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16. Abstract

Reliable T&R forecasts are critical to the success of toll proposals. However, a number of studies by the bond rating agencies—specifically Standard & Poor's (S&P)—have shown that a majority of toll roads failed to meet revenue expectations in their first full year of operation. These studies alluded to the existence of an optimism bias in T&R forecasts, with an over-estimation of traffic by 20-30 percent in the first five years of operation. This uncertainty contributes to increased risks about the feasibility of toll roads, requirements for escrow accounts of up to 30 percent of the amount borrowed, and thus high interest payments (and ultimately higher costs to the users) to compensate investors for higher risks. The objective of this research study was to expand upon the analysis conducted by the bond rating agencies. The research focused on toll road case studies that have been operational for varying lengths of time in areas with similar demographic and transportation characteristics as Central Texas. Special care was taken to ensure the inclusion of more mature systems. This research report (a) summarizes the analysis done by S&P, J.P. Morgan, and a recent National Cooperative Highway Research Program Synthesis study on toll road demand and revenue forecasting, (b) details the researchers' understanding of the general T&R approach used by the industry, (c) documents the research approach and summarizes the salient case study findings, (d) lists a number of areas that requires an improved understanding to enhance the reliability of T&R forecasts of toll roads, (e) provides specific recommendations to address some of the concerns about data and data sourcing, the identification of key variables and how they are considered in the T&R forecasts, the limitations of the modeling methods used, and the sensitivity of T&R forecasts to changes in key variables, and (f) concludes with a brief description of the next year's research activities.

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Chapter 1. Introduction

1.1 Background

Road infrastructure is a key component of any region's transportation system. It allows unprecedented levels of mobility, accessibility, and economic growth. Conversely, the cost associated with inadequate road infrastructure can amount to billions of dollars.[1] For example, it has been estimated that congestion costs the U.S. 3.7 billion hours of delay and 2.3 billion gallons of wasted fuel per year, or almost $200 billion, considering unreliability, inventory, and environmental impacts (DeCorla-Souza, 2007).

In the U.S., the largest revenue source for the funding of transportation infrastructure is the federal and state fuel taxes.[2] These taxes were conceived in the 1950s as an indirect charge to recover the costs of vehicle travel on the U.S. highway system. However, this tax has not increased with the inflation rate[3] and, given increasing maintenance and construction costs and more fuel-efficient vehicles, the vehicle per mile tax has become inadequate. It has thus been predicted that the Highway Trust Fund could be bankrupt by FY 2009 (The American Society of Civil Engineers [ASCE], 2006). At the same time, ASCE's Infrastructure Report Card estimated a 5-year spending need of $1.6 trillion for the nation's infrastructure (ASCE, 2005). Inadequate funding from the traditional fuel tax together with increased demand for transportation and increasing maintenance needs, resulting from an aging highway system, have thus resulted in significant deficits. For example, $387 million are needed to fund the transportation maintenance backlog in Nevada, $583.4 million in Oklahoma, $110 million in Texas, $734 million in Idaho, and $12 billion in New Jersey. These "*budget shortfalls undermine [the] ability of states to maintain existing facilities properly, leading to deferred maintenance [and] reducing the useful lifespan of roads, bridges, ports, and other infrastructure*" (Teigen, 2007). Fixed costs, such as utilities and materials, typically dominate maintenance spending. For example, 93 percent of the New York DOT's Maintenance and Operations Division budget is allocated for fixed costs (Wilcox, 2006). Given these significant maintenance backlogs and the challenges associated with preserving the existing infrastructure, even less funding is available for major capital investment projects.

Traditionally, government agencies financed transportation infrastructure—both maintenance and additional capacity—using the pay-as-you-go method or through debt financing (or public bonding). Both these financing methods have advantages and disadvantages (see Table 1.1).

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1 According to Biggs (2007), the cost of congestion in the U.S. amounts to the following:
"For U.S. cities with populations over 3 million, a 30 min. trip takes about 55 min. in the peak travel hours. Urban congestion (based on wasted time and fuel) costs about $63.1 billion per year in the U.S. The average cost of urban congestion is $794 per traveler. On average, individual congestion delay is about 40 hours per year. About 40 % of daily travel takes place under congested conditions."

2 Since 1993 the United States Congress has rejected all legislation that would increase the federal gas tax (Buechner, ND).

3 In Pennsylvania, alone, highway funding has not increased with inflation rates. As a result, the state has lost $350 million in purchasing power (Pennsylvania Transportation Funding and Reform Commission, 2006).

Table 1.1: Traditional Financing Methods

Financing Method	Advantages	Disadvantages
Pay-as-you-go	• Future funds are not tied up in servicing debt payments • Interest savings can be put toward other projects • Greater budget transparency • Avoid risk of default	• Long wait time for new infrastructure • Large project may exhaust an agency's entire budget for capital projects • Inflation risk
Debt financing	• Infrastructure is delivered when needed • Spreads cost over the useful life of the asset • Increases capacity to invest • Projects are paid for by the beneficiaries of the capital investment	• Potentially high borrowing rate • Debt payments limit future budget flexibility • Diminishes the choices of future generations forced to service debt requirements.

Source: Teigen, 2007

Also traditional procurement methods have the following characteristics:

- the public sector pays for all services in advance,
- the public sector is responsible for all capital and operating costs, as well as the risks associated with project overruns and late deliveries,
- the private sector's role and risks are limited to delivering in terms of the contract and performing maintenance within a determined time period,
- the public sector is responsible for project management, and
- ultimately the public sector is accountable for the performance of the infrastructure and long-term maintenance unless otherwise specified in the contractual agreement[4] (Teigen, 2007).

States have typically one of two primary options to address funding shortfalls, i.e., through efficiency improvements and through increased revenues. Efficiency improvements include the downsizing and outsourcing of previous in-house activities, such as maintenance, design, construction, and operations. Outsourcing is claimed to improve efficiencies because it is believed that the private sector in using a for-profit business model will eliminate unjustified costs. In terms of increased revenues, it is generally agreed that increasing the fuel tax can be implemented without major technological or operational changes. For example, Washington State, which in 2005 only had funding available for 47 percent of its necessary projects, passed a Transportation Funding Package that increased the fuel tax 3 cents in 2005 and 2006, 2 cents in

[4] In Europe, warranty clauses are often used to ensure a quality pavement is constructed. A warranty clause or specification can be defined as a "*guarantee of the integrity of a product and of the contractor's responsibility for the repair or replacement of deficiencies*" (Johnson, XVII). In Europe, the warranty clause usually lasts for five years. These types of clauses and specifications have become more common also in the U.S.

2007, and 1.5 cents in 2008 (Washington Department of Transportation, 2004). While fuel tax increases have been proposed in other states as well, it remains a sensitive political issue.

Another option for increasing available funding—both for capital and maintenance projects—is to concession existing facilities to the private sector. Such concession agreements, if appropriately structured, can provide significant initial time-of-lease capital that can be used to fund maintenance or provide long-term future infrastructure funding. In return, the concessionaire acquires the right to operate and toll the road for a period of time specified in the agreement. The Chicago Skyway was leased for 99 years to a private concessionaire, composed of the Australian company, Macquarie, and the Spanish company, Cintra, for a *"lump sum"* of $1.83 billion (Federal Highway Administration, 2005; Skyway Concession Company LLC, 2005). In Indiana, the 75-year lease of the Indiana Toll Road to Cintra-Macquarie for $3.85 billion provided dedicated capital funds for addressing a backlog of over 200 highway and bridge projects. Revenues from the lease agreement were also used to retire existing transportation debt (Testimony of Governor Mitchell Daniels, 2006). The interest on the capital collected will also be used for future transportation projects.

A third option is to expand the highway system (i.e., Greenfield projects) by charging users a toll for the use of the road. This can take the form of a public agency funding, constructing, operating, and maintaining a toll road or by using private capital to finance, design, construct, operate, and maintain the road for a specific period of time (i.e., concession). The private company collects the toll revenue from the facility to cover any initial "lump sum" payments to the public agency, their expenses, as well as to allow for a profit during the specified contract period. At the end of the contract period, the facility is transferred back to the public agency at no cost. A number of U.S. State DOTs, including Texas, are actively pursuing tolling as a means to provide much needed capacity sooner. The latter was supported by the survey findings of PB/Strategic Consulting on the trends and analysis of current tolling and pricing activity in the U.S. (Perez, 2007). Their survey data revealed 21 toll road projects under construction and another 61 in the finance/design, NEPA process, and planning phases (see Table 1.2). Of the total 168 existing and planned toll roads and High Occupancy Toll (HOT)/Express Toll Lanes (ETC), 26 are implemented through a Public Private Partnership (PPP), while in the case of another 48 a PPP is being considered (Perez, 2007).

Table 1.2: Toll Road Activity in the U.S.

Projects	**Toll Roads**	**HOT/ETL**	**Number of States**
Opened Since ISTEA	45	6	13
Under Construction	21	3	10
In Finance/Design	13	4	10
In NEPA Process	17	17	13
In Planning	31	11	13
Total	**127**	**41**	**28**

Source: Perez, 2007

A number of these tolling projects provide the private sector with a more active role in funding the new infrastructure. However, varying levels of private sector involvement can be accommodated, and the level will depend on the project characteristics, the area's willingness to release control to the private sector, and the available funds for the transportation project. PPP models that utilize private funding to accelerate the construction schedule of a project are:

- Design-Build-Finance-Operate (DBFO),
- Build-Own-Operate (BOO), and
- Concessions.

DBFO projects involve private sector funding initially, but the government repays the private sector using "shadow tolls" or "pass-through" tolls. These types of projects allow for the building of infrastructure much earlier than possible given traditional financing methods. The public sector's own line of credit (debt level) is not impacted, but the public sector does agree to make set future payments to the private sector. These payments are often a function of the usage of the road. Typically, DBFO projects are returned to the public sector at the end of the contract period. BOO projects are rare because the private sector is responsible for all project aspects and usually retains ownership of the project indefinitely (FHWA, 2005). Concessions, the new trend in large scope U.S. transportation projects, are similar to DBFO projects, but the toll is paid by the road users, not the government. The private company pays the government a lump sum up front (or enter in a revenue sharing arrangement with the public agency) for the right to build, maintain, and toll the road for a set amount of time that in the past has ranged from fifteen years to 99 years. Contractual agreements are constantly adapting to reflect the changing objectives of the public sector. The advantages and disadvantages of concessions are listed in Table 1.3.

Table 1.3: The Advantages and Disadvantages* of Concession Financing

Advantages	Disadvantages
The public sector receives an upfront payment from the private sector at the beginning of the project (or shares in the revenue)	Historically, if the road generates high levels of revenue, the public sector does not receive additional funds
Construction time is often decreased and delivery of the project is accelerated	If the private sector goes into default, often the government must take control of the asset
Private sector retains a large portion of the risks	Tolls are charged based on a business perspective and not a public interest perspective
Maintenance cost are covered by private sector	

The advantages and disadvantages listed above refer only to the use of private funding to build new infrastructure. They do not necessarily apply to the lease of existing infrastructure to the private sector.

Source: Teigen, 2007

This trend towards the use of concessions for the delivery of new highway infrastructure (i.e., roads, tunnels, and bridges) or leasing of existing transportation infrastructure is, however, not only evident in the U.S.[5] Besides North America, toll roads have been in existence for many years in countries, such as Mexico, China, Spain, Brazil, the United Kingdom, Germany, Chile, Canada, Argentina, and even South Africa (see Table 1.4). Appendix A highlights the findings of the literature review as it pertains to U.S. and international toll road facilities.

Table 1.4: Top Countries—Public Private Partnerships in Highways (Cumulative sum of number of projects and estimated costs since 1985)

Country	Number of Projects	Project Cost (US$ billion)	Country	Number of Projects	Project Cost (US$ billion)
United Kingdom	37	30.5	Australia	12	8.6
China	53	21.6	Malaysia	18	7.8
Spain	47	21.1	Canada	22	7.7
Mexico	78	20.4	Russia	2	6.6
Italy	3	18.5	Chile	24	6.3
Germany	34	17.1	Argentina	20	3.7
Republic of Korea	18	16.2	Ireland	14	3.0
Japan	1	14.4	Denmark	1	2.7
Greece	11	11.8	South Africa	6	2.3
Brazil	44	11.4	Czech Republic	2	2.2
France	8	10.2	Indonesia	6	2.1
Portugal	15	9.8	Thailand	3	2.1

Source: Irigoyen, 2006

The largest PPP transportation developers in the world are listed in the Table 1.5.

Table 1.5: Top Ten Transportation Developers (2004)*

Transportation Developer	PPP Projects Under Contract	Awarded
ACS Dragados	45	18
MIG/Macquarie Bank	23	4
Laing/Equion	21	1
Ferrovial/Cintra	20	14
Sacyr Vallehermoso	19	13
Abertis/La Caixa	12	2
FCC	17	8
OHL	17	1
Cheung Kong Infrastructure	16	22
Vinci/Cofiroute	15	19

*Active ownership role in PPPs (1985–2004)

Source: Irigoyen, 2006

5 More than 26 U.S. states have expanded or modernized their road infrastructure through tollways.

The developers listed in Table 1.5 are all international (non-U.S.) firms. In recent years international transportation developers have started to invest in the U.S., either by constructing new infrastructure or leasing existing roads.

1.2 Importance of Toll Traffic and Revenue Forecasts

Reliable traffic and revenue forecasts are critical to the success of a toll proposal. Given the trend towards an increased usage of tolling to provide transportation infrastructure in the U.S., the reliability of toll road forecasts will become even more pertinent in future. For the developer of a toll proposal (whether it is a public agency or the private sector) reliable traffic and revenue forecasts are required to achieve investment-grade ratings and avoid high risk premiums. However, unreliable toll revenue and traffic forecasts can also impact the public agency—even if they are not the developer—as such toll traffic and revenue forecasts might skew public decision-making and result in (a) the over or under compensation of risk, (b) prevent investments in feasible projects that had underestimated forecasted traffic and revenues, and finally (c) result in costly renegotiations.

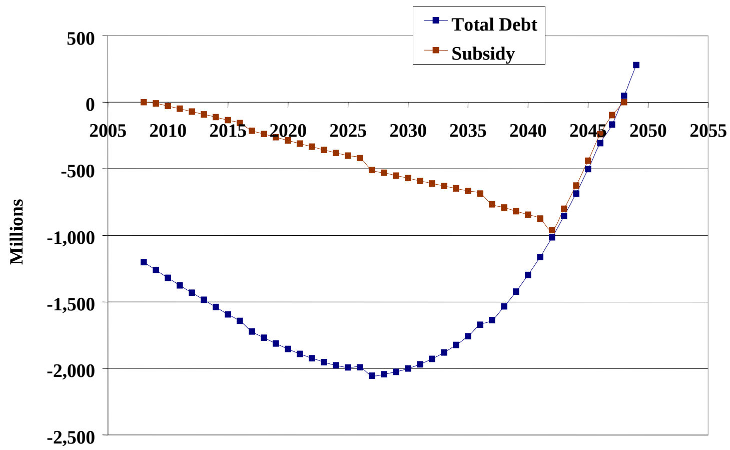
1.2.1 Project Feasibility

Toll traffic and revenue (T&R) forecasts are used by the bond markets to determine the amount of debt a public agency—and to some extent even a private company—can obtain. Although each project is unique, financing markets often consider the forecasting reliability of the industry when reviewing a specific project. Thus, significant overestimation on a specific facility can result in increased scrutiny of the T&R forecasts of all similar facilities—particularly because historically the U.S. T&R industry has been dominated by only three firms: Wilbur Smith and Associates (WSA), Stantec (formerly Vollmer), and URS (Smith, Chang-Albitres, Stockton, and Smith, 2005).

The risk associated with toll revenue and traffic, usually borne by the developer, is more problematic as higher risks affect the credit quality of a toll road project (ultimately requiring higher interest payments to compensate investors for higher risks and thereby raising the cost to the users). This may result in the concessionaire having to demonstrate financial resilience under various sensitivity and stress tests. Bond rating agencies typically require a revenue-to-expense ratio of 1.25 to 1.3 to grant a satisfactory rating to a debt issue.

1.2.2 Skewed Public Decisions

Biased toll traffic forecasts might also prevent investments from being made in projects with potentially more reliable forecasted traffic and returns. In other words, it may result in investment, either in the wrong facility or in the wrong place. It can also skew public decisions and result in the over or under compensation of risk associated with the revenue streams. For example, Figure 1.1 illustrates the projected debt pattern for SH130 considering the initial construction debt of $1.2 billion (compounded at the 5.75 percent bond interest rate), operation and maintenance expenses, and 100 percent of the revenue applied against debt. According to this projection, revenues will not be sufficient to cover all expenses until 2027, so total debt will increase to $2.1 billion. The projected shortfall, which is guaranteed by TxDOT, is shown as a line of credit, or a *"subsidy,"* and will exceed $900 million by 2043, being finally paid off in 2048. However, these estimates are very sensitive to the toll traffic forecasts and revenues.



Source: Texas Department of Transportation, 2002.

Figure 1.1: SH 130 Projected Debt Pattern

1.2.3 Debt restructuring

If for some reason a toll facility does not attract the traffic levels projected and consequently does not generate the amount of revenue forecasted, costly future renegotiations and debt restructuring[6] might result. Although the World Bank has demonstrated that few toll road projects (only 8 percent) have been cancelled, the statistics mask the high incidence of costly renegotiations when, among other factors, T&R forecasts are not met. Between 1988 and 2004, 67 percent of the transportation concessions have had to be renegotiated on average after 3.1 years (Queiroz, 2006). In Australia, which is considered a mature PPP environment, the Cross City Harbour Tunnel managed to achieve only 30 percent of the predicted 90,000 daily vehicles—18 months after opening—and was declared insolvent with debts exceeding AU$500 million in December 2006. There is thus a need to incorporate lessons learned into new toll traffic forecasts or at a minimum to consider the uncertainty surrounding toll traffic forecasts (i.e., forecasting risk) in the negotiation of agreement structures.

1.3 The Objectives of this Report

Reliable T&R forecasts are critical to the success of toll proposals. However, a number of studies by Standard & Poor's (S&P) have shown that a majority of toll roads—almost 90 percent of new toll roads in 8 states—failed to meet revenue expectations in their first full year. By year 3, 75 percent remained poor performers. These studies alluded to the existence of an optimism bias in T&R forecasts, with an over-estimation of year 1 traffic by 20-30 percent. Even though over the long term toll traffic may exceed forecasts and toll roads can generate surplus revenue, shortfalls in the ramp-up period are common. This uncertainty contributes to increased risks about the feasibility of toll roads, requirements for escrow accounts of up to 30 percent of the amount borrowed, and thus high interest payments (and ultimately higher costs to the users) to

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6 Refinancing can result from construction-related delays, optimistic T&R forecasts, or an economic downturn. Refinancing to address high traffic projections is, however, problematic and should be avoided when possible (Queiroz, 2006). Fewer toll roads will have to be refinanced if the reliability of forecasts improves.

compensate investors for higher risks. As indicated in this chapter, it can also skew public decision-making.

The objective of this research study was to expand upon the analysis that was done by the bond rating agencies, specifically (S&P). However, the research approach differed from the work conducted by S&P in two ways. ***First***, the research focused on the identification of toll road case studies in areas with similar demographic and transportation characteristics as Central Texas and ***second***, the research included toll roads as case studies that have been operational for varying lengths of time. Special care was taken to ensure the inclusion of more mature systems.

As mentioned, Appendix A highlights the findings of the literature review as it pertains to U.S. and international toll road facilities. Chapter 2 summarizes the analysis done by S&P, J.P. Morgan, and a recent National Cooperative Highway Research Program (NCHRP) Synthesis study on toll road demand and revenue forecasting. This chapter contextualizes Chapter 3, which details the researchers' understanding of the general T&R approach used by the industry. Chapter 4 provides the research approach and summarizes the traffic forecasts and main findings for the different case study examples. A detailed review of the history, the toll roads, and the T&R forecasts, as well as the assumptions that impacted the T&R forecasts are provided in Appendix B to E. Based on the case study reviews, Chapter 5 lists and discusses the various factors introduced uncertainty into the T&R forecasts. Finally, Chapter 6 provides some concluding remarks, recommendations, and the objectives of phase II of the research study.

Chapter 2. Literature Review

The number of planned toll roads is increasing in the U.S. and with that the reliability of T&R forecasting is under increasing scrutiny. The bond rating agencies—specifically Standard and Poor's (S&P) and J.P. Morgan—have assessed the reliability of T&R forecasts in a number of articles. S&P has pointed to an optimism bias in T&R forecasts, especially during the first years of operation of a new toll road. On the other hand, Fitch Ratings (Fitch) has shown that in many instances the actual performance, while not meeting forecasts in the initial years, did gravitate back, and often exceeded the original forecast over time. They recommend structuring a worst case scenario for the first ten years to reduce pressure on the financial structure underpinning the projects (Fitch, 2004). Persad et al. (2004) also reported that most toll roads experience traffic growth similar to non-toll roads after an initial low growth period of 5 to 15 years. The argument is that, over the long term, commuters will be more willing to pay the toll if the road results in time savings, or increases connectivity and access. Nonetheless, the financial markets want to see an overall increase in the reliability of industry forecasts—not just for individual toll road forecasts. Concerns about forecasting uncertainty are thus stemming from the financial markets rather than the transportation community, suggesting some sort of disconnect between the developers of the models and the users (NCHRP, 2006). This chapter summarizes the salient findings of the S&P analysis, the J.P. Morgan review, and a recent NCHRP synthesis on estimating toll road demand and revenue.

2.1 Standard and Poor's

A number of recent studies by Standard & Poor's (S&P) (2002, 2004, and 2005) have demonstrated a significant difference between forecasted and actual toll traffic in the first year of operations, through ramp-up and beyond, in comparison with non-tolled roads, and between regions that have a history of tolling and those that have not. In 2002, 2004, and 2005, S&P provided evidence for the existence of significant optimism bias—forecasts exceeding actual use of toll roads—in the first year of operations[7].

Bain (2002) sampled 32 toll facilities worldwide including highways, bridges, and tunnels[8]. He selected only projects that he could double source the original forecast and where data allowed for a like-to-like comparison[9]. Bain's research used the original T&R forecasts (the ones used in the bond document to initially fund the facility). Bain compared the actual traffic volumes to the forecasted traffic volumes, developing a Forecast Performance Ratio as follows:

- if the ratio>1: the traffic volumes were underestimated,
- if the ratio=1: the actual and forecasted traffic volumes were the same, and
- if the ratio<1: the traffic volumes were overestimated.

7 Bain aimed to examine the differences in forecasted and actual traffic volumes during a facility's ramp-up period and identify key factors introducing uncertainty in the forecasting process. Ramp-up is considered by most to be the most uncertain period of a toll facility. Thus, Bain's study examined toll facilities during their most unpredictable operational period.

8 Only 10 of the 32 facilities were U.S. highways; 4 of the 32 facilities were shadow toll projects.

9 This means that the project has not significantly changed from the time of the forecast to the opening of the facility.

All but one of the ten U.S. highway facilities included in the sample had overestimated traffic forecasts. Of the 32 facility sample, 28 facilities had over-predicted traffic with an average Forecast Performance Ratio of 0.73. Thus, on average, traffic volumes were about 70 percent of their forecast. Bain concluded that an optimism bias prevails in T&R forecasts during the ramp-up period. Bain did not attribute this bias to model errors[10], but rather identified a number of factors he felt caused the discrepancies. Bain identified these factors from the annual data required to certify the continuance of an agency's bond rating and the explanations that were given for any discrepancies between actual and forecasted traffic. Based on these explanations and his professional experience, Bain identified the following factors to introduce optimism bias in the forecasting process:

- the miscalculation/overestimation of users' willingness to pay a toll, specifically commuters,
- smaller time savings than forecasted,
- recessions/economic downturns,
- expected land use not materializing or materializing slower than estimated,
- overestimation of truck traffic on the road,
- unforeseen improvements to competitor routes (e.g., increased capacity, new routes, etc.), and
- fewer off peak and weekend trips (Bain, 2002).

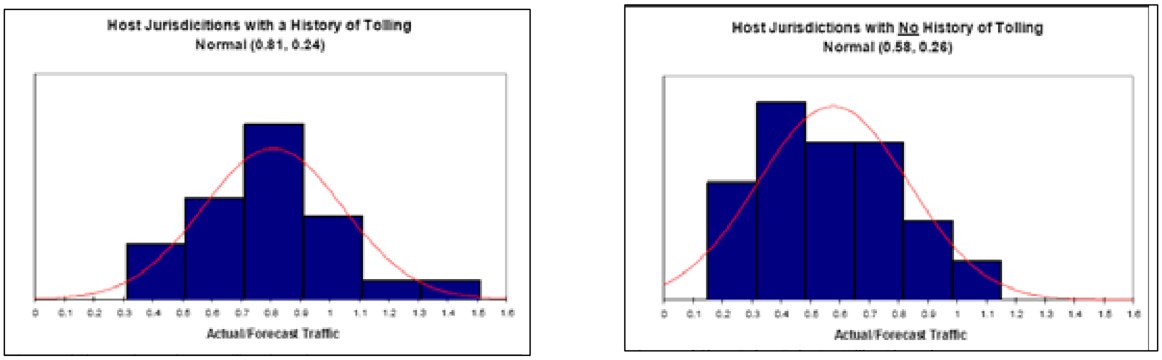
Because Bain's research focused on the ramp-up period, he expanded on the uncertainties in forecasting ramp-up effects. The three ramp-up factors highlighted were the scale, the length, and the *"catch up"* period for the toll road. The scale refers to the difference in actual versus forecasted traffic. The length refers to the time for traffic growth rates on the toll road to mimic area-wide traffic growth rates. The *"catch up"* period is the time required for traffic to catch up to the forecasted values (if at all). Bain concluded that if the scale was large, the length would be large, and *"catch up"* would be almost impossible (Bain, 2002). Bain also concluded from his 2002 study that the forecasting errors were not random, and therefore their effects were not canceling each other out. Rather, the errors were systematic. Bain also noted the critical role of the professional judgment of the T&R and bond market consultants in the forecasting process. His findings resulted in S&P creating a Traffic Risk Index[11] to assess the key factors that influence toll traffic forecasts (Bain, 2002).

Bain's 2003 update expanded the study sample to 68 facilities. The same conclusion was reached with the larger sample: in general, toll traffic forecasts are overestimated by 25 percent in their first operational year. Bain then divided the sample into facilities from countries with a history of toll projects and countries where tolling is a relatively new occurrence. The forecasts from countries with a history of tolling were on average more reliable than for countries without a history of tolling. There is thus some evidence to suggest that with an increase in experience

[10] This opinion seems to be held by most members of the T&R industry.

[11] The Traffic Risk Index is used to evaluate a single toll facility. The index reviews the key factors and attempts to gauge the level of uncertainty introduced in the forecasted values. Stress tests are then conducted on key variables with large uncertainty.

with tolling this systematic *"optimism"* bias can be reduced. Figure 2.1 illustrates that on average actual toll traffic was overestimated by 42 percent in those countries with no history of tolling compared to 19 percent in those countries with a history of tolling. This can partly be explained by a better understanding of the consumer response to tolling (i.e., availability of revealed preference data).



Source: S&P, 2003

Figure 2.1: Actual to Forecast Traffic Ratio in Jurisdictions with a History of Tolling and No History of Tolling

Bain also identified the following additional factors that introduce uncertainty in the T&R process:

- "Complexity of the transaction (hence the traffic modeling challenge),
- Underestimation of the severity and duration of ramp up,
- Underestimation of value of time,
- Use of a single, average value of time rather than a distribution of values of time, and
- Longer-term traffic forecasts are very sensitive to macroeconomic predictions, such as assumptions about GDP growth" (Bain and Plantagie, 2003).

In his 2004 update, Bain expanded his sample to 87 facilities. The 2004 study compared toll facility traffic forecasts with non-toll facility forecasts. Bain computed the ratio of actual traffic to forecasted traffic on 87 toll and 183 non-tolled facilities in the first year of operation. The distributions of the respective traffic ratios are shown in Figure 2.2. For the 183 non-tolled facilities, the average ratio was 0.96. In other words, on average actual traffic was overestimated by four percent in the first year of operations on non-toll facilities. On the other hand, for the 87 toll projects, the average ratio was 0.76, meaning on average actual traffic was overestimated by 24 percent in the first year of operations of the toll facility. Ignoring the long right tail[12] of the non-tolled projects, Figure 2.2 clearly demonstrates the systematic 20 percent optimism bias associated with toll projects relative to non-toll projects.

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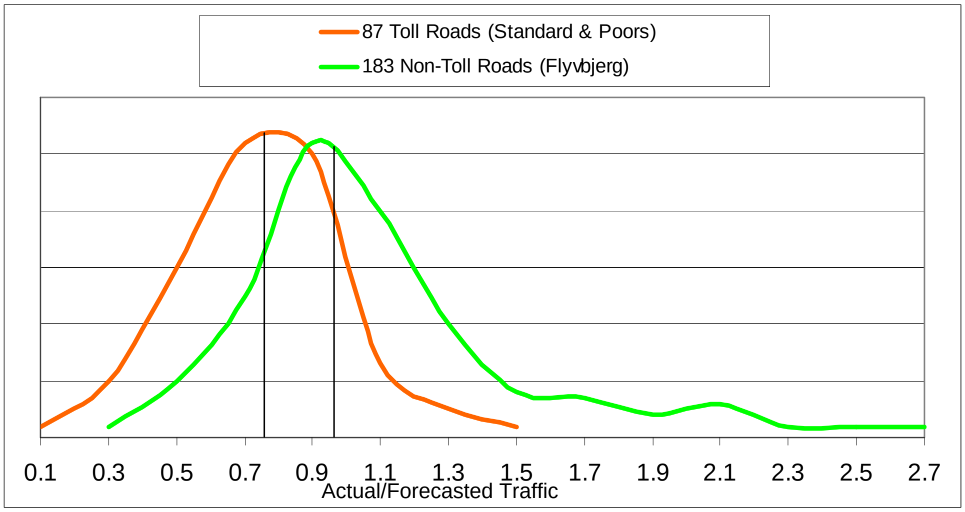
[12] The long right tail represents the less than 7 percent of the public non-toll projects whose actual traffic exceeded forecasted traffic with more than 100 percent.



