It’s Getting HOT in Here:
A Case Study of the SR-91 in California

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Lastly, I would like to thank Estella Shin, for giving me the motivation to finish this report.

Jordan Lee
Executive Summary

In 2007, the Ontario Ministry of Transportation created their High Occupancy Vehicle (HOV) Lane Network Plan for the 400-Series Highways in the Greater Golden Horseshoe. As part of that plan, an HOV lane will be constructed on the 401, in Peel and Halton Regions, west of Toronto. This report sets out determine whether a high occupancy toll (HOT) facility would be more appropriate for the Greater Toronto Area (GTA).

Methodology

The case study comes from California, where the SR-91 Express Lanes HOT facility has been in operation since 1995, and was the first of its kind in North America. All phases of the project will be explored, from the context before implementation, to the present functioning of the facility. In order to determine its operational performance, a set of performance criteria was established. They are summarized in the following table:

<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Unit of Measurement</th>
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<tbody>
<tr>
<td>Effect on Transit Ridership</td>
<td>Average daily riders on transit</td>
</tr>
<tr>
<td>Vanpooling/Carpooling</td>
<td>Daily traffic volume for pay vs. free and total riders in vanpools</td>
</tr>
<tr>
<td>Travel Time Savings &amp; Speed</td>
<td>Minutes saved; Kilometres per hour</td>
</tr>
<tr>
<td>Average Vehicle Occupancy</td>
<td>Persons per vehicle</td>
</tr>
<tr>
<td>Public Sentiment &amp; Equity</td>
<td>Approval percentage; HOT user demographics</td>
</tr>
</tbody>
</table>
By examining the case study, six factors have been identified, all of which were instrumental in the successful implementation and continuing viability of the HOT facility. Taking these factors, they have been assessed for the context of the GTA, in order to determine if a similarly operating facility can be implemented on the 401. The six factors are:

1. Employment, demographics and income levels;
2. Very high congestion levels before implementation;
3. Political will and support;
4. Space to build 4 new lanes;
5. Use of advanced electronic system for collection and detection;
6. Removal of non-compete clause

Findings and Conclusions

The following are the conclusions that have been drawn, based on the assessment of the six factors:

1. Demographic and income distribution across the GTA appear to offer favorable circumstances for a large number of toll paying customers. However, those living closer to the 407ETR probably will not persuaded to use a potential HOT facility on the 401, as it would not provide additional time savings.
2. Like the SR-91 before the Express Lanes, the 401 is severely congested, which is a prerequisite to HOT facility implementation.
3. There is political and public support for addressing the GTA’s congestion issues, but Torontonians are looking more toward mass transit as a solution, and there is minimal support for an HOT facility.

4. The 401 does not have the necessary space to build an additional four lanes in the median of the highway, as seen in the case of the SR-91. Any lanes that are built must be constructed on the outer edges of the highway, most likely increasing costs. Another option is to convert existing lanes to HOT.

5. With the implementation of its electronic systems on the 407ETR, the GTA has shown that it is a leader in welcoming new technologies in their transportation models.

6. It is reasonable to expect that MTO can avoid a non-compete clause in a potential public private partnership agreement, as there is currently no such clause for the 407ETR.

Recommendations

Since there are many similarities between the cases of the SR-91 and the GTA, there is good evidence that a similarly operating facility may be implemented on the 401 in the GTA. Therefore, it is recommended that MTO explore the possibility of implementing an HOT facility instead of the HOV lanes that are currently planned. It should be noted that not all of the success factors are present, and therefore, the option of an HOT facility should be explored carefully.

Thus, MTO should initiate several studies in order to explore the possibility and viability of an HOT facility. They are:
1. Traffic projections;
2. Public opinion survey;
3. Financial viability study;
4. Best practices study;
5. Update to Edward Sullivan’s study of the SR-91 Express Lanes
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1 Introduction

The 400 series highway system in southwestern Ontario serves the Greater Golden Horseshoe (GGH), the economic engine of Canada. Over the next 25 years, projections indicate 47 percent growth in population for the GGH, accounting for 80 percent of Ontario’s population growth (Ontario Ministry of Public Infrastructure Renewal, 2006). With a rapidly increasing population, traffic congestion could potentially become a greater problem than it is today, especially in the Greater Toronto Area (GTA). In fact, the segment of the 401 that runs through Toronto is already the busiest road in North America, used by more than one million vehicles per day (Mekky, 1999).

The cost of congestion of the 400 series highways is substantial. In fact, clogged transportation corridors cost the province upwards of $5 billion in lost GDP every year, due to the delay in the movement of goods (Ontario Ministry of Public Infrastructure Renewal, 2006). In order to combat highway congestion, the Ontario government plans to introduce High Occupancy Vehicle (HOV) lanes across the 400 series highways in the GGH. According to the Ministry of Transportation’s (MTO) HOV Lane Plan 2007, implementing HOV lanes will reduce congestion by allowing for shorter commute times, more travel choices (carpooling), and more reliable and convenient bus service (MTO, 2007). In particular, an HOV lane is being planned for the 401 highway in the medium term (2011-2016) (Refer to Figure 1). An extension of this HOV lane is planned as a long term addition (2017+). The original HOV lane and the addition will both be located west of Toronto, in Peel and Halton Regions.
Although a network of HOV lanes is being planned, some experts advocate for High Occupancy Toll (HOT) lanes, claiming that there are additional benefits and efficiencies.

*Figure 1: Medium-Term HOV Lane Priorities (2011-2016) and Longer-Term HOV Additions (2017+)*


This report sets out to examine whether an HOT facility similar to that of the SR-91 Express Lanes in California can be built instead of the planned HOV lane on the 401 highway. Ultimately, the report will recommend either to build an HOT facility on the 401, or that an HOT lane should not be built. An in depth case study of the SR-91 HOT lane will be conducted to explore the factors that have contributed to its successful implementation, revenue generation and ability to reduce traffic congestion (justification for case selection is discussed in Section 3.1). These factors
will then be applied to the context of the GTA in order to determine if similar success can be replicated.

1.1 Travel Patterns in the Greater Toronto Area

The GTA has experienced an increasing number of total automobile trips and longer commute times. In fact, a study of the University of Toronto’s Transportation Tomorrow Survey (TTS) database by Rakim Mitra (2007) shows that from 1986 to 2001, cumulative trips for drivers have increased by 12 percent. In addition, a study of commute times among 21 international cities shows that Toronto ranks last among the cities studied, with the longest average commute time of 80 minutes (Toronto Board of Trade, 2011). Other Canadian cities that were included in the study include Halifax, Calgary, Vancouver, and Montreal. Not only are commute times long, but they appear to be getting longer. Between 1992 and 2005, the average commute time for those traveling by car went from 51 minutes to 59 minutes (Statistics Canada, 2006). The increase was more pronounced for transit users, who saw commute times rise from 94 to 106 minutes (Statistics Canada, 2006). There are two major reasons attributed to these travel patterns.

One of the main reasons for such long commute times is the growing suburbanization of the GTA. Not only has residential expansion increased in the suburbs, but employment within these regions has increased as well. Newer developed urban centres such as Mississauga, Brampton, Vaughan, Richmond Hill and Markham have seen the highest growth in overall employment within the GTA (Mitra, 2007). This should translate into reduced commute times, as employment
becomes decentralized, but a trend of “reverse commuting” has been seen in the GTA (Mitra, 2007). This describes a phenomenon where workers reside within the central city, but commute to their place of employment outside of the central core. Scarborough, North York, Mississauga and Markham have contributed to decreasing “self-containment” of employment in downtown Toronto (Mitra, 2007).

Extensive and easily accessible transit systems have yet to be established within many of these newer communities, so the majority of trips must be made with the automobile. As a result, transit usage has seen a decline of 4 percent from 1986 to 2001 (Mitra, 2007). As people within the GTA suburbs rely more heavily upon personal automobiles, traffic congestion on the region’s highways is likely to increase.

One of the major contributors to increasing automobile usage is population growth. As Mitra (2007) points out, household automobile ownership has remained static over 15 years from 1986 to 2001 at 1.4 vehicles per household. However, the number of total households in the GTA increased by 24.7 percent from 1986 to 1996 (City of Toronto Urban Development Services, 1997). Therefore, the number of personally owned vehicles in the GTA has increased by over 450,000.

With a greater number of total vehicles, and increasing cross-commuting, there has been a greater strain on the highways in the GTA. With all else being equal, if more vehicles are added to the region’s highways, transportation planners will be forced to explore methods of mitigating increasing congestion. Thus, MTO developed their HOV plan in order to address these possible issues.
1.2 Defining High Occupancy Vehicle Lanes

A discussion of HOT lanes will require a background and understanding of HOV facilities, since the underutilization and cost of many existing HOV lanes are seen as a precursor to HOT facilities (A more detailed discussion is available in Chapter 2).

The United States Federal Highway Administration defines High Occupancy Vehicles (HOV) as motor vehicles that carry two or more persons, and include carpools, vanpools and buses (2008). Therefore, one of the main functions of an HOV lane is to encourage multi passenger vehicles and thus, reduce the number of total vehicles, effectively reducing congestion, with all else being equal. It is noted that the most appropriate situations for an HOV facility are in corridors with high travel demand and traffic congestion (Federal Highway Administration, 2008).

Typically, HOV lanes have vehicle occupancy requirements of two-persons per vehicle (2+), but there are also (3+) occupancy requirements. Examples of a 3+ HOV facility include the I-395/I-95 in Virginia (only during the peak hours of 6AM-9AM northbound and 3:30PM-6PM southbound on weekdays) (Virginia Department of Transportation, 2011) and the SR520 in Washington (Washington State Department of Transportation, 2011).

1.3 Defining High Occupancy Toll Lanes

High Occupancy Toll (HOT) lanes are defined as, “specialized lanes open to both qualifying high-occupancy vehicles (carpools and transit) and paying customers (typically solo drivers) (Poole and Orski, 2003).
The use of high occupancy toll lanes is considered a form of congestion pricing, which entails “pricing” the time costs and delays that are imposed on other road users by the addition of another driver (Alabate and Bel, 2009). There are many forms of congestion pricing, including cordon tolls, area wide pricing, city centre toll rings, and HOT lanes (Lindsey, 2008). HOT facilities are considered a weak variant since only a portion of the highway capacity is allocated by price (Altshuler, 2010). However, the growing momentum of HOT facilities within North America suggests that significant steps are being made towards congestion pricing, which may be partially motivated by economic and financial reasons.

On the other hand, some academics insist that “value pricing” is a more appropriate term for HOT lanes. Poole and Orski (1999) define value pricing as “a system of optional fees paid by drivers to gain access to alternative road facilities providing a superior level of service and offering time savings compared to the free facility” (pg. 17). According to them, the fundamental difference is that the purpose of traditional road pricing charges is to reduce demand on congested roads by charging users a fee, whereas value pricing simply offers the option of an alternative facility for a higher level of service, without discouraging driving.

