to use HOV lanes. This exemption from minimum HOV lane occupancy requirements only applies to on-duty personnel. However, anecdotal evidence suggests that off-duty officers and even government workers are availing themselves of this privilege. Indiscriminate use of the HOV lane by enforcement personnel and government workers directly undermines the role and purpose of enforcement, which is in part to maintain the integrity of the HOV lane. As HOV lanes are increasingly utilized, and new uses for HOV lanes are developed (such as HOT operations), the negative public perceptions of indiscriminant HOV lane use will only increase.

It is important to ensure that current FHWA policies and guidelines on the use of HOV lanes by law enforcement and emergency vehicles are clearly communicated to the responsible agencies, policy makers, and the public. A number of outreach approaches may be used to communicate these policies, including letters or directives from top law enforcement personnel to their staff, information on agency websites, newsletters, bulletins, and outreach through police unions and professional organizations. The guidelines should also be clearly communicated to HOV lane enforcement personnel as part of standard training procedures. Enforcement efforts should be monitored to ensure the policies or guidelines are being implemented.

## **9. Minimally Intrusive Enforcement Practices for HOV Facilities**

**Purpose:** The promulgation of non-disruptive enforcement practices

**Area(s) of Focus:** Training, Outreach

**Facility Type(s):** All HOV, HOT Facilities

**Enforcement Priority:** High

**Cost:** Moderate

**Time Frame:** Short

**Product(s):** Research Reports, Pilot Implementation Projects

**Influence on Current Practice:** Broader adoption of minimally intrusive enforcement practices serves to enhance the safety of HOV lane users and enforcement personnel by contributing to smoother traffic conditions on HOV facilities. Attendant benefits include more positive public perceptions of enforcement and decreased HOV lane travel times.

**Participant(s):** Enforcement Agencies, Facility Operators

**Potential Sponsor(s):** Federal Highway Administration, State Department of Transportation, Facility Operators

**Description:** Although visible enforcement is desirable, heavy enforcement can be disruptive to traffic as it usually induces rubbernecking. For example, the Minnesota State Patrol's attempts to provide effective enforcement on the I-394 concurrent-flow HOV lane resulted in severe congestion on the general-purpose lanes due to onlooker delay. More recently, enforcement efforts near Exit 166 on the I-95 HOV lane in Northern Virginia caused an eight-mile backup, as motorists slowed and even stopped on the freeway to observe the more than one dozen Virginia State Patrol officers as they pulled over HOV violators.

Minimally intrusive enforcement techniques can significantly reduce the potential for traffic disruption. Enforcement personnel trained in these techniques

- Reduce the use of emergency lighting during traffic stops,
- Avoid multiple patrol vehicles at one location,
- Have no more than one car waiting to be ticketed at any time,
- Refrain from standing outside the vehicle, and
- For concurrent-flow lanes, release violators cited in the median back into the HOV lane

Wider efforts to increase awareness of these techniques, such as outreach to enforcement agencies and the dissemination of training materials, is recommended, especially with the recent growth in the number of HOV facilities. Enforcement personnel on new facilities may not have direct experience with patrolling HOV lanes, and could significantly benefit from the collective experiences of more established enforcement programs. Minimal-enforcement techniques are of particular value to HOT facilities, where the decision to use the facility is strongly influenced by perceived travel time benefits.