Source: S&P, 2004

Figure 2.2: Distribution of Ratios of Actual/Forecast Traffic on Tolled and Non-tolled Roads

Bain used and referenced the work by Danish professor Bent Flyvberg on the non-toll facility forecasts. Flyvberg examined 183 international facilities that opened between 1969 and 1998. His sample included 170 highways, 3 tunnels, and 10 bridges—more than 90 percent was not tolled. Flyvberg claimed that at a 95 percent confidence level no difference existed in the forecast accuracy of the various facility types—i.e., highways, bridges, and tunnels. His research found that the traffic forecasts were overestimated as much as they were underestimated during their first year of operation. Half of the facilities had forecasts that were off by plus or minus 20 percent. He attributes these discrepancies to uncertainty surrounding forecasting land use, trip generation (i.e., demographic and geographic information), and trip distribution (Flyvberg, Holm, and Buhl, 2005). Bain compared Flyvberg's non-toll sample with his own toll sample. Bain concluded that after adjusting for a 20 percent optimism bias in toll forecasts, that *"there is little difference between the accuracy of forecasts prepared for toll roads and those prepared for toll free roads"* (Bain and Plantagie, 2004).

Flyvberg also examined the claim by many traffic forecasters that forecast accuracy has increased in recent years. Flyvberg analyzed the accuracy of first year forecasts from 1970 to 2000 and concluded that accuracy has actually been declining. He attributes this partly to what he calls *"assumption drag."* Assumption drag is the *"continued use of assumptions after their validity has been contradicted by the data"* (Flyvberg, Holm, and Buhl, 2005). In other words, modelers are using faulty assumptions to calibrate their models. An example would be if an area were going through a recession or economic upturn during the forecasting period. The forecaster might assume that this is a trend and not a brief occurrence (Flyvberg, Holm, and Buhl, 2005).

For the 2005 update, Bain compared the actual and forecasted traffic volumes for 104 toll road, bridge and tunnel case studies in the first year of operations. He also reported on average an optimism bias of 20 to 30 percent—similar to the results reported in his previous analyses. In other words, on average, traffic projections are approximately 20 to 30 percent higher than actual usage in the first year of operations. The 2005 study further reported no evidence of a *"systematic improvement in forecasting accuracy"* through years 2 and 5. Even beyond ramp-up, a number of toll roads failed to reach forecasted traffic volumes. Although only about 25 of the toll case studies in the sampling frame have been operational for five years, the preliminary analysis for Years 2 to 5 indicated no significant difference in the mean or standard deviation during the first five years of operation (see Table 2.1).

Table 2.1: Forecast Performance Distribution Statistics for Years 1 to 5

Years from Opening	Mean	Standard Deviation
Year 1	0.77	0.26
Year 2	0.78	0.23
Year 3	0.79	0.22
Year 4	0.80	0.24
Year 5	0.79	0.25

Source: S&Ps, 2003

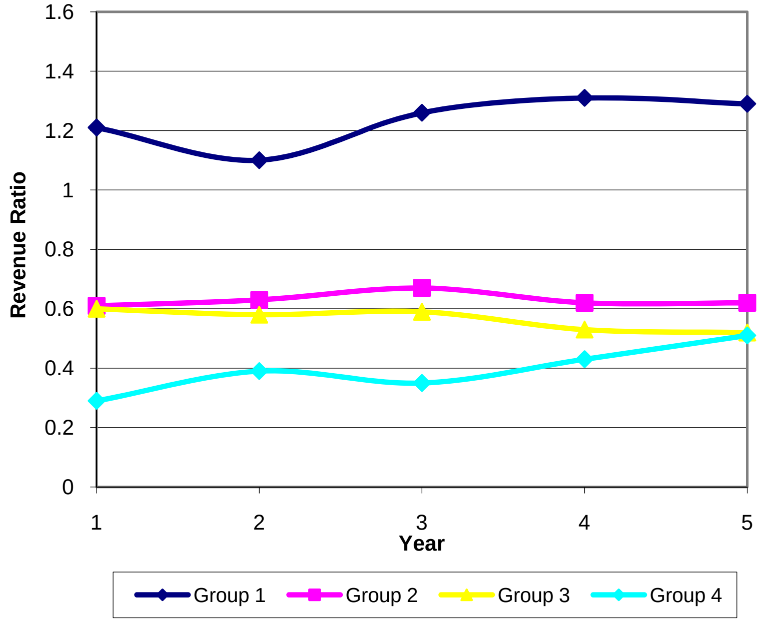
2.2 J.P. Morgan

Research on the reliability of T&R forecasting has also been done by Robert Mueller for J.P. Morgan. In his 2002 article entitled *"Start-up Toll Roads: Separating Winners and Losers,"* Mueller reviewed both the traffic and the revenue forecasts.[13] His sample consisted of 20 projects from 8 U.S. states. With the exception of two projects, all his case studies have been in operation for longer than two years. Mueller divided the case studies into the four groups listed below; a toll road example is provided for each group:

- Group 1: High Congestion, Suburban Areas (President George Bush Expressway, Dallas, Texas),
- Group 2: Outlying Roads of Metropolitan Areas and Established Agencies (Foothill North, Orange County, California),
- Group 3: Developed Corridors, Parallels of Existing Roads and/or Faulty Economic Forecasts (Sam Houston Toll Road, Houston, Texas), and
- Group 4: Least Developed Areas (E470, Denver, Colorado).

The groups were defined considering a number of project characteristics, including location, ownership, and ramp-up performance (see Tables 2.2 to 2.5). Mueller then calculated the actual to forecasted revenue ratio for each toll road for the first five years of operation (where applicable), as well as the mean value for each group and year (Mueller, 2002). A calculated ratio of one means actual and forecasted revenue were equal. A ratio of less than one means the actual revenue was below forecasted revenue, and a ratio of more than one means the actual revenue exceeded forecasted revenue. The mean revenue ratio (i.e., actual/forecasted revenue) for each group and year is illustrated in Figure 2.3.

[13] All the T&R reports were conducted by either WSA, Vollmer (now Stantec), and URS.



Source: Mueller, 2002

Figure 2.3: Actual Revenue to Forecasted Revenue Ratio

From Figure 2.3, it is evident that revenue was consistently overestimated for Groups 2, 3, and 4 in all five years. On the other hand, the Group 1 facilities generated more revenue than predicted in every year. It is also interesting to note that the ratio between forecasted and actual revenue did not substantially improve over the five-year time period—arguable with the exception of Group 4. The characteristics and common sources of inaccuracy for each group are listed in Tables 2.2 to 2.5.

Table 2.2: Group 1—Characteristics and Common Sources of Inaccuracy

High Congestion, Suburban Areas	
Characteristics of Roadway	**Common Sources of Inaccuracy**
Located in a well developed urban or suburban part of a larger metropolitan area Residents within the project corridor tend to enjoy higher income levels Substantial traffic in corridors Value of time is high Good existing road network connections at both ends of project Modest forecasted traffic growth Moderate toll rates Lower initial debt service due to high credit ratings Very rapid adjustment of traffic patterns following opening Moderate gains in traffic in the first 2 or 3 years following opening, then growing more slowly	Most of the road's traffic and revenue were underestimated Length and severity of ramp-up was overestimated

Source: Adapted from Mueller, 2002

Table 2.3: Group 2—Characteristics and Common Sources of Inaccuracy

Outlying Roads of Metropolitan Areas and Established Agencies	
Characteristics of Roadway	**Common Sources of Inaccuracy**
Less established traffic patterns Less integral to the existing network of extensions of roadways with limited operating history Usually serve above-average income suburban areas, but with less-established development patterns Partial beltways (circumferential highway) Further from employment centers Moderate to high toll rates, though usage appears somewhat inelastic (drivers already accustomed to paying tolls in area) Substantial forecast revenue growth, averaging 35% over the first four years	Accuracy in forecasting for this group was inconsistent Accuracy depended on the road's part of the area's existing highway system (toll or non-toll) Mostly experienced high traffic growth during ramp-up but the forecasted ramp-up had such high growth rates, the roads had a hard time meeting these expectations Forecast error appears to result from overestimation of initial base period usage of the roadway

Source: Adapted from Mueller, 2002

Table 2.4: Group 3—Characteristics and Common Sources of Inaccuracy

Developed Corridors, Parallel of Existing Roads and/or Faulty Economic Forecasts	
Characteristics of Roadway	**Common Sources of Inaccuracy**
Corridors with more developed or already established traffic patterns	Models that underestimate the impact of a reasonable non-toll alternative road
Completion of freeway project expansions often routing away toll-payers	Overly optimistic economic forecasts
Moderate forecast revenue growth	Failure to account for recessions
Forecasted time savings that appeared solid	Time savings that are often overestimated
Usually constructed in larger metropolitan or active tourist areas	Overestimated corridor growth rates
Unusual ramp-up problems, occasionally with projects actually ramping down from higher traffic levels	Not understanding characteristics of the ramp-up period
High toll rates and pre-programmed toll increases on newer projects	Overestimated truck usage
No other toll project existing in the area at the time of financing or limited toll history	

Source: Adapted from Mueller, 2002

Table 2.5: Group 4—Characteristics and Common Sources of Inaccuracy

Least Developed Areas	
Characteristics of Roadway	**Common Sources of Inaccuracy**
A specific traffic generator (airport, theme park, etc.) serving as a basis for the project	Single destination did not generate as much traffic as forecasted
High growth rates following opening that are insufficient to overcome the initial forecasting (overestimation) error	Ramp-up period traffic levels below forecasted. Also, ramp-up traffic levels were forecasted at low traffic growth rates resulting in high bond payments later
Construction through undeveloped areas and the toll road is critical in stimulating growth	Construction of the road was early (before the demand was there)
Models which overestimate time savings of the value of time	Inaccurate estimates of value of time and time savings
Existing traffic congestion that is insufficient to produce accurate forecasts from the models	
High revenue growth rates	
Forecasts that assume periodic toll increases	

Source: Adapted from Mueller, 2002

Mueller's contribution lies in his characterization of different toll roads and identifying the main sources of uncertainty for each group. This allows road developers and the financial markets to identify and evaluate common factors that have introduced uncertainty in revenue forecasts for that specific type of facility.

2.3 National Cooperative Highway Research Program (NCHRP)

The objective of NCHRP Synthesis 364 entitled *"Estimating Toll Road Demand and Revenue"* was to report on the state-of-the-practice in toll road forecasting using information acquired through literature reviews and surveys of state DOTs. Various types of toll facilities were considered, including tunnels, bridges, HOT lanes, as well as urban and inter-urban tolled highways. The synthesis focused primarily on the models used to forecast toll traffic and introduced the reader to the common four-step travel demand modeling process. The synthesis concluded that there was no standard in the toll road demand forecasting process. It was recommended that a first step may be to standardize the terminology and develop a set of commonly used questions.

The synthesis also reviewed several studies that have investigated the reliability of travel demand forecasts. For example, a 1989 study commissioned by the U.S. DOT compared actual and predicted ridership for 10 light rail projects and found that the actual ridership was considerably below projections. The study concluded that this discrepancy between actual and forecasted ridership could be attributed to the structure and nature of federal grant programs that favor high capital transit investments. Another study that was particularly relevant to the objectives of the current research study, categorized the performance of toll roads based on the characteristics of the facility. For example, the study found that toll roads in highly congested urban areas were more likely to have forecasts that approximated or exceeded projections whereas facilities in undeveloped areas were more likely to have forecasts that significantly overestimated actual usage.

The synthesis also included a chapter entitled *"Checklists and Guidelines to Improve Practice"* that provided guidelines and checklists in an attempt to introduce some consistency into the forecasting process. Checklists compiled by the FHWA, the Texas Turnpike Authority (TTA), and financial analysts were provided. However, no specific checklist or guidelines were recommended, and it is left up to the reader to decide which are appropriate.

Finally, the survey responses from the state DOTs did not isolate a single modeling factor as the reason for poor-performing forecasts. The next section, however, summarizes the synthesis findings in terms of the key factors that affect forecasting performance.

2.3.1 Factors Affecting Forecasting Performance

Land Use and Socioeconomic Inputs

The synthesis highlighted two main concerns regarding the impact of land use and socioeconomic inputs on poor forecasting performance. First, it was argued that land use and socioeconomic forecasts may reflect a MPO's planning policy rather than actual market trends. T&R consultants thus consider historical trends to adjust these inputs in an effort to represent a more likely growth trend. Second, it was noted that there is an apparent lack of concern about the impact of economic fluctuations on forecasts. A recession can have a significant impact on travel demand as demonstrated by the national recession of 1990-1991, which impacted the Central Florida Greeneway and the tollways in Oklahoma.

Travel Characteristics

The quality and availability of data characterizing travel behavior was cited as a major contributor to forecasting uncertainty. Also of concern was the importation of data from other projects, which can introduce significant uncertainty. Most DOT respondents stressed the need for more comprehensive data to improve toll demand forecasting.

Value of Time and Willingness to Pay

Value of time is typically measured using surveys and is often used in the traffic assignment stage of the travel demand model. However, value of time is a function of the trip purpose and the characteristics of the driver. Surveys in areas with no history of tolling tend to result in low values of time, because respondents commonly express anti toll sentiment. Furthermore, some evidence suggests that the use of ETC may also affect a user's value of time, because these users may be less aware of the toll being paid.

Tolling Culture

The study also cited that the behavior of drivers in countries with no tolling history was harder to predict, which may cause forecasters to rely on theoretical techniques. Forecasting performance is thus greatly enhanced in areas that have a history of tolling.

Truck Forecasts

Truck forecasts were found to exhibit even more variability than passenger car forecasts. The study mentioned that the decision to use a toll road is highly dependent on the type of trucker or trucking firm with larger firms more likely to pay a toll, while independent truckers were very sensitive to tolls.

Ramp-up

T&R consultants estimate the scale and duration of the ramp-up. This requires experience and a familiarity with the area. Ramp-up duration is often assumed longer when the toll facility is in an undeveloped area to account for the possibility of delays in anticipated developments.

Time Choice Modeling

Many travel demand models only forecast peak period travel, which requires T&R consultants to develop factors to convert to daily and annual travel. It was stated that there is a great need for models that more accurately capture variations in travel patterns by time of day, week, month, or year.

Risk

The financial community has expressed the need for T&R consultants to address risk and uncertainty in toll road forecasts. In general, uncertainty is addressed by using conservative values and sensitivity analyses of the impact of changes in certain key variables. However, conducting sensitivity analyses by varying one variable at a time ignores the possibility of multiple events occurring at once. In reality, poor performance of a toll facility is often traced to the simultaneous occurrence of several events. One proposed strategy is to assign a probability distribution to some of the inputs, which should provide a better understanding of the variability of the outputs.

Bias

The study mentioned the absence of a formal method for dealing with optimism bias in toll road forecasts and reference guidance developed by the British Department for Transport on how to deal with bias in transportation planning.

Model Validation

Different from model calibration, model validation seeks to demonstrate how reasonable the model predicts actual observed behavior. It was argued that very little time goes into the model validation phase in the forecasting process. The study argued for reasonableness checks of parameters and coefficients to ensure that they have the right sign and make sense. The model should also be validated by predicting demand for a time period other than that used for calibration.

Peer Reviews

There are currently no formal requirements for peer reviews of T&R forecasts for toll roads. The value of a peer review process is thus largely unknown.

2.3.2 Specific Recommendations

Finally, the financial community made the following specific recommendations for further research:

- improve understanding of impact of ETC on value of time,
- incorporate risk analysis in T&R forecasts,
- account for changed economic conditions (recessions) in T&R forecasts,
- improve understanding of ramp-up,
- improve methods for estimating value-of-time,
- improve truck forecasting, and
- improve validation of models.

2.4 Concluding Remarks

The variability in forecasting traffic for facilities that will rely heavily on traffic and revenue to support debt payment, has led to the rating agencies and the capital markets noting that *"challenges remain"* (Fitch, 2003). As is evident from the literature summarized in this chapter, these forecasting uncertainties have been mainly attributed to the inability to obtain good data or incorrect modeling assumptions. It has been argued that the T&R industry is constantly adapting their model and approach to address previous sources of uncertainty. However, Bain and Flyvberg have concluded that the accuracy of T&R forecasting has not changed dramatically. Therefore, these changes have not resulted in a better product for the project owners, financial markets, and investors. The next chapter summarizes the researchers' understanding of the general T&R approach followed by the consultants based on an extensive review of numerous T&R reports and interviews with T&R firms, including WSA, Cambridge Systematics, Halcrow, and URS.

Chapter 3. Traffic and Revenue Forecasting Approach

The T&R report forms part of the bond document and is reviewed and of importance to bond markets, bond insurers, banks, equity investors, and the project owner. It is critical that the T&R consultant is committed to independence when conducting its assessment of the usage and ultimately revenue potential of a proposed toll facility. First Southwest Bank noted the important difference between the T&R consultants providing what the client wants to hear and what the client needs to hear (personal interview with First Southwest Bank, 2007).

Some investment banks attempt to validate the T&R consultant's assumptions, while others rely on the consultant's experience and professionalism in producing reliable results (Smith, Chang-Albitres, Stockton, and Smith, 2005). First Southwest Bank indicated that the bond rating agencies and bond insurers[14] probably have an understanding of the model structure that is used. However, in general, the banks and financial advisors might have less of an understanding of how models are internally adjusted for each potential toll project.

This chapter provides an overview of the research team's understanding of the general approach to forecasting toll demand and revenue after reviewing numerous T&R studies and conducting interviews with T&R firms, including WSA, URS, Halcrow, and Cambridge Systematics.

3.1 The Role of the Metropolitan Planning Organization's Model

T&R consultants usually begin with the local Metropolitan Planning Organization's (MPO's) traffic demand model. Since the 1980s, the federal government has required each MPO to complete a long-range transportation plan and a four-year transportation improvement program (TIP). These plans require extensive traffic forecasts and are used for the allocation of transportation funding. In preparing the plans, a MPO first looks at their area's current transportation system, capacity, and problem areas. The MPO then seeks input from local officials, area stakeholders, business organizations, and various government organizations to develop economic and demographic forecasts for the area. The economic and demographic information is an input into the MPO's planning model to forecast the future transportation system demand (personal interview with the North Central Texas Council of Governments, 2008). The MPO planning model is calibrated for the region and then subsequently used to predict transportation demand in the region.[15]

3.1.1 Four-step Travel Demand Model

Most MPOs use the four-step travel demand model[16]. The steps of the four-step travel demand model are:

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[14] Bond insurance can be critical to the feasibility of a toll facility. Without insurance, ratings would be lower and interest rates higher, which may affect the facility's feasibility.

[15] When a T&R firm is hired to conduct a T&R forecast for a particular toll road, one of the first steps is to familiarize themselves with the area. For most firms, this means getting familiar with the area MPO model. T&R consultants, in general, build on the MPO model to save resources and in an effort not to duplicate any models.

[16] In recent years, there has been some interest in activity-based models. However, this type of model requires very detailed data that historically have not been collected. Historical data is used to benchmark or calibrate a model so the lack of historical information could prove problematic. Most modelers interviewed indicated that activity-based models were not yet ready for implementation. In a meeting with Halcrow, the consultant mentioned that

1. Trip Generation—Total number of trips originating in and destined to a particular zone are calculated based on the different land uses of each zone.
2. Trip Distribution—Matches trip travelers' origins and destinations to form a trip matrix, which identifies how many trips are going from each origin to each destination zone. This step commonly employs the gravity model, which assumes that the amount of activity between two locations decreases with increasing distance, time, and cost.
3. Modal Split—Trips are allocated to one of several travel modes. This step typically employs the logit function, which takes into account travel time, out of pocket cost, comfort, number of stops, etc associated with different modes of travel.
4. Network Assignment—All trips are loaded onto the traffic network. Equilibrium assignment assigns all vehicles to the route that minimizes travel time and iterates to account for changes in travel time as the network is loaded.

Variations of the four-step model have been used for a very long time. A schematic of the four-step travel demand model is provided in Figure 3.1.

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the proponents of activity-based models could not yet prove that these models represent actual travel patterns more accurately. Until the latter is achieved, the added complexity of this type of model prevents any justification for implementing an activity-based model.

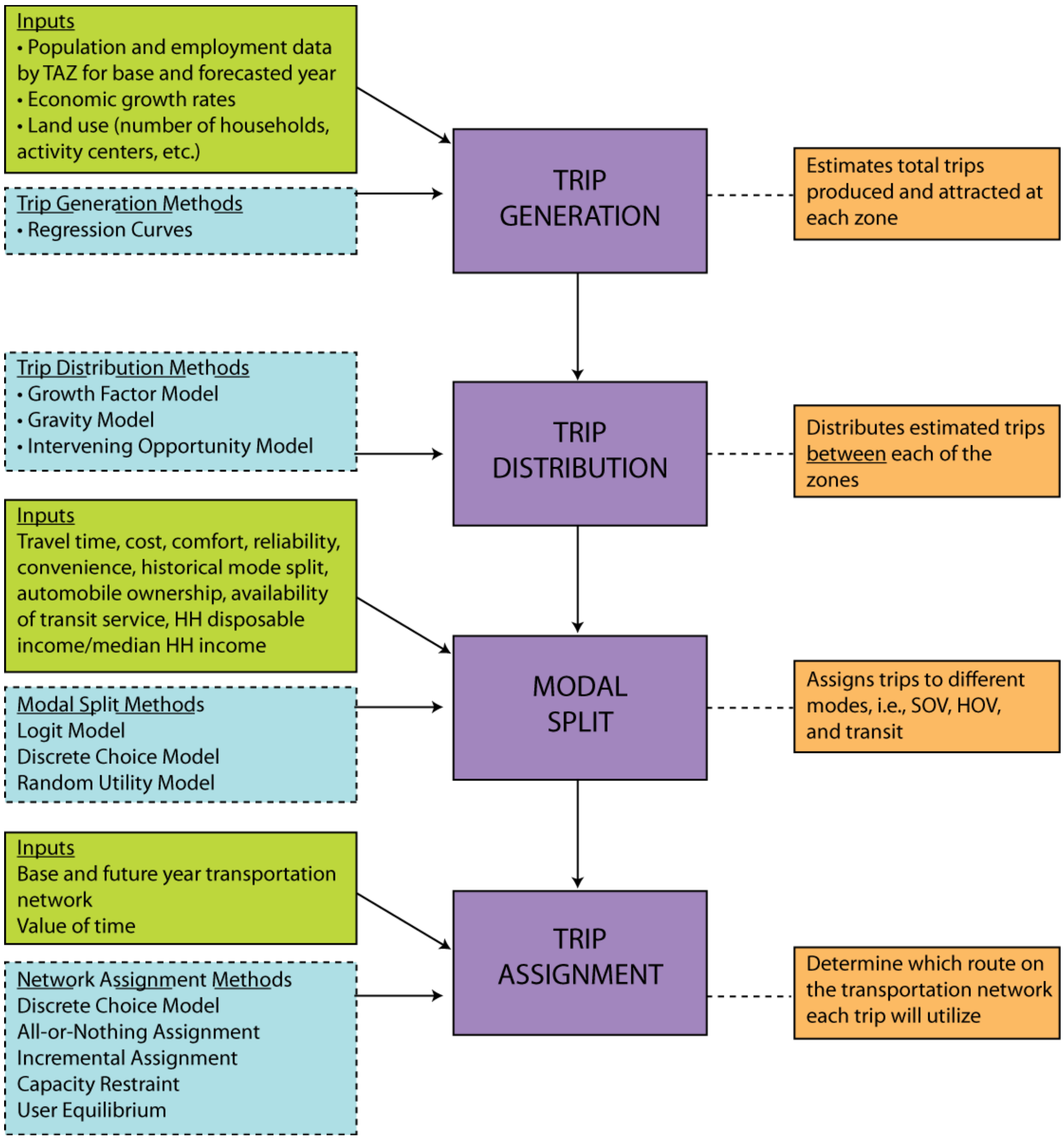

Figure 3.1: The Four-step Travel Demand Model

Figure 3.1 provides examples of the typical data inputs that are needed in each step of the travel demand model, as well as some of the more general methods used in each step. The first step is to divide the MPO area into homogenous zones—called Traffic Analysis Zones (TAZ)—based on land use. TAZs are represented as centroids and connected to the network through links. Developing population and employment values by TAZ for a base and forecasted model years require data, for example, about current employment locations by sector, household locations by income quartile, land use inventories, travel time matrices, number of workers per household, district level household change, acres of vacant land, density of future residential development, proximity to transportation infrastructure, etc. MPOs typically use a demographic model to develop the population and employment estimates by TAZ. The NCTCOG uses the

DRAM/Empal model. Regression curves are then typically used to estimate the total trips produced at and attracted to each TAZ.

The Trip Distribution step estimates the number of trips between each origin and destination TAZ. As indicated before, the gravity model is typically used to distribute trips between origin and destination TAZs. Larger MPOs also typically gather additional information about travel trends, times, and speeds in the area through traffic counts and surveys.

The modal split step assigns trips to different modes of travel, considering travel time, cost, comfort, reliability, convenience, and other factors associated with each mode. Typically, this step can also account for any biases towards or against a specific mode of travel.

A detailed network of the area's transportation system (i.e., major road and highway network, as well as public transportation network) is needed for the trip assignment step. Most traditional four-step models employ static traffic assignment (STA). Using this method, traffic is assigned to each road in an attempt to optimize some function, for example to minimize total travel time.[17]

MPO travel demand models vary greatly in terms of level of sophistication, data used, and output. For example, the model outputs can be for different time periods in a day, (e.g., peak and non peak) or for daily traffic volumes (e.g., weekday and weekend days). The conversion from peak or daily traffic volumes to annual traffic volumes requires the use of annualization factors. Annualization factors are needed because converting from daily to annual traffic volumes involves more than simply multiplying by the number of days in a year. Annualization factors, for example, attempt to account for variations in weekend and weekday traffic patterns. Finally, very few MPO models account for truck traffic.

3.1.2 Modeling Toll Road Demand

Typically, T&R consultants start with the local MPO model and adapt or expand it subsequently to forecast toll road usage. There has been some discussion as to when to model the toll option in the four-step process. According to Spear (2007) this has resulted in three approaches whereby the toll option is either:

- introduced in the modal split step, or
- introduced in the trip assignment step, or
- introduced as a sub-step in the trip assignment step or post processor outside the four-step model (almost representing a fifth step).

Figure 3.2 attempts to illustrate the three approaches to modeling toll traffic in the context of the four-step travel demand model.

[17] Thus the traffic is loaded on the fastest roads until the travel time approaches that on alternate routes. Then traffic is loaded on the other routes until either (a) all traffic has been assigned, or (b) all roads are at capacity. In the latter case, a factor called volume-delay is activated, increasing travel time and suppressing demand. The output is the total traffic volume carried by each road segment and travel time (called *skims*). The results are verified against actual traffic counts and travel times. Discrepancies are addressed by re-calibrating various input factors. However, it has been argued that STA employs a number of simplifications that contribute to error in traffic forecasting (see Chapter 5).

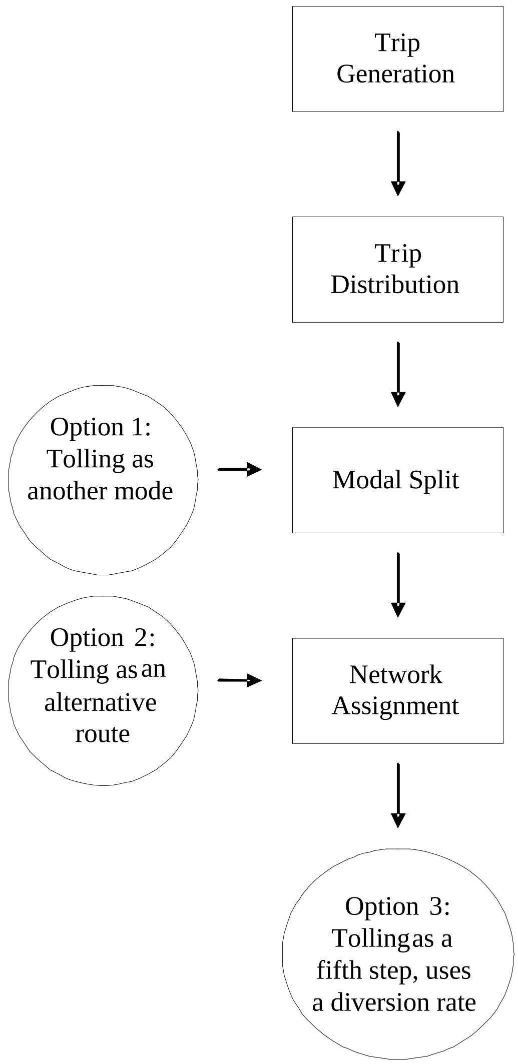

Figure 3.2: Introducing the Toll Option in the Four-Step Travel Demand Model

If the toll lanes are considered in the mode choice step, then tolling is simply treated as another mode and characterized by mode choice variables (e.g., travel time, cost, reliability, etc.). This is the easiest option to introduce in the existing four-step modeling process. However, it is not necessarily dynamic so that increased congestion on the non-tolled alternatives (resulting from the assignment step) will not be accounted for without a feedback loop from the trip assignment step.