Real-time variable pricing schemes can be used in order to reduce congestion and maintain free-flowing traffic in the HOT lane. For example, if there is little to no congestion in the HOT lane, while the general purpose lanes are highly congested, the price for entry into the HOT lane can be lowered, motivating single occupancy drivers to pay the reasonable cost of avoiding the traffic congestion. This can also
work in the opposite way, with a higher price being paid for access to a congested HOT lane. The pricing of the tolls is communicated to the drivers by highway signs, which can be changed whenever necessary. With this method, free-flowing traffic can be maintained in the HOT lane(s) at all times, even during the peak hours. The I-394 HOT lane in Minnesota and the I-15 in San Diego are examples of real-time variable pricing.

1.4 Research Purpose

This report focuses on whether an HOT facility similar to that of the SR-91 Express Lanes in California can be built on the 401 highway, where an HOV lane is currently in the planning stages. The main objective of the report is to examine the case of the SR-91, see if similar factors are present in the GTA context and based on the findings, make recommendations to the Ontario government. Ultimately, the report will recommend either to build an HOT lane on the 401, or that an HOT lane should not be built.

1.5 Relevance

Throughout the earlier years of automobile usage in North America, the solution to increasing congestion was to build more roads, which is widely considered unsustainable. The reason for this is that building more road capacity as a reaction to congestion actually encourages more single occupant drivers, since the costs (monetary and time) are lowered, which contributes to the problem (Davis, 1992). In addition, a recent study of U.S. highways by Winston and Langer (2007) estimates
that each dollar spent on general highway capacity only reduces congestion costs by 11 cents. Therefore, it is clear that highway construction has lagged far behind the rate of congestion increase, even though surface transportation is the largest grant-in-aid program in the United States, at $67 billion in 2010 (U.S. Department of Transportation, 2010). Likewise, Canada’s highways can be considered comparable because unlike their European counterparts, congestion pricing has not progressed as quickly in North America. Recently, a new ideology has been adopted, dubbed “the new realism,” which accepts that road building will not solve the problems of transportation in our cities (Davis, 1992).

Considering that projections for population growth in the Greater Golden Horseshoe indicate 47 percent growth over the next 25 years, transportation planners should be aware of the potential problems of highway congestion, and be ready to offer alternative solutions apart from building more road capacity. An HOT lane on a congested highway such as the 401 may be the first breakthrough case of HOT facilities in Canada, as the SR-91 was in the United States, and may be the first step to relieving some of the urban congestion in the GTA.

1.6 Report Structure

Chapter 1 introduces the topic of HOT facilities, sets the context by discussing the travel patterns of the GTA, and states the purpose of this report. An introduction of the MTO’s HOV Plan for the Greater Golden Horseshoe is also introduced, which has prompted the research question.
Following this introduction, Chapter 2 explores the existing literature on the topic of HOT lanes, the purported benefits and costs, and discusses potential issues with implementation.

Chapter 3 details the methodology used to explore the research question stated in the introduction. This chapter discusses the selection of performance criteria that have been applied to the evaluation of the case study. Each criterion is briefly explained, and justified in its purpose within the framework.

Chapter 4 explores the case study. The case comes from California, where the SR-91 express lane facility in Orange County has been operation since 1995. Edward Sullivan from the Department of Civil and Environmental Engineering at Cal Poly State University completed an extensive performance report entitled, “Evaluating the Impacts of the SR 91 Variable-Toll Express Lane Facility” in 1998, which was submitted to Caltrans. The objective of the study was to analyze and understand travelers’ reactions to road pricing and explore other possible impacts. In 2000, Sullivan released his continuation study, which builds upon the data and observations of his 1998 report.

Chapter 5 applies the success factors from the SR-91 case study to the context of the GTA, in order to determine if similar success can be replicated.

Chapter 6 focuses on the main outcomes of the evaluation and offers a list of recommendations for Ontario Ministry of Transportation staff. This chapter also
concludes the report with a brief overview and highlights the main discoveries of the research.
2 Literature Review

The purpose of the literature review is to gain a better understanding of the benefits, costs and motivations for HOT lanes. In addition, reviewing some of the existing HOT facilities in North America can expose issues and successes with implementation. The existing literature on HOT facilities is quite large, and thus, for the purposes of this report, the literature review is a general overview of academic and expert observations and opinions. By reviewing the main benefits and costs of HOT lanes, a better understanding of the key aspects that should be studied in the case study will be developed. Therefore, the discussions within this chapter will inform and will be reflected in the selection of evaluation criteria.

2.1 Rationale for HOT

In general, there are two major reasons for HOT implementation in North America. The first is the underutilization of HOV lanes, which are sometimes converted to HOT facilities in order to utilize unused highway capacity. The second rationale is economic, as the revenue generation capability is attractive in a time where public funding for infrastructure developments is decreasing. Each of these factors will be discussed in detail in the following sections.

2.1.1 HOV Lanes as a Precursor

The main criticism of HOV facilities is that they are generally underutilized, to the irritation of motorists on the adjacent lanes. The history of HOV lanes in the United States points to the constant readjustment of HOV strategies to address underused capacity. Originally, high occupancy vehicle lanes were planned as bus-only, in order to encourage transit ridership (Altushuler, 2010). However, it was soon discovered
that only a few corridors within the United States contained enough bus traffic to use most of the lane capacity on highways (Altshuler, 2010). Therefore, the next step was to allow carpools with a minimum of three occupants into the bus lanes, which then became HOV lanes (Altshuler, 2010). Even then, there was considerable unused capacity on HOV lanes, which was apparent to the motorists on the adjacent, mixed flow lanes. Therefore, going into the early 1980s, most HOV lanes were opened to two-person carpools, and yet, unused capacity remained, which motivated policy-makers and academics to search for a different strategy to allocate the remaining capacity (Altshuler, 2010).

In fact, even with a growing number of HOV lanes in America, the number of commuters that carpooled to work decreased by 19 percent during the 1980s, and average vehicle occupancy in metropolitan areas also decreased from 1.17 persons/car in 1970 to 1.09 in 1990 (Poole and Orski, 1999). Alan Pisarski (1996) claims that levels of ridesharing and carpool activity have not seen the expected improvements because those trips are made with family members who have similar destinations and timing, and therefore, “trip chaining” becomes prevalent. Trip chaining describes travel behaviour where multiple destinations are made in the same trip, in order to save time and money. For example, when a mother drops her child off at day care, she may choose to go grocery shopping in the mall that is located close to the day care. In other words, people are not being motivated to change their trip and occupancy patterns: those who use HOV lanes would have the same occupancy regardless of the availability of HOV facilities. As a result, HOV
lanes will only benefit a small segment of the population—those who already had high occupancies in their vehicles.

In 1998, New Jersey decommissioned two of its HOV lanes due to concerns about the wasted capacity, and introduced legislation that required a study of HOV lane effects (Dahlgren, 2002). In California, Bill AB 2129 was introduced in 2000, which stated that HOV lanes that are found to be ineffective will be converted to HOT or general purpose lanes (Dahlgren, 2002). In order to determine the effectiveness of HOV lanes, several bills have been passed that require their study and assessment (Dahlgren, 2002). Part of the analysis would require the consideration of four options: an HOV lane, an HOT lane, a mixed-flow (general purpose) lane, and a “no-build” option (Poole and Orski, 1999). Therefore, in order to implement an HOV lane, it would have to be proven that it is the most efficient compared to the other alternatives, in terms of traffic throughput and travel time (Poole and Orski, 1999).

All of this relates to a discussion of HOT because often, the costs of failed HOV lanes (monetary and unused capacity) will trigger discussions of HOT as an alternative. If MTO’s planned HOV lanes on the 401 will suffer the same challenges as those discussed in this section, it might be prudent to proactively consider HOT, not as a reactionary measure to a failed HOV lane, but as an anticipatory measure to maximize capacity usage and offset construction and maintenance costs.
2.1.2 Cost and Lack of Public Funding for Infrastructure

The second major driver for HOT acceptance in North America is the growing issue of infrastructure underinvestment, due to lack of public funding. From 1985 to 2007, Canadian municipalities have seen the municipal infrastructure deficit reach $123 billion dollars, compared to $12 billion in 1985 and $60 billion in 2003 (Mirza, 2007). Canada is in a particularly difficult situation because its relatively small population is spread out across a very large country. Therefore, building and maintaining infrastructure is very costly.

In particular, the $123 billion infrastructure deficit includes a “sub-deficit” of $21.7 billion for transportation infrastructure (Mirza, 2007). Most of the roads and highways in Canada were built in the 1950s and 1960s, and thus, have reached the end of their service life, and even the newer roads and highways require immediate maintenance, due to a deferral of maintenance over the last 20 years (Mirza, 2007). Even Statistics Canada admitted “governments have boosted the flow of investment in roads from $4.3 billion in 1998 to $7.3 billion in 2005, but this has barely offset the erosion of the road system” (2007, pg. 36).

The transportation deficit becomes particularly troubling in times of economic struggle. In those times, governments see the costs of providing public services increase, while tax revenues decrease. Therefore, when the economy is performing poorly, governments are more likely to defer infrastructure to the future. The problem is, deferring maintenance and repair runs the risk of jeopardizing the infrastructure and reducing service life (Mirza, 2007). According to a study done by
Dr. Saeed Mirza (2007), a professor of civil engineering at McGill University, in a worst case scenario of no maintenance (constant deferral), by 2067, the infrastructure deficit will reach over two trillion dollars. These facts are relevant to this study because of the state of the global economy and in particular, Ontario’s infrastructure investment strategies.

In 2005, before the global economic recession of 2008, the Ontario Ministry of Infrastructure developed ReNew Ontario, a five year investment plan to address the issue of aging infrastructure. Transportation investments totaled $11.4 billion by 2010 (Ministry of Infrastructure, 2011). After the program had been completed, and the global recession hit, there were concerns that infrastructure investment would not remain strong. However, according to the Ontario 2011 budget, infrastructure investment will hit its highest point ever, with $14.1 billion in 2010-2011 and $12.8 billion in 2011-2012 (Ministry of Finance, 2011). While these numbers are encouraging signs of addressing the issue of infrastructure underinvestment, the need ($21.7 billion) is greater than the current provision. One strategy to reduce the need is to explore avenues of generating revenue from their infrastructure investments. HOT facilities are one form of that strategy, whether they are built through a public-private partnership or with public funds.

One simple way to realize the benefits of HOT with minimal cost is to convert existing HOV lanes to HOT. The cost of converting is relatively low, since new lanes do not have to be built. The initial capital expenditures would include plastic pylons, changeable message signs, gantries, toll collection and video equipment, and the
computer hardware and software (Poole and Orski, 1999). General operating costs include staff to operate the electronic tolling system, advertising/marketing to explain the HOT lane to the public, as well as enforcement costs (Poole and Orski, 1999). The I-15 was an example of a conversion, which required $1.85 million in capital costs, and it has generated revenue of approximately $1 million per year (Poole and Orski, 1999).

The SR-91 is the only HOT facility that was built as new capacity, and part of the reason was that private investment was introduced in a public-private partnership arrangement. This was in contrast to the alternative of public ownership, where both costs and revenues would belong to the public transportation agency. A more detailed analysis of the financing will be available in the case study.