If the toll lanes are introduced in the trip assignment step, then the toll rate is converted to represent a time penalty. This allows the model to account for congestion conditions on the non-tolled routes. For example, if the non-toll road's congestion level increases then the travel time on the non-tolled route will also increase. As the time penalty increases on the non-toll route, the toll paid (as represented by an increase in travel time) will become relatively smaller, and hence the toll road will become more attractive.

The final option is the most commonly used by T&R consultants to estimate toll road demand. In this option, a T&R consultant develops

> “at least two alternative paths for each trip—one using the toll facility and one using the best available (i.e., shortest time) non-toll route. The diversion model compares travel time, distance, toll cost, and occasionally other factors, for the two routes and assigns a percentage of the market to each route. The diversion formulae used in the models are based on an accumulation of empirical data collected by the consulting firms from other toll revenue studies, results of site-specific surveys of potential users, and professional judgment. The precise formulae used are considered to be proprietary to each firm” (Spear, 2007).

None of the T&R reports reviewed, with the exception of the 1995 T&R report, included the 1995 North Texas Tollway Authority Bond Document that stated specifically which of the above options were adopted, but from the interview with WSA it is clear that they have used both Option 2 and Option 3 when estimating toll road usage.

3.2 Traffic and Revenue Forecasting Approach

Most T&R consultants[18] interviewed start with the local MPO’s travel demand model. Typically, the consultant obtains the following information from the MPOs:

- socio-economic information by TAZ for the base and forecasted model years,
- trip tables (e.g., peak and off-peak trip tables) for the base and forecasted model years, and
- TAZ network structure and highway network characteristics for the base and forecasted years.

The MPO’s input data are then typically verified for the base year and adapted for the specific toll facility. For example, the MPO data is available on a regional level, and must be adapted for the formal study area (i.e., corridor) of the proposed toll facility. Most T&R consultants also conduct traffic counts and Origin-Destination (O/D) surveys to calibrate the MPO models. Traffic counts are usually conducted along the proposed toll corridors. These counts tend to collected for weekdays only, and are used to calibrate the models for peak and off-peak travel. The O/D surveys are used to determine if the MPO trip table replicated the observed travel patterns (obtained from the survey data). However, most T&R studies do not explain exactly how these O/D surveys are used to calibrate the trip tables produced by the MPO model. Even when a wealth of information is collected and provided (as is the case in some of the T&R reports reviewed) to describe trip purpose, frequency, vehicle occupancy, etc., it is seldom clear how this information was used in the T&R forecasts.

Most T&R consultants also attempt to validate the MPO’s demographic and socioeconomic datasets (e.g., population and employment growth rates) either in-house or by hiring “independent” consultants. The demographic and socioeconomic characteristics of the area—or more specifically the corridor—are widely regarded as a very important variable in estimating the potential demand for a toll facility.

Other factors that are typically mentioned in the T&R reports reviewed are:

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[18] Typically the forecasting team includes a project manager that is well versed in modeling, economists, modelers, GIS analysts, and other analysts with specific expertise as required (for example, to conduct more detailed Stated Preference Survey data collection) (personal interview with Cambridge Systematics, 2007).

- the added capacity (i.e., freeways, tolled facilities, and public transit, such as future rail capacity) included in the MTP program,
- willingness to pay or value of time,
- vehicle operating costs, including wear and tear, maintenance, tires, oil, and fuel,
- the toll schedule,
- the opening dates of various toll road sections,
- toll collection system, for example ETC only or ETC and non-ETC,
- toll traffic growth, and
- median household income/household effective buying power.

Also, annualization factors are also typically required to convert the obtained trip tables (typically peak and off-peak trip tables) into annual volumes. As mentioned earlier, the conversion between these types of model outputs and annual volumes can be complicated. The process becomes even more complicated if different toll rates for different time periods (peak, off peak, night, weekend, etc.) are applied.

Once the model is validated, forecasts are made for selected model years and the toll usage for non-modeled years is obtained through interpolation. In the case of the 99-year lease of the 407 ETR, Halcrow modeled the road usage for a selected number of future years and then assumed a transaction growth rate after that. This seems to be standard practice. Finally, a number of post processor adjustments are typically made to future year estimates if the model validation step revealed an over or under estimation of base year demand. Figure 3.3 illustrates in broad terms the inputs obtained and factors considered in conducting T&R forecasts.

3.3 Concluding Remarks

The introduction of tolling did not only require the altering or expansion of the traditional four-step model, but it also increased the focus on the model inputs, such as demographics, time savings, land use inputs, value of time inputs, traffic growth rates (ramp-up period), and the actual model's performance. This leads T&R consultants to a critical review of the input values obtained from the MPOs and the collection of additional data to allow for corridor specific analysis. Also, T&R firms typically use stated-preference surveys and more detailed origin-destination matrices to model a corridor specific forecast (personal interview with Cambridge Systematics, 2007).

As mentioned before, there seems to be a general consensus that traffic and revenue forecasting uncertainty does not stem from the models and methodology used, but rather from the model inputs and assumptions employed. However, the precise approach used by each T&R consultant to forecast toll demand is considered proprietary so it is impossible to explore whether the models used or the approach adopted introduces any significant uncertainty in the process. The next chapter summarizes the research approach and the study results of the research team in comparing actual and forecasted toll road usage for an identified number of case studies.

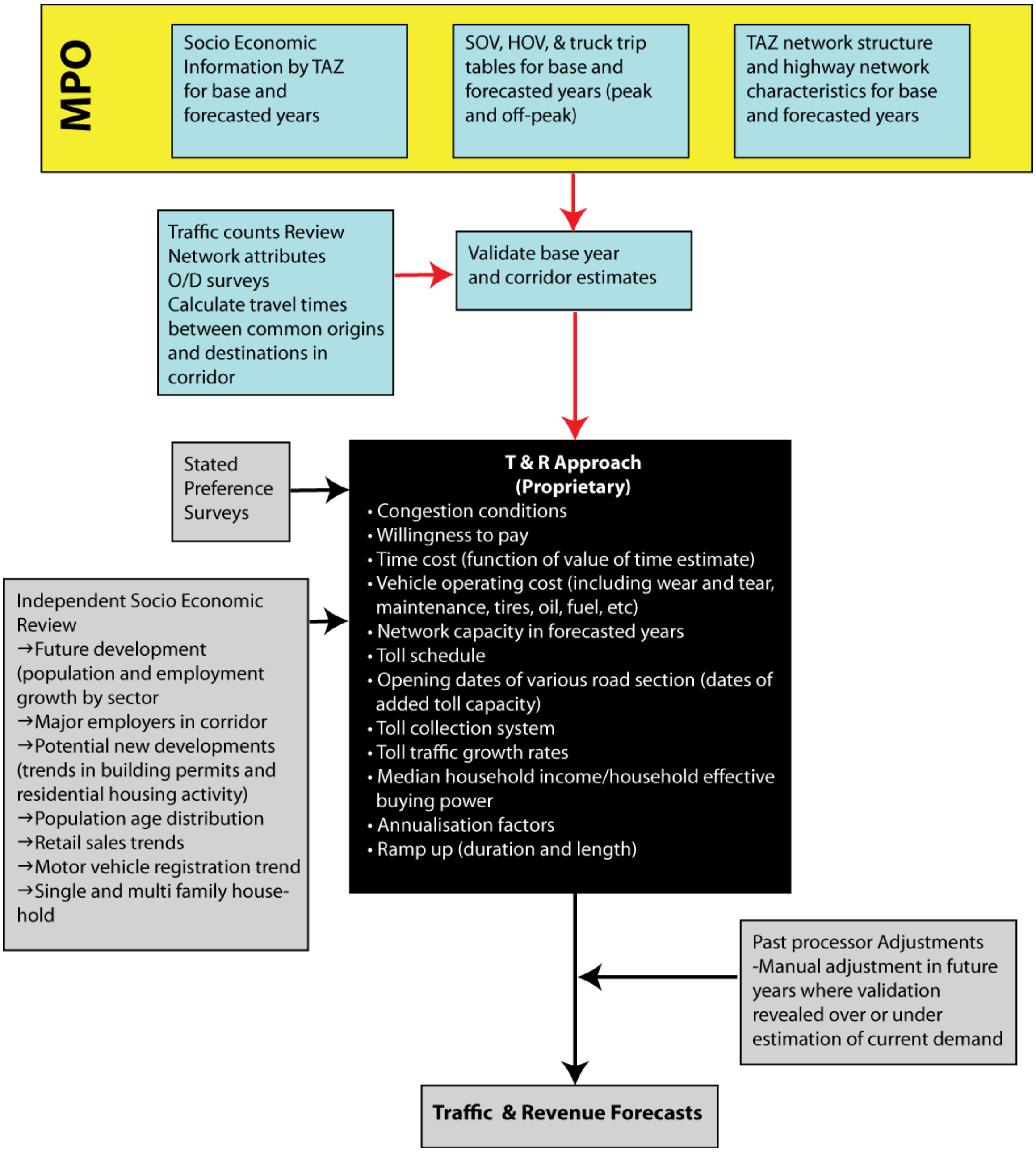

Figure 3.3: Traffic and Revenue Forecasting Approach

Chapter 4. Research Methodology and Case Studies

In 2005, toll roads accounted for 3 percent, or 4,800 miles, of the 160,000 miles of U.S highways (Monnier, 2005). However, the more than 150 toll roads in operation have very different characteristics. Differences pertain to the toll pricing system, responsibility for setting the toll rates, the toll collection system (i.e., Electronic Toll Collection [ETC], Open Road Tolling [ORT], etc.), and the general ownership and system characteristics.

The objective of this research was to extend the work that was conducted by the financial analysts (described in Chapter 2) by examining three to five toll road case studies that were comparable in scope and have been implemented in urban areas that have similar demographic and transportation characteristics as Central Texas. Also, most of the S&P analysis, with the exception of the 2005 analysis that considered the first five years of operation, only considered the first year of operations of the tolled facility. In this study, the focus was on toll roads that have been operational for varying lengths of time. Special care was taken to ensure the inclusion of more mature systems and to exclude toll roads whose usage could have been biased by significant changes to the project in terms of design, delayed openings, or renegotiations. This chapter documents the research methodology and summarizes the case study findings.

4.1 Selection of Toll Road Case Studies

Initially, the research team identified 13 potential case studies as follows:

- E-470 (Denver, Colorado),
- John Kilpatrick Turnpike (Oklahoma City, Oklahoma),
- Sam Houston Tollway (Houston, Texas),
- Hardy Toll Road (Houston, Texas),
- Holland East-West Expressway (Orlando, Florida),
- Central Greeneway Expressway (Orlando, Florida),
- Powhite Parkway (Richmond, Virginia),
- GA-400 (Atlanta, Georgia),
- Veteran's Expressway (Tampa, Florida),
- Lee Roy Selmon Parkway (Tampa, Florida),
- Dallas North Tollway (Dallas, Texas),
- President George Bush Turnpike (Dallas, Texas), and
- 407 ETR (Toronto, Canada).

These potential case studies were identified as follows:

- First a list was compiled of urban areas that have transportation attributes similar to Central Texas—e.g., peak period travelers, freeway lane miles, freeway daily vehicle miles traveled, total system lane miles, annual delay per person, etc.

- Second, the research team obtained a list of urban areas with similar demographic characteristics as Central Texas from the Institute for Demographic and Socioeconomic Research at The University of Texas at San Antonio.
- These lists were compared and urban areas with similar transportation and demographic characteristics as Central Texas—urban areas on both lists—were identified. Finally, the research team listed the toll facilities, if any, in these urban areas.

Fairly detailed information was collected on each potential case study to facilitate an informed decision. Ultimately, the following case studies were selected in consultation with the TxDOT Project Monitoring Committee.

- Orlando's Eastern Beltway (Florida),
- 407 ETR (Toronto, Canada),
- HCTRA system (Houston, Texas),
- President George Bush Turnpike (Dallas, Texas), and
- the 2002 Central Texas Turnpike Project (Austin, Texas).

All these toll roads, with the exception of the Central Texas Turnpike Project, were considered beyond their ramp-up period, but have not been operational for longer than 20 years. Most of these toll roads opened in various sections so often more than one T&R report was consulted for each case study. The oldest T&R report was dated 1984 and the newest 2002. An extensive review of each of these case studies was conducted. The literature sources reviewed included bond documents, the original T&R forecasts, annual reports, official statements, history books, news releases, research articles, and news releases. A number of in-person meetings as well as telephone interviews were conducted with various stakeholders, including the road owners, T&R firms, Metropolitan Planning Organizations (MPOs), financial consultants, toll industry experts, and government officials. More importantly site visits were made to all case study locations to get a better understanding of the scope of the project, land use in the corridor, and how the roads are operated.

The objective was to conduct a detailed examination of the actual and forecasted toll road usage in an effort to identify factors that introduce uncertainty in toll traffic forecasting. The initial T&R statements (used to structure the debts) were used as the official forecasts. The actual usage numbers were obtained from the road owners. Each documented assumption was evaluated in an effort to understand the assumption's qualitative and, if possible, quantitative contribution to the forecast. Every effort was made to verify each documented assumption with the information available from the sources listed above.

The remainder of this chapter summarizes the salient findings in terms of forecasted and actual usage of toll roads as it pertains to each case study. For more detailed information, the reader is referred to Appendix B to E. The appendices provide a detailed discussion of the road's initial feasibility, a detailed description of the projects funded by the bond document(s), all relevant data, tables, and figures, and an extensive review of each T&R report to assess the T&R firm's assumptions for both the traffic and revenue (T&R) forecasts. Each appendix concludes with a comparison between actual and forecasted toll traffic and revenue, when available, as well as a discussion of the assumptions identified earlier and their potential impact on the (T&R) forecasts.

4.2 Orlando Eastern Beltway (Florida)

The Orlando Eastern Beltway, an approximately 62-mile loop around the Orlando area, consists of three main roads:

- The 18-mile Seminole Expressway is the most northern section and is owned by the Florida Turnpike Enterprise (FTE).
- The 33.4-mile Central Florida Greeneway composed of the Northeastern Beltway, the Southwestern Beltway, and the Southern Connector is owned by the OOCEA.
- The 6.4-mile Southern Connector Extension is the most southern section and is owned by the FTE.

Figure 4.1 provides a map of all the toll roads in Orlando to orient the reader as to the location of the Eastern Beltway.

Source: Adapted from Orlando Orange County Expressway Authority, 2005

Figure 4.1: Orlando's Toll Roads by Owner

Because the Eastern Beltway is composed of three different roads that were built in six sections, various T&R reports have been conducted resulting in a separate T&R study for each section. The OOCEA's T&R consultant was Vollmer. The FTE's T&R consultant is URS. The toll traffic forecasts that were included in the various bond documents to finance the construction of the various segments are analyzed in this section of the report.

4.2.1 OOCEA 1986 Bond Document[19]

The OOCEA sold bonds in November 1986 to support the construction of the first sections of the Eastern Beltway. The bond was to support the following five projects:

1. The north section of the Eastern Beltway—Northeastern Beltway,
2. The eastern extension of the East-West Expressway,
3. The south section of the Eastern Beltway—Southwestern Beltway,
4. The western extension of the East-West Expressway, and
5. General improvements to the East-West Expressway.

Only the first and third projects were sections of the Eastern Beltway. Two of the projects, the second and fifth, would have a significant impact on the traffic on the Eastern Beltway, and without the eastern extension of the East-West Expressway, the traffic on the Eastern Beltway would not have been able to connect to the downtown area.

Traffic and Revenue Forecasting Approach

Vollmer's projections for the northeastern and southwestern Beltway sections considered the historical trends in the Orlando area and the existing system conditions. The growth rates in the Orlando area for years 1985 to 1995 (in five-year increments), the existing system's traffic, and the newer segment revenues were projected. Vollmer predicted the growth of the Orlando area based on historical trends. The report noted that historically the traffic on the OOCEA system *grew annually about three times as fast as the area population.* Vollmer applied a reduction factor to this difference, and stated that "*this reduction factor results from conservative estimates of traffic growth to reflect possible deceleration in the rate of growth of other activities such as business development and tourism*" (OOCEA Bond Issuance, 1986). The report noted, however, that there were no signs of a slowdown so their forecasts were more likely to be under than over.

Vollmer predicted the traffic on the existing OOCEA system—consisting of the East West Expressway and the Bee Line Expressway—prior to the opening of the new segments for the last month of 1986 and 1987. Vollmer's 1987 projections conservatively predicted only a 5 percent increase over 1986 revenues. Previous increases had been double digits. Vollmer also made predictions for the existing system after the new segments opened. Initially, the predicted revenue from the existing system was insufficient to cover the bonds for the newer segments. Thus, the OOCEA planned to raise toll rates to increase the revenue and therefore bonding capacity of the authority. The tolls were set to increase January 1987 and again in July 1990. The new toll rates were used in the final revenue projections for the existing system and the new segments.

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[19] Unless otherwise noted, the information and data in this section are from the 1986 OOCEA Bond Document (OOCEA Bond Issuance, 1986).

Vollmer anticipated that the toll increases would result in some traffic loss. Vollmer examined the effect of a previous 1980 toll rate increase on the OOCEA's traffic. The report noted that at that time the United States was in an economic recession. However, even during an economic recession the toll rate increase had little impact on traffic volumes. Vollmer also examined the impacts of toll rate increases on other roads to evaluate the general effect of a rate increase on toll road usage. The report then estimated the expected traffic loss on the existing system based on (a) the average effect of toll rate increases, (b) the expected conditions on the competing non-toll routes, and (c) the amount of toll rate increase. For the Northeastern Beltway, Vollmer predicted a traffic loss of between 10 percent and 20 percent after the 1990 toll rate increase. The Southwestern Beltway was scheduled to open in 1990 at the higher toll rate and thus no effect was expected.

Forecasted and Actual Traffic

Vollmer predicted diversion rates from the non-tolled alternatives on opening day on the Northeastern and Southwestern segments (Table 4.1).

Table 4.1: Forecasted Diversion Rates for Northeastern and Southwestern Segments

	Daily Corridor Volume	**Daily Diversion Volume**	**Diversion Rate (%)**
Northeastern	93,000	11,000	11.8
Southwestern	80,000	11,000	13.8

Vollmer also forecasted revenues for the next six years on the Northeastern and Southwestern segments of the Eastern Beltway (see Appendix B). Vollmer also predicted that the construction of the segments will induce trips that would not have been taken otherwise. Accordingly, Vollmer increased revenue predictions by 20 percent to account for these induced trips. However, Vollmer did not provide induce trip numbers. Also, Vollmer predicted a 6 percent average annual revenue growth rate. Vollmer noted that this is slightly higher than the rate used for the existing system, because they felt that traffic growth on new roads is higher in the initial operating period than in later years when the road reaches capacity.

The OOCEA does not publish daily volumes so a comparison between the forecasted and actual values was not possible. However, the OOCEA history book provides the non-toll opening day volume, which allows the non-toll diversion rate to be calculated. Also, the OOCEA history book provides the average users per day in March 1989 (three months after opening). The values are compared to the forecasted diversion rate in Table 4.2.

Table 4.2: Actual and Forecasted Diversion Rates

	Forecasted Diversion Rate (%)	**Actual Diversion Rate (non-toll) (%)**	**Actual Toll *"Diversion"* Rate (%)**
Month	January 1989	December 1988	March 1989
Northeastern	11.8	19.2	40.8

Source: Shofner, 2001

As expected the non-toll diversion rate was higher than the forecasted tolled diversion rate. However, the *"diversion"* rate with tolls in March 1989 is much higher than the forecasted diversion rate (for January 1989). Some of these trips could have been induced trips, i.e., trips that would not have existed without the existence of the road, and it is arguable that more trips could have been diverted to the toll road the longer the road was operational. As Vollmer did not predict a diversion rate for March 1989, it can only be noted that the 30 percent difference between the two rates is significant.

Factors that Impacted Forecasts

This T&R report provided few model input assumptions used in their forecasts. As mentioned before, Vollmer considered existing demographic, economic, and transportation trends in the area. They assumed that the historical trends will continue in the future. However, the values used were not provided and it is also unclear how these forecasts are considered in the T&R forecasts.

<u>Employment</u>

The T&R report listed the average annual employment growth rate for a three-county region—Orange, Seminole, and Osceola Counties—during 1970 to 1985 at 6.4 percent. The more recent employment growth rates (in five-year increments between 1985 and 2000), however, fluctuated between 5.0 and 5.7 percent (Bureau of Economic Analysis, 2008) in the three-county region.

<u>Occupancy Rates</u>

Vollmer also listed the historical occupancy rates for the same three-county region from 1978 to 1985 at 79 to 83 percent. However, the T&R report did not source this information, which prevented a comparison with more recent trends.

<u>Existing OOCEA System</u>

The historical transaction growth rate was listed for the existing expressway system at 9.0 percent, but the actual average annual expressway system growth rates varied a lot in the five-year increments between 1985 and 2005—from a low 1.5 percent in 1990 to 1995 to a high 9.2 percent between 1995 and 2000 (OOCEA Bond Issuance, 2007).

Vollmer also predicted a 5 percent increase in revenues from 1986 to 1987. However, the actual revenues increased by 43.7 percent on the system. Furthermore, the 1990 scheduled toll rate increases was predicted to result in a traffic loss of between 10 to 20 percent. The traffic volumes did decrease 16.2 percent between 1990 and 1991, but because of the toll rate increase revenues in that same year increased by 29.6 percent.

Population Growth

Vollmer forecasted the average annual population growth rates for the Orlando area. Actual population growth rates turned out to be substantially higher than predicted, especially for the 1985 to 1990 time period. Although, forecasts for time periods in the distant future are typically more uncertain than for the near term, Vollmer's predictions for the later period—1990 to 1995—were closer to the actual rates. Population estimates could impact traffic volumes, i.e., an increase in population could translate into higher toll road usage.

Concluding Remarks

Vollmer only predicted the "opening day" volume for the northeastern and southwestern segments of the Eastern beltway. Also, only a six-year (four for the Southwestern Segment) revenue forecast—i.e., not traffic—was provided. Bain's research could thus not be replicated in this case, because Vollmer did not forecast toll traffic volumes.

The T&R report also provided few model input assumptions used for their forecasts. Interestingly, it is arguable that the higher actual population growth rates than forecasted would have contributed to an underestimation of traffic and revenue forecasts. Thus, the only factor that Vollmer provided was underestimated yet revenues were severely overestimated (see Appendix B).

4.2.2 OOCEA 1990 Bond Document[20]

The OOCEA sold bonds in December 1990 to support the construction of the Southern Connector. The Southern Connector is the southern extension of the Southwestern Beltway, which opened in mid 1990.

Traffic and Revenue Forecasting Approach

Vollmer's predictions considered: (a) existing traffic, (b) traffic from the airport expansion, and (c) traffic from new developments in the area.

Existing Traffic

Vollmer considered the area's existing traffic. Vollmer used a traffic survey conducted for the 1988 Bond Document to determine the potential usage of the road. Time and distance adjustments were made to the survey information, which then allowed Vollmer to calculate the potential time savings from using the road. Vollmer predicted diversion rates from non-toll alternatives based on this information, but the information or implicit assumptions are not provided in the T&R study.

[20] Unless otherwise noted, the information and data presented in this section are 1990 OOCEA Bond Document (OOCEA Bond Issuance, 1990).

Airport Trips

Next, Vollmer analyzed the effects of the airport's expansion on toll road demand. Vollmer assumed different behavior for airport-related trips and non-airport-related trips. Local planners were predicting that the airport would see an average annual growth rate of 10 percent, which is why airport-related trips were forecasted at a 6 percent growth rate compared to a 3 percent growth rate for non-airport trips. The report also noted that they predicted tourists will use the road more than Orlando residents. The hypothesis was that tourists will only need to use the road a few times and consequently be more willing to pay the tolls. However, Vollmer predicted Orlando residents will know other routes—and thus be less likely to use the road every day.

Land Use

The effect of new developments in the area was considered. For this analysis, Vollmer considered all developments that had been approved[21] at the time of the bond document and were in various stages of completion as traffic generators for the Southern Connector. Retail developments were thought to generate the least amount of traffic because nearby residents would make those trips. In total, Vollmer considered 21 residential developments. Twelve of the 21 developments were under construction at the time of Vollmer's report. Vollmer added additional time onto the construction phase of most developments in an effort to be conservative. For example, Vollmer estimated that 50 percent of the projects would be constructed by the Southern Connector's opening date. Vollmer predicted that 30 percent of the projects would open by 2000 and 20 percent would never be constructed. For the remaining nine developments, Vollmer assumed that:

> "only 80 percent of the first phase of each development would be completed as scheduled with the remaining 20 percent completed with the second phase…The developments used for vehicle trip generation were reduced in size to reflect 80 percent of the development scheduled for completion after 1995, 70 percent after 2000, and 60 percent after 2005."

These predictions were input into the Institute of Transportation Engineer's Trip Generation Manual to generate approximate trips for each development. The percent of total generated trips by the developments predicted to use the Southern Connector ranged from 5 to 20 percent. No development was predicted to contribute more than 18 percent of the Southern Connector's first five-year revenue. The location of the developments helped to determine the predicted trip length and thus toll revenue.

Forecasted and Actual Traffic

Predictions for the Southern Connector's first year, fiscal year 1994, were 17.5 million transactions. The forecasted and actual traffic for the Southern Connector is illustrated in Figure 4.2.

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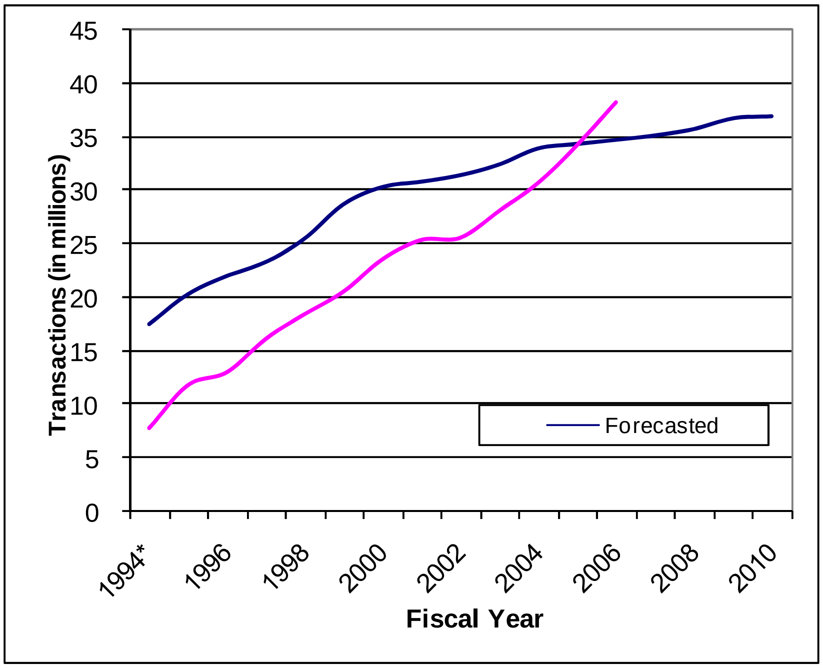
[21] Vollmer did state how many more developments were planned, but because they had not yet received permits of approval their effects were ignored.



*Assume opening of July 1, 1993
Source: OOCEA Bond Issuance, 2007A

Figure 4.2: Forecasted and Actual Transactions on the Southern Connector

Figure 4.2 shows traffic levels did not meet projections until after year 2005. The actual traffic growth rates seem to match the forecasted growth rates for the first seven years—1994 to 2001—as the slopes of the two lines are similar. The difference seems to come in the initial traffic volumes projected by Vollmer. The difference in first year actual and forecasted transactions was 9.7 million. Transactions were thus not even half of projections during the first year.

Factors that Impacted Forecasts

Historical Trends

Historical trends were used as the basis for forecasting future trends. The 1990 T&R report used average annual employment growth rates and average annual expressway growth in their forecasts. A comparison between the historical trends and the actual trends was provided in the discussion of the 1986 bond document.

Population Growth Rates

In the T&R report, the only demographic factor forecasted was average annual population growth rates. Vollmer revised the annual population growth rates that were used in the 1986 bond document. For example, the forecasted rates for 1990 to 1995 were higher than the values forecasted in the 1986 Bond Document. The forecasted values included in the T&R report and the actual values are listed in Table 4.3.

Table 4.3: Forecasted and Actual Average Annual Population Growth Rates

	Years	Forecast Rate (%)	Actual Rate (%)
Orange County	1990 to 1995	2.6	2.6
	1995 to 2000	1.9	3.0
Entire Region* (4 counties)	1990 to 1995	2.9	4.3
	1995 to 2000	2.2	2.5

*Orange, Brevard, Osceola, and Seminole Counties

Source: Bureau of Economic Analysis, 2008

The actual population growth rates were again different from what was forecasted. In most cases, the actual rates were higher than the forecasted rates. Again, the under estimation of population growth rates could arguable cause an underestimation of traffic and revenue levels.

Airport and Non-airport Trips

Vollmer also predicted different growth rates for airport and non-airport trips (6 and 3 percent, respectively). It is impossible, however, to determine origin destination information from the OOCEA transaction data. Thus, the trip purpose cannot be determined, and these growth rates cannot be verified. However, Vollmer predicted an average annual growth rate of 10 percent for the airport. In general, a number of interviews revealed that this airport growth did not materialize.

Land Use

Vollmer also made projections regarding the timeline of developments. The percentage of trips generated from all the developments were to range from 5 to 20 percent of the total Southern Connector trips. Without origin destination information about the trips there is no way to verify these predictions. However, a major commercial development, ICP, was planned near the intersection of the Southern Connector and the Bee Line. ICP was predicted to divert traffic from I-4 to the Southern Connector. ICP was not constructed and thus those expected trips did not materialize.

A light rail train, which was supposed to run along I-4 to connect the suburbs to the central city, never occurred. The goal of the transit line was to link three major destinations to the suburbs: the Disney theme park, the CBD, and the airport. Originally, there was an additional proposal to build a light rail center near the Southern Connector Extension with a spoke to the airport. The project had been planned and funded at the time of the T&R projections and was therefore probably considered. However, mainly due to political reasons, the transit line was never constructed and the predicted trips did not occur (personal interview with Orlando Orange County Expressway Authority, 2007).

Concluding Remarks

The only demographic forecast included was for the annual average population growth rates, which were in general underestimated. The assumptions specific to the traffic estimates were based on various traffic generators, such as the airport, but the level of detail included in the document prevented the verification of these assumptions.

4.2.3 FTE 1991 Bond Document[22]

The Florida Turnpike sold bonds in 1991 (the 1991A series) to fund Phase 1 of the Seminole Expressway and the preliminary engineering and right-of-way acquisition for the Northwest Hillsborough Expressway. The FTE did not sell bonds for either Phase 2 of the Seminole Expressway or the Southern Connector Extension. Because no bonds were sold for these sections, the original T&R reports could not be obtained (personal interview with Jim Ely, 2008).

Traffic and Revenue Forecasting Approach

URS forecasted T&R on the existing expressway system and the new Seminole Expressway based on an assessment of the Orlando area, the local transportation system, the existing system, and the project description. Also, roadside surveys conducted in 1989 during the months of January and February were one of the main sources for predicting future traffic on the road. The 12-point roadside survey resulted in 15,000 interviews with *"data on vehicle classification, origin-destination, trip frequency, trip purpose, and vehicle occupancy."* The traffic survey locations were at historical traffic count locations. Thus, URS had historical AADT counts and survey information for these locations. This survey sampled 16 percent of the actual traffic in the area. From this survey, URS noted that 94 percent of the trips were made by passenger cars. Of the passenger car trips, 47 percent were made five or more times a week and 70 percent had a work-related purpose. Thus, at the time of the bond document, the area had a large amount of commuter traffic. It was anticipated that some of this traffic would divert to the Seminole Expressway upon the road's opening.

From the historical AADT counts, URS estimated the 1990 AADT volume. URS assumed a 7.4 percent average annual growth rate based on URS's earlier analysis of the historical Seminole County AADT growth rates. Next, URS used the survey data to predict a diversion rate for the Seminole Expressway. The diversion rate was then applied to actual 1989 traffic volumes. Thus, URS predicted the traffic volume that the Seminole Expressway would have generated if it had been open in 1989.

URS predicted that of the potential trips, 31.1 percent (i.e., 20,269 trips) would use the Seminole Expressway. URS noted that based on their experience, most facilities generated trips just by existing. The number of these trips can vary from 1 to 100 percent of the diverted trips (here 20,269 trips). URS used Lake Jessup as the dividing point and calculated two trip generation factors. For trips south of Lake Jessup (both origin and destination), a 10 percent trip generation factor was applied. For trips north of Lake Jessup (again both origin and destination), a 20 percent factor was applied. After applying the two factors that were based on the survey, URS added 7,609 induced trips. The total traffic thus amounted to 27,878 trips: 20,269 diverted trips and 7,609 induced trips.

Forecasted and Actual Traffic

The predicted 27,878 trips for 1989—had the road been open in 1989—were split by ramp based on the origin destination survey information. This information was the starting point

[22] Unless otherwise noted, the information and data in this section are from the 1991A FTE Bond Document (URS/Cloverdale & Colpitts, 1990).

for URS's traffic forecast. URS predicted the AADT for the Seminole Expressway toll collection locations for 1995 and 2000. These predictions are provided in Table 4.4.

Table 4.4: Forecasted Traffic for the Seminole Expressway, Phase 1

	AADT		
	1989*	**1995**	**2000**
S.R. 426/Aloma Ramps	4,651	7,783	8,828
Red Bug Lake Road Ramps	8,515	18,793	21,977
S.R. 434 Ramps	3,545	4,994	5,595
Lake Jessup Barrier	11,167	14,952	17,354
Total	**27,878**	**46,522**	**53,754**

*If road had opened in 1989

From these traffic projections, revenue projections were generated for the first seven years of operations, assuming that the toll remained constant. URS also considered the effect of a planned toll increase in 1999. Truck factors were applied to each ramp. These factors are different for each ramp, but the document provides little insight into how the truck factors were developed.

In this analysis, the AADT counts have been totaled and multiplied by 365 to get annual volumes. This seems appropriate because URS noted that revenue was calculated by multiplying the AADT by 365 and then by the passenger toll rate and the truck factor. This suggests that annual volumes are simply AADT multiplied by 365. Also, it was assumed that because the road has one mainline plaza, each car counts as one transaction. This is consistent with the OOCEA's system (which the Seminole Expressway replicated). The forecasted and actual annual transactions are in Table 4.5.

Table 4.5: Forecasted and Actual Traffic on Seminole Expressway, Phase 1

Year	**Transactions (in millions)**	
	Forecasted	**Actual**
1995	17.0	9.6
2000	19.6	17.4

Source: Florida's Turnpike Enterprise Finance Office, 2007

URS provided forecasts for only two years. The 1995 forecast is very high, but the 2000 forecast is closer to actual traffic.

Factors that Impacted Forecasts

<u>Historical Trends</u>

URS assumed that historical demographic and transportation trends will continue into the future. The report reviewed the following statewide demographic trends:

- average annual employment growth,

- average annual motor vehicle registration growth, and
- average annual growth in the number of tourists.

Average annual employment growth for the period 1980 to 1990 of 2.8 percent was provided in the T&R study. However, employment has been growing at a higher rate of 5.4 percent between 1990 and 2000 (Office of Economic and Demographic Research, 2008). Motor vehicle registration average annual growth rates have been decreasing significantly (3.5 percent in 1980 to 1990 compared to 0.7 percent from 1990 to 2000) (FHWA, 2008) and the average annual growth rate for tourists have remained more-or-less constant (6.2 percent in 1980 to 1990 compared to 5.9 percent in 1990 to 2000) (Visit Florida, 2008). However, URS does not provide the explicit values that were used or any insight into how the values were considered in the T&R process.

Population Growth Estimates

Again, the only demographic forecast was the population growth estimates. The forecasted and actual average annual growth rates are provided in Table 4.6.

Table 4.6: Forecasted and Actual Average Annual Population Growth Rates

Years	Forecast Rate* (%)	Actual Rate (%)
1990 to 1995	2.5	2.8
1995 to 2000	2.1	2.9
2000 to 2005	1.6	2.9
2005 to 2010	1.3	-

*Orange, Seminole, and Osceola Counties
Source: Bureau of Economic Analysis, 2008

The rates for the first two five-year periods were similar to the actual growth rates, although slightly lower. The 2000 to 2005 forecasted rate was much lower than the actual growth rate. The underestimation of population growth rates could arguable lower the forecasted traffic levels.

Trip Generation Factors

URS applied trip generation factors (for south of Lake Jessup and north of Lake Jessup). These factors cannot be verified as it is impossible to determine which trips were simply generated by the road and which existed before from the FTE transaction data.

Concluding Remarks

The level of detail included in more recent T&R reports differ dramatically from this T&R document so that few conclusions should be drawn from these results. In a meeting with the URS consultant for the FTE, the possible reasons as to why forecasts were higher than actual values were discussed. The URS consultants identified two key inputs: land use lag and peaking characteristics of the road. The predicted land use did not occur as planned, and the land use that did occur was often later than originally expected.

Also, the peaking characteristics of the road were not considered. The peaking characteristic is the difference in the weekday versus weekend traffic patterns. There is usually less passenger cars in the off-peak, at night, and on weekends. Diversion rates thus tend to be different during the different time periods (personal interview with URS, 2008).

4.3 407 ETR, Toronto (Canada)

Highway 407—the first all-electronic open access toll highway[23] in the world—was envisaged as an alternative to the highly congested Highway 401 in Ontario, Canada. The road was developed under a design-build-operate agreement with the private contractor responsible for the operations and the government responsible for the financing of the road. Highway 407 was completed in 1997 and runs east–west north of Toronto in Canada. It was anticipated that the $1.6 billion in bonds sold to fund the construction of the road would have been repaid from user fees, i.e., tolls, over a 35 year period. However, the provincial government leased the highway in 1999—after 18 months of operation—to 407 International Inc, which comprises Cintra Concesiones de Infraestructuras de Transporte, Macquarie Infrastructure Group, and SNC-Lavalin. The concession agreement between the private concessionaire and the Ontario government is for 99 years (Samuel, 2007). Thus for $3.1 billion, the concession company obtained the right to own, operate, and toll the 108 kilometer road for 99 years. The concession began April 6, 1999.

Figure 4.3: Highway 407 ETR, Toronto

23 A system of cameras record license plate numbers and drivers are charged subsequently. The tolls are differentiated on a peak/ off-peak basis.

WSA conducted three T&R reports for Highway 407 before it was leased to the private concessionaire:

- a preliminary 1993 assessment,
- an official 1996 report, and
- a 1998 report that was an updated version of the 1996 report.

The preliminary 1993 assessment considered different toll collection systems, examined the area's traffic model, and considered the area's sensitivity to tolls. An important component of this report was the traffic information that was collected for the area, including stated preference surveys, corridor origin-destination surveys, traffic counts, and the journey time surveys. The 1996 WSA report provided actual T&R forecasts. However, little is known about this 1996 report except through Halcrow's[24] evaluation of the 1998 report that is an update of the 1996 report. Both the 1996 and the updated 1998 reports are not available to the public.

Traffic and Revenue Forecasting Approach[25]

<u>WSA and Halcrow's Initial Base Case</u>

WSA started with the existing Ministry of Transportation Ontario (MTO) traffic model and their 1996, 2001, 2011, and 2021 trip tables for the AM, PM, and off-peak periods. For the 1998 WSA T&R report, WSA began with the MTO's 1996 trip tables and their own traffic model, TRANPLAN. This model was an adaptation of the MTO's model. WSA calibrated its TRANPLAN model by comparing their 1998 traffic forecasts with actual 1998 traffic volumes on the 407 ETR. Instead of using the 2001 MTO trip table, WSA used their calibrated model to generate a more realistic 2001 trip table. Future year trip tables—i.e., 2011 and 2021- were so far in the future that WSA chose to use the MTO trip tables for these years. The WSA 1998 report was made available to the private bidders, but WSA did not provide their estimated 1998 and 2001 trip tables to the private bidders. Halcrow therefore did not have access to these trip tables.

The WSA 1998 and 2001 trip tables divided the potential trips into ETC trips and video billing trips. There was no differentiation for freight trips. WSA noted that

> "freight traffic is not explicitly modeled as a separate class (it forms 7 percent of current [407 ETR] trips) but the extra revenue generated by these vehicles is taken into account in the revenue estimates (through increases to assumed toll rates in the revenue calculations)."

When the government released the 1998 WSA report to the potential bidders they were also interested in the bidders constructing the two extensions. The traffic volumes for these extensions were thus also predicted by WSA. WSA adjusted their model results (forecasts) for the extensions based on their professional judgment. WSA felt that the model had overestimated off-peak period traffic for the Western extension and for all periods for the Eastern extension.

[24] Halcrow, the T&R consultant for the 407 ETR concessionaire, considered WSA's assumptions and forecasts. This included examining economic growth factors, land use changes, trip tables, value of time assumptions, and many other factors.

[25] Unless otherwise noted, the information and data in this section are from the 407 ETR 1999 Bond Document (407 International Bond Issuance, 1999).

WSA thus reduced their off-peak traffic estimates for the Western extension by 40 percent and 10 percent in 2001 and 2011, respectively. In the case of the Eastern extension WSA reduced their modeled 2001 traffic estimates by 10 percent in both the peak and off-peak periods. Halcrow noted that the adjustments to the Western Extension seemed a little over conservative as that particular corridor is quite congested.

Halcrow also started with the MTO's traffic model. They also modified it to replicate the actual traffic volumes on the 407 ETR. The model runs considered the toll rate schedule on the highway pre-lease. Halcrow evaluated the accuracy of their model on a link basis. The Halcrow model predicted a value of 375,000 total vehicle kilometers and the actual volume was 379,200 vehicle kilometers, which is a difference of less than 2 percent. Thus, their model sufficiently replicated current traffic conditions. Halcrow stated though that their model is reliable when projecting traffic on the whole road, but not on individual sections of the road.

An important input into Halcrow's trip generation model is value of time. Halcrow agreed with the 1996 WSA value of time assessment. The value of time for the AM peak, PM peak, and off-peak was $0.27, $0.29, and $0.23 per minute, respectively. The pre-lease toll rate schedule required the average speed on the 407 ETR to be double the speed on Highway 401 during peak periods to justify the use of the road (based on these values of time).

Demographic and socio-economic factors were also important inputs into Halcrow's trip generation model. The main source of population forecasts were the Hemson report (see Appendix C). Given a discrepancy between the Hemson report and the Census values, the Regional Municipalities were asked to revise the forecasts. Halcrow indicated that the WSA-adjusted Hemson forecasts were optimistic, but could be reached if the economy continued to prosper. Halcrow considered both the regional forecast and the individual city forecasts. The only forecasted economic values were for the years 1999 to 2003, predicting a GDP annual growth rate of 2.5 percent in the Greater Toronto Area (GTA). Other factors that Halcrow considered were the length of the ramp-up period, the trips the road itself would generate (induced trips),[26] and special events that could cause spikes in traffic volumes.

WSA and the government considered the ramp-up period to be over by September 1998. However, the historical traffic volume information listed in the T&R report (for September 1998 to May 1998) seems to suggest that traffic volumes were still increasing after accounting for the seasonal effect. Also, the WSA report forecasted that ramp-up for the two extensions will last from July 1, 2001 to December 31, 2001. The latter implied that both extensions will open well before their scheduled opening dates and that the ramp-up period will be very short. WSA's 2002 traffic volume forecasts thus did not include any ramp-up effects. Halcrow assumed that the central section would still experience some ramp-up effects and the extensions would experience a ramp-up period of approximately six months. Halcrow also assumed that the extensions would open by July 1, 2001.

The following key assumptions were included in the 1998 WSA forecasts and also in Halcrow's initial base case forecasts in an effort to verify the reliability of Halcrow's model:

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[26] Often the mere existence of a road induces residents to take trips that would not have otherwise been taken. These trips can be difficult to quantify. WSA did not consider the additional trips the road itself would generate in their forecasts. However, during the peak periods the road will offer substantial time savings over the non-tolled alternatives. Halcrow hypothesized that the road would generate induced trips during the peak periods and considered these trips in their risk analysis.

- "Current toll rates on the Highway 407 are increased by 10 percent in real terms by 2001, by a further 27 percent by 2011, and by a further 21 percent by 2021 in the peak periods but only 7 percent at other times
- The video surcharge remains at $1
- The proportion of transponder users will gradually increase over time (and that of video users decrease) [see Figure 4.3]
- Both the West Extension and the East Partial Extension are open to traffic by July 1st, 2001
- The carriageways on Highway 407 will be widened as necessary to maintain adequate service levels to meet the increasing traffic demands
- No new interchanges will be added to Highway 407 although existing partial interchanges will be converted to full interchanges by 2001."

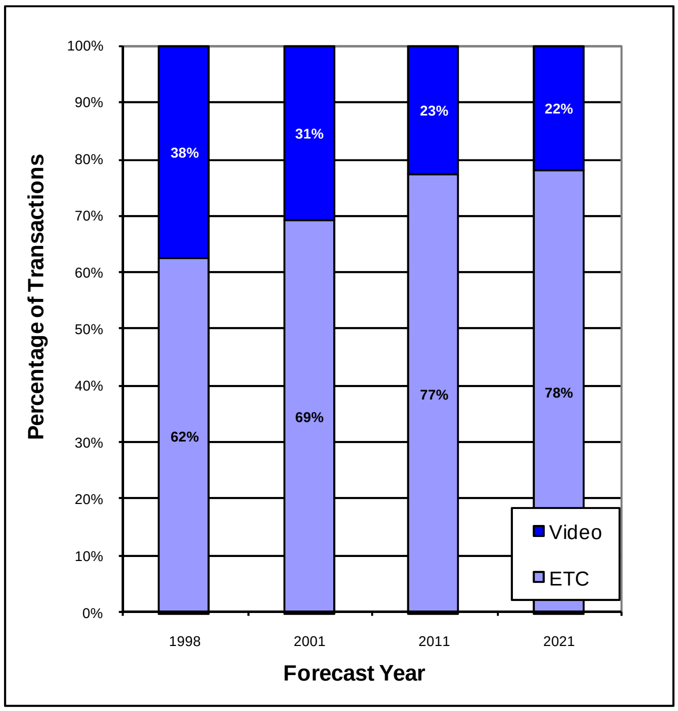


Figure 4.4: WSA and Halcrow Initial Percentage ETC and Video Users/Day

ETC usage was assumed to increase at higher rates during the road's early years and thus reach WSA's proposed penetration level (22 percent) in a later year. The forecasts for the years between the modeled years (i.e., 1998, 2001, 2011, and 2021) were determined through interpolation.

<u>Halcrow's Sensitivity Analysis</u>

Halcrow subsequently took WSA's base case forecast and performed a sensitivity analysis based on their observations and expertise. They tested various factors and predicted their impact on the initial base case traffic volumes and revenue values. It should be noted that Halcrow only changed the factors they explicitly state to have changed in their final base case model (see next section). However, this analysis revealed the sensitivity of the overall traffic or revenue levels to changes in each of these factors (considered in isolation). In general, these impacts should also be applicable to the final base case forecasts. The various factors considered and Halcrow's analysis is summarized in detail below:

- Halcrow compared the forecasted traffic volumes from the WSA and Halcrow models for the AM peak period. The comparison showed that the models predicted very similar traffic volumes given the base case assumptions. One difference between the two models is the rate at which the road will be expanded. The WSA model assumed that only the segments that experience congestion will be expanded. The Halcrow model assumed that the entire road will be expanded each time any segment experience a certain level of congestion. The Halcrow model forecasted slightly higher traffic volumes than the WSA model for 2001 (approximately 1.5 percent) and 2021 (4.2 percent). In general though, the two models (given the same assumptions) forecast similar traffic volumes, indicating a respectable replication of WSA's adjustments to the MTO model.

- The toll rate has a direct effect on traffic volumes. Halcrow listed their revenue maximizing toll rates for each forecasted year as well as the values used by WSA. Halcrow indicated that a reduction in tolls during the off-peak periods will maximize toll revenue.

- The private concessionaire has the right to adjust the toll rates by road segment. Halcrow thus suggested that an additional supplementary toll be charged for use of the Western Extension. Halcrow speculated that where the 407 ETR will parallel the congested QEW, users will be less sensitive to toll rates as there are fewer options. Also, the Western Extension traverses a wealthy area in the GTA. The suggested supplementary tolls were an additional 2.5 cents/km and 1.75 cents/km during the peak and off-peak, respectively. The additional revenue from these supplementary tolls was estimated at 1 percent for the peak periods and 8 percent for the off-peak periods. This was the only toll rate schedule and strategy that was explicitly explained, but the bond document noted that other strategies could also be profitable and should be explored.

- Halcrow examined the effects on traffic volumes if the land use did not change as expected. For example, if the land use did not disperse as Hemson forecasted, but instead densified in the existing locations. Halcrow did this forecast using the 1996 trip distributions and the total trip volumes from the 2001, 2011, and 2021 MTO trip tables. This analysis suggested traffic during all time periods would decrease if the area does not experience some amount of sprawl.

- Halcrow reviewed the impact of reduced growth in the area. In this test, Halcrow halved the model inputs for economic growth in each time period. Not surprising, the lower economic growth assumptions reduced the traffic volumes on the 407 ETR.

- The completion of the Western Extension and East Partial Extension was found to have a positive impact on traffic on the overall road as drivers using the extensions will also use at least part of the existing central section. Although the 24-mile (39-km) extensions will represent only 36 percent of the total road length, Halcrow suggested that they will generate proportionally more traffic on the central section than a 36 percent increase in length.

- Halcrow tested the impact of a 25 percent higher and 25 percent lower value of time on the forecasted traffic volumes for years 2001 and 2011. The results in Table 4.7 show that value of time is an important factor in determining toll road usage and that uncertain value of time assumptions can lead to large differences in forecasted traffic volumes (especially if value of time was overestimated).

Table 4.7: Percent Change in Value of Time

		AM Peak		**Inter-Peak**	
		+ 25%	**-25%**	**+ 25%**	**-25%**
Percent Change in Revenue	2001	10.30	-17.50	5.40	-27.50
	2011	4.10	-12.80	2.10	-28.40

- Halcrow conducted a sensitivity analysis to determine the traffic volumes if a certain number of lanes are open for the whole road in years 1998, 2001, 2011, and 2021. In general, traffic volumes in any given year increases if the road capacity increases. Halcrow concluded from this sensitivity analysis that the most congested segments of the road will need three, four, and five lanes in years 2001, 2011, and 2021, respectively.

The forecasted effects on traffic volumes given Halcrow's sensitivity analysis are summarized in Table 4.8.

Table 4.8: Summary of Halcrow's Sensitivity Analysis

Factor	**Affect on Traffic**
Model Comparison	Little impact
Change Peak to Off Peak Toll Rate Ratio	-
Charge Different Toll Rates by Segment	-
Lower Land Use Expansion	Decrease
Reduced Economic Growth in the Area	Decrease
Impact of Opening Extensions on Entire Road's Traffic	Increase
Higher than Estimated Value of Time	Increase
Lower than Estimated Value of Time	Decrease
Impact of Widening the 407	Increase

Summary of Halcrow's Risk Analysis

Halcrow also conducted a Risk Analysis of their forecasts. The objective of the analysis was to quantify the level of uncertainty associated with specific variables within a reasonable range of values: "*The overall objective is thus to identify ranges of revenue levels, with* *confidence limits, taking account of variation in key socio-economic, land use development, and other variables."* Halcrow's risk analysis as provided in the T&R report included the following four steps:

- identify the key input variables that affect the *"Final Base Forecasts,"*
- define the probability distributions for each key variable,
- define the sensitivity functions for each variable, and
- run the Halcrow Fox's RISK model.

However, Halcrow's analysis seems mainly founded in their professional judgment, not necessarily on statistical evidence. The key factors identified were:

- GDP growth rates,
- socio-economic growth rates,
- value of time,
- tolls charged,
- the differences between the WSA and Halcrow models,
- traffic generation,
- unbillables, and
- model errors.

For the Risk Analysis, the analysts had to identify the lowest and highest possible value for each key variable. The final steps of the risk analysis involve selecting various values for each variable within their possible ranges and thus simulating various scenarios that could possibly occur. The scenarios were selected using the Monte Carlo method. Halcrow generated revenue levels for 10,000 possible scenarios. Halcrow did this for the three model years, i.e., 2001, 2011, and 2021. The resulting distributions for these scenarios were *"effectively display[ed] as a normally distributed profile"* where the *"mean and median for each distribution are very similar in each case."* The revenue ranges were widest for the year 2021 as information for this year is obviously more uncertain. Because the objective of the risk analysis was to identify the impact of certain key variables on revenues (i.e., not transactions) it is not further discussed here. However, the risk analysis as described in the T&R report is summarized in more detail in Appendix C.

Forecasted—Halcrow's Final Base Case and Actual Traffic

Based on their expertise, research, sensitivity analysis, and assumed discussions with the private bidder, Halcrow made a number of adjustments to their initial base case forecasts that mostly impacted the revenue projections with the exception of:

- The construction of three more central section interchanges required by the concession agreement. WSA estimated that these interchanges will increase traffic by 2.6, 2.0, and 1.9 percent in years 2001, 2011, and 2021, respectively.

- The ramp-up period for the central section was extended beyond the WSA September 1998 end date. Halcrow assumed that *"half of the 17 percent [traffic volume weekday] increase is background traffic"* but that the other half *"is due to continuing ramp-up."* This factors into the predicted growth in future years.

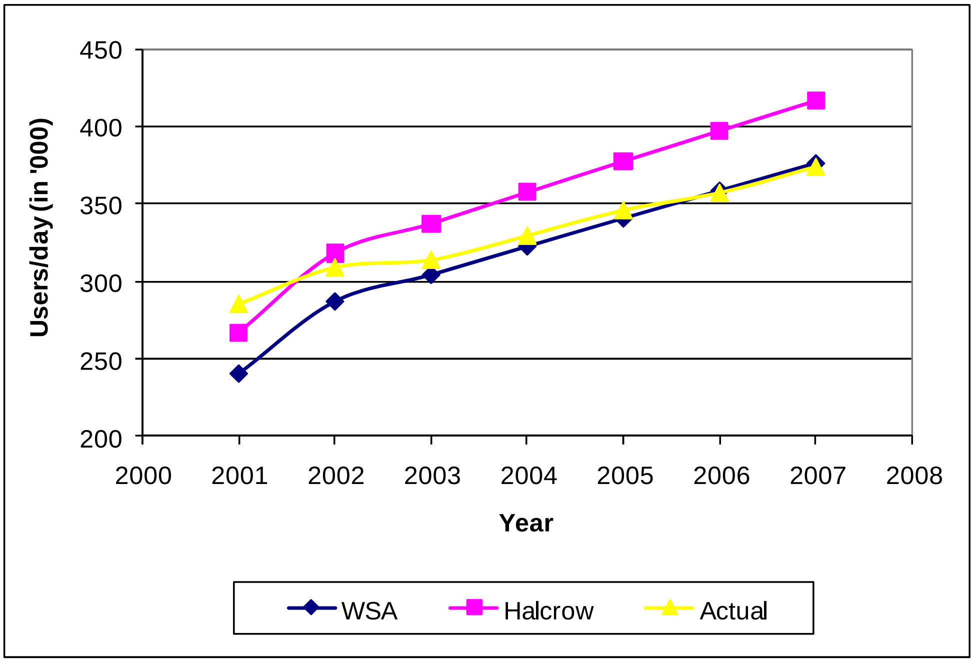
Halcrow's adjustments to their initial base case to derive their final base case traffic are shown in Table 4.9 for year 2001.

Table 4.9: Adjustments to Halcrow's Initial Base Case to Derive Final Base Case Traffic (2001)

Source	Adjustment	Users per Weekday
Initial Base Forecast		240,000
3 new Interchanges	+ 2.6% in traffic	46,200
Continuing Ramp-up	+ 8.5%	21,000
Final Users		**267,200**

Halcrow did a similar forecast for years 2011 and 2021. Halcrow noted that traffic volumes and revenue for each year not explicitly modeled can be determined through simple interpolation. Halcrow used the Highway 401 traffic growth rates, historic economic growth rates, and a future 2.5 percent annual economic growth rate for Ontario to forecast average traffic growth on the 407 ETR after 2021. This resulted in a forecasted 3 to 4 percent per year corridor traffic growth rate.

The users per day forecasted by Halcrow and WSA compared with the actual users per day are provided in Figure 4.4.



Source: 407 ETR News Release, 2008

Figure 4.5: Forecasted and Actual Users/Day

From Figure 4.4, it is evident that Halcrow's 2001 and 2002 forecasts are very similar to the actual traffic volumes—more so than in the case of WSA. WSA's toll road usage forecasts for 2001 and 2002 were substantially lower than the actual usage. However, after 2002 actual traffic volumes were much closer to WSA's projections, while it seems that Halcrow overestimated toll road usage from 2003 onwards. However, the information in the Figure has to be interpreted against the large toll rate increase that occurred in 2002 and subsequently in each year since then, i.e., 2003, 2004, 2005, 2006, and 2007. These toll rate increases were much higher than the inputs used by Halcrow in their forecasts.

Factors that Impacted Forecasts

<u>Vacancy Rate</u>

Halcrow assumed that existing socio-economic, and transportation trends in the area would continue in the future. Halcrow noted that at the time of the bond document the vacancy rate in Toronto had been at 5 percent for the last few years. A comparison of more recent vacancy rates with the historical values revealed that the vacancy rates for Toronto for the years 1999 to 2003 ranged from about 0.75 to 4 percent. During this time period, vacancy rates have been increasing steadily—i.e., the 4 percent was for the year 2003 (Ministry of Municipal Affairs and Housing, 2007).