Since highways are seen as public domain, and HOT lanes are expected to generate revenue, the use of private sector financing has been problematic. An HOT lane project’s viability for a private investor requires the continuation of congestion on the adjacent free lanes, in order to maximize profits (Althshuler, 2010). This runs in contradiction to one of the purposes of the HOT lane, which is to reduce congestion. The SR-91 is the only case where the project was financed by private investment, and it was eventually bought out by the public agency, the Orange County Transportation Authority. A more detailed analysis of the situation will be discussed in the case study. All subsequent HOT projects have been purely public (Althshuler, 2010).
As new technology—such as non-stop electronic toll collection with transponders—becomes cheaper to implement, the costs of an HOT lane will be reduced and make them more financially feasible. Individual drivers pay for the cost of the transponders (Poole and Orski, 1999). In addition, alternatives to an electronic toll system such as conventional toll booths and the use of permits may be unpractical in some situations. For example, on many congested highways, there is simply no room to add toll booths, and requiring cars to stop at the booths would increase congestion, create safety issues, and make the HOT lane politically unpopular (Poole and Orski, 1999). Also, toll booths are labor intensive and result in high costs (Poole and Orski, 1999). The problem with permits such as window placards is that they reduce the operator's ability to manage traffic flow, since they are limited to a very crude form of pricing such as weekly or monthly flat rates (Poole and Orski, 1999).

Therefore, the low cost of converting underutilized HOV lanes, as well as the revenue generation capabilities (through public ownership or a lease agreement in a public-private partnership) have caused HOT facilities to become an increasingly attractive option for cash strapped governments.

### 2.2 Where Have HOT Lanes Been Implemented?

As of Spring 2010, there were 10 cases of HOT lanes in operation in North America (Refer to Table 2). To date, the only HOT facility that has been implemented as new capacity is the 91 Express Lanes in California. All the others were originally HOV lanes that have been converted.
**Table 2: HOT Facilities in North America as of Spring, 2010**

<table>
<thead>
<tr>
<th>Site, Scale, &amp; Date of Opening</th>
<th>Occupancy Required to Avoid Tolls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange County, CA (SR91) Opened 1995 (16 km, two lanes in each direction)</td>
<td>3+ carpools free except eastbound 4-6pm weekdays, when they pay 50% of the toll applicable to one- and two- occupant vehicles</td>
</tr>
<tr>
<td>San Diego (I-15) Opened 1996 (13 km, one lane in each direction); expansion to two lanes in each direction in progress</td>
<td>2+ carpools free at all times</td>
</tr>
<tr>
<td>Houston (I-10, US 290) I-10 opened 1998 (64 km, in a single reversible lane); In 2009 three new lanes opened on a 19 km stretch of I-10, which now has two HOT lanes in each direction US 290 opened 2000 (22 km, in a single reversible lane)</td>
<td>3+ carpools free in the original reversible lane. 2+ carpools free except 2.25 peak hours on weekdays. Solo drivers excluded. In the 19 km expansion, 2+ carpools travel free during four peak hour weekdays, pay small toll other times; solo drivers tolled at all times</td>
</tr>
<tr>
<td>Minneapolis (I-394, I-35W) I-394 opened 2005 (18 km, one lane in each direction) I-35W opened 2009 (19 km, one lane in each direction)</td>
<td>2+ carpools free at all times</td>
</tr>
<tr>
<td>Denver (I-25) Opened 2006 (11 km, in two reversible lanes)</td>
<td>2+ carpools free at all times</td>
</tr>
<tr>
<td>Salt Lake City (I-15) Opened 2006 (71 km, one lane in each direction)</td>
<td>2+ carpools free at all times. Solo drivers pay $50 monthly fee</td>
</tr>
<tr>
<td>Seattle (SR167) Opened 2008 (14 km, one lane in each direction)</td>
<td>2+ carpools free at all times</td>
</tr>
<tr>
<td>Miami (I-95) Opened 2008 (11 km, one lane in each direction)</td>
<td>3+ work carpools free at all times. At least three work occupants must be registered</td>
</tr>
</tbody>
</table>

Source: Altschuler, 2010.
2.3 Advantages and Disadvantages of HOT Lanes

Table 3: Purported Advantages and Disadvantages from the Academic Literature

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trip Time Reliability</strong>: Traffic volumes on HOT lanes are managed to ensure consistent and reliable travel times, particularly during peak travel periods</td>
<td><strong>Equity Issues</strong>: Runs the risk of “luxury lanes” or “Lexus Lanes,” meant for only those who are able and willing to pay for better service</td>
</tr>
<tr>
<td><strong>Travel Time Savings</strong>: Allows HOV and paying non-HOV motorists to travel at higher speeds than vehicles on congested general-purpose lanes</td>
<td><strong>Encourages SOV Drivers</strong>: By allowing single occupant vehicles to purchase the use of uncongested lanes, rather than restricting their access like on HOV lanes, HOT may encourage drivers to travel alone</td>
</tr>
<tr>
<td><strong>Revenue Generation</strong>: Can provide an additional source of revenue to support transportation improvements such as the construction and operation of the lanes themselves, or to address corridor transit needs or other local demand management strategies</td>
<td><strong>Cost</strong>: HOT lanes are more expensive to implement, with the requirement of enforcement, toll collection and monitoring</td>
</tr>
<tr>
<td><strong>Transit Improvements</strong>: Revenues may be used to support transit improvements, and new HOT lane facilities provide faster highway trips for transit vehicles</td>
<td></td>
</tr>
<tr>
<td><strong>Trip Options</strong>: In congested corridors with HOV facilities and transit service, HOT lanes provide SOV motorists with an additional travel choice: the option of paying for a congestion-free, dependable and faster trip</td>
<td></td>
</tr>
<tr>
<td><strong>Utilization of Excess Capacity</strong>: HOT lanes may provide an opportunity to improve the efficiency of existing or newly built HOV lanes by filling “excess capacity”</td>
<td></td>
</tr>
</tbody>
</table>


The following sections highlight some of the academic literature on key aspects of HOT lanes that have been discussed already. Empirical evidence and expert opinion
will allow for a proper understanding of factors that should be studied when evaluating the case study.

2.3.1 Performance and Efficiency

Joy Dahlgren (2002), a researcher at the Institute of Transportation Studies at the University of California, Berkeley, points out that HOT lanes can be effective in certain circumstances, citing the 91 Express Lanes in Orange County, California. On the other hand, Dahlgren finds that the I-15 in San Diego and the Katy Freeway in Houston have not had the improvements in delay and revenue generation that has been seen on the SR-91.

Therefore, Dahlgren conducted a study to determine how adding an HOV lane, an HOT lane, or a general purpose lane to an existing freeway would affect travel delay in certain circumstances. Dahlgren discovered that adding a general purpose lane is more effective than both an HOV lane and an HOT lane at reducing delay, except when initial delay is very high. There is also the added benefit of lower cost to implement a general purpose lane. Also, a general purpose lane has lower maximum delay, since the delay is equalized across all the lanes (Dahlgren, 2002). In Dahlgren’s point of view, it is worse if the delay is grossly disproportional across the lanes in comparison to a higher average delay that is equal for everyone. For example, it is better that all drivers take 20 minutes to travel 15 kilometres on an all general purpose lane highway, rather than 80 percent of drivers taking 40 minutes, while 20 percent (HOV/HOT users) travel the same distance in 15 minutes.
However, Dahlgren points out that an HOV lane is more effective than the other options when both the initial delay and the initial proportion of multi-occupant vehicles are very high. In other words, the potential users of the HOV lanes are already existent. In these situations, they are more appropriate than HOT lanes because they both reduce congestion and provide faster travel for carpoolers, but do not require installing an expensive toll collection system (Dahlgren, 2002).

If the proportion of multi-occupant vehicles is not high, then the HOT lane is the most effective at reducing congestion because of its ability to allow allocation of unused capacity to single occupant vehicles. If, however, the proportion of multi-occupant vehicles is high, then there will not be much capacity for toll-paying single occupant drivers, so tolls will rise to limit those drivers, resulting in low revenues and upset toll-paying customers (Dahlgren, 2002). In such a case, Dahlgren suggests an increase in the required occupancy for high occupancy vehicles, citing the case of the Katy Freeway in Houston, which was raised from 2+ to 3+ during peak hours. Another option would be to convert the HOT lane to an HOV lane, since the costs of running an HOV facility are lower than an HOT facility.

There have been several studies conducted that indicate that a person's decision to use a high occupancy vehicle is not very sensitive to in-vehicle travel time. For example, Kenneth Small (1977) claims that people place an equal value on one minute of pre-trip waiting time as ten minutes of in-car waiting time. In other words, people are much more impatient waiting for a bus or carpool in comparison to being stuck in traffic. This claim suggests that the motivation to shift to a higher
occupancy mode of travel is generally not strong enough to motivate many people to give up their single occupant vehicles. Some experts even claim that HOT policies discourage carpooling, since entry into the HOT lane can be bought by single occupant drivers (Kinoshi and Mun, 2010). If this is true, at the very least, the conversion of HOV lanes to HOT lanes will generate revenue and use some of the existing excess highway capacity on those lanes.

### 2.3.2 Effect on Public Transit

Congestion pricing strategies such as HOT lanes are supposed to have mutual benefits with public transportation.

HOT lanes should benefit public transit by improving their speeds and the reliability of service, by providing an uncongested highway lane for transit users (U.S. DOT, 2011). This will in turn, increase transit ridership and lower costs for public transportation providers (U.S. DOT, 2011). Lastly, HOT lanes provide an opportunity for greater investment in public transit by being a source of increased revenue, which may be used for transit expansions, service increases, maintenance and improvements (U.S. DOT, 2011).

Public transit is also supposed to benefit HOT lanes by absorbing commuters who wish to shift their mode of travel from automobile to bus or rail (U.S. DOT, 2011). This will reduce the number of personal vehicles on the highway, resulting in faster speeds and more traffic throughput. Moreover, public transit options such as bus or rail provide a greater “passenger-carrying capacity,” which will increase the
passenger throughput on the highway, without increasing congestion (U.S. DOT, 2011).

Therefore, it appears that HOT lanes and transit improvements are strategies that are well suited for each other. However, in practice, those benefits have not been fully realized. According to the U.S. Department of Transportation (2011), the current experience with HOT lanes suggests that they generally do not perform very well in shifting commuters to public transportation. Other congestion pricing strategies such as zone-based (cordon or area) pricing schemes have been much more effective.

For example, on the I-394 in Minneapolis, there appears to be a weak connection between the HOT lanes and public transportation. A November 2006 evaluation of the project found that most public transportation providers reported a negligible impact on transit operations as a result of the HOT lane deployment (Jackson et al, 2008). One of the conclusions of the evaluation was that the HOT lane would not result in mode-share changes within the I-394 corridor (Jackson et al, 2008). Similar results have been seen on the I-10 in Houston, Texas, and the I-15 in San Diego, California. On the other hand, there are encouraging signs for transit users that funding will be directed to transit on the I-15. Approximately half of the revenues generated from the HOT lane ($1-$2 million annually) are used to fund the Inland Breeze express bus service (U.S. DOT, 2011). Moreover, with the new 19 kilometre expansion of the I-15 underway, a key component of the project was the inclusion of direct access ramps for five new bus rapid transit stations (Jackson et al, 2008).
2.3.3 Carpooling and Average Vehicle Occupancy

A study by Jianling Li (2001) at the University of Texas shows that there is a positive correlation (0.65) between vehicle occupancy and HOT lane use, which is statistically significant at the 0.001 level. The study also showed that with each additional passenger in the car, the likelihood of HOT lane use increased by 92 percent. However, these statistics only show whether cars with high occupancy counts will use HOT lanes if available; they do not hypothesize or show any causal relationship between the introduction of an HOT lane and vehicle occupancies. Therefore, studies such as Li’s do not show whether people are changing to carpool/vanpool travel once an HOT facility is built.