<u>Land Use</u>

Land use was considered in terms of housing starts, building permits, and land values. Halcrow noted that the number of housing starts is an indicator of the state of the economy. However, the housing starts Halcrow included in the T&R report were simply general trends for the GTA that was obtained from the Canadian Mortgage and Housing Corporation (CMHC). Halcrow noted that housing starts were in the range of 20,000 per year during the early to mid 1990s, and provided the actual starts for 1997 and 1998 (i.e., 28,848 and 28,683). However, the actual number of housing starts increased from about 16,000 in1995 to more than 45,000 in 2003, but has since been decreasing. Halcrow also does not expand upon how housing starts were factored into their forecasts.

<u>Local Transportation System</u>

A section of 407 ETR parallels the most congested road in Toronto, Highway 401. Capacity had been added to Highway 401 multiple times, even reaching 16 lanes in certain highly congested areas. Halcrow thus assumed that traffic will divert from this congested option to the new, less congested toll alternative. Halcrow emphasized that even during economic downturns traffic in the area remained constant although it may not have grown. Halcrow did not reference their information, but it was assumed that the MTO provided the traffic numbers for Highway 401. Updated Highway 401 AADT figures were obtained from the MTO and an attempt was made to replicate Halcrow's calculations. The results proved to be quite different from the growth rates included by Halcrow in their T&R report (see Appendix C).

<u>Economic Growth Rate</u>

Halcrow examined the annual GDP growth in Canada for the following time periods—1990 to 1996, 1997, 1998—and predicted the annual growth for the 1999 to 2003 time period.

Actual annual growth rates obtained from Statistics Canada and some of Halcrow's numbers are provided in Table 4.10.

Table 4.10: Annual GDP Growth for Canada

	Halcrow		Statistics Canada	
	1990-1996	1999-2003	1999-2003	2003-2006
	Historical	Forecasted	Actual	Actual
Annual GDP Growth (%)	1.3	2.5	3.1	3.0

Canada experienced a higher annual GDP growth rate during the late 1990s when compared to the early 1990s. From Table 4.10, it is evident that the actual GDP growth (from Statistics Canada) was higher than the forecast used by Halcrow for the 1999 to 2003 time period.

For the Ontario/Toronto area specifically, Halcrow compared traffic growth on Highway 401 with the economic growth in the area. Economic growth values for Ontario were obtained from Statistics Canada. Table 4.11 provides the change in GDP in the respective time periods—not annual GDP growth as in Table 4.10.

Table 4.11: Economic Growth in Ontario

	1986-1989	1989-1992	1992-1995	1997-2000	2000-2003	2003-2006
	Halcrow (included in bond)			Statistics Canada		
Economic Growth in Ontario (%)	13.5	-3.8	9.2	19.7	5.7	8.1

Source: Statistics Canada, 2008

Halcrow used the historical economic growth information to forecast future growth in the Ontario area. Table 4.11 shows that the economy experienced very different growth rates in the different time periods, ranging from -3.8 to 19.7 percent. However, the bond document does not provide the actual model inputs that Halcrow used for future economic growth rates, so no quantitative comparison could be conducted. The values in the Table above, however, illustrate the uncertainty associated with using historical economic growth values to predict future economic growth.

Population Estimates

The forecasted population estimates were compared with the actual population numbers for the year 2001 (Statistics Canada, 2008). For Toronto, Peel, and York, the actual population values were very similar to the Hemson forecast. For Durham and Halton, the regional forecasts were closer to the actual population values than the Hemson forecasts.

Population was also forecasted for 2011. Actual population values for 2006 were obtained and compared with the forecasted 2011 population values (see Table 4.12).

Table 4.12: Forecasted and Actual 2001 Population Values

City/Area	Actual*	Forecasted	
		Hemson	Region
	(in millions)		
Toronto	2.49	2.42	-
Peel	0.99	0.99	1.04
York	0.73	0.74	0.74
Durham	0.51	0.61	0.56
Halton	0.38	0.42	0.38
GTA	-	5.18	-

*Data from Statistics Canada, 2008

As is evident from Table 4.13, the City of Toronto has almost reached the predicted 2011 population in 2006. The City of Peel's population has already surpassed the Hemson 2011 forecast. Only Durham seems to be lagging behind and it is uncertain whether the population in this city will reach the forecasted values.

Table 4.13: Forecasted 2011 and Actual 2006 Population Values

City/Area	2006	2011	
	Actual*	Forecasted	
		Hemson	Region
	(in millions)		
Toronto	2.50	2.54	>2.50*
Peel	1.16	1.15	1.21
York	0.89	0.93	0.94
Durham	0.56	0.80	0.76
Halton	0.44	0.53	0.49
GTA	-	5.95	>5.90

* Data from Statistics Canada, 2008

Opening Dates

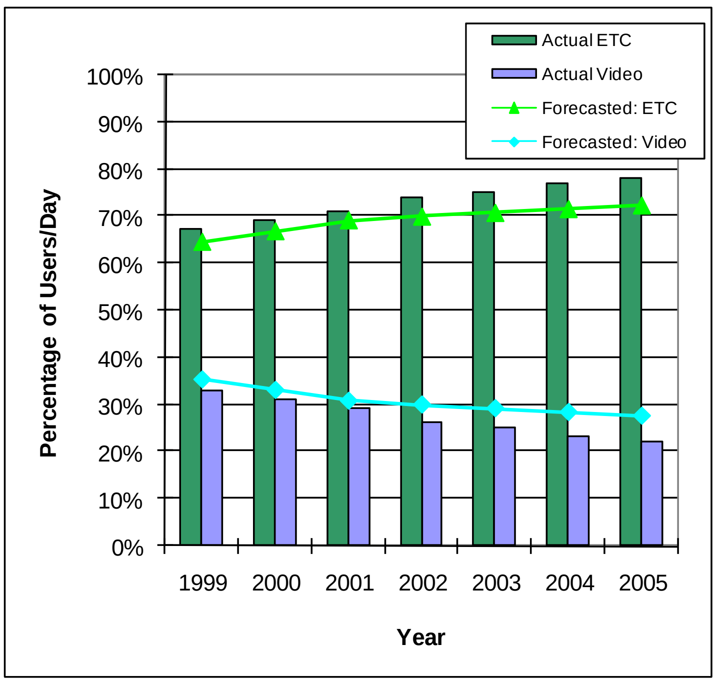
Both the WSA and the Halcrow T&R forecasts assumed that the new extensions would be open by July 1, 2001 after a construction period of 26 months. The actual opening dates of the extensions were one month later on July 31, 2001 for the West extension and two months later on August 30, 2001 for the East extension. The T&R reports therefore include an additional three months of toll road usage on the two extensions in their 2001 forecasts. Despite the additional T&R resulting from the extensions opening later than assumed by the T&R firms, both 2001 revenue and traffic forecasts were lower than actual values.

Construction of Additional Interchanges on Central Section

In terms of the concession agreement, the private concessionaire agreed to complete several interchanges and construct two new interchanges on the existing Central section. The partial interchanges to be completed were: Britannia Road, Mavis Road, Woodbine Avenue, Kennedy Road, and McCowan Road (Caro and Saenz Ormijana Valdes, 2008). The two new interchanges were at Centre Street and Kipling Avenue. WSA's initial forecasts included only four of these interchanges, so they later revised their forecasts in a letter to Merrill Lynch in February 1999. The letter stated that the three additional interchanges[27] would generate 1.3, 1.5, and 1.7 percent additional revenue in years 2001, 2011, and 2021 respectively (407 International Bond Issuance, 1999). These interchanges were, however, very closely spaced and this prompted the concessionaire to negotiate the number of interchanges they were required to build. In the end the following interchanges were completed: Britannia Road, Mavis Road, Woodbine Road[28], Kennedy Road, and McCowan Road. The two new interchanges at Centre Street and Kipling Avenue were never constructed (personal interview with 407 ETR International, 2008).

Electronic Tag Usage and Market Penetration

The 407 ETR had a 50 percent ETC usage during the first year of operation. In 1999, ETC usage reached 67 percent. Furthermore, the number of ETC transactions has increased from 300,000 in 1999 to 857,000 in 2007. Figure 4.5 shows the growth in ETC usage as a percentage of users/day and the associated decrease in video users over time. It also illustrates WSA's initial ETC and video usage percentages, as well as the interpolated percentages for the non-modeled years. Halcrow did not document a change in the ETC usage levels used by WSA, so it was assumed that Halcrow used the WSA estimates in their final base case.



Source: Nassereddine, 2008

Figure 4.6: Forecasted and Actual ETC and Video Usage

27 It does not stipulate which interchanges.

28 The Woodbine Interchange was possibly completed at a later date.

For 2011, WSA predicted that 77.1 percent of the daily users would use a transponder, but as Figure 4.5 shows, ETC usage already reached 78 percent of daily users by 2005. WSA's prediction of ETC usage is thus lower than the actual values. The level of ETC penetration is important as it impacts revenue levels and to some degree usage,[29] but it is impossible to determine the extent of the impacts. In Halcrow's review of WSA's initial base case forecast, and consequently their own analysis, there is very little discussion of transponder penetration levels and how that might affect traffic or revenue levels.

Toll Rates

The right of the concessionaire to increase toll rates has been a contentious issue between the concessionaire and the Liberal McGuinty government. In terms of the concession agreement, the concessionaire can raise tolls to a specified toll threshold in the base year. Then, as long as traffic volumes were higher than the traffic threshold, the concessionaire could raise tolls to their desired rates. If the traffic volumes are below the traffic threshold and the toll rates above the toll threshold, the concessionaire has to pay the province a steep penalty.

The T&R report stipulated the assumed toll rate increase schedule. WSA and Halcrow assumed that tolls would increase by 10 percent in real (constant terms) from 1999 to 2001, another 27 percent from 2001 to 2011, and from 2011 to 2021 another 21 percent for peak periods and 7 percent for off-peak periods. The tolls implemented by the concessionaire, however, differed greatly from this schedule.

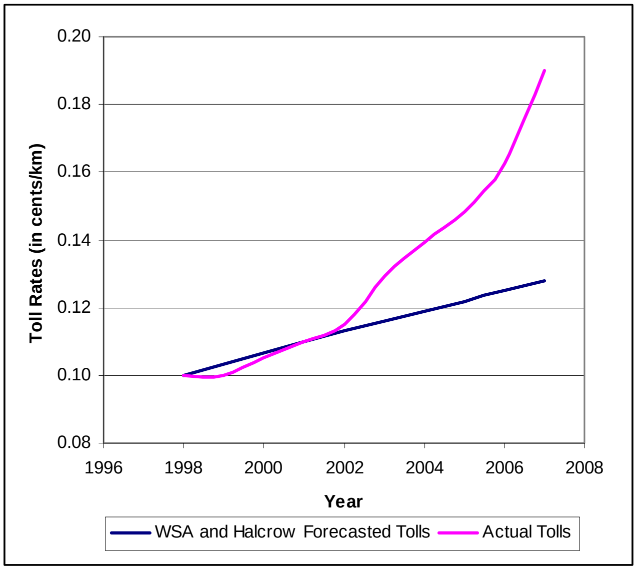
In 2000, 2001, and 2002, the concessionaire charged the same peak and off-peak toll rates for passenger cars. During these years, the highest toll rate the concessionaire could charge was the peak period toll rate. The concession agreement with the Province did not define the peak hour periods though. The concessionaire interpreted this to mean the peak period for toll rate purposes—not actual traffic volumes—could be all day. This all-day peak period resulted in slightly lower traffic volumes, but higher revenue levels than if peak toll rates were charged for 7 hours a day (as the Ontario Transportation Capital Corporation (OTCC) had done previously).

This toll rate strategy[30] suppressed the traffic during the base year. Because all future traffic thresholds would be determined considering the base year volume, the lower the base value the lower the traffic needed to reach the following year's traffic threshold. In other words, the lower the traffic threshold, the higher the chance for the threshold to be met, and the higher the chance for the concessionaire to charge the toll rate they chose.

A comparison between the tolls charged by the concessionaire and the tolls that were used to forecast the T&R are provided in Figure 4.6.

[29] It is often argued that an electronic tag makes the user less sensitive to the toll rate charged. Users are billed monthly, with the result that users only become aware of the charges a full month later. On the other hand, an occasional user—who does not have a transponder account—might choose not to use the road because of a lack of information about the total costs that will be incurred.

[30] The all-day peak period angered the government and litigation resulted that challenged the use of 2002 as the base year. However, the courts sided with the concessionaire. Legally, the concessionaire has the right to charge any toll rates as long as traffic volumes are above the traffic threshold.



Source: Nassereddine, 2008

Figure 4.7: Forecasted and Actual Passenger Car Toll Rates (Peak Period)

The figure clearly illustrates the large difference in the toll rates used in the forecast and that were implemented given the 2002 base year. The use of a lower toll rate potentially impacted both the traffic and revenue levels. Higher toll rates should decrease traffic volumes, hence leading to the overestimation of traffic volumes. Also, higher tolls increase the revenue to a point, potentially leading to the underestimation of revenue levels.

Truck Percentages

Because trucks pay two or three times higher tolls than passenger vehicles, depending on the size of the truck, the revenue generated by trucks could be substantial in terms of total revenue. The T&R document stated that trucks accounted for approximately 7 percent of the Highway 407 transactions and thus it was assumed that the same truck percentage will remain in the future. Truck percentages on the Highway 401 non-toll alternative, where it parallels 407 ETR, are approximately 12 to 13 percent. On the western section of Highway 401 the percentage reaches 15 to 20 percent. The concessionaire indicated that Highway 401 attracts a number of trucks because many truck destinations (i.e., industrial areas) are around the road. Many trucks also use Highway 401 to get to Toronto, not through Toronto (personal interview with Ministry of Transportation, 2008). Unfortunately, the concessionaire does not release information about the current 407 ETR vehicle profile, so it was not possible to verify this assumption.

Annualization Factor

An annualization factor is a value that is used to convert daily traffic volumes and revenues to annual values. The reason for an annualization factor is because conversion from daily to annual traffic volumes is more complicated than simply multiplying by 365, especially when conducting revenue forecasts. The bond document states that *"there are fewer trucks at weekends, toll rates are lower than during the rest of the week, and there is a different proportion of transponder and video users at weekends."* An annualization factor attempts to balance these differences out and thus allow daily volumes to be converted to annual volumes. Ultimately revenue is estimated on an annual, not daily, basis.

WSA indicated the need to adjust their annualization factors in 1998 as follows:

- For Traffic: 308.2 for ETC trips, 335.8 for Video trips
- For Revenue: 289.9 for ETC trips, 319.5 for Video trips

Halcrow also used these factors in their calculations (407 International Bond Issuance, 1999). However, it was not possible to multiply the average users/day Halcrow predicted with the annualization factors to obtain total annual users, because Halcrow did not provide separate estimates for ETC usage and video trips in each year. WSA provided ETC usage percentages for 2001, 2011, and 2021. However, ETC usage was predicted to increase as time passed, but it was not stated whether this increase was linear or not. Thus, to interpolate in-between year values without this information could discredit any conclusions.

However, by using available information—i.e., actual average users/day, actual ETC percent usage, actual video percent usage—and the assumed annualization factors, the number of annual trips the annualization factors would have generated can be calculated and compared with the actual annual trips.[31] The results of this calculation, i.e., annual trips calculated based on actual users/day and the annualization factors, are summarized in Appendix C. Table 4.14, however, illustrates the difference between the estimated annual trips (using the annualization factors) and the actual annual trips as obtained from the concessionaire.

Table 4.14: Annualization Factor Annual Trips and Actual Annual Trips

	Total Yearly Trips		
Year	**Actual**	**Annualization Factor**	**% Difference**
	(in millions)		
2000	79.4	83.6	5.2
2001	86.1	90.1	4.7
2002	93.2	97.4	4.6
2003	94.5	98.9	4.7
2004	99.5	103.6	4.2
2005	103.6	108.8	5.0

Source: 407 ETR News Release, 2008

Table 4.14 shows that the annualization factor resulted in an overestimation of the annual trips in each year between 2000 and 2005. This would also result in an overestimation of the revenue. However, there is little discussion about these factors, how they are determined, or the rationale for adjusting these factors.

[31] The concessionaire provided actual annual trip information for 2000 to 2005.

Ramp-up Period

WSA assumed that the ramp-up period for the central section was finished, while Halcrow assumed it was still ongoing. Halcrow noted a traffic growth of 17 percent more users/day from September 1998 to May 1999—the time of handover). Halcrow assumed half of the 17 percent is normal traffic growth and the other half is trips that are diverted from other routes. Accordingly, in their final base case adjustments they added an additional 8.5 percent total users/week. This resulted in an additional 21,000 users/day and $17 million in additional revenue for the 2001 forecast. It seems unclear as to why the consultant added these users to the 2001 forecast. By that time, the central section would have been open for three years, which is much longer than the predicted ramp-up period by both Halcrow and WSA.

One rationale for adding these users might be to account for the extensions' ramp-up period. However, both Halcrow and WSA predicted the two extensions would be open by July 1, 2001, and have a ramp-up period of only six months—thus ending in December 2001. WSA included the effect of the extension's ramp-up in their forecast, which was the starting point for the Halcrow forecast. In addition, Halcrow noted in their trip generation section that the opening of the extensions might spur additional trips on the central section, but decided not to include these trips in the final base case forecast.

Concluding Remarks

There is a clear difference in the level of detail and number of assumptions included in this T&R report compared to Orlando, Dallas, and Houston. In addition, this document includes a sensitivity analysis and a risk analysis, unlike all the other T&R documents.

However, the most notable observation is that a private concessionaire's innovation and operational strategies can result in a large discrepancy between actual T&R and forecasted T&R. For example, the 407 ETR concessionaire's higher toll rates suppressed traffic levels—i.e., traffic demand for the road is higher than the actual usage of the road due to the high toll rates—and resulted in higher than forecasted revenues. The private concessionaire could implement these higher toll rates because it is not beholden to a board or the public (as a public toll agency would be). Given the continued growth in the use of the toll road and high congestion levels on the parallel alternatives, it is also probable that Toronto motorists are not as sensitive to toll rates as WSA and Halcrow predicted through their value of time estimates. It is thus arguable that the toll road users have a higher than predicted value of time. Until conditions change (such as value of time, congestion, etc.) the concessionaire will be able to raise toll rates unilaterally, aggravating the difference between forecasted and actual T&R levels.

4.4 Houston Toll Road System (Texas)

The Houston toll road system opened in various sections. Table 4.15 shows each section with its opening date, length, how it was funded, and when it first appeared in a T&R study. For T&R studies, HCTRA has used WSA exclusively.

Table 4.15: Houston Toll Road System[1]

Road	Section	Opening Date	Funding	First T&R Study	Actual Miles
Hardy	North	Sept. 20, 1987	1983 Bond	T&R 1984	14
	South	June 28, 1988	1983 Bond	T&R 1984	8
	Airport Connector	Jan. 28, 2000	Other[2]	N/A	3
Sam Houston	West/South	June 29, 1988	1983 Bond	T&R 1984	8
	West/Central	June 24, 1989	1983 Bond	T&R 1984	6
	West/North	July 8, 1990	1983 Bond	T&R 1984	11
	Ship Channel Bridge	May 6, 1994 (May 6, 1982)[3]	April 1994 Bond	T&R 1994	4
	East	July 1, 1996	April 1994 Bond	T&R 1994	9
	South/East	March 1, 1997	Oct 94 Bond	T&R 1994	11
	South/West	May 3, 1997	Oct 94 Bond	T&R 1994	12
Westpark	IH610 to SH6	May 1, 2004	Pooled Debt[4]	Westpark 2002	11
	SH6 to SH1464	June 8, 2005	Pooled Debt[4]	Westpark 2002	3
Spur 90A		March 15, 2005	Toll Revenue[5]	April 2002	3
				Total	**103**

1 Information provided by HCTRA
2 Provided equipment and operate it. Construction was financed with outside funds.
3 When built by TTA
4 After 1994, all HCTRA debt was pooled. There is no specific bond document for each new project.
4 Paid for using available toll road revenue
5 Responsibility of Fort Bend Toll Road Authority

WSA has conducted a series of comprehensive T&R studies for HCTRA in 1984, 1989, 1994, and June 2006. In between those comprehensive studies, updates to the T&R studies were done, as well as a T&R study of the Westpark Corridor in 2002.

HCTRA sold general obligation (GO) bonds to finance the construction of the toll roads (see Appendix D). As a result the bond documents do not contain individual T&R studies. Furthermore, after 1994 all debt was pooled and as a result there are no specific bond issuances for each new toll road segment or section.

4.4.1 1983 Bond Document[32]/1984 Traffic & Revenue Study

HCTRA sold $50 million of GO bonds in November 1983 to support the construction of the Hardy Toll Road and the western section of the Sam Houston Toll Road or Western Belt (see Figure 4.7). Construction of the Hardy Toll Road construction began first, because it was believed it would generate more traffic than the Western Belt. The first section opened in 1987, with additional sections opening approximately every year thereafter until 1990 when both the Hardy Toll Road and the West Belt were complete.

32 Unless otherwise noted, the information and data in this section are from the 1983 Bond Document.

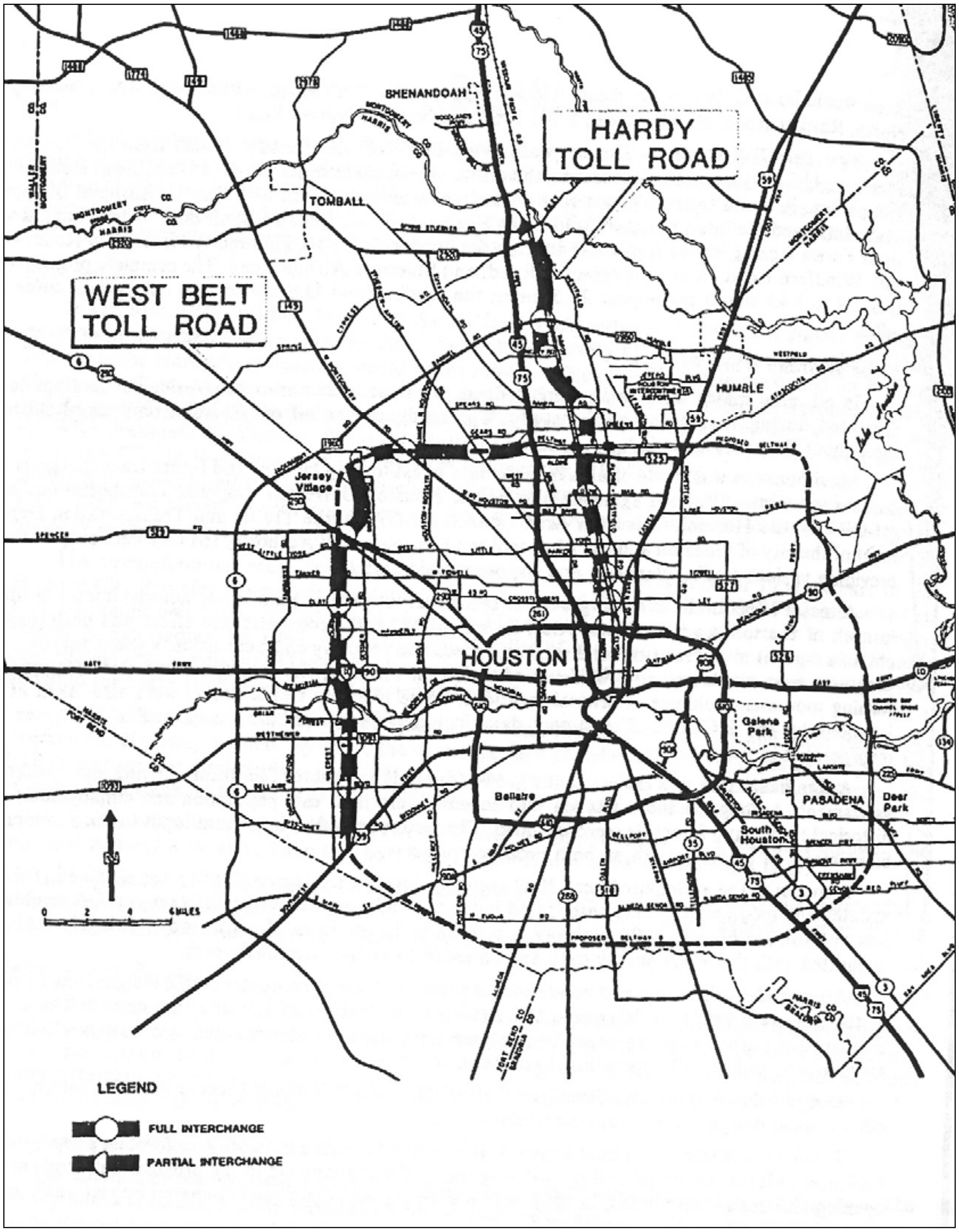


Figure 4.8: Projects Included in the 1983 Bond Issuance

Traffic and Revenue Forecasting Approach[33]

Travel Patterns and Trip Characteristics

To obtain a clearer picture of the potential traffic on the proposed toll roads, WSA conducted motorist interview surveys and traffic counts in 1981 and 1984 in the Hardy Corridor and in West Houston. The survey results for the two years were combined and used to determine travel patterns and trip characteristics for the corridors. WSA looked at vehicle profiles in terms of the number of axles, trip purpose distribution by trip frequency, and vehicle occupancy. WSA also performed a traffic inventory in the area. This included obtaining annual traffic trends along existing freeways in the corridor and calculating travel times between common destinations. A general increase in traffic was observed between 1977 and 1983, with the Hardy corridor seemingly growing faster than the West Belt corridor.

To estimate the percentage of people that would use the new toll road, WSA had to calculate the benefit of using the toll road. This was accomplished by calculating the average time savings compared to various non-toll routes for common origins and destinations. For example, to travel between Glenshire and Jersey Village using US59, the I610 West Loop and US290 would take 30.1 minutes. Whereas using US59 and the proposed West Belt Toll Road would only take 18.6 minutes—a total saving of 11.5 minutes. This data combined with people's value of time and the proposed toll rate schedules allowed WSA to estimate the diversion rate to the toll roads from the other freeways in the corridors.

Economic and Demographic Characteristics

The economic and demographic characteristics of a region are indicative of likely transportation demand. The second part of WSA's analysis of the toll roads' traffic potential entailed a comprehensive economic growth analysis of the entire eight county H-GAC region, but particular attention was paid to Harris and Montgomery counties. More specifically, WSA focused on the two study areas of the West Belt Toll Road Corridor and the Hardy Toll Road Corridor. They also looked at broader county level data when appropriate. The selected indicators to forecast traffic growth were:

- population,
- office employment,
- industrial employment,
- retail employment,
- retail sales activity,
- single and multi-family households, and
- average household disposable income.

WSA evaluated the Effective Buying Income (EBI) and retail sales in an effort to estimate the region's purchasing power and economic health. EBI was calculated to have been growing at a rate of about 10 percent per year. However, when inflation was taken into account,

33 Unless otherwise noted, the information and data in this section are from the 1984 Traffic and Revenue Study.

those numbers were closer to 2 percent. Retail sales figures revealed a booming retail industry in the 1970s when retail sales grew at a rate in excess of 20 percent per year—more than doubling during the decade. And although rates had slowed, it was concluded that retail sales would continue to grow at a rate of 15 percent per year. This was predicated on a successful recovery of the downtown area, stabilized oil and gas prices, and a shift to a more diversified technology and service oriented economy.

Population was also regarded an important factor generating travel demand within the corridors. Population in both corridors was projected to grow at slower rates in the future. However, population growth in the two corridors was still predicted to outpace the total overall population growth in Harris County. Much of the population growth in the Hardy corridor was predicted to come from southern Montgomery County, whose population was expected to more than double by the year 2000. The population growth within the West Belt corridor was driven by suburban growth that was prevalent in the years preceding the study (see Appendix D for corridor population trends and projections).

Another significant input into the trip generation calculations by WSA was employment statistics for retail, industrial, and office employment in the area. This was an important factor because travel to work is one of the largest trip generators in travel demand modeling. Also, retail employment was seen as particularly important, because although it may not be the largest economic sector in terms of total employment, daily trips associated with retail are generally three to four times higher than for other types of employment, such as industrial or office. Appendix D includes the trends and projections that WSA used for determining the retail employment in the corridors. WSA chose fairly conservative growth rates for the two corridors given previous growth trends.

The industrial sector is one of the largest employers in Houston. In projecting industrial growth, WSA assumed a rate much lower than the actual rate during the 1970s, because the early 1980s showed an increasing amount of available industrial space. This arose because of the decrease in energy sector employment following the 1980's oil and savings and loan crisis. Appendix D contains the industrial employment trends and projections.

Finally, office employment trends were considered and projected. Office employment was the largest sector within Houston. Using information from the Chamber, WSA projected strong office employment growth in the study areas (see Appendix D). In particular, WSA predicted that the completion of the West Belt would generate demand for office space in its direct vicinity.

<u>Trip Table Development</u>

The economic and demographic projections were converted into typical trip generation levels for each of the categories and traffic in the corridors was grown accordingly. The economic and demographic trends and projections were also combined with the trip level data from the 1981 and 1984 motorist interview surveys and a detailed traffic model was developed for the study area. Figure 4.8 shows how the zonal growth factors are integrated into the development of the trip table. Then, using the previously calculated trip diversion rates, the trip assignment was undertaken.