Another study by Chu and Fielding (1994) explored the effect of an HOT lane on average vehicle occupancies (AVO), by running a simulation exercise that looked at AVO on an HOT facility over the course of 15 years. There were a number of limitations/assumptions made in their study. Firstly, the model considered all drivers to be homogenous and therefore they were restricted to the same behavioural patterns as all the other drivers. Also, the model was restricted to the afternoon peak, not allowing travelers to change their travel behaviour in order to avoid the higher tolls of this period.

The results of the simulation showed that AVO can be increased on HOT lanes by adjusting tolls. In the latter years, higher tolls were required to increase AVO and discourage single occupant drivers from overcrowding the lanes. These findings contradict other studies (Konishi and Mun, 2010) that claim that HOT lanes
discourage carpooling activities. All in all, there appears to be no consensus on whether HOT lanes will encourage or discourage carpooling and higher vehicle occupancies.

2.3.4 Equity Issues and Public Sentiment

In conversations about HOT lanes, the topic of equity always arises as a contentious issue. HOT lanes are often dubbed “Lexus Lanes” for their perceived disproportional benefit to higher income users. The argument is that low-income drivers may not have equal access to jobs, social services, and other essential activities if travel on an HOT corridor is required (Weinstein and Sciara, 2006). They still have the option of using the free general purpose lanes, but the cost (in terms of travel time) may be unevenly distributed to favour the wealthy. However, Poole and Orski (1999) point out that there are positive spinoff benefits for everyone, including those who choose not to pay the tolls. By diverting vehicles off of the general purpose lanes, those who choose to avoid paying still benefit from less vehicles within their lanes.

Although opinion poll data is scarce, the available data shows that there is no conclusive relationship between income and support for HOT lanes. In 2001, a survey was conducted in San Diego for both HOT lane users and nonusers, and the results found that “support is high across all income groups, with the lowest income group expressing stronger support than the highest (80% vs. 70%)” (Altshuler, 2010). On the other hand, using a Canadian example, a survey of 4,000 GTA residents found that household income has a substantial effect on willingness to pay (WTP) in order to avoid congested lanes. Those within the low income group ($0-
59,999) consistently showed a much lower WTP than the middle ($60,000-$119,999) and the high income group ($120,000+) (Finkleman, 2010).

Also, public sentiment and support will vary according to other factors such as public versus private ownership, and whether the new lanes are built as new capacity or by converting general purpose lanes to HOT lanes. If they are built with public funds as new capacity, then the public is less likely to support the project, since it is financed with taxpayer funds but only benefits a few select users. However, if the public transportation agency is financially unable to build new capacity, then private financing may be the best option for addressing congestion issues.

2.4 Conclusion

Clearly, there are many issues surrounding HOT implementation, as well as many factors to consider. The literature review has highlighted some of the pertinent areas of concern, and will inform the selection of evaluation criteria, which will be discussed in the next chapter.
3 Methodology

The purpose of this chapter is to outline the methods that have been used to conduct the research for this report. These methods contribute the necessary information that is required to answer the research question stated in the introductory chapter.

A literature review was completed to gain a better understanding of the theoretical benefits and costs of HOT facilities, as well as some of the issues or obstacles to successful implementation. The literature review provides a context surrounding the research and identifies where this report will fall within the existing body of academic and government research. Also, since the literature review highlights some of the main benefits and potential costs with HOT lanes, the main areas for evaluation have been identified.

In addition, a case study analysis of an HOT lane was conducted. The case is the SR-91 Express Lanes from Orange County, California. The case study will consist of two sources for information:

1. For operational performance, an extensive report by Professor Edward Sullivan entitled, “Evaluating the Impacts of the SR 91 Variable-Toll Express Lane Facility” will be used. The report was submitted to the California Department of Transportation (Caltrans) and released to the public in 1998. Two years later, Sullivan’s continuation report was released that built upon the observations of the previous study. Where possible, the updated data will be used.
2. For context, aspects such as the motivations behind its implementation, the political history, financing, public sentiment, demographics, revenue generation, as well as other relevant issues will be explored. The SR-91 has been covered extensively as a case study within the academic literature, which will be the main source of information. Newspaper articles will also be a supplementary source.

Both operational performance and contextual factors play unique and interdependent roles in determining whether the SR-91 HOT project is viewed as a successful or unsuccessful facility. A number of experts (Dahlgren, 2002; Poole and Orski, 2003) use the 91 Express Lanes as an example of how an HOT facility can effectively reduce delay and generate revenue in the right circumstances. The point of the case study is to draw out the factors to its success.

Following the SR-91 case study will be a discussion of the potential for implementing an HOT lane on the 401 highway in the GTA. As mentioned in Chapter 1, an HOV lane is currently being planned for the 401 from the 410 in Mississauga out to Regional Road 25 in Milton. If the success factors from the case study are found to be present in the GTA, an HOT lane may be a better strategy than the planned HOV lane.

3.1 Reasoning for Case Study Selection

The SR-91 provides the best example of an HOT lane because it was the first variable toll scheme implemented to charge single occupant vehicles for using HOV lanes (Richards, 2006). Completed in 1995, an extensive study was completed three
years later, giving a large scope and temporal boundary for the study. Having been the first HOT lane project in the United States, there is a wealth of information on the SR-91.

### 3.2 Performance Criteria Selection

In Chapter 2 (Literature Review), the advantages and disadvantages of HOT facilities were discussed, as well as some of the academic literature on the main areas of focus. These main benefits and costs can be categorized into four major areas for evaluation. They are: 1) performance and efficiency; 2) effect on public transit; 3) carpooling and average vehicle occupancy; and 4) equity issues and public sentiment. In order to measure the effectiveness of the case study in addressing these issues, a number of performance criteria must be used. The criteria were selected based on the objectives and purported benefits of an HOV system, identified in the reports, “Preferential Lane Treatments for High-Occupancy Vehicles,” (1993) and “HOV Facilities: Traveler Response to Transportation System Changes” (2006). The Transportation Research Board of the United States published both reports. Using an evaluation system for HOV is appropriate based on the shared goals of reducing congestion, encouraging transit usage and multi-occupancy travel, and promoting equity. Each of the criteria will be briefly explained, and justified for their use within the evaluative framework. In addition, the unit of analysis for data measurement in Sullivan’s report has been included in Table 4.
Table 4: Units of Measurement for Performance Criteria

<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Unit of Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect on Transit Ridership</td>
<td>Average daily riders on transit</td>
</tr>
<tr>
<td>Vanpooling/Carpooling</td>
<td>Daily traffic volume for pay vs. free and total riders in vanpools</td>
</tr>
<tr>
<td>Travel Time Savings &amp; Speed</td>
<td>Minutes saved; Kilometres per hour</td>
</tr>
<tr>
<td>Average Vehicle Occupancy</td>
<td>Persons per vehicle</td>
</tr>
<tr>
<td>Public Sentiment &amp; Equity</td>
<td>Approval percentage; HOT user demographics</td>
</tr>
</tbody>
</table>

3.3 Performance Evaluative Criteria

3.3.1 Effect on Transit Ridership

By allowing transit buses to use uncongested HOT lanes free of charge, the expectation is that travel time savings will occur for transit riders. By making transit a more attractive option, the hope is that a modal shift will occur, with solo commuters who refuse to pay the toll giving up their vehicles for transit.

3.3.2 Vanpooling/Carpooling

A vanpool or carpool describes a prearranged ridesharing function between several people, to travel in a single automobile (Transportation Research Board, 1993). The minimum number of persons required is two or more occupants, including the driver, although the requirements for HOV designation may vary across different facilities. A higher average vehicle occupancy is an expected outcome from greater vanpooling/carpooling activities.
3.3.3 Travel Time Savings and Speed

One of the greatest incentives for drawing single occupant motorists to an HOT or HOV lane is the potential for travel time savings. However, the savings must be significant enough to outweigh the costs of either taking transit or arranging carpools/vanpools. Research suggests that a speed of below 48 to 64 kilometres per hour must be experienced on the general purpose lanes for single occupant motorists to switch to HOV/HOT facilities (Institute of Transportation Engineers, 1992). Research also indicates that HOV/HOT facilities must produce a time travel savings of one minute per 1.6 kilometres, with a minimum total of five minutes’ worth of savings (Transportation Research Board, 1992). Therefore, based on these minimums, an HOT lane will be only relevant for trips that are longer than eight kilometres, which is half the length of the SR-91.

Closely tied to time travel savings is speed, which is why these measurements have been categorized together. Speed is a good indicator of highway congestion, since vehicle movement on highways is meant to be optimized at 100 kilometres per hour. Low highway speeds increase commute times, and reduce the volume of traffic flow.

3.3.4 Average Vehicle Occupancy

Increasing the number of persons per vehicle, and thereby, increasing the person-movement along the highway will allow for the reduction of congestion on general purpose lanes. Increases in average vehicle occupancy (AVO) can result from either mode changes or spatial changes, or a combination of the two. Mode changes result
when an individual decides to switch from solo-commuting to either carpooling, vanpooling, or taking transit (Los Angeles County Metropolitan Transportation Authority, 2002). Spatial changes result when vehicles switch lanes, from general purpose lanes to an HOT lane (Los Angeles County Metropolitan Transportation Authority, 2002).

3.3.5 Public Sentiment & Equity

Transportation agencies are responsible to the public to ensure that highways are run efficiently, whether they are publicly or privately owned. They also have a responsibility to ensure that equity is maintained, which is closely linked to public sentiment. If these responsibilities are inadequately addressed, public support for the project, and other similar projects will result. Moreover, HOT lane user demographics can indicate whether the facility is benefitting a particular segment of the population, and excluding others.

3.4 Validity and Reliability

By complementing the case study research with a wide range of knowledge from the academic literature, the construct validity has been strengthened. Moreover, by using existing performance assessment criteria from credible sources such as the United States Transportation Research Board, the validity of the evaluative framework has been strengthened. Also, information about the case study has been used from newspaper articles. Therefore there is triangulation of sources: Sullivan’s reports, academic literature, and newspaper articles.
3.5 Biases and Limitations

The issue of bias must be addressed in all instances of research. One possible limitation of this methodology is the use of research, data collection, and analysis provided by a third party. On the one hand, Edward Sullivan, a civil and environmental engineering professor at California Polytechnic University can be considered a reputable source. However, his report was submitted to Caltrans, a public agency, which has a vested interest in presenting the SR-91 as a successful facility.

The research team, based on their own initiatives and performance indicators, has determined the data collection methods. Conducting such research requires vast resources, time, and technical expertise. The author of this report possesses none of those qualities, and therefore, the data from Sullivan’s reports must be used. However, the credibility of the data and analyses contained in these reports will be critically evaluated in order to determine any biases. It should also be mentioned that Sullivan’s work has been cited within a number of peer-reviewed academic journals.
4 Case Study – SR-91 Express Lanes

The purpose of the case study is to examine the SR-91 Express Lanes in California, and to determine if a similarly operating HOT facility can be built in the GTA. Since there are a variety of factors that affect the planning, performance, and revenue generation of the facility, all phases of the project will be explored, from the context before implementation, to the present functioning of the facility. Challenges as well as successes will be highlighted as the last section of this chapter, in order to introduce the next chapter, which will examine whether the GTA presents conditions for a similarly operating facility.