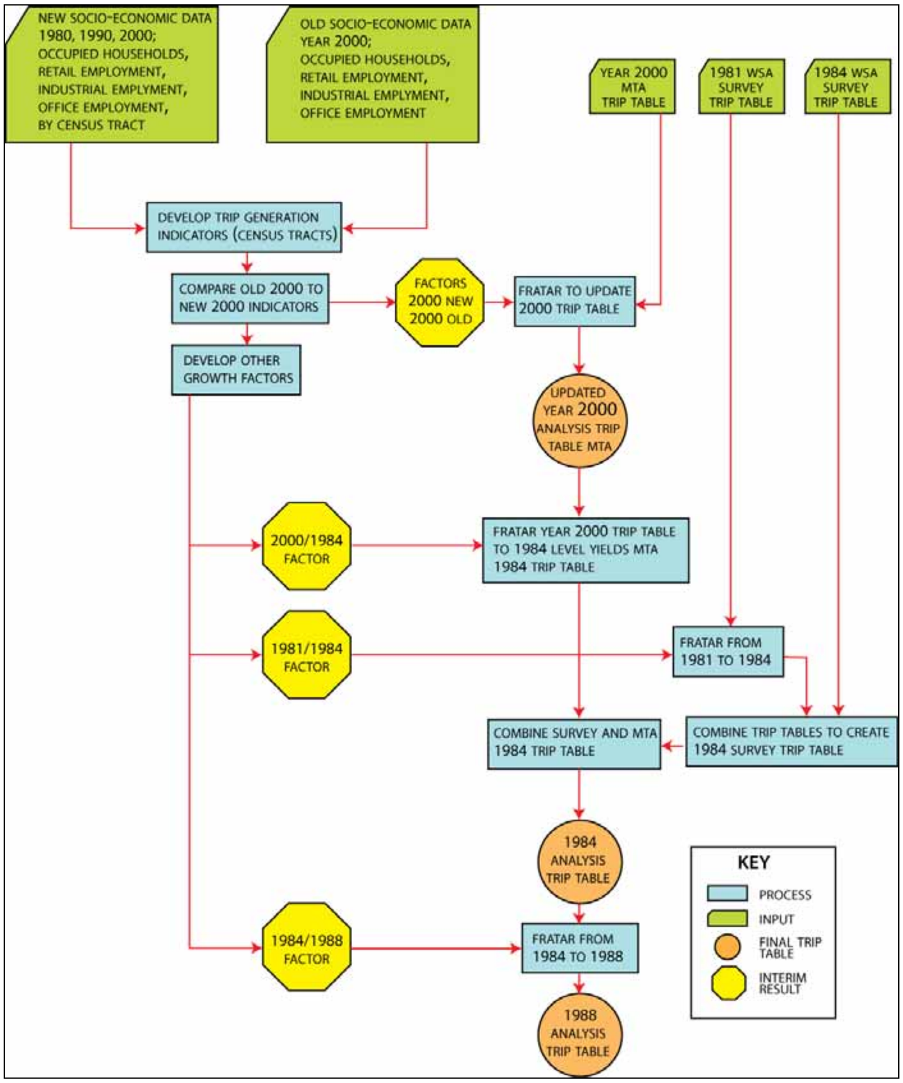


Figure 4.9: Use of Zonal Growth Factors in Trip Table Development

Forecasted and Actual Traffic

Using a recommended toll rate schedule, WSA projected average daily traffic (ADT) and annual toll revenue by vehicle class for the first full year of operation, 1989, and 1991. The years 1989 and 1991 were modeled to account for the phased opening of the West Belt. 1989 represented the first full year of operation for the West Belt between US59 and I10, and 1991 is the first full year of operation for the entire West Belt. It was assumed that the Hardy Toll Road was fully open in 1989. Table 4.16 summarizes the estimated ADT by vehicle class and toll plaza. It was estimated that passenger cars, pick-ups, vans, motorcycles, and trailers would account for 91 percent of the revenue and 95 percent of total toll transactions.

Table 4.16: Estimated First Full Year, 1989, Average Daily Traffic by Vehicle Class

Average Daily Transactions						
Toll Plaza	Passenger Cars, Vans or Motorcycles, and Trailers	Trucks, Buses, and Trailers				Total
		2-axle, 6 tire	3-axle	4-axle	5 or more axles	
West Belt Toll Road						
Mainline South	53,020	1,980	630	280	390	56,300
Westheimer Rd	11,020	410	130	60	80	11,700
Bellaire Blvd.	6,030	220	80	30	40	6,400
Subtotal	70,070	2,610	840	370	510	74,400
Hardy Toll Road						
Mainline North	31,990	1,010	330	100	170	33,600
F.M. 1960	12,750	400	140	50	60	13,400
Richey Road	5,980	200	60	20	40	6,300
Rankin Road	7,040	220	80	20	40	7,400
Mainline South	61,010	1,930	640	200	320	64,100
Aldine Mall Rd	12,750	400	140	50	60	13,400
Little York Rd	21,970	700	240	70	120	23,100
Tidwell Rd.	8,120	230	80	30	40	8,500
Subtotal	161,610	5,090	1,710	540	850	169,800
Total	231,680	7,700	2,550	910	1,360	244,200

Table 4.17 summarizes the estimated average daily traffic by vehicle class and toll plaza for 1991 when the entire West Belt was open.

Table 4.17: Estimated 1991 Average Daily Traffic by Vehicle Class

Average Daily Transactions						
Toll Plaza	Passenger Cars, Vans or Motorcycles, and Trailers	Trucks, Buses, and Trailers				Total
		2-axle, 6 tire	3-axle	4-axle	5 or more axles	
West Belt Toll Road						
Mainline North	30,140	1,120	350	160	230	32,000
Montgomery Rd	24,840	930	300	140	190	26,400
Windfern	1,020	50	10	10	10	1,100
Mainline Center	58,310	2,170	680	310	430	61,900
Clay Road	11,780	430	140	60	90	12,500
Hammerly Rd	9,640	350	330	40	60	10,200
Mainline South	83,810	3,120	980	460	630	89,000
Westheimer Rd	12,900	480	150	70	100	13,700
Bellaire Blvd.	7,540	280	80	40	60	8,000
Subtotal	239,980	8,930	2,800	1,290	1800	254,800
Hardy Toll Road						
Mainline North	36,260	1,150	390	110	190	38,100
FM 1960	9,900	310	110	30	50	10,400
Richey Rd	5,700	180	70	20	30	6,000
Rankin Rd	6,770	210	70	20	30	7,100
Mainline South	63,210	1,990	670	200	330	66,400
Aldine Mall Rd	12,460	400	140	40	60	13,100
Little York Rd	18,840	590	200	60	110	19,800
Tidwell Rd	4,930	170	50	20	30	5,200
Subtotal	158,070	5,000	1,700	500	830	166,100
Total	398,050	13,930	4,500	1,790	2,630	420,900

WSA only forecasted ADT for the Hardy Toll Road and West Belt Toll road for 1989, 1991, and 2007 in this T&R. However, WSA did not provide the annualization factors that were used to convert ADT to annual volumes. This prevented a comparison of the actual and forecasted usage of these toll facilities. However, the forecasted and actual revenues are compared and discussed in Appendix D.

Factors that Impacted Forecasts

WSA had predicted that the Hardy Toll Road would be the main revenue generator and that the West Belt would only be feasible during its first few years if the entire system's revenue was pooled. Almost exactly the opposite situation materialized. There are several reasons that can be offered to explain the discrepancy between the actual and predicted revenues. First, WSA's forecasts did not account for the improvements on US59 and I45 that improved travel times on those routes. This resulted in lower usage as fewer vehicles diverted to the Hardy Toll Road. Second, the fact that Hardy did not connect into downtown may have also reduced its usage. Even if users saved time using the toll road, they would have had to merge into traffic once they reached the I610 loop. For this reason, Hardy was not an attractive or alternate route that saved time for downtown destinations. The West Belt, on the other hand, did not have any direct competition from non-tolled alternatives and aided in congestion management. Furthermore, the energy crisis of the mid to late 1980s also impacted toll road usage. This resulted in WSA revising their T&R forecasts downward in 1988 and 1989 to be more in line with what HCTRA had experienced in the first few years of operation. Finally, the motorist surveys seemed to have been an important input into computing the value of time and diversion rates. It has been argued that WSA as an out of state company from Pennsylvania were trying to estimate value of time for Houstonian drivers without a good understanding of the area. This arguable could have introduced uncertainty about their estimates of drivers' willingness to use toll roads. However, this is highly speculative and because WSA's methodology and value of time estimates cannot be verified it is not clear how, if at all, the forecasts were impacted.

4.4.2 April 1994 Bond Document

HCTRA sold more than $232 million worth of bonds in April 1994 to support the purchase of the Houston Ship Channel Bridge[34] from TTA and the construction of the Sam Houston Tollway South (SHT-South) and Sam Houston Tollway East (SHT-East). Figure 4.9 shows the original projects that were included in the 1994 bond issuance.

[34] As part of the purchase of the Ship Channel Bridge, HCTRA listed all their proposed projects that would constitute their *"entire system"* and pooled their debt. The agreement with TTA stated that as long as there was outstanding debt, the entire system would remain under HCTRA's control and would not be turned over to TxDOT.

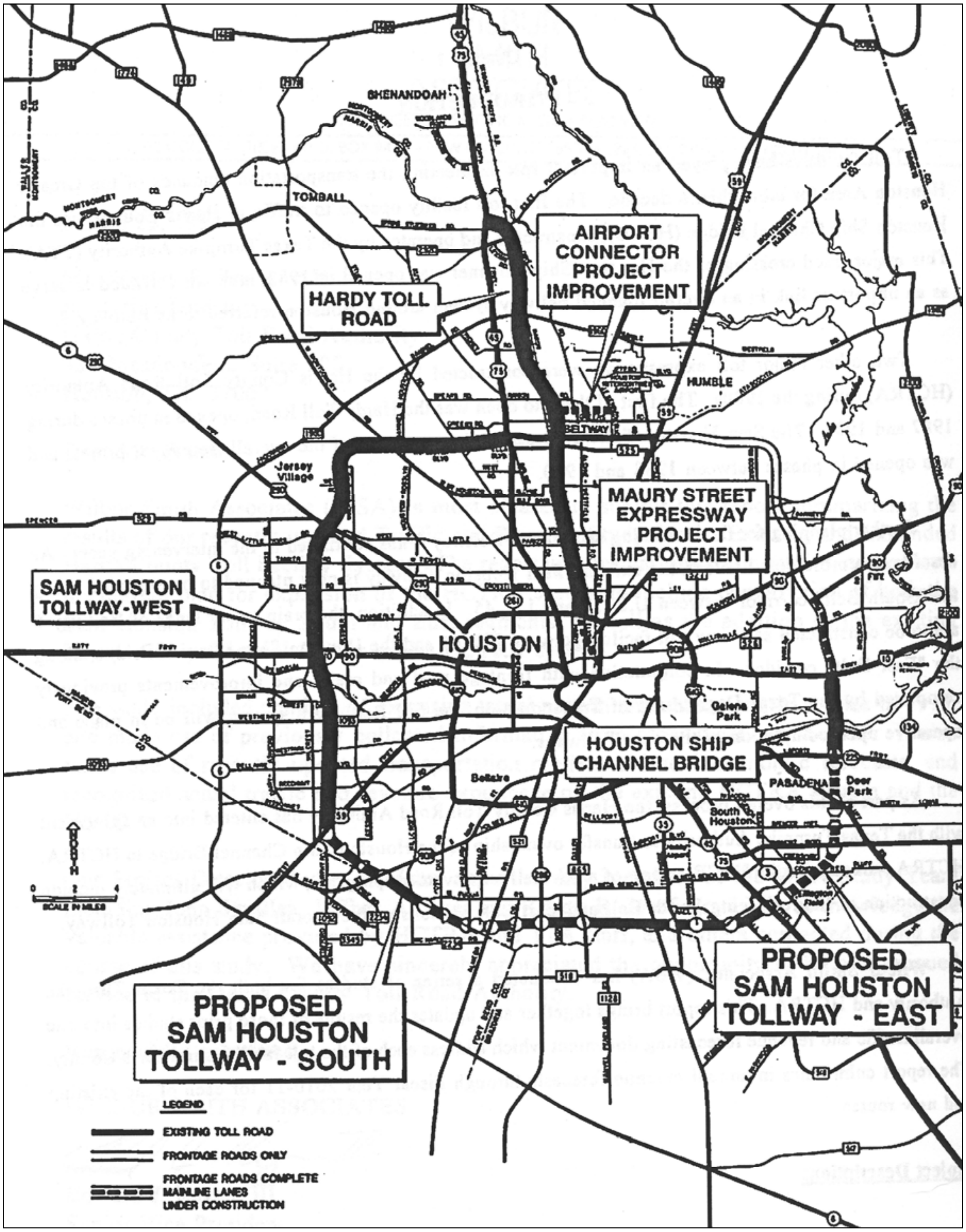


Figure 4.10: Projects Included in the April 1994 Bond Document

Traffic and Revenue Forecasting Approach[35]

Due to the downturn in the economy in the mid to late 1980s, WSA revised their projections in an updated T&R study dated June 27, 1989. The updated report reduced the T&R projections substantially from those presented in the 1984 report. The T&R report in the 1994 bond document adjusted the forecasts upwards again after traffic and toll predictions veered closer to the original 1984 forecasts. This section summarizes WSA's T&R forecasting approach as described in the 1994 bond document.

<u>Historical Trends</u>

WSA reviewed the historical trends on Houston area freeways, the existing HCTRA system, and the existing trends on the Houston Ship Channel Bridge. The average annual percentage change in traffic on all major competing or supporting freeways in the Houston area were reviewed. The data was obtained from permanent recorder counts by TxDOT. The data seemed to suggest an overall positive trend in traffic volumes for all the freeways over the ten-year period from 1983 to 1993 (see Appendix D).

The historical traffic trends and current toll rates on the existing HCTRA system were also reviewed in detail. WSA analyzed the monthly traffic variations on the existing system. Both the Sam Houston and Hardy Toll Roads exhibited fairly little monthly variation throughout the year with only marginally lower traffic during January and to some extent February. Daily traffic variations (see Figure 4.10) reveal a clear week day use pattern. This suggested that the toll roads were mainly commuter routes. Because the Sam Houston Toll Road has a slightly higher percentage of shoppers compared to the Hardy Toll Road, its weekend indices are also higher.

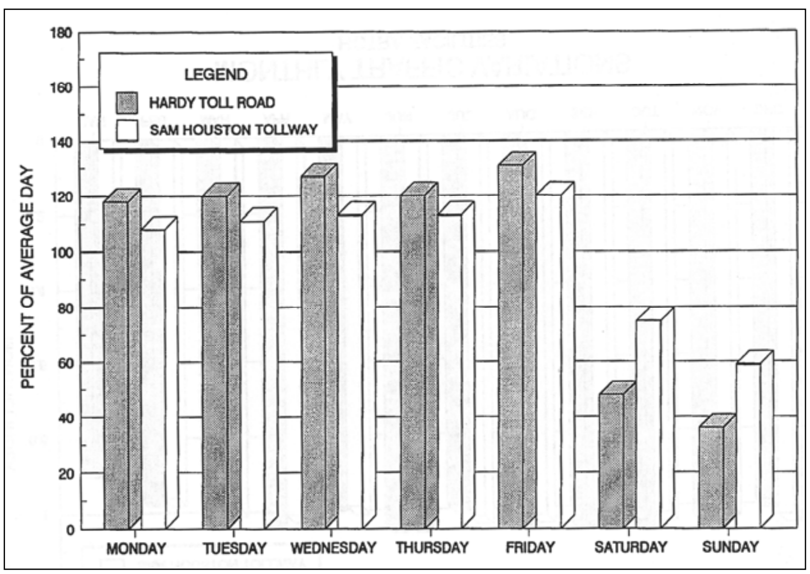


Figure 4.11: Daily Traffic Variations (HCTRA Facilities)

35 Unless otherwise noted, the information and data in this Section are from the 1994 Bond Document.

Toll Collection System

WSA also looked at a breakdown of the revenue and traffic shares by payment type. In 1994, HCTRA had begun the use of EZ Tags that entitled drivers to pay a discounted rate at main lane plazas. This explained the high usage of exact change: almost 44 percent of the Hardy toll road transactions and about 51 percent of the Sam Houston toll road transactions (see Appendix D).

Travel Patterns and Characteristics

WSA also conducted motorist travel pattern and characteristics surveys in 1989 and 1993. The March 1989 surveys were conducted for TTA as part of the proposed SHT-East toll road, and therefore focused specifically on that corridor. The surveys in January and February of 1993 focused on the SHT-South corridor. The 1989 survey showed that a large percentage of drivers drove the SHT-East corridor at least five days a week. A large percentage of the respondents—51.5 percent in the case of the Houston Ship Channel Bridge—were commuting to or from work. The 1993 survey revealed similar characteristics for the SHT-South corridor, with approximately 60 percent of the respondents making at least 5 trips a week and 48.1 percent traveling to or from work.

Economic and Demographic Characteristics

Finally, similar to the 1984 study, WSA reviewed the economic and demographic characteristics of the eight county region using data from H-GAC. This data was used together with the updated traffic trends and motorist surveys in the development of the trip tables. At the time of this report, Houston and the nation were recovering from a recession, although the recovery was slow. This manifested in the Houston economy and employment market flattening during the early 1990s. Houston's energy industry was also affected, but not to the extent that occurred in the early 1980s.

WSA obtained population and employment trends and projections until 2010 from H-GAC. The economic recession did not seem to have an impact on either population or employment in the area, and it was predicted that population would continue to grow at a similar rate until 2010, reaching over 5 million. Employment was predicted to reach almost 3 million by 2010.

Forecasted and Actual Traffic

Based on the trip tables and the toll rate schedule, WSA projected annual revenue on the existing and expanded system. Toll usage in given corridors was predicted using the time-distance tables, the estimated value of time, and proposed highway improvements in the area that may divert toll users away from the toll roads, an assumed toll rate schedule, as well as the projected economic and demographic trends. WSA forecasted ADT on the:

- Hardy toll road for 1999 and 2011,
- SHT-West for 1999 and 2011,
- SHT-South with east belt (1999),
- SHT-East for 1999 and 2011, and

- SHT-South for 2011 (see Appendix D).

The volumes on the SHT-South were expected to be lower than the existing volumes on the SHT-West, because of a lack of existing development. Also, the Hardy estimates did not include traffic on the airport connector nor did it consider the southern extension into downtown—known as the Maury Street Expressway—in their forecasts.

It was noted that the forecasts presented the ADT and that the average weekday totals would be higher. Similar to the 1984 bond document, WSA did not provide the annualization factors that were used to convert ADT to annual volumes. This again prevented a comparison of the actual and forecasted usage of these toll facilities.

Factors that Impacted Forecasts

WSA over predicted the revenues[36] on both the Hardy Toll Road and the Sam Houston-West sections in their 1984 T&R. In the 1994 T&R, the forecasts were adjusted downwards. This resulted—with the exception of a few years in the case of the Houston Ship Channel Bridge and the SHT-South sections—in the underprediction of revenues on all the sections and the HCTRA system as a whole. It thus appears that WSA was probably too conservative in their 1994 forecasts given their experience with the 1984 forecast.

WSA projected total population at 4,330,039 in 2000, while actual population in the area was 4,177,644 in 2000. WSA thus slightly over predicted (by 4 percent) the total population in the region. At the same time, employment was predicted at 2,269,271 in 2000, while actual employment in the area was 2,080,500 in 2000. WSA thus also over predicted (by 8 percent) employment in the region.

In addition, a number of specific factors seem to have contributed to increase usage and thus revenues on the HCTRA system, i.e., enhance connectivity to the non-toll freeway system in Houston, the construction on IH10/Katy Freeway, an expanded network, the growth in the suburbs, and the increase in EZ tag usage. Specifically, HCTRA's toll road system was expanded with the completion of the airport connector and the south and east sections of the Sam Houston Tollway. This provided greater connectivity within the system, which resulted in additional time savings to users. Also, high growth rates in the suburbs, particularly in western Houston and in Fort Bend County, resulted in increased usage because of the time savings the toll road offered. Finally, the introduction of EZ tags also enhanced toll road usage, because EZ tag users received a discount and were not required to stop, resulting in additional time savings.

4.4.3 2002 Westpark Traffic and Revenue Study

HCTRA's debt was pooled in 1994 and as a result bonds are not issued any longer to fund individual projects. Thus T&R studies are no longer required for individual projects when new bonds are issued. However, because the Westpark Toll Road represented a large investment,

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[36] Forecasted revenue by WSA for 1994 to 2011 is included in Appendix D for the:

- Hardy Toll Road,
- Sam Houston Tollway-West,
- Houston Ship Channel Bridge,
- Sam Houston Tollway-East,
- Sam Houston Tollway-South, and
- the HCTRA system.

an investment grade T&R study was completed for this toll road by WSA in 2002. This 2002 T&R was used to justify a toll road in the METRO-owned corridor and former rail line and to help determine a possible toll schedule. WSA noted that:

> "In general, overall demand in this travel corridor would likely exceed the amount of capacity being provided, especially over the long term. However, the facility is designed to fit within the constrained available right of way, and cannot be expanded to accommodate that demand. Therefore, demand will need to be managed through variable toll pricing if the facility is to succeed in expanding accessibility."

Traffic and Revenue Forecasting Approach[37]

At the time of this T&R, WSA staff was also performing a T&R study for the extension of this route into Fort Bend County and a review of the I10 managed lanes, which was going to be constructed as part of the I10 improvement program. WSA thus collected a substantial amount of travel data, including:

- travel volumes on alternative competing facilities,
- travel speeds/times on alternative competing facilities,
- origin/destination surveys, and
- joint stated preference survey data to estimate driver's value of time.

Traffic Trends

WSA's collected data revealed that traffic on I10 west of SH6 had grown on average about 3.3 percent between 1990 and 2000, resulting in an increase from 96,000 vehicles per day in 1990 to about 128,000 vehicles per day by 2000. I10 West of Beltway 8 saw slightly lower increases in traffic, averaging about of 2.4 percent per year. Traffic growth had been highest around the Grand Parkway SH99, which is located at the far west end of the proposed Tollway. Traffic growth here averaged 12 to 15 percent per year, partly because of strong economic and residential growth in this region.

WSA also reviewed the total transactions on the Sam Houston Tollway. Traffic on the tollway was growing rapidly, with the SHT-South section showing an average annual growth rate of 11 percent in the five years prior to this study. The Tollway overall showed a steady pattern of growth, with 1997 being the only year in which growth were less than 5 percent. The strong growth, according to WSA would *"be served by the Westpark Toll road,"* which would be in the same corridor serviced by the Sam Houston Tollway.

Vehicle Travel Speeds

WSA reviewed travel speeds for the I10 corridor and selected other routes. In the AM period (i.e., 6:00 a.m. to 7:35 a.m.) two elapsed runs produced an average of one hour in travel time for the 23 mile trip on I10. This translated into an average speed of approximately 25 miles per hour for the 23 miles. Congestion routinely occurred in the easternmost 15 to 17 miles of the corridor, resulting in even lower speeds for this segment. For the PM period, congestion occurred

[37] Unless otherwise noted, the information and data in this section are from the 2002 Westpark Traffic and Revenue Study.

at specific points on the route, for example just past I610 and at SH8. From these points onwards traffic moved at a lower speed all the way to Pin Oak Road. Most of the trips in the PM period averaged 35 to 45 minutes for the 23 mile trip. WSA noted that while congestion routinely occurred on I10, the planned expansion program for I10 could alleviate some of the congestion.

Travel Pattern and Characteristic Surveys

Extensive travel pattern and characteristic surveys were conducted in the Westpark Corridor and at entry ramps along I10. Twenty locations[38] were chosen for the surveys—four on arterial routes located west of SH6 and 16 on entry ramps along I10. Most of the trips were identified as *"journey to work"* during the peak periods, representing 68 percent of the responses for the I10 and Sam Houston Stations (IH10/SH6) and 76 percent of the responses for the Westpark stations. In the off-peak however, *"journey to work"* represented only 35 percent and 49 percent of the responses, respectively for the IH10/SH6 and Westpark stations. The next main trip purpose was personal business—24 percent in the case of the IH10/SH6 stations and 18 percent in the case of the Westpark station—in the off-peak period.

Trip frequency was also reviewed. The reponses for the IH10/SH6 and the Westpark stations are very similar in the AM peak period, as well as in the PM peak period. In the AM peak, 55 percent of the respondents on IH10/SH6 indicated that they make 5 trips per week, compared to 59 percent of the respondents surveyed at the Westpark arterial stations.

Stated Preference Survey

WSA also conducted a stated preference survey for the 2002 T&R study. Data was collected at various sites for two days in August 2001. The questionnaire comprised four main sections:

- context questions—to collect information about a traveler's most recent trip in the corridor,
- project questions—to collect information about the drivers' likely use of corridors after they were provided information about proposed improvements,
- stated preference questions—after selecting a route nine questions were administered regarding future travel choices under a variety of configurations, and
- debrief questions—to provide insight as to why choices were asked.

More than 50 percent of the respondents indicated their trip purpose to be commuting to and from work. However, more than 20 percent of the respondents traveled during the shoulder periods, i.e., during a two-hour window on either side of the peak. This indicated that the peak period would have a wider distribution than is normally expected, i.e., the peak period would be longer.

Approximately 75 percent of the survey respondents indicated that they would use the newly configured Katy Freeway[39] for their trip if it was available. More than half of the survey

[38] In addition, WSA took 1999 data that were collected for HCTRA and factored it to current traffic levels to be used in the 2002 study. The travel pattern surveys were conducted at different screen lines in the corridor in 1999.

[39] Katy Freeway is part of I10 and is colloquially known as *"the Katy Freeway"* to Houstonians.

participants who used the Katy Freeway indicated they would continue to do so. However, the percentage of respondents that used an arterial and chose Katy Freeway, and those who used an arterial and chose Westpark were similar—approximately 16 percent. The main reason for not choosing Westpark was *"not wanting to pay a toll."*

Economic and Demographic Characteristics

WSA contracted with a regional economist to conduct a comprehensive demographic and economic review of the area. Harris County and Houston has experienced continued population and economic growth throughout the twentieth century. Highway development in the late 1990s within Houston and Harris County also contributed to increased suburbanization within the region. The Sam Houston Tollway, for example, made large parcels of land that was previously undeveloped economically viable for development. The T&R also noted that a number of residential developments had occurred in proximity to the proposed Westpark tollway.

Notwithstanding the sizeable growth in Harris County, the T&R highlighted major non-market constraints on growth. For example, regional flood plains restrict development on large land areas in the region. Another non-market issue was ownership patterns, which according to the T&R, made it almost impossible for developers to acquire sufficiently large areas of land. The latter had led in large part to the westward growth that was seen around Houston. The report also noted sizeable areas in Harris County's north western portion, where thousands of acres of small broken parcels would prevent major developments. However, the eastern portion of Fort Bend County—which would be served by the toll road as it would terminate close to this boundary—had many large parcels of land that could be *"transformed into master-planned communities if the toll road ultimately crosses the Brazos River."* If this occurred, according to the T&R study *"the master planned communities within the toll road corridor would be unsurpassed anywhere within the Houston metropolitan area."*

The T&R predicted general spatial trends for the central metropolitan statistical area (CMSA). Population and employment growth was predicted to occur in the western portion of the CMSA, although it was predicted that Houston's highways would induce high density residential and commercial development within the central city. Scattered growth was predicted to occur throughout the region, but the largest growth was anticipated to occur between SH6, FM 1960, and the Grand Parkway to the west of Houston.

The T&R study also provided the office, warehouse, and retail development that occurred within Harris County between 1996 and 2000. The study forecasted moderate growth for the next five years, mostly because of the post 9/11 slowdown, which had a temporary negative impact on the U.S. and regional economies. The T&R report also cautioned about not being misled by recent headline news stories, for example the collapse of Enron and other energy trading enterprises. However, it was anticipated that the economy would then gain momentum due to growth in the non-energy sector. In the long run, the economic outlook was positive, although this was caveated due to the sheer size of the metropolitan area. The report warned that the size of the economy would impose burdens and cause the overall growth rate to decline. Houston's economy was anticipated to diversify and reduce its dependence on energy. However, it was felt that this would not be as rapid looking forward to the next twenty years as compared to the previous 15 years.

Historic population, employment, inflation, and income data were reviewed for the five-year period 1997 to 2002. The following trends emerged:

- population grew by 13.1 percent,
- real per capita income grew by 6.9 percent,
- inflation grew by an average annual 2.2 percent,
- overall the economy grew by 11.4 percent, and
- employment grew by 13 percent.

The largest employment growth occurred in the construction sector (25 percent), services sector (18.5 percent), and finance, insurance and real estate sector (16.8 percent). Growth was expected to continue in the near-term, although the T&R indicated that some sectors would slow down. Historic and projected population and employment values were included in the T&R study for 1997 to 2007. Employment was expected to continue to grow alongside population.

The population values were also allocated and projected for the eight counties that constitute the HGAC. Population was projected to increase steadily over the five-year time periods until 2020. Overall, population was anticipated to increase by almost 20 percent in Houston between 2000 and 2020. Similarly, employment was expected to grow until 2020. Overall, employment was anticipated to increase by almost 27 percent in Houston between 2000 and 2020.

Forecasted and Actual Traffic

Table 4.18 provides the traffic predictions for the Westpark Toll Road that were developed in the T&R study.

Table 4.18: Estimated Annual Transactions

Year	Annual Transactions
2005	53,560,100
2006	54,915,850
2007	49,508,800
2008	51,231,400
2009	52,954,000
2010	54,767,600
2011	57,419,880
2012	60,163,160
2013	62,906,440
2014	65,649,720
2015	68,393,600
2016	69,611,700
2017	70,830,400
2018	72,049,100
2019	73,267,800
2020	74,486,500

The Westpark Toll Road has not been open for very long with the result that only three years of data could be analyzed. However, Figure 4.11 clearly illustrates that the toll road has not met the forecasted transactions projected for the ramp-up period. The difference between actual and forecasted traffic is, however, starting to narrow as of the end of 2007. It is also interesting to note that Westpark is considered to be congested during the peak hours. This has resulted in an attempt by HCTRA during 2007 to implement a considerable toll rate increase[40] in an effort to shift peak users to the shoulder and off-peak periods, thereby alleviating congestion and ensuring a better level of service. Tolls were to be raised from $1 to $2.50 during rush hour periods from 6:00 to 9:00 A.M. and from 4:00 to 7:00 p.m. (Murphy, 2007). This was not well received by the general public. After the public outcry the Commissioner's court on June 15, 2007 rescinded and instead voted to raise tolls on all HCTRA facilities by 25 cents beginning September 2007 (Harris County, 2007).

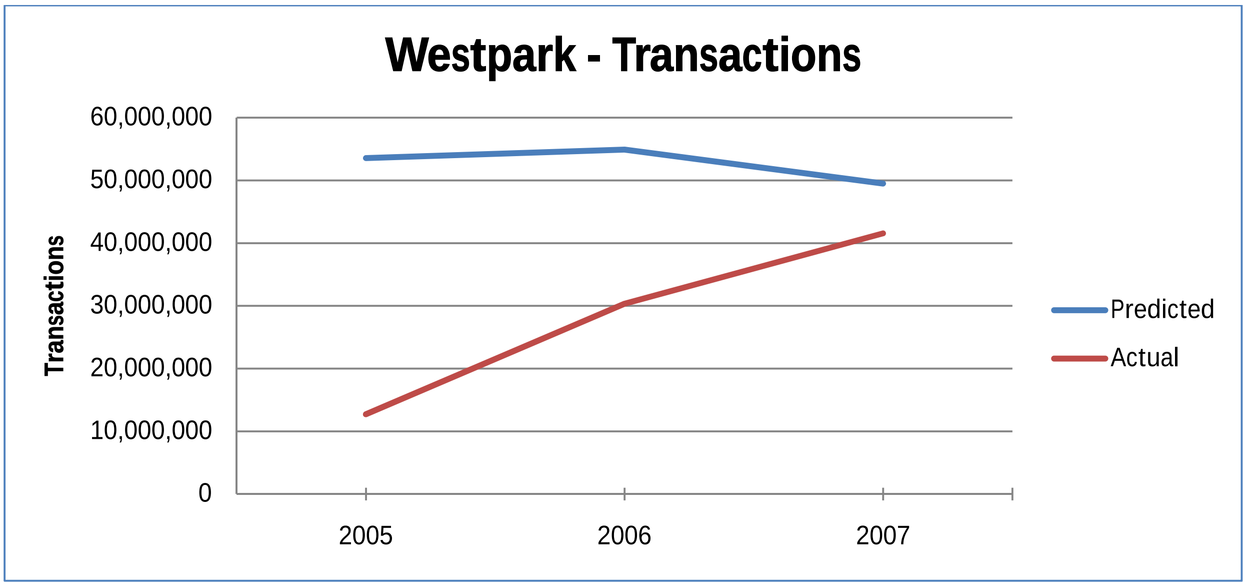

Figure 4.12: Actual and Forecasted Transactions on Westpark Tollway

Factors that Impacted Forecasts

<u>Toll Rate Schedule</u>

One factor that could have contributed to the difference between actual and forecasted transactions is the toll rate schedule that HCTRA adopted for the Westpark Tollway. WSA recommended a discounted toll rate for the off-peak periods. However, HCTRA adopted a uniform toll rate for the whole day. It can be speculated that a lower off-peak rate would have diverted some peak users to the off-peak periods, resulting in a higher level of service on the toll road. However, the extent of the impact on the total number of transactions and actual revenues are unclear.

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40 The Commissioners Court voted to implement a congestion charge on the Westpark Tollway in 2007. WSA was asked to review ways to lower peak hour usage on the heavily congested Tollway. WSA recommended a toll of $2.50 to $3 to reduce peak hour usage below Westpark's capacity of 3,600 vehicles an hour at 50 miles per hour.

Economic and Demographic Values

The Westpark Toll Road has only been open for three years and thus it is a little premature to compare the differences in actual and predicted population and employment values as the data used would be mid-census estimates. For example, the economic and demographic data available for review are estimates released by the US Census and the Texas State Data Center since the road opened mid census. However, the U.S. has experienced a slowdown economically since the opening of the Westpark Tollway with gas prices reaching record highs of over $4.00 a gallon in 2008 and the sub-prime housing dilemma.

Land Use

The number of housing developments in and around the Westpark Toll Road corridor has increased substantially. For example, in 2004 Centex proposed to develop 355 homes at Bradford Park on the corner of Beechnut and Harlem Road. Furthermore, developers McGuyer and David Weekley Homes are also planning a master-planned community on a 588-acre plot at the Westpark Tollway and Grand Mission Boulevard exit. With increasing land prices, the developer also purchased an additional 688 acres in 2004 (Sarnoff, 2004). The latter development will have 3,000 homes and 30 acres of commercial frontage along the Westpark Toll Road (David Weekley Homes). In November 2000, voters in Fort Bend County authorized bonds to extend Westpark to the Grand Parkway. However, it is premature to comment on whether, or if, these factors have or may have an impact on the Westpark Tollway.

Concluding Remarks

The Westpark Toll Road has not been open for very long. It is conceivably still in the ramp-up phase, which is typically the most uncertain period in terms of forecasted traffic and revenues. Actual transactions and revenues have not met the forecasted transactions or revenues projected by WSA, but it looks as though the difference between the actual and forecasted values are narrowing as of the end of 2007.

However, the toll road must have benefited from the fact that it opened during a time when the competing facility—i.e., I10—was undergoing extensive reconstruction to widen it. Also, large residential developments are planned and being constructed in Fort Bend County to the west of the toll road that could result in increased demand and usage of the facility in the future. Usage is further facilitated by the extension that was built by the Fort Bend Toll Road Authority (FBTRA) to allow these developments easy access to the toll road.

However, of concern is the fact that the toll road already experiences significant congestion levels during peak periods. Without an appropriate increase in toll rates, the level of service on the road will continue to worsen and probably impact future usage, especially once the reconstruction of I10 is completed.

4.5 SH190/President George Bush Turnpike, Dallas (Texas)

SH190 opened in five segments. Segments I to IV were financed with the 1995 bond issuance and later refinanced with the 1997A bond issuance. Segment V was financed with the 1998 bond issuance. However, Segment IV required additional funds and thus additional bonds were issued in 2003. Below is a list of the bonds and the T&R documents[41] for SH190.

[41] All the T&R reports were done by WSA.

- Series 1995: Funded Segments I to IV and included the 1995 T&R report.
- Series 1997A: Refinanced Series 1989. The bond document includes the 1995 T&R report and a letter with revised assumptions.[42]
- Series 1998: Funded Segment V. The 1998 T&R report used the same forecast methodology as the 1995 T&R with slightly revised assumptions, as well as updated demographic information.
- Series 2003A: Provided additional funding for Segment IV. The T&R report is a brief document, using the same methodology as the 1995 T&R report, but highlighting any differences from the 1998 T&R report.

Only the 1995 and 1998 T&R reports were reviewed in this research study, because these reports were included in the Series 1995 and 1998 bond issuances that were used for funding Segments I to V. The same methodology was used in both T&R reports. Table 4.19 summarizes the assumed characteristics of each Segment included in the T&R reports.

Table 4.19: SH190 Segments Included in T&R Reports

1995 T&R Segments			**1997 T&R Segments**		
Segment	**Borders**	**Scheduled Opening**	**Segment**	**Borders**	**Scheduled Opening**
IA	Midway Road to Preston Road	Mar-98	IA	Midway Road to Preston Road	Nov-98
IB	Preston Road to US75	Mar-98	IB	Preston Road to Coit Road	Jun-99
			IC	Coit Road to US75	Dec-99
II	US75 to SH78	Jul-99	IIA	US75 to N. Garland Road	Dec-99
			IIB	N.Garland Road to SH78	Apr-00
III	Midway Road to I35E	Jul-01	III	Midway Road to I35E	Jul-01
IV	I35E to I635	Jul-04	IV	I35E to I635	Jul-04
			V	I635 to Belt Line Road	Jan-02

4.5.2 1995 NTTA Bond Document[43]

The NTTA sold bonds in 1995 to fund the construction of the first four segments of SH190. The NTTA aspired to construct all segments at the same time to avoid concerns about preferential treatment by the cities. Also, simultaneous construction would allow the road to

[42] Examples of these revised assumptions are a new opening schedule and the inclusion of new ramps. Also, the segments were changed from IA and IB to IA, IB, and IC and from II to IIA and IIB.

[43] Unless otherwise noted, the information and data in this section are from the 1995 NTTA Bond Document (NTTA Bond Issuance, 1995).

open faster, which would result in overall higher traffic volumes. The objectives of the T&R report were to:

1. project T&R levels for SH190 Segments I through IV,
2. examine and select a toll collection method for SH190,
3. assess toll sensitivity by examining various toll pricing scenarios,
4. determine the impact of SH190 on the Dallas North Tollway (DNT) toll revenue levels, and
5. assess the impacts of implementing HOV lanes along SH190.

The segments changed in the 1997 T&R report.[44] This analysis refers to the segments included in the original 1995 T&R. Figure 4.12 illustrates the location of the different segments included in the 1995 T&R study.

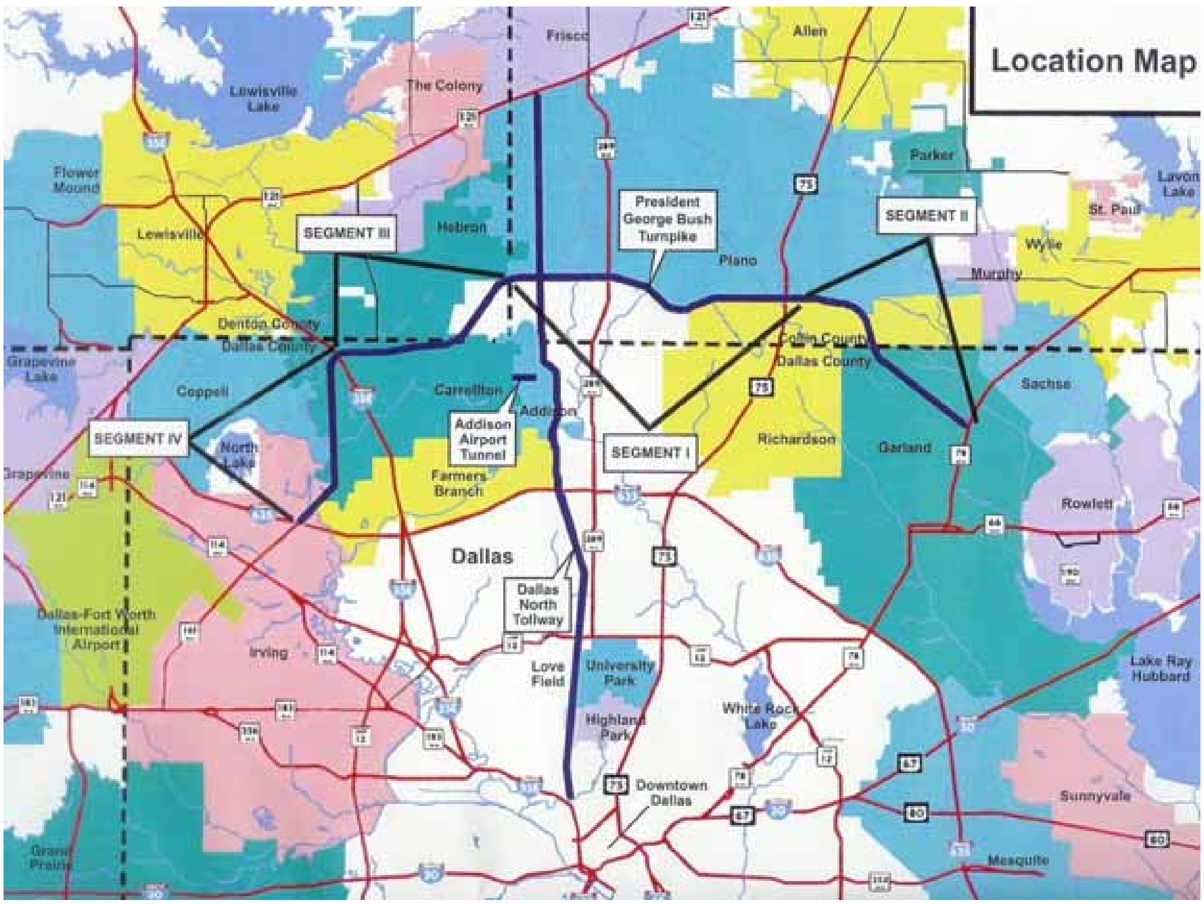

Figure 4.13: SH190 Segments Funded by the 1995 NTTA Bond Document

A major objective of SH190 was to relieve congestion in the cities of Richardson, Plano, Dallas, and Carrolton. The toll road serves as an outer loop—the inner loop being I635—around

44 However, a new T&R report was not completed using these new segment designations.

Dallas, connecting the Dallas area suburbs. It was anticipated that the road will divert traffic away from the mostly parallel I635, as well as Beltline Road, FM544, and SH121.

Traffic and Revenue Forecasting Approach[45]

Land Use

WSA reviewed current land development, major employers, and land use in the SH190 corridor. The land development in the corridor was found to be closely linked to the area's major employers because most of the land bordering SH190 was owned by 12 major corporations. The level of development in the SH190 corridor varied by city, but the land use was dominated by upscale apartments, office developments, industrial areas, and residential homes. In particular, the City of Carrollton was surrounded by industrial and high density developments. In a portion of the SH190 corridor development was restricted, because of existing railroad right of way.

Local Transportation System

A key component of WSA's analysis was a detailed review of existing traffic conditions. WSA used their prior 1994 field survey data, as well as local historical traffic and transportation statistics. In particular, the local MPO—the North Central Texas Council of Governments (NCTCOG)—provided the annual and monthly traffic counts from their four permanent traffic counters[46] in the city to the consultant. The TTA provided the consultant with traffic counts for the DNT. Finally, WSA conducted manual counts in the future roadway corridor to estimate the demand for the road and the potential diversion rate.

WSA also reviewed the monthly traffic patterns, which revealed that in general traffic volumes were the lowest in January and the highest in June. Counter Number 4 on the DNT was the only location that showed large seasonal differences. Counter Number 4 recorded the lowest traffic volumes in January (the same as the other three counters), but recorded the highest traffic volumes in December.

In addition to analyzing the traffic count data obtained, WSA also conducted a traffic survey in the project corridor. The survey effort began in August 1994 with the distribution of mail back survey cards at selected locations across the metroplex. Information collected included:

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45 Unless otherwise noted, the information and data in this section are from the 1995 NTTA Bond Document (NTTA Bond Issuance, 1995).

46 Data from four permanent counters was collected. Counter Number 1 at I635 east of I35E was the closest to the corridor and thus regarded to best represent future traffic patterns on SH190. However, the traffic growth rates do not necessarily present the growth in demand as the corridor is heavily congested, thereby suppressing traffic growth. Nevertheless, Counter Number 1 had the highest daily traffic volumes. Counter Number 2 at I35E north of US67 exhibited more variable growth rates over the last ten years compared to Counter Number 1. The consultant noted that the traffic growth in this corridor—where Counter Number 2 is located—has begun to plateau. Counter Number 3 at US75 south of SH121 exhibited constant high growth rates over the last ten years. However, traffic volumes were also the lowest at this location, so that the growth rates have to be considered in relation to the overall daily traffic volumes. Counter Number 4 on the DNT was located on the only operational toll facility in the area. The growth rates in this corridor exhibited the most variability, but WSA predicted that this was attributable to the opening schedule of the DNT phases. Nonetheless, an increase in traffic was recorded at this count location in nine of the ten years between 1983 and 1993.

- trip origin,
- trip destination,
- trip purpose,
- trip frequency,
- vehicle occupancy, and
- the time of day the trip was undertaken.

The objective of the survey was to estimate the traffic that could potentially be diverted to SH190. WSA developed four "screenlines." These screenlines aimed to record all traffic entering a particular section of the project area. The screenlines are described below.

- Screenline A—survey stations left of Josey Lane,
- Screenline B—survey stations east of Coit Road,
- Screenline C—survey stations east of North Garland Road,
- Screenline D—survey stations on north-south routes, and
- additional survey locations on the on-ramps at I635, I35E, and US75.

In addition to distributing mail back cards, hourly machine traffic counts and vehicle classification counts were conducted in both directions during card distribution hours. In most locations, the traffic counts were conducted for 48 hours. However, at 10 key locations, selected by WSA for their relation to SH190, the traffic counts were conducted for a seven-day period.

The vehicle classification counts revealed that passenger cars accounted for more than 97 percent of the traffic. The survey also revealed that in the project corridor approximately 63 percent of the trips were commuting trips. WSA noted that respondents surveyed at traffic count locations nearer to the downtown area had a slightly different trip purpose distribution. These stations recorded even higher percentages of commuting trips. A large percentage (i.e., 29 percent) of respondents indicated a trip frequency of 5 or more trips a week, which also supported the hypothesis that SH190 would attract large numbers of commuters. Furthermore, the vehicle occupancy being dominated by single occupant vehicles (i.e., 76 percent) provided additional support for the hypothesis of largely commuter traffic using the corridor.

Next, WSA conducted travel time runs to compare the time and distance on four existing alternative routes[47] with the predicted time and distance on SH190.[48] The start and end distances, the travel time, and the calculated average speed are provided in Appendix E. In all four cases, the average speed was higher using SH190, ranging from 11 mph to 14 mph faster than the existing alternatives. SH190 thus resulted in significant time savings, ranging from 8 to 14 minutes.

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47 All alternative routes were within two miles of SH190. Although not included in this section, the T&R document does provide the exact routes driven in each case.

48 During the AM peak only.

Dallas

Population and employment growth rates were assumed to be key predictors of traffic growth. WSA reviewed historical population values and growth rates (i.e., for 1970 to 1980 and for 1980 to 1990), as well as other growth indicators.[49] WSA also predicted population, employment, and other growth indicators for the major cities in the project corridor. The bond document noted that population is used to estimate trip production in the trip tables and employment is used to estimate trip attractions. Thus, both are key factors in the forecasting of future demand for the SH190. The population and employment forecasts used by WSA are provided in Appendix E.

WSA also forecasted population and economic growth rates for a two mile corridor on either side of SH190. The employment forecasts considered NCTCOG's trip tables, as well as WSA's assessment of any new developments that could have an impact on employment levels. WSA also listed major impending roadway projects in the SH190 corridor that could result in traffic not diverting to SH190. Finally, WSA listed the major land use projects in the corridor. The development schedule for the identified projects varied and the risk of delays was also noted. It was anticipated that these facilities would impact the traffic levels on SH190 in future operational years.

Toll Transactions on the Existing NTTA System

The bond document included information on the existing NTTA toll system to establish the reputation of the toll authority, but it was not discussed in any detail in the T&R report. WSA also did not conduct a new forecast in this T&R document for the existing NTTA system (the DNT and the Addison Airport Toll Tunnel (AATT)). Instead, WSA noted that because SH190 and the DNT intersect, increased traffic on one will have a positive impact on the traffic of the other. WSA thus predicted that the existing NTTA system will experience an increase in traffic volumes and revenue after SH190 opens. The forecasted revenue on the existing system resulting from the opening of SH190 between 1998 and 2020 is provided in Appendix E.

NCTCOG Traffic Model

The historical trends discussed above, the area's expected future population and employment[50] growth rates, and the local area's adapted traffic models and trip tables formed the basis for WSA's T&R projections for SH190. For this T&R study, WSA began with the NCTCOG traffic model, which they had used previously for their 1992 T&R report. The model inputs included the 1986 and 2010 network systems and trip tables. The 1996 base year network was created by adjusting the 2010 network to represent the actual built network characteristics.[51]

WSA reviewed the NCTCOG information for the cities of Garland and Rowlett because the project corridor runs through these cities and supplemented the information with additional

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49 WSA also reviewed the following growth indicators: *Age Distribution, Median Household Effective Buying Income, Retail Sales Trends, Motor Vehicle Registration Trends, and Energy Considerations.* The listed indicators, together with the population factors, were included in the T&R's overview of the area's historical trends.

50 The demographic inputs to the trip tables and models—i.e., population and employment - were from the 1990 Census and the latest Transportation Improvement Program for the Dallas-Fort Worth Metropolitan area.

51 These characteristics include actual speeds or roadway capacity, confirming that the link is actually built and operational, as well as other factors.

data. Based on the area's Transportation Improvement Program (TIP), WSA created new networks for years: 1998, 1999, 2001, and 2004. Each network included those SH190 segments that would become operational during that year. The 2004 network was thus the first network with the entire SH190 operational. For comparison, WSA also created no-build networks[52] for the same years. WSA also reviewed the planned improvements to the traffic network in the DFW area. These improvements were included in the 1994 DFW TIP and in NCTCOG's Mobility 2010: The Regional Transportation Plan. The planned improvements by the state were obtained from TxDOT. A total of 37 projects were considered with completion dates ranging from 1994 to beyond 2002.

At the time of the T&R report, the NTTA was considering implementing dynamic pricing. The 1986 trip table, however, only had daily traffic volumes. WSA divided the daily traffic volume trip table into A.M. peak, P.M. peak, and off-peak trip tables. The demographic inputs—i.e., population and employment—from the 1990 Census and the latest TIP for the Dallas-Fort Worth Metropolitan area were then used to adjust the 1986 trip table to 1990 conditions. WSA subsequently converted the 1990 trip tables to 1994 trip tables[53]. The 1994 trip tables were revised using previously collected survey data.[54] WSA also updated the 2010 trip tables—used previously in their 1992 T&R report—given revised 2010 demographic forecasts.

In addition to dynamic pricing, NTTA was considering implementing HOV lanes. Thus, the trip tables were further subdivided into single occupancy (SOV) trips and high occupancy vehicle (HOV) trips for each time period, resulting in six trip tables for each year. The 1994 trip table was used to calibrate the model, using WSA traffic survey data. The various model runs used the 2004 SOV and HOV trip tables (separately) in different scenarios, including:

- no build condition, i.e., no SH190,
- non-toll condition, and
- various toll pricing strategies, i.e., mainline passenger car toll ranging from $0.50 to $1.50 in $.025 increments, which resulted in the selection of an optimum toll rate.[55]

The model forecasted traffic levels on SH190 in the trip assignment step. The toll was implemented as a time penalty. This assignment process dynamically takes account of growing congestion on alternative routes. Thus, if the non-tolled route's congestion levels increase then the travel time on the non-tolled route will also increase. The toll paid—implemented as a time penalty—will become relatively smaller, resulting in the increased attractiveness of the toll road. WSA repeated this trip assignment process for the 1998, 1999, 2001, and 2010 trip tables under

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52 Networks without SH190.

53 1994 is the base year in the WSA model.

54 Model generated data were replaced with count data where count data were available.

55 Assuming higher toll rates for higher axle counts, WSA tested both peak and off-peak period toll sensitivity. The peak periods comprised six hours and the off-peak period comprised the remaining 18 hours. The ramp tolls were assumed to be lower than the mainline tolls. Toll sensitivity curves were developed and included in the T&R report. The peak period mainline curve showed increasing revenue with increasing toll rates beyond a peak period toll rate of a $1.50. WSA suggested an optimum mainline toll rate of $1.50. In the case of the off-peak period curve revenue started to reach a plateau at the $1.00 and $1.25 mainline toll rate. WSA estimated that the optimum off peak mainline toll rate is $1.00, but recommended the use of a $0.75 mainline toll rate because the curve is moderately flat. Although WSA conducted this toll sensitivity analysis, the recommended toll rates were based on the current DNT toll rate policy. This resulted in a mainline and ramp toll rate of $0.50 and $0.25, respectively.

the three scenarios listed above.[56] The output is forecasted traffic volumes on SH190 for the four years. WSA extrapolated the 2010 traffic volumes to 2020 levels.[57]

Twelve Conditions

WSA assumed in their model predictions that the following 12 conditions will be met:

1. "The opening schedule will be as…[tabled previously in this Chapter].
2. The location of interchanges and general route alignment will be as discussed in this [T&R] report.
3. The recommended toll collection concept and toll schedule will be adopted as shown in this [T&R] report, and the same toll rates will remain in effect throughout the forecast period.
4. Capacity constrained diversion traffic assignments were developed assuming a six lane facility.
5. Traffic and toll revenue estimates are based on the assumption that the necessary improvements would be implemented on the proposed facility to meet future year traffic demands.
6. Existing toll rates on the DNT and Addison Airport Tunnel are assumed to remain in effect throughout the forecast period.
7. Improvements to the present highway system in the travel corridor will be limited to those currently scheduled in the Transportation Improvement Program prepared by NCTCOG and TxDOT, and no competing limited-access highways will be constructed in the turnpike corridor.
8. A fully-attended system of toll collection is assumed at all toll plaza locations.
9. In accord with the policy on all toll facilities operated by the Authority, the S.H. 190 Turnpike will be well-maintained, efficiently operated, and effectively signed, to encourage maximum usage.
10. Economic growth in the travel corridor and the prospects of future expansion generally will follow the assessment described in this [T&R] document.
11. Motor fuel will remain in adequate supply, and future increases in fuel price will generally occur in proportion to the overall rate of inflation.
12. No local, regional, or national emergency will arise which would abnormally restrict the use of motor vehicles."

Some of these assumptions were specific to the road (e.g., the opening dates), but the majority are project neutral and are listed in most of WSA's NTTA T&R reports.

Toll Collection System

WSA also recommended that the toll collection system used on the DNT be implemented on SH190. This will ease operations for the NTTA and facilitate inter- operability at the DNT and SH190 intersection. Four mainline toll barriers and various toll ramps were recommended for the barrier toll collection system. This translates into one mainline barrier per segment, which facilitates the different opening dates of the various segments.

[56] Using the optimum toll rate from the range of toll rates tested.

[57] 2020 is the design year for traffic.

Forecasted and Actual Traffic

WSA estimated opening year ADT volumes by ramp and plaza for each segment's opening year and for the year 2020. It was noted that these volumes would be slightly higher on a weekday and slightly lower on a weekend. A summary of the average daily traffic volumes by segment are provided in Table 4.20.

Table 4.20: Estimated Average Daily Traffic in Opening Year

Segment	Average Daily Traffic			
	1998	1999	2001	2004
IA	10,800	12,400	20,200	22,000
IB	37,000	54,800	63,600	70,400
II		63,200	66,000	69,200
III			50,800	62,600
IV				41,000
Total	47,800	130,400	200,600	265,200

After segment III opens in 2001, the peak volume appeared to be concentrated around US75. In 2004, this same location was forecasted to experience a traffic volume of more than 72,000 vehicles per day. Few through trips were predicted for SH190. Instead SH190 was expected to serve as a beltway, resulting in shorter trips.

WSA also conducted a corridor share analysis to test the reasonableness of their forecasted 2004 ADT volumes. WSA used four screenlines—one for each segment—to determine the existing traffic volumes on the routes from which future SH190 traffic was expected to divert from. WSA divided the traffic between the new SH190 and the other existing routes. A comparison between WSA's original and corridor share forecasts is provided in Appendix E.

The 2020 traffic forecasts are provided in Table 4.21.

Table 4.21: Estimated Average Daily Traffic in 2020

Location	Average Daily Volume (vehicles)
Four Mainline Toll Plazas	85,000 to 105,000
Segment Volumes	slightly below 100,000
Peak Load Point	136,000

WSA's Average Annual Daily Traffic (AADT) forecast was for each segment's opening year, making a comparison between forecasted and actual AADT somewhat problematic. Nonetheless, available forecasted and actual AADT values are compared in Table 4.22 and Figure 4.13. However, it should be noted that the actual values include volumes from Segment V, which were not included in the forecast.