4.1 Context Before Implementation

Figure 2: Map of the 91 Express Lanes

In the 1980s, western Riverside County—the fastest growing county in the United States—experienced significant subdivision growth which fueled unexpected increases in congestion on the SR-91, which connected Riverside County and Orange County (Kim, 2000). Due to the nature of the mountainous terrain, the SR-91 is the only major highway that can connect the residences in Riverside County with the employment centres in Orange County (McDonald et al., 1999).

In order to relieve congestion on the SR-91, the Orange County Transportation Authority planned to build HOV lanes within the median of the existing highway, but realizing that the public sector could not fund the project, transportation officials were receptive to the idea of private sector involvement (Boarnet and Dimento, 2004). In fact, in 1980, Caltrans announced that there was a $912 million shortfall in their State Transportation Improvement Plan (STIP), igniting a debate about motor vehicle and gas tax revenues (Kim, 2000). The fiscal crunch was somewhat alleviated by the introduction of SB 215 in 1981-1982, which increased gas taxes by 2 cents to 9 cents per gallon, but by the late 1980s, transportation officials had to respond to statewide frustration over increasingly congested highways by raising gas taxes again to 18 cents per gallon (Kim, 2000). Over ten years, the gas tax bills increased transportation revenues by $18.5 billion dollars, which was directed toward various highway and transit projects (Kim, 2000). The state legislature passed AB 680 in 1989, which allowed up to four demonstration projects, which would use private tolls (Kim, 2000).
Rather than designating specific locations or routes as potential private facilities, AB 680 encouraged private sector participants to be innovative and flexible, having leeway to locate, finance, and operate the roads as deemed necessary (Boarnet and Dimento, 2004). CPTC, a limited partnership formed of subsidiaries of several highway construction companies, submitted a proposal for four lanes to be built within the median of the SR-91, which became the prime candidate for private franchising (Boarnet and Dimento, 2004).

A franchise agreement for a 35 year lease was completed in 1990, and the privately owned HOT facility was opened on December 27, 1995 (Boarnet and Dimento, 2004). The total cost for construction of the project was approximately $135 million (Avila and Estiot, 2004). The 91 Express Lanes to date has been the only operating toll road project that was allowed under the AB 680 legislation of 1989 (Avila and Estiot, 2004). The facility runs east-west from the Costa Mesa Freeway (State Route 55) interchange in Anaheim to just west of the Chino Valley Freeway (State Route 71) interchange in Riverside County (Refer to Figure 2). The ten mile (16 kilometre) toll lanes run parallel to the most heavily congested section of the 30 mile (48 kilometre) corridor (Boarnet and Dimento, 2004).

### 4.2 Operation of the Facility During CPTC Ownership

Initially, HOV3+, as well as motorcycle and special disabled licenses were not charged a toll, and estimates by CPTC were that approximately 30% of the vehicles on the Express Lanes fell into those categories (McDonald et al., 1999).
It’s Getting HOT in Here: A Case Study of the SR-91 in California

Not only was the SR-91 HOT facility notable for being the first of its type in the country, but it also used innovative technology for its time. Toll collection is completely electronic, with transponders mounted on the inside windshield of cars, and funds automatically withdrawn from an account (McDonald et al., 1999). Every user, even those who are exempt from paying the tolls are required to initially set up an account and deposit money, either $40 by credit card or $80 cash. There are three lanes for the toll collection area: two for toll paying customers and one for HOV customers. Those who pay tolls can drive through at normal speeds, while motorists who wish to avoid tolls by exercising HOV status must have their occupancy requirements verified by an employee (McDonald et al., 1999).

While under CPTC ownership, a published toll schedule was used rather than having variable tolls based on traffic volumes (McDonald et al., 1999). The reasoning for this was that marketing analysis by the company indicated that potential customers would be uncomfortable with unpredictable tolls (McDonald et al., 1999). Early public opinion polls indicated that most drivers on the SR-91 Express Lanes were in support of the peak/off-peak pricing scheme implemented by CPTC (Boarnet and Dimento, 2004).

Due to favourable conditions, revenues started climbing soon after the facility opened. By the third month of operation, the 91 Express Lanes reached the operating break-even point, and by the third year of operation, the facility had reached its cash flow break-even point (Avila and Estiot, 2004). From 1996 to 2001, CPTC saw total vehicle trips logged increase by 53 percent (Refer to Figure 3), total
transponders issued increase by 71 percent (Refer to Figure 4), and total operating revenue increase by an amazing 227 percent (Refer to Figure 5).

*Figure 3*

![Figure 3](image1.png)


*Figure 4*

![Figure 4](image2.png)

Figure 5


4.3 Challenges and Changes

4.3.1 The Non-Compete Clause

After the first few years of operation, demands for more capacity on the highway surfaced, causing Caltrans to consider traffic improvements (Price, 2001). Specifically, Caltrans wanted to add merging lanes between the SR-91 and the new Eastern Transportation Corridor (Boarnet and Dimento, 2004). However, such improvements were against the “non-compete” clause within the partnership agreement, unless those improvements were made for the purposes of safety (Price, 2001). As a result, Caltrans attempted to justify the new lanes on accident rates and improved safety. However, this was a contentious issue as Caltrans’ safety analysis was disputed (Boarnet and Dimento, 2004). The Orange County Register (Kindy) even reported in 2000 that,
Caltrans manipulated traffic accident numbers in an effort to recast a road-widening project on the Riverside Freeway as a serious safety issue, Caltrans documents show... In another document, dated January 14, 1999, Caltrans project engineer Javier Galindo said he was changing the project from a widening for capacity to a safety project to get around the franchise agreement. (p. A1)

The purpose of the non-compete clause within the agreement was to “safeguard the economic viability of the Project and CPTC’s substantial capital investment” and to “restrict the right of Caltrans to design, finance, construct or operate any public transportation facility within the Absolute Protection Zone and restrict Caltrans’ right to adversely affect the volume of traffic to, or the revenues generated by the Project” (Settlement Agreement, 1999, pg. 1-2). Therefore, Caltrans was restricted from increasing any highway capacity within 1.5 miles (2.4 kilometres) of either side of the toll lanes for the entire life of the franchise agreement (Boarnet and Dimento, 2004).

CPTC moved quickly and exercised the non-compete clause, filing a lawsuit in March 1999 (Price, 2001). During the course of the debate, public opinion turned against all the parties involved: what had once been viewed as a needed tool for congestion relief was being viewed by many as contributing to traffic congestion (Boarnet and Dimento, 2004). As a result, both total vehicle trips and total revenue generated took mild dips during 1999, a reversal of the annual increase trend that had been occurring since the facility opened in 1995 (Refer to Figures 3 and 5). A settlement was reached in October 1999 without further litigation (Price, 2001).
In order to avoid the headaches of the souring partnership, OCTA acquired the 91 Express Lanes for $207.5 million, and assumed $135 million of taxable debt from CPTC (Avila and Estiot, 2004). After the sale of the SR-91 Express Lanes to OCTA, the non-compete provision was eliminated, and revenues from the facility have been set aside as seed funding for general freeway improvements along the corridor (OCTA, 2011b). For example, in November 2002, voters approved Measure A to fund nearly $0.5 billion in road improvements throughout the SR-91 corridor, which would have been restricted due to the non-compete clause (Sullivan, 2003).

Clearly, using public-private partnerships offers flexibility in some forms, and inflexibility in others. Using private financing allows public transportation agencies to expand highway capacity, when public funding is unavailable for large infrastructure projects. On the other hand, since a private firm has a vested interest in the HOT facility, it will do whatever is necessary to protect its profit margins. What is good for the public is not always good for business.

### 4.3.2 Policy and Toll Changes Under OCTA Ownership

Having already removed the non-compete provisions that were so focused on profit maximization rather than improvements to congestion, the OCTA began a series of other policy changes.

First, a new toll policy was adopted by the Board of Directors on July 14, 2003, which was based on the concept of congestion management pricing (Avila and Estiot, 2004). Congestion management pricing entails constant monitoring of hourly
traffic volumes, and if volumes reach a trigger point, tolls are adjusted accordingly, and will stay frozen for six months (Avila and Estiot, 2004). All customers are notified at least ten days in advance through on-road message signs, website updates and e-mail notifications (OCTA, 2011b). Other toll prices are adjusted based on annual inflation, with the first in July 2004 (OCTA, 2011b). The first toll adjustment occurred on August 1, 2003, which raised the highest one-way toll to $5.50 USD (Avila and Estiot, 2004). Since then, there have been numerous adjustment increases made in order to deter congestion on the Express Lanes. Most recently, a toll adjustment downward was made, effective April 1, 2011, reducing the maximum one-way toll to $9.45 USD (Refer to Figure 6). All toll changes are made based on the principle that the debt service ratio should be at least 1.00 to 1.30, in order to pay off the debt (Avila and Estiot, 2004). The most updated toll schedule has been included in this report (Figure 6).

Secondly, in May 2003, the OCTA adopted the “Three Ride Free” policy, which reverts back to allowance of free travel for HOV3+ users that was initially offered by the CPTC (OCTA, 2011b). There is a slight limitation on this policy however, when HOV3+ drivers must pay half the toll between 4:00 p.m. and 6:00 p.m., Monday to Friday, only traveling Eastbound (OCTA, 2011b).

One of the most significant milestones for the SR-91 Express Lanes was the approval of Senate Bill 1316 (Correa), signed by California Governor Arnold Schwarzenegger in 2008. The bill approves the extension of the 91 Express Lanes an additional ten miles (16 kilometres) into Riverside County, and also paves the way for more
collaboration between OCTA and Riverside County Transportation Commission (RCTC) in the SR-91 corridor (OCTA, 2008). Other improvement projects enabled by the bill include (OCTA, 2008):

1. Adding a general purpose lane in each direction from the Orange County line to I-15
2. Building a direct connector flyover from the eastbound SR-91 to the northbound SR-71
3. Constructing one HOV/HOT lane in each direction on the I-15
4. Adding auxiliary lanes at various locations along the SR-91

Figure 6: Most Recent Toll Schedule, Effective April 1, 2011

Note: The tolls highlighted in blue indicate recent toll reductions
Source: OCTA, 2011c.
4.3.3 More Success During OCTA Ownership

Under the ownership of OCTA, the 91 Express Lanes have seen considerable growth, with total vehicle trips increasing a further 46 percent from 2002 (the last year of CPTC ownership) to 2009 (Refer to Figure 3). In addition, total operating revenue saw an increase of 85 percent from 2002 to 2009 (Refer to Figure 5). Vehicle trips, transponders issued, and operating revenue all hit highs in 2007 (Refer to Figures 3-5). The traffic growth on the Express Lanes has outpaced growth within the corridor by 50 percent (Hausdorfer, 2007).

One possible reason for these trends is the introduction of congestion management pricing that OCTA implemented, which is supposed to more accurately reflect and change based on recent traffic levels, compared to an unchanging toll schedule. Also, the public was quickly becoming frustrated with the non-compete feud between CPTC and OCTA. Therefore, when the 91 Express Lanes became fully publicly owned, drivers were more willing to support the facility.

Despite the recent successes, total vehicle trips and total operating revenue took a mild dip in 2008 and 2009, most likely caused by the global economic recession of late 2008. As pointed out earlier, a large proportion of the 91 Express Lane users are those who commute from Riverside County to Orange County for employment. Orange County felt the pressures of the recession, mainly due to close ties with the financial services and construction industries, which were hurt particularly hard during the recession (L.A. County Economic Development Corporation, 2009). From a low of 3.4 percent in unemployment in 2006, within two years, this figure had
jumped a full two percent, representing over 64,000 in lost jobs (L.A. County Economic Development Corporation, 2009). However, despite these losses, the 91 Express Lanes are still generating a significant amount of income and ridership.

4.3.4 Looking to the Future

Riverside County continues to experience an explosion of population growth, with an increase of 37.5 percent from 2000 to 2009, outpacing the pace of state population growth by nearly 30 percent (U.S. Census Bureau, 2011a). Over the long term, this trend is expected to continue, with estimates of a doubling of the population to 4.73 million by 2050, which would make it California’s second largest county (California Department of Finance, 2007).

Moreover, the attraction of well paying employment in Orange County seems likely to continue. According to a report prepared by Beacon Economics (2011) for the University of California, Riverside School of Business Administration, 41 percent of Inland Southern California (Riverside and San Bernadino) residents commute outside the region to work. Moreover, 40.7 percent of those commuters earn more than $40,000 USD annually, compared to 21.2 percent who earn less than $15,000 USD (Beacon Economics, 2011). Also, Orange County is the second most popular destination for these commuters, following Los Angeles (Beacon Economics, 2011). The continuation of these trends indicates that traffic along the SR-91 will continue to increase, presenting an opportunity for increased revenues for the 91 Express Lanes.
4.4 Operational Performance

Sullivan’s report was completed in 1998, three years after the opening of the SR-91 Express Lanes. Two years later, Sullivan released another report, which was a continuation study to update data and give a broader temporal scope. To date, these reports have been the most extensive, in-depth exploration of the operational performance of the facility. Consequently, even though there have been many changes to the 91 Express Lanes since 2000, the observations summarized in these reports are the most reliable sources of information. Where available, updated data, graphs and figures were used from the 2000 study; otherwise, information from the initial 1998 report was used.

4.4.1 Effect on Transit Ridership

Section 2.3.2 of the literature review pointed out that in theory, congestion pricing strategies are supposed to increase transit ridership by absorbing commuters who choose to shift their travel modes. However, experience with HOT lanes in the United States has indicated that transit ridership increases are minimal.

The two public transit services in the SR-91 corridor that were studied were the Route 149 express bus service, and the Inland Empire – Orange County (IEOC) commuter rail line. Studying these two transit lines is appropriate because they both run parallel to the facility in the SR-91 corridor, and therefore, offer an alternative mode of travel.
The Route 149 express bus line, operated by a cooperative agreement between Riverside Transit Agency and Orange County Transit, does not operate on the SR-91 lanes, but rather, on parallel streets to the facility (Sullivan, 1998). By the time of Sullivan’s report, the facility had been in operation for more than five years, but had experienced some service cutbacks in July of 1995 (Sullivan, 1998). The effects of the cutback are evident in Figure 7.

*Figure 7*

In addition, the graph shows that there has been stable ridership on the express line since early 1996, after the recovery from the service cutbacks the year before. Therefore, we can conclude that there has been no relationship between the opening of the 91 Express Lanes and Route 149 ridership rates (cited in Weinstein and Sciara, 2004).

Measuring the relationship between the 91 Express Lanes and the IEOC commuter line is much trickier, because the latter opened just two months before the former (Sullivan, 1998). What makes it more difficult is that daily rail ridership was only
1,000 boardings both ways, which only accounts for 0.5 percent of average daily traffic on SR-91, and is even smaller than the fluctuations in traffic volume from day to day (Sullivan, 1998). Therefore, Sullivan’s team looked at survey data from Metrolink riders to explain trends in ridership. Among those Metrolink riders who reported commuting in the SR-91 corridor the year before, 65 percent had driven alone, while only 4 percent had used transit (Sullivan, 1998). This indicates that the IEOC commuter line actually diverted solo commuters onto transit. In addition, since the 91 Express Lanes opened, IEOC Metrolink ridership has steadily increased (Refer to Figure 8). However, since transit ridership accounts for less than 1 percent of highway traffic in the corridor, these increases are so minimal that there is little impact (cited in U.S. Department of Transportation, 2009).

\textit{Figure 8}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure8.png}
\caption{IEOC Metrolink -- Ridership and Service Frequency}
\end{figure}


\subsection{4.4.2 Vanpooling/Carpooling}

After the SR-91 Express Lanes opened in 1995, roadside counts indicated that the number of peak period HOV3+ vehicles and vanpools increased by more than 40
percent in the corridor, which is most likely because until January 1998, HOV3+ were not charged a toll (Sullivan, 1998). Despite the small sample size of activity, Sullivan notes that the average increase from 1994-1995 of 496 HOV3+ vehicles to 725 in 1996-1996 is substantial, and statistically significant at the 99 percent confidence level (1998). However, despite the impressive increases in HOV traffic, Figure 9 shows that increases have been much more substantial for drivers who are toll paying customers.

**Figure 9**

![Weekday Pay vs Free](image)


Many employers within the region encourage vanpools, as they are an economical way of allowing employees to have shorter commute times through the SR-91 corridor. However, vanpool ridership is complex and tricky because of large swings in industrial employment, and changing regulations (Sullivan, 1998). For example, aerospace and defense contractors such as Boeing Co. and Parker Aerospace often have their work forces fluctuate by the tens of thousands, which has a drastic impact
on traffic volumes, and subsequently, vanpool activity (Sullivan, 1998). From June 2010 to June 2011, the largest defense and aerospace contractors have cut 22,865 jobs in Orange County (Casacchia, 2011). Despite those difficulties, Sullivan’s team was able to use vanpooling data from an unnamed major regional aerospace employer, which has a significant number of employees who commute through the SR-91 corridor.

Sullivan found that there has been a fairly stable trend in total vanpool and passenger counts throughout the 2.5 year study period. He notes that 90 percent van occupancy is required as a minimum for financial costs, and if demand increases, more vans will be used, rather than overloading the existing vans with higher occupancy. Therefore, the slight jump in number of vans and riders seen in spring 1996 (Refer to Figure 10) can be explained by either an increase in relative demand for vanpooling during that period, or by an increase in employment in

*Figure 10*

![Trends in Van Occupancy and Capacity](image)

Orange County. However, employment actually decreased 4 percent between March and November of 1995, indicating that the jump is most likely due to higher incentives for vanpool activity (Sullivan, 1998). Most likely, the incentives for this increase are less congestion on the HOT lanes, avoidance of tolls and employer rideshare and transit incentive programs (DeCorla-Souza, Lee and Jacobs, 2004).

4.4.3 Travel Time Savings and Speed

As mentioned previously in this report, commuters who travel from residential Riverside County to the employment centres in Orange County cause most of the heavy freeway traffic on the SR-91. Therefore, it is expected that the heaviest congestion occurs around the morning rush-hour (8-9 A.M.) traveling westbound, and around the afternoon rush-hour (5-6 P.M.) for those traveling eastbound. Since the Express Lanes were introduced in part to reduce congestion, the percentage of toll paying customers should be highest during those peak hour times. The reasoning for this is that the heavier congestion motivates individuals to use the Express Lanes in order to realize travel time savings. Figure 11 confirms this fact, as it shows that for the eastbound P.M. peak period, savings for travel time peaks at the same time as Express Lane usage.

Travel time savings are calculated as the difference between actual trip time and the fastest estimated trip time from 1996 observations (Sullivan, 1998). Figure 11 indicates that the time savings for peak Express Lane users in June 1997 was 12 minutes. Therefore, since the peak toll during that time was $2.75, a 12 minute time savings implies that the monetary value of these savings was $13.75 per hour.
In general, travel time during peak periods for the entire corridor, including the free lanes dropped from seventy minutes in June 1995 to under thirty minutes in June 1996 (Sullivan, 1995; cited in Boarnet and Dimento, 2004). In addition, travel speeds for the peak periods more than doubled for all the lanes (Sullivan, 1995; cited in Boarnet and Dimento, 2004 and Poole and Orski, 2004).

Interestingly, surveys of SR-91 Express Lane customers show that a large proportion of them overestimate the true time savings. Figure 12 shows that over one-third of survey respondents believe that their use of the Express Lanes saves them more than 20 minutes, which is substantially greater than the 12 to 13 minutes that were found through observational data. This begs the question of whether travel behaviour would change if toll paying customers were aware of the true value of their time savings.
So far, the focus of the discussion has been on time savings for those individuals who use the Express Lanes. However, Sullivan’s study indicates that by diverting thousands of vehicles from the free lanes, general congestion and travel times for all SR-91 commuters have improved. Figure 13 shows cumulative travel times for eastbound traffic from Magnolia Avenue, near the interchange of SR-91 and Interstate Canyon, and Coal Canyon, near the Orange-Riverside County line.


---

*Figure 12*

**Reported Time Saved by Toll-Paying Express Lane Users**

- 10.7% for 10 minutes or less
- 17.9% for more than 30 minutes
- 23.6% for 11 - 20 minutes
- 47.8% for 21 - 30 minutes

*Figure 13*

**Cumulative Travel Times - SR91 EB from Magnolia to Coal Canyon**

(Sullivan, 1998). Figure 13 shows that in June 1995, at the afternoon peak period, it would take 70 minutes to travel 29 kilometres between the two reference points, but in the two years after the Express Lanes opened, the same trip would take less than half that time.

### 4.4.4 Average Vehicle Occupancy

Since the 91 Express Lanes were built as an alternative to an HOV facility, it is important to look at the effect of an HOT facility on average vehicle occupancies.

*Figure 14*

![Graph showing trends in occupancy counts, PM peak, SR 91 EB at Lakeview](image)


(AVO). Figure 14 shows the growth trends in the counts of SOV, HOV2 and HOV3+ traffic. There is a much steeper trend in SOV growth, compared to slower growth in HOV trends (note that there are different Y-axes for HOV and SOV counts). Therefore, with a steeper growth in SOV traffic on the SR-91, SOV share of traffic has
increased with time. This may run in contradiction to the aims of an HOV facility, but for the 91 Express Lanes, it could indicate that the facility has been generally successful in attracting toll paying customers. Moreover, in early 1999, counts for SOV traffic declined sharply, while HOV2 traffic saw its highest increases. These dates coincide with a sharp peak in gas prices (Refer to Figure 15), which motivated commuters to carpool in order to reduce costs.

Figure 16 shows the trends in AVO from 1994 to 1999. The regression line for the whole dataset (1-line fit) shows that throughout the period studied, there is a negative slope, indicating a general decrease in AVO over time. This finding is consistent with the trends in occupancy counts, as it was pointed out that the increase in SOV traffic significantly outpaced the modest gains in HOV2 and HOV3+

![Figure 15](image-url)

**Historical Gas Prices in California**

traffic. Therefore, it is expected that there should be an overall decline in peak period AVO on the SR-91.

4.4.5 Public Sentiment & Equity

One of the greatest challenges facing HOT lanes in North America is public disapproval with toll based access to better service. In the early years of the SR-91 Express Lanes, the most cited reasons for disapproval with the facility were “unfair,” “only benefits the rich,” and “new lanes should be free to all” (Refer to Figure 17).

In general, the SR-91 serves an affluent population, because of the high proportion of commuters who work in Orange County and reside in Riverside County. As Figure 18 depicts, approximately 68 percent of SR-91 users have an annual household income of at least $60,000 USD, based on a survey of 1,964 users in 1999. Note that
these statistics are reflective of all the highway lanes, including the HOT lanes and the general purpose lanes (a discussion of HOT lane usage will follow).

*Figure 17*

![Chart showing reasons for disapproval of toll lanes to bypass congestion](image)


*Figure 18*

![Pie chart showing annual household incomes of SR-91 peak period users (1999)](image)


Moreover, Figure 19 shows that modal choice is not greatly affected by income. There appears to be a slight tendency for lower income users to travel with high
occupancies, reflecting the reduced costs of traveling in this mode. Again, the graph is a reflection of all the lanes on the highway.

Focusing solely on the Express Lanes, it is clear that there is a relationship between use and income. The majority of those within the lowest income groups are unlikely to use the Express Lanes, with the majority (almost 70 percent) of respondents in this category never using the facility (Refer to Figure 20; cited in Li, 2001). This is in contrast to approximately 55 percent of users with household income of at least $100,000 describing themselves as “frequent” users of the HOT lanes. Clearly, the financial cost of driving alone and paying tolls is great enough that lower income users are deterred from using the HOT lanes.

Interestingly, although there is a clear relationship between paying tolls for the use

\textit{Figure 19}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{income_distribution.png}
\caption{Income Distribution by Travel Mode (1999)}
\end{figure}

of the HOT lanes, and income, there appears to be no discernable relationship between income and approval of toll lanes in order to bypass congestion (Refer to
Figure 21). The highest income group of $100,000+ has the highest approval rating at over 70 percent, but ranking second is one of the lower income groups of $25,000-40,000 at nearly 60 percent (cited in Weinstein and Sciara, 2006). Therefore, it appears that issues of equity have been overemphasized, as the most disadvantaged users appear supportive of the HOT facility.

4.5 Learning Lessons/Summary

The following is a summary of the SR-91 case study, highlighting some of the pertinent details.

1. The SR-91 corridor serves many high income users, who commute from Riverside County to employment centres in Orange County. Those high income users are more likely to pay for SOV access.

2. Congestion in the corridor had become so severe that Caltrans and OCTA were forced to build more highway capacity, but did not have the funds.

3. Building upon the previous point, there was public and political motivation to seek alternative forms of financing in order to address congestion.

4. Normally, building four new lanes would increase costs substantially, but luckily, there was space within the median of the existing highway to add lanes.

5. Like many other HOT facilities in North America, benefits to public transit have been minimal.

6. Carpool/Vanpool activity has seen mild growth, whereas SOV toll-paying customers have increased significantly.
7. Not surprisingly, toll-paying customers use the Express Lanes most during peak periods, and average time travel savings during that time was 12 minutes.

8. The opening of the Express Lanes has reduced travel time for all lanes by more than 50 percent.

9. Low income SOV drivers are much less likely to pay for HOT lane access, but still remain supportive of the facility.

10. Electronic toll collection and detection has allowed for faster, more efficient flow of traffic.

11. The existence of a non-compete clause restricted Caltrans and OCTA from pursuing any highway improvements near the HOT facility.

4.6 Success Factors of the SR-91 Express Lanes

Based on the information provided within the case study, six success factors have been drawn out from the case study’s learning lessons/summary list. Each of these factors has been identified as being critical to the SR-91 Express Lanes’ initial implementation and continuing viability. These factors will then be applied to the GTA, in order to determine if a similarly operating facility can be implemented on the 401 in Peel/Halton.

1) Employment, demographics and income levels

Simply building an HOT lane will not ensure congestion relief or revenue generation. There are a multitude of factors that contribute to its viability and
efficacy. As mentioned in the case study, a large proportion of the 91 Express Lane users are higher income earners who commute from their homes in Riverside County to employment centres in Orange County. The higher incomes allow them to be more willing to pay the tolls necessary to save minutes from their commute.

2) *Very high congestion levels before implementation*

The ability of an HOT lane to divert drivers away from the general purpose lanes is contingent upon offering a better level of service in terms of time travel savings. With greater congestion on the general purpose lanes, the option of using an HOT lane becomes more attractive. Therefore, there is a symbiotic relationship between the HOT lane and congestion: although HOT lanes reduce congestion, they also require congestion in order to offer an attractive alternative.

3) *Political will and support*

Building upon the frustrations of SR-91 corridor drivers and the lack of public funds, the passing of AB 680 in 1989 indicated that there was political will and support for addressing congestion issues on in the corridor. Moreover, the legislation allowed for more flexibility and creative solutions to the problem.

4) *Space to build 4 new lanes*

Based on the increasing congestion in the corridor, new highway capacity was needed. Luckily, because there was space to build an additional four lanes within the median of the existing highway, additional land did not have to be purchased, which minimized costs.
5) Use of advanced electronic system for collection and detection

The 91 Express Lanes was a leader in the use of new technologies to maximize the efficiency of the facility. The functioning of the HOT lanes would be much slower if transponders and electronic toll collection were not implemented.

6) Removal of non-compete clause

Some of the problems associated with public private partnerships can be seen with the SR-91 Express Lanes. The private party had a mandate to maximize profit for their owners or shareholders, whereas the public agency was responsible for acting in the best interests of the public. Removing the non-compete clause has allowed the OCTA more flexibility to plan for the transportation needs of the SR-91 corridor, and has allowed for the provision of needed funds for highway improvements, which were restricted during CPTC ownership.
5 Is An HOT Facility Appropriate for the 401 Highway in the GTA?

Having conducted an in-depth case study of the SR-91 Express Lane facility, six factors were identified as being crucial to the successful implementation and continuing viability of the project. In this chapter, the GTA will be assessed according to these factors, to determine if a similar facility is appropriate and viable. A regional map of the GTA has been provided for reference purposes (Refer to Figure 22).

*Figure 22: Map of the Greater Toronto Area (regional municipalities in blue letters)*

5.1 Employment, Demographics and Income Levels

As noted in the case study of the SR 91 Express Lanes, the ability to generate revenue has been driven by two main factors: cross-commuting from Riverside and Orange Counties and; high income levels for many commuters who use the SR 91 corridor.

Since the early 1990s, the GTA has seen explosive growth in population and employment outside of the city boundaries. In particular, the 905 regions of Peel and York have seen the greatest increases in both categories (Refer to Figure 23).

For all regions surrounding Toronto, employment growth has actually outpaced population growth from 1991-2001. In contrast, Toronto has seen the opposite: population growth has outpaced its employment growth. This means that there are an increasing number of Toronto residents who are commuting to their places of employment in the surrounding regions.

Figure 23: Population and Employment Growth for the GTA, 1991-2001

Source: MMM Group, 2008.
As Table 5 shows, there have been significant increases in cross-commuting patterns between the different GTA regions. In particular, Halton has become a popular employment destination for Durham and York Region residents, with 166 percent and 162 percent increases, respectively. Halton is situated in the southwest corner of the GTA, requiring commuters to travel along the 407 Express Toll Route (ETR) or the 401 for the fastest route. The intended HOV lane for the 401 is planned for Halton Region.

In addition, the only decrease in travel has been seen in Toronto origin and destination trips. In general, the GTA has become decentralized in terms of population and employment. Therefore, determining the demographic conditions for an operation similar to the SR-91 Express Lanes is more complex for the GTA.

*Table 5: Origin and Destination Commuting Trends, 1991-2001.*

<table>
<thead>
<tr>
<th>ORIGIN</th>
<th>DESTINATION</th>
<th>Toronto</th>
<th>Durham</th>
<th>York</th>
<th>Peel</th>
<th>Halton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toronto</td>
<td>-1%</td>
<td>16%</td>
<td>33%</td>
<td>10%</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>Durham</td>
<td>17%</td>
<td>12%</td>
<td>74%</td>
<td>55%</td>
<td>166%</td>
<td></td>
</tr>
<tr>
<td>York</td>
<td>33%</td>
<td>60%</td>
<td>58%</td>
<td>91%</td>
<td>162%</td>
<td></td>
</tr>
<tr>
<td>Peel</td>
<td>11%</td>
<td>68%</td>
<td>93%</td>
<td>41%</td>
<td>66%</td>
<td></td>
</tr>
<tr>
<td>Halton</td>
<td>15%</td>
<td>45%</td>
<td>92%</td>
<td>50%</td>
<td>7%</td>
<td></td>
</tr>
</tbody>
</table>

Source: MMM Group, 2008.

Moreover, unlike the SR 91, which is the only main highway that connects Riverside and Orange Counties, the 407ETR provides an alternative to the 401 for those traveling east-west in the GTA. The 407ETR runs parallel to the 401, approximately eight kilometres north (Refer to Figure 19). While the 407ETR is a toll expressway that does not offer any free lanes, it takes approximately five minutes to travel by
car from the 401 to the 407ETR by taking the 400 highway (Google Maps, 2011). Therefore, for travelers who want to avoid the often congested 401, the 407ETR provides an alternative route for a price. However, depending on the circumstances of travel origin and destination, the additional 10 minutes that would potentially be spent on rerouting would reduce time travel savings. Of course, for those who have both trip origin and destination closer to the 407ETR, it might be more feasible to use that facility. In addition, there are only four north-south highway interchanges between the 401 and 407ETR, providing fewer opportunities for quick rerouting. In particular, east of the 404, there are no highway connections between the 401 and 407, meaning that motorists must use local roads to reconnect to the 401 (Refer to Figure 24).

Figure 24: Map of the Greater Toronto Area

Source: Google Maps, 2011.
In order to generate revenue, there must be a sizeable population that is willing to pay for a better level of service. The 91 Express Lanes were able to capitalize on an affluent population that frequently traveled through the corridor. In fact, in 1999, 58 percent of toll paying customers on the Express Lanes had an annual household income over $60,000 USD per year (Sullivan, 2000). This is in contrast to the median household income in California of $47,000 USD for 1999 (U.S. Census Bureau, 2005).

*Figure 25*

![Median Household Income by GTA Region, 1990-2000](image)


Likewise, the GTA has seen relatively high incomes across the region, in comparison to the province. The provincial median household income was $60,248 in 2000, while Halton, York and Peel had household incomes of $74,946, $75,719 and $69,162 respectively (Refer to Figure 25). In addition, these three regions saw the highest increases in cross commuting patterns, as shown in Table 4.
Therefore, the increases in cross-commuting and high income levels across the GTA appear to present favorable demographics for an HOT lane on the 401. However, the existence of the 407ETR could present competition, based on the origin and destination of trips.

5.2 Very High Congestion Levels Before Implementation

In 2008, Metrolinx, the regional transportation authority in the GTA, conducted a study of the costs of congestion to the region. It found that in the GTA, there is a travel time index (TTI) of 1.63, and the City of Toronto has an index of 1.88 (Metrolinx, 2008). TTI is the ratio of peak period travel time compared to free-flow travel time (Metrolinx, 2008). For example, with a TTI of 1.63, a trip that would take one hour in free-flow traffic would take 98 minutes during peak periods (a 63 percent time penalty). As a result of high TTI, commuting times in the GTA have increased. A study conducted by the Toronto Board of Trade (2011) found that commuting time in Toronto ranked last of 21 international cities with an average time of 80 minutes, falling behind cities like New York (69.1), Los Angeles (55.9), Tokyo (69.0), Berlin (63.2), Vancouver (67.0) and Montreal (76.0).

Moreover, without an integrated regional mass transit system that reaches beyond the borders of the city proper, it will be difficult to persuade commuters in Peel, Halton, York, and Durham to abandon their vehicles. Therefore, in the present, the GTA has shown that there is sufficient congestion to prompt discussions of HOT lanes as a possible solution.
5.3 Public and Political Will and Support

The Toronto Board of Trade (2011) estimates that traffic congestion in the GTA is costing Canada over $5 billion per year. This has prompted the municipal government of the city to search for solutions in the form of public transit. In 2007, under the sponsorship of mayor David Miller and Toronto Transit Commission (TTC) chair Adam Giambrone, a plan for seven new light rail transit (LRT) lines was proposed, called Transit City. Although the newly elected mayor Rob Ford eventually scrapped the plan, a new transit plan has been proposed, using most of the money that was allocated for Transit City. In any case, there have been strong indications that the public and politicians are willing to address the congestion problems in Toronto.

However, the idea of implementing toll or congestion charges on Toronto’s roads seems to have limited support by its current mayor and the public. On May 30, 2011, Rob Ford claimed that he is absolutely opposed to the idea of charging motorists to use roads, and two days later, a public opinion poll showed that 65 percent of Torontonians also agree with Ford (Popplewell, 2011). Despite these resistances, some experts like Harry Kitchen, professor of Economics at Trent University, claim that, “it’s inevitable. It’s going to come. It has to come” (Popplewell, 2011). In the interim, however, it appears that HOT lanes would not have public or political support.
5.4 Space to Build Four New Lanes

One of the key reasons that contributed to congestion relief on the SR-91 was the addition of highway capacity, by constructing four additional lanes in the median of the highway. However, in the case of the 401, adding an additional four lanes seems unlikely to occur, due to space constraints. At its widest, the 401 consists of 18 lanes, with congestion still becoming severe during peak period hours (Persad et al., 2005). On the other hand, MTO claims in their HOV Plan for the 400-Series Highways, that lanes will be added to “key corridors such as Highway 401 in Peel Region” (MTO, 2007). For certain, this will be a challenge, a fact admitted by MTO in their plan.

In addition, any lanes that are built must be constructed on the outer edges of the 401 rather than the median, because currently, there is insufficient space in the median for additional lanes. This would increase costs, since the land must be acquired. Therefore, in the future, the option of converting existing lanes to HOV will be considered and evaluated (MTO, 2007). Moreover, additional space may be required for checking/inspection areas to verify HOV status.

Clearly, the 401 does not present ideal circumstances to build an additional four lanes, as seen in the case of the SR-91.

5.5 Use of Advanced Electronic System for Detection and Collection

The GTA can boast of the fact that within its boundaries, the world’s first all-electronic, barrier-free toll highway was developed as the 407 ETR (407 ETR, 2011).
Like the 91 Express Lanes, transponders and an electronic system are used to detect motorists who use the facility. Also, the 407 ETR uses license plate detection cameras for those vehicles without transponders. In addition, accounts can be set up, as well as payments made online.

With such a history of technological leadership in the transportation industry, it would be an easy transition to implement an electronic system for an HOT facility. The problem of space requirements for HOV verification can even be addressed by implementing new technologies in automated occupancy monitoring. Although the effectiveness and accuracy of such systems has come under some scrutiny, new technological advancements and ideas have developed which could make automatic occupancy verification easier and simpler (Schijns and Matthews, 2005). Since 2006, 100 percent of model vehicles sold in the United States have occupancy detection systems for the use of “smart” air bags (Schijns and Matthews, 2005). These systems create electronic data that can be linked to transponders, satellite based GPS, and wireless ground-based systems (Schijns and Matthews, 2005).

An HOT facility with these new types of technologies has not been implemented as of yet, but with the 407 ETR, the GTA has shown that it can be a leader in new transportation models, and embracing technology to maximize efficiency.

5.6 Removal of Non-Compete Clause

Greg Hulsizer, the general manager of CPTC at the time of the non-compete controversy, pointed out that, “the only public-private project without a non-
compete agreement—the Dulles Greenway toll road in Virginia—failed when the state built a competing facility nearby” (2000, pg. 2).

In the case of the GTA, the 407ETR functions without a non-compete clause (Minnesota Department of Transportation, 2009; Persad et al., 2005), which explains why the planned 401 HOV lane can move forward. If an HOT facility on the 401 is constructed, a non-compete clause can and should be avoided, as they can be highly restrictive to highway improvements and the ultimate goal of congestion relief. Since the Ontario provincial government has successfully avoided a non-compete clause in the 407ETR lease agreement, it is reasonable to expect that a non-compete clause can also be avoided for a potential 401 HOT facility.
6 Conclusions and Recommendations

The purpose of this chapter is to offer conclusions from the analysis in the previous chapters, and offer recommendations to the Ministry of Transportation, in regards to their HOV plan for the 400-series highways. In particular, a recommendation will be made as to whether an HOT facility similar to that of the SR-91 Express Lanes can be implemented on the 401 in Peel/Halton.

6.1 Summary and Conclusions from Chapter 5

1. Demographic and income distribution across the GTA appear to offer favorable circumstances for a large number of toll paying customers. However, those living closer to the 407ETR probably will not persuaded to use a potential HOT facility on the 401, as it would not provide additional time savings since they run parallel to each other and both offer uncongested highway travel.

2. Like the SR-91 before the Express Lanes, the 401 is severely congested, which is a prerequisite to HOT facility implementation.

3. There is political and public support for addressing the GTA’s congestion issues, but Torontonians are looking more toward mass transit as a solution, and there is minimal support for toll based congestion strategies.

4. The 401 does not have the necessary space to build an additional four lanes in the median of the highway, as seen in the case of the SR-91. Any lanes that are built must be constructed on the outer edges of the highway, most likely increasing costs. One option is to convert existing lanes to HOT, which may be controversial, as drivers are usually opposed to losing free capacity.
5. With the implementation of its electronic systems on the 407ETR, the GTA has shown that it is a leader in welcoming new technologies in their transportation models.

6. It is reasonable to expect that MTO can avoid a non-compete clause in a potential public private partnership agreement, as there is currently no such clause for the 407ETR.

Based on these conclusions, it appears that the GTA offers many similar circumstances to those seen in the case of the SR-91 in California, but is missing some requirements such as necessary space in the median of the highway, as well as public and political support for HOT facilities. However, public and political support may change over time as traffic potentially worsens, or if the facility is built by a private entity, as in the case of the SR-91.

6.2 Recommendations

Since there are many similarities between the cases of the SR-91 and the GTA, there is good evidence that a similarly operating facility may be implemented on the 401 in the GTA. Therefore, it is recommended that MTO explore the possibility of implementing an HOT facility instead of the HOV lanes that are currently planned. It should be noted that not all of the success factors are present, and therefore, the option of an HOT facility should be explored carefully.

Thus, MTO should initiate several studies in order to explore the possibility and viability of an HOT facility.
Studies that should be conducted by MTO include:

*Study #1: Traffic Projections*

Based on factors such as income, employment and travel patterns, projections should be made on the amount of traffic that can be expected if an HOT facility were implemented on the 401 highway. These travel demand projections should include expected number of vehicles both on the general purpose lanes, and the HOT lanes. Estimates will no doubt vary based on HOV occupancy requirements, as well as tolling strategies. Moreover, medium and long term projections should be conducted, as the GTA is a quickly evolving metropolis, due to high levels of immigrant settlement, and fairly strong residential growth.

Although traffic projections should be conducted, it should be noted that unexpected external factors may arise. As highlighted in the SR-91 case study, during the first few years of operation, there may be obstacles as the operator (whether public or private) establishes itself and adjusts its policies. In addition, sudden changes in gas prices or the economy may bring about significant changes in travel behavior and willingness to pay for an uncongested drive (such as that seen on the SR-91 in 1999).

*Study #2: Public Opinion Survey*

In order to gauge public sentiment on the possibility of toll lanes for the 401, a public opinion survey should be conducted. As mentioned in Chapter 5, Torontonians in general (65 percent) claimed that they were opposed to the idea of charging motorists for the use of roads. However, the question is too broad: it does
not specify what type of tolling would be used, the purposes, and where any tolling facilities would be located. The use of HOT lanes is a specific form of tolling that offers an alternative to the use of free general purpose lanes. Moreover, Torontonians might be more likely to accept an HOT facility on the 401, knowing that congestion on that particular highway can be severe during peak periods.

In addition, the survey should request the collection of demographic information from respondents, as a clearer picture of equity issues in HOT lanes may be drawn. As highlighted in the case of the SR-91, drivers in the lower income category were generally supportive of the facility, but were less likely to pay for the use of the HOT lanes. If similar survey results can be found in the GTA, then this may inform projections of potential user demographics.

**Study #3: Financial Viability Study**

Based on the traffic projections, a financial viability study should be conducted to estimate potential revenue generation, implementation costs, and operational costs. In the case of the SR-91, vehicle trips saw very strong and steady growth, despite the constant rising of tolls throughout CPTC and OCTA ownership periods. That translated into significant increases in operating revenue. Since the Ontario government has committed to investing in infrastructure, but remains in a budgetary deficit, if similar growth in traffic and revenue can be expected in the GTA, an HOT facility may be an attractive option for MTO.

In addition, the option of using a public-private partnership (PPP) may also be explored, if public financing options are unavailable. However, the obstacles that
have been highlighted in the SR-91 case study should be considered when contemplating a PPP HOT lane.

*Study #4: Best Practices Study*

Since there have been a number of HOT facilities implemented in North America, a best practices study would allow MTO to better understand what has succeeded, and why. Moreover, understanding the local context such as travel behavior, employment and demographics is particularly important, as was in the case of the SR-91. Some of the innovative strategies that were highlighted in this report may be included in the study.

*Study #5: Request an Update to Edward Sullivan’s Reports*

Sullivan’s reports were completed before OCTA ownership, and therefore, some of the 91 Express Lanes’ most successful years have not been adequately studied and analyzed. An additional update to Sullivan’s studies would allow for a more accurate depiction of its current operation, as well as providing a larger temporal scope.

**6.3 Closing Remarks**

HOT facilities as a form of congestion pricing, are becoming increasingly popular solutions to the congestion problems in North America. Progressive governments in Europe have already begun to embrace the idea that those who use the roads should pay for them. However, in conservative North America, there has been some resistance, but small incremental changes are being made as people begin to realize
that more general highway capacity is not the solution. The case of the SR 91 Express Lanes is a good example of this change.
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