Table 4.22: Actual versus Forecasted AADT

Year	Average Annual Daily Traffic (AADT)	
	Forecasted	Actual
2000	-	120,312
2001	200,600	197,518
2002	-	323,249
2003	-	341,392
2004	265,200	350,704
2005	-	387,454
2006	-	472,916

Source: Wilbur Smith Associates, 2007

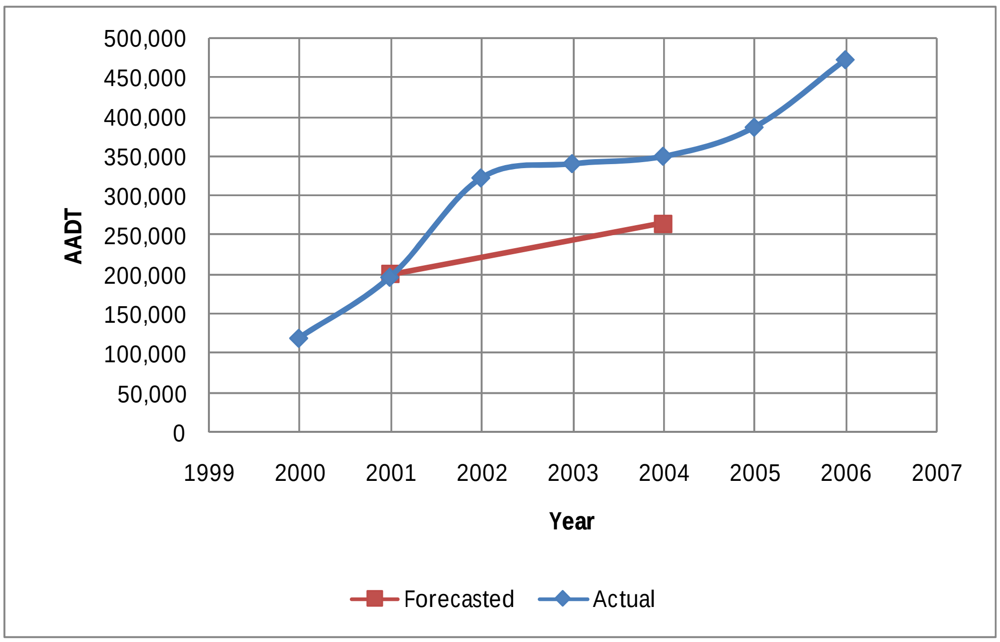


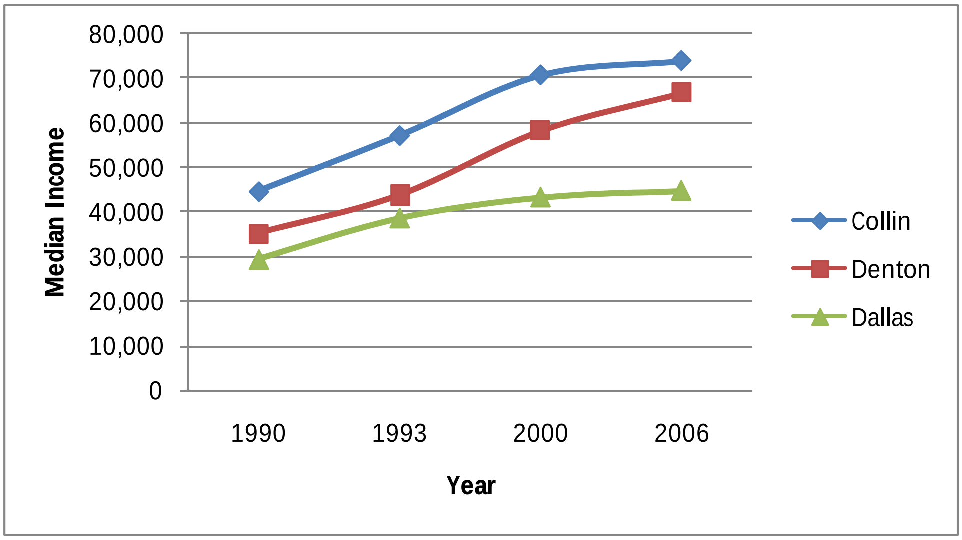
Figure 4.14: Actual versus Forecasted AADT

From the above table and figure it is evident that only two data points can be compared: the AADT for 2001 and 2004. Although it seems that the actual traffic has exceeded the forecasted traffic, both years—but especially 2004—include traffic on Segment V that was not accounted for in the forecast.

Factors that Impacted Forecasts

Median Household Income[58]

Figure 4.14 illustrates the trend in the median household income for Dallas, Denton, and Collin Counties. The first two values are from WSA's 1995 report and the last two values are from the Census Bureau.



Source: U.S. Census, 2008

Figure 4.15: Median Household Income

The Figure above shows that median household income has increased substantially since WSA's 1995 report.

Energy Condition

The energy situation has changed dramatically since WSA's 1995 assessment. At that time, the real cost of oil was actually decreasing year to year. For comparison, in early 2008 oil prices have reached $130 a barrel as opposed to $15 a barrel in 1995. This impacts fuel prices and potentially traffic volumes on SH190.

Travel Characteristics[59]

WSA conducted another mail-back card survey during their 2007 T&R report for NTTA. From this survey, updated trip purpose, trip distribution, and trip frequency information are available. Although the survey locations were not the same as in the 1995 study, WSA did distribute cards on the DNT and SH190 routes. WSA analyzed the survey information:

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[58] WSA reviewed the following growth indicators: age distribution, median income, retail sales, motor vehicle registrations, and energy conditions. However, the age distribution, retail sales, and motor vehicle registration trends could not be compared as data were unavailable.

[59] Unless otherwise noted, the information and data in this section are from the 1995 NTTA Bond Document and the 2007 SH121 report as referenced.

- for the peak and off-peak periods,
- for mainlines and ramp plazas,
- by cash and toll tag responses, and
- for the DNT and SH190 routes.

WSA noted numerous times that a major objective of SH190 was to relieve commuter congestion. The 2005 survey revealed a much higher percentage of commuting trips compared to the 1995 values used as an input to forecast traffic on SH190. It is unclear what the impact of this variable was on the forecasted T&R levels, but the data does seem to validate the hypothesis of SH190 being a commuter route. Also, a higher percentage of respondents indicated making their trip five times a week (34.9 percent in 2005 compared to 28.8 percent in 1995), while a lower percentage indicated making trips six or more times per week (14.8 percent in 2005 compared to 23.4 percent in 1995). This survey finding substantiates the trip purpose findings. Commuting trips are usually made five times a week, and because a higher percentage of commuting trips were reported, a higher percentage of five trips per week can be expected. Finally, a higher percentage of respondents indicated SOV use in 2005 compared to 1995, while all the remaining categories of vehicle occupancy recorded lower percentages in 2005 compared to 1995. Again, this concurs with the increasing commuting trips reported.

Population and Employment Growth Rates

The demographic forecast included predicted average annual growth rates for population and employment between 1990 and 2010. Table 4.23 compares the projected and actual population growth rates at the county level.

Table 4.23: Forecasted and Actual Average Annual Population Growth Rates

County	**WSA Projected Growth Rate (%) 1990 to 2010**	**Actual Growth Rate (%) 1990 to 2000**
Collin County	6.4	3.9
Dallas County	1.8	0.7
Denton County	4.7	2.8

Source: Wilbur Smith Associates, 2007

As can be seen from the Table above, WSA's projected population growth rates were much higher than the actual growth rates for all three counties. Population values are used to forecast trip productions in an area. The overestimation of population growth rates would thus arguably overestimate the demand and thus forecasted usage of the facility.

Table 4.24 compares the predicted and actual average annual employment growth rates at the county level between 1990 and 2010.

Table 4.24: Forecasted and Actual Average Annual Employment Growth Rates

County	WSA Projected Growth Rate (%) 1990 to 2010	Actual Growth Rate (%) 1990 to 2000
Collin County	4.3	6.4
Dallas County	1.7	1.8
Denton County	3.3	4.7

Source: Wilbur Smith Associates, 2007

As is evident from the Table above, the employment growth rates projected by WSA were lower than the actual growth rates in Collin and Denton County. However, in the case of Dallas county the forecasted employment growth rate is similar to the actual growth rate. Employment is a key indicator in the estimation of trip attractions, and thus, the higher the employment the more trip attractions in the county. In general, there is some correlation between population and employment growth rates. In this case, however, the population forecasts were higher and the employment forecasts were lower.

Opening Schedule

WSA listed twelve assumptions that were the basis of their forecasts. An important assumption that impacted the traffic on SH190 was the proposed opening schedule. The actual opening schedule is compared with the assumed 1995 and 1997 opening schedule in Table 4.25.

Table 4.25: Actual and Assumed Opening Schedule

Segment	Borders	1995 Scheduled Opening	1997 Scheduled Opening	Actual Opening Date
Phase IA	Midway Road to Preston Road	Mar-98	Nov-98	Dec-98
Phase IB	Preston Road to Coit Road	Mar-98	Feb-99	Jun-99
Phase IC	Coit Road to US75		Aug-99	Dec-99
Phase IIA	US75 to North Garland Road	Jul-99	Aug-99	Dec-99
Phase IIB	North Garland Road to SH78		Oct-99	Apr-00
Phase III	Midway Road to I35E	Jul-01	Jul-01	Jul-01
Phase IV	I35E to I635	Jul-04	Jul-04	Jan-06

Source: Wilbur Smith Associates, 2007

The delayed opening dates must have resulted in lower traffic and revenue, but it is not clear by how much. In the case of the Phase IIB and Phase IV segments, the opening was delayed substantially. It should be noted that the 1997 bond document revised the opening schedule, but even these dates were ultimately optimistic in all cases except the Phase III segment.

ETC effect

WSA did not mention whether the use of ETC tags was considered in the T&R forecasts of SH190. ETC tags facilitate faster travel times and is often argued reduce users' sensitivity to the charged toll, thus potentially resulting in increased usage. The use of ETC on SH190 would thus arguable have had a positive impact on traffic volumes and revenues.

Annualization Factor

WSA offers no explanation of how AADT were converted to annual totals. Often the conversion from daily to annual values can be tainted by the use of an inappropriate annualization factor. This can, however, only be noted as WSA did not provide the annualization factors that were used in their forecasts.

4.5.3 1998 NTTA Bond Document[60]

Segment V in the City of Irving linked Segment IV to the north end of SH161. The 3.7-mile route was anticipated to have ramps at San Jacinto, Royal Lane, Gateway Road, and Las Colinas Boulevard. Segment V would increase the length of SH190 to 30.5 miles. Figure 4.15 illustrates the location of Segment V.

Figure 4.16: SH190, Segment V Funded by the 1998 Bond Document

60 Unless otherwise noted, the information and data in this section are from the 1998 NTTA Bond Document (NTTA Bond Issuance, 1998).

It was anticipated that Segment V would provide a faster commuting route and a link to the DFW airport from eastern Dallas and Tarrant Counties. Also, the construction of this segment would help complete the outer loop around the Dallas area. The road was expected to divert traffic from major highways—e.g., I635, SH114, and SH183—and from major arterials—e.g., Belt Line Road, MacArthur Boulevard, Valley View Lane, and Luna Road.

The 1998 Bond Document funded Segment V of SH190 and included an updated T&R forecast for Segment V. However, most of the assumptions used in the 1995 T&R report were also used in the 1998 T&R report. Thus, this section focuses only on the information and assumptions that differ from the information and assumptions that were included in the 1995 T&R report.

Traffic and Revenue Forecasting Approach[61]

Population and Employment Growth Rates

In the 1995 T&R report, WSA listed population growth rates for 1970 to 2010 in 10 year increments. In the 1998 T&R, WSA listed population growth rates for 1990 to 1995, 1995 to 2005, 2005 to 2010, and 2010 to 2020 (see Table 4.26). WSA provided more detailed employment growth rates in the 1998 T&R report as well. The 1998 report included employment growth rates for 1990 to 1995, 1995 to 2005, 2005 to 2010, and 2010 to 2020. The 1995 study only provided employment growth rates for 1990 to 2010.

Table 4.26: Forecasted Population and Employment Growth Rates in the Project Corridor

Study Area		**Average Annual Population Growth Rate (%)**			
		1995 to 2005	**2005 to 2010**	**2010 to 2020**	**1995 to 2020**
Dallas County		0.8	0.8	0.5	0.7
	Irving	1.3	1.3	0.8	1.1
	Study Corridor	1.2	1.2	1.2	1.2
Denton County		2.8	2.8	2.6	2.7
Tarrant County		1.3	1.3	1.0	1.2
Study Area		**Average Annual Employment Growth Rate (%)**			
		1995 to 2005	**2005 to 2010**	**2010 to 2020**	**1995 to 2020**
Dallas County		1.6	1.6	1.2	1.4
	Irving	2.0	2.0	1.6	1.8
	Study Corridor	2.0	2.0	2.9	2.4
Denton County		3.0	3.0	4.2	3.5
Tarrant County		2.3	2.3	1.9	2.2

Employment growth was expected to exceed population growth in most areas, especially the study corridor. These values were based on NCTCOG's forecasts. However, WSA did conduct a more detailed inventory of the employment in the corridor by market area.

61 Unless otherwise noted, the information and data in this section are from the 1998 NTTA Bond Document (NTTA Bond Issuance, 1998).

The T&R report noted that when the corridor population and employment information were examined at the traffic zone level, overall trip growth mimicked the demographic information. The 1995 T&R report listed other growth indicators, such as age distribution, median household effective buying income, retail sales trends, energy considerations, and motor vehicle registration trends, but these were not mentioned in the 1998 T&R report.

Land Use

WSA discussed the existing land use in the proposed Segment V corridor and the City of Irving. The land use in Irving was dominated by residential developments.[62] The City of Irving experienced dramatic growth in past decades, mostly spurred by the development of the Dallas/Fort Worth (DFW) Airport. The other major traffic generator in the area was the Las Colinas area, which houses a large share of the employment in Irving.

WSA also evaluated future land use in the area, because the Segment V corridor was relatively undeveloped. Potential future trip generators were identified. However, a portion of the Segment V corridor would not be zoned for residential use. This is the result of a potential new runway location for DFW Airport. If the new runway is built, the flight path would be over this portion of the SH190 corridor.

Local Transportation System

Overall, the annual traffic growth trends in the 1998 T&R study were from the 1995 T&R report. However, WSA conducted additional field surveys in October 1996 and April 1997. The data collection effort comprised the distribution of mail back cards and machine traffic counts at ten survey stations. The survey locations formed two screenlines as follows:

- Screenline G—six survey locations for motorists traveling north-south in the Segment V corridor.
- Screenline F—four survey locations for motorists traveling on SH183.

A higher percentage of commute trips compared to 1995 (59 percent in the 1998 T&R report compared to 45 percent in the 1995 T&R report) was recorded. Similarly, a higher percentage of respondents indicated single occupant vehicle use (81 percent) in the 1998 T&R report compared to the 1995 T&R report (76 percent).

Even though the survey response distributions were different (as noted above), the overall trends and conclusions regarding trip purpose and trip occupancy were the same in the 1998 T&R report as in the 1995 T&R report. In other words, the majority of the trips are commuter trips and single occupant vehicles are the dominant mode. Furthermore, the trip frequency information indicated that 59 percent of the respondents made five or more trips per week. Only 15 percent of the respondents indicated that they made less than one trip a week. Finally, the vehicle classification counts revealed that passenger cars represented 99 percent of the traffic volume.

[62] About 22 percent of the land use comprised single-family developments and 4.3 percent was multi-family developments.

Travel Time Savings

For Segment V, WSA developed four additional travel time runs. The alternative four non-SH190 routes[63] were chosen based on existing traffic flows and logical route choices. The start and end distances, the travel time, and the calculated average speed are provided in Appendix E. In all four cases, the average speed was higher using SH190, ranging from 7 mph to 19 mph faster than the existing alternatives. The SH190 thus resulted in time savings ranging from about 9 to 12 minutes.

NCTCOG Traffic Model/Data

The same methodology was used in forecasting traffic and revenue for Segment V as was used in the 1995 T&R report. The data, trip tables, networks, and models were the most recent NCTCOG updates. The 1998 forecasts used the 1990, 1995, 2000, 2010, and 2020 NCTCOG trip tables and zonal socioeconomic data sets as a basis. The future land use assumptions were based on discussions with city and regional agencies, as well as other organizations such as the area's Chamber of Commerce.

Existing NTTA System

WSA revised their projections for the NTTA system considering the following scenarios:

1. A no-build scenario,
2. A segment I-IV build scenario, and
3. A segment I-V build scenario.

Based on these projections, the expected revenue impact of Segment V on the DNT was determined. Ramp-up effects were also accounted for. The construction of SH190 was anticipated to have a positive impact on the revenues of the DNT (see Appendix E).

Twelve Conditions

The 1998 forecasted traffic volumes[64] were also based on 12 assumptions. Most of the 1998 assumptions were exactly the same as the 1995 assumptions, with the exception of assumption 1, 3, 4, and 5 listed below:[65]

1. "The opening schedule is now as listed in the Table below.

63 Although not included in this section, the bond document does provide the exact routes driven in each case.
64 Diverted volumes were based on the time-distance relationships discussed earlier and diversion rates. The forecasted values also included the expected induced trips.
65 The numbering is different than in the1995 T&R report.

Proposed Opening Schedule

Segment	*Borders*	*1995 Scheduled Opening*	*1998 Scheduled Opening*
Phase IA	*Midway Road to Preston Road*	*Mar-98*	*Nov-98*
Phase IB	*Preston Road to Coit Road*	*Mar-98*	*Jun-99*
Phase IC	*Coit Road to US75*		*Dec-99*
Phase IIA	*US75 to North Garland Road*	*Jul-99*	*Dec-99*
Phase IIB	*North Garland Road to SH78*		*Apr-00*
Phase III	*Midway Road to I35E*	*Jul-01*	*Jul-08*
Phase IV	*I35E to I635*	*Jul-04*	*Jul-04*
Phase V			*Jan-02*

3. *The interchange at SH183 and SH161 only directly connects to SH183 access to and from the west.*
4. *The T&R forecasts are based on a 10 percent toll rate increase as well as the removal of the southbound exit ramp north of MacArthur Boulevard. The toll rates for the resulting NTTA system will increase by 10 percent in January 2002.*
5. *The same modeling technique used in the 1995 study was used in this study."*

Toll Sensitivity Analysis

WSA also conducted another toll sensitivity analysis. The same analysis methodology was used as in the 1995 T&R report, but updated project configurations, new models, new trip tables, and a 10 percent toll increase was used in the 1998 T&R report. Based on WSA's analysis, it was concluded that a toll rate increase of between 10 and 15 percent will generate the optimum toll revenue. Also, WSA noted that the toll sensitivity on Segment V was higher than on Segment I to IV.

Forecasted and Actual Traffic

The actual AADT for SH190 Segments I to V was summarized and discussed in the 1995 T&R section. In the Figure below, the AADT forecast for Segment V was added to the AADT forecasts for Segments I to IV obtained from the 1995 T&R study and compared to the actual AADT values for the whole road. As can be seen from the Figure below, the forecasted and actual values in 2004 differed with 41,204 transactions. In other words, actual traffic was approximately 13 percent higher than forecasted in 2004.

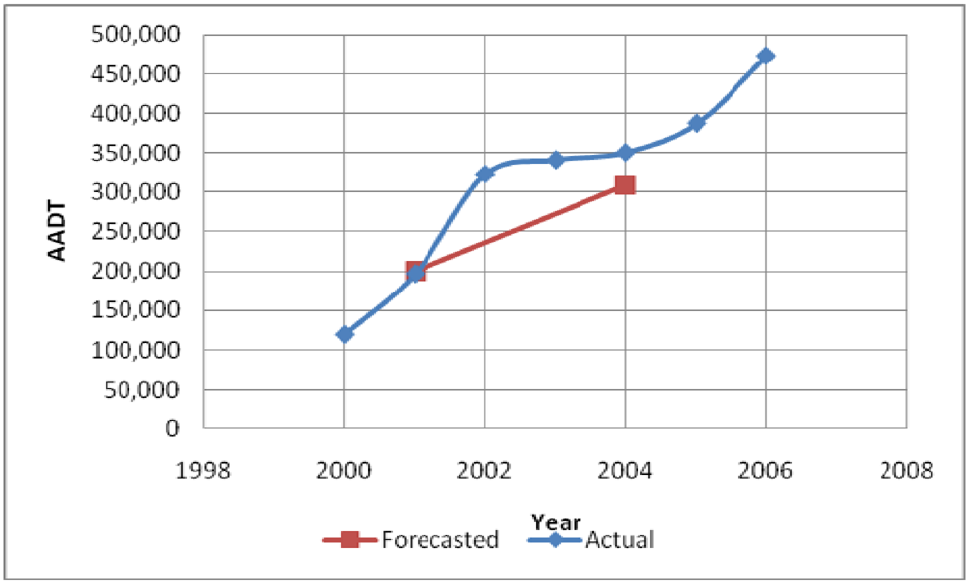

Figure 4.17: Actual and Forecasted AADT for SH190

Factors that Impacted Forecasts

Opening Schedule

As discussed earlier in this section, WSA assumed a specific opening schedule of the various SH190 segments in the 1998 T&R. Even though the 1998 opening schedule was the third revision, it still differed from the actual opening dates in the case of some segments. Segment I, II, and III opened on schedule but the opening of segment IV was severely delayed (see Table 4.27). Again, T&R levels would be negatively affected by delayed openings, thus exacerbating the under-estimating of WSA's forecasted traffic and revenue levels.

Table 4.27: Assumed and Actual Opening Schedule

Segment	Borders	1995 Scheduled Opening	1998 Scheduled Opening	Actual Opening Date
Phase IA	Midway Road to Preston Road	Mar-98	Nov-98	Dec-98
Phase IB	Preston Road to Coit Road	Mar-98	Jun-99	Jun-99
Phase IC	Coit Road to US75		Dec-99	Dec-99
Phase IIA	US75 to North Garland Road	Jul-99	Dec-99	Dec-99
Phase IIB	North Garland Road to SH78		Apr-00	Apr-00
Phase III	Midway Road to I35E	Jul-01	Jul-08	Jul-01
Phase IV	I35E to I635	Jul-04	Jul-04	Jan-06
Phase V			Jan-02	Dec-01

Ramp-up Effects and Other Factors

As pointed out earlier, most of the other factors that could have impacted the WSA's forecasts were discussed earlier, in the 1995 T&R report section. These factors included ramp-up effects, ETC usage, and the annualization factor. There was no difference in any of these factors between the 1995 and 1998 T&R reports.

4.6 The 2002 Central Texas Turnpike Project (CTTP) Traffic and Revenue Forecast[66]

4.6.1 Introduction

The 2002 Central Texas Turnpike Project (CTTP) consisted of three turnpike elements: Loop 1 and SH 45, both located in northern Travis County and southwest Williamson, are referred to as the *Northwest Austin Area Turnpike Elements* and SH 130, which extends from Georgetown into Travis County, just south of Austin Bergstrom International Airport. Figure 4.17 illustrates the location of the 2002 CTTP elements.

[66] Unless otherwise noted, the information and data in this section are from the 2002 Texas Turnpike Authority Bond Document.

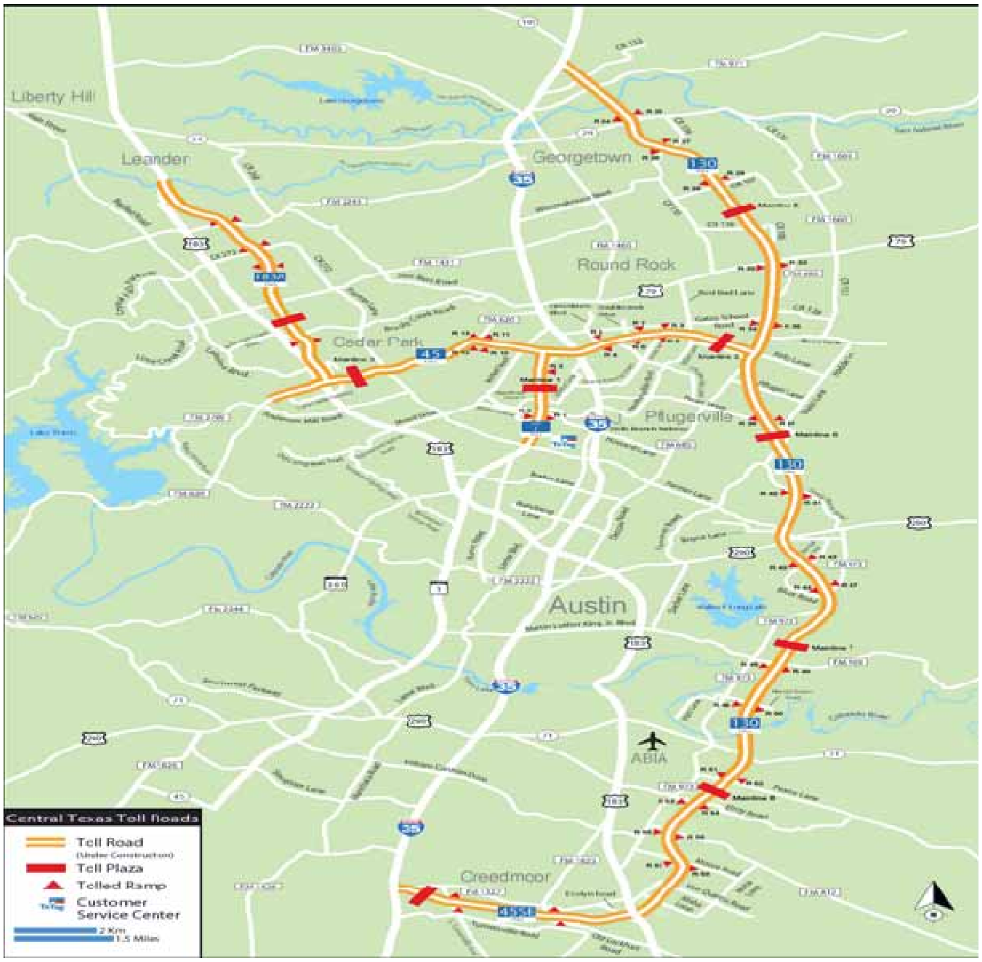

Figure 4.18: The 2002 Project Elements

A T&R forecast was jointly developed by Vollmer Associates LLP and URS Corporation for TxDOT's Series 2002 Bonds and the USDOT's TIFIA loan issued for the 2002 Project. Vollmer was responsible for the Northwest Austin Area Elements, and URS was responsible for SH 130.

The following sections provide an account of the travel patterns at the time, the T&R forecasts developed, the methodology used in the traffic forecasting model, the socioeconomic forecasts, and the highway networks that were used as input to the model. The sensitivity analysis that was conducted is also described. Finally, the T&R forecasts are compared with the actual traffic and revenue on these turnpike elements.

4.6.2 Forecast Methodology

The models used to forecast the traffic and revenue presented in the 2002 T&R report were calibrated using traffic counts, travel time estimates, and origin-destination surveys. Because the 2002 CTTP covered a large study area and multiple projects, the consultants used the regional travel demand model that had been developed by CAMPO and validated with extensive travel survey data collected in 1997. The consultants also measured traffic volumes across representative screenlines to obtain the average annual traffic growth rates in Austin. The CAMPO model employs the "four-step" travel demand forecasting approach, typical of travel demand models used in other urban areas. The model also contains detailed level data that could be use as the basis for estimating traffic on the turnpike elements and for generating trip tables. Numerous travel time runs were made for the principal arterials in the Austin area during the peak and non-peak hours, which helped provide an indication of the congestion that each respective corridor experiences. Origin-destination surveys were also conducted to collect data on motorist travel patterns that were subsequently included in the CAMPO model. Other regional travel data collected by CAMPO and TxDOT were also used in the development of the T&R forecasts.

The consultants converted the single 24-hour TRANSCAD highway assignment procedure embedded in the CAMPO model into a 'time-of-day" assignment, using the TP+ planning package. This allowed for the 24-hour period to be divided into an AM peak period, a PM peak period, and a residual off-peak period. This more advanced assignment technique allows for forecasting the travel variations by time-of-day and for conducting time-cost tradeoffs, i.e., important considerations when assigning traffic to the tolled and non-tolled alternative.

To validate the adapted CAMPO model, the consultants compared the 1999 CAMPO forecast with field data collected for that same year. The consultants considered the degree to which the model replicated VMT by facility type and area type and made comparisons of observed and estimated speeds by time-of-day. To compare the modeled and observed travel patterns, the consulting team conducted a select-link analysis of key road segments using the origin-destination data from the surveys conducted by CAMPO in 1997. The consultants also reviewed estimated and observed traffic for the primary roadways in the project corridor. Table 4.28 presents the estimated and observed traffic for different roadway segments, the ratio between the estimated and observed VMT, and the ratio between the original CAMPO model estimates and the estimates from the revised model. As Table 4.28 shows, the revised model provides a more accurate replication of the observed traffic than the original model.

Table 4.28: Observed and Estimated VMT by Facility Type

Facility Type	Observed VMT	Estimated VMT	Ratio	CAMPO Ratio*
IH 35	6,165,000	6,142,785	1.00	1.05
Other Freeways	2,541,383	2,481,256	0.98	1.14
Expressway	1,134,056	1,154,126	1.02	1.04
Principal Arterial Divided	5,724,070	6,002,921	1.05	0.99
Principal Arterial Undivided	4,661,529	4,914,510	1.05	1.08
Minor Arterial Undivided	3,159,592	3,220,974	1.02	1.11
Collector	181,861	145,450	0.80	1.06
Local	797	518	0.65	1.42
IH 35 Express	144,274	159,714	1.11	1.07
Freeway Ramps	308,553	299,350	0.97	0.92
Freeway Frontage	1,410,279	1,065,695	0.76	0.71
Total	**25,431,394**	**25,587,298**	**1.01**	**1.04**

CAMPO ratio was obtained from report entitled "Capital Area Metropolitan Planning Organization (CAMPO) Urban Transportation Study" and dated May 2000.

The revised CAMPO model also allowed for truck traffic to be assigned separately from auto traffic to the road network. According to the forecasts, truck traffic currently using the congested IH 35 will be diverted to SH130. Table 4.29 includes the estimated truck traffic on IH 35 and compares the estimated truck percentages with the truck percentages obtained from TxDOT.

Table 4.29: Estimated and Observed Truck Percentages on IH35

Location	County		1997 Validation				TxDOT % Truck (1998)
			Auto	Truck	Total	% Truck	
North of FM 306	Comal	Main	39,316	10,625	49,941	21.28	20.40
		Frontage	1,278	226	1,504	15.03	
		Total	40,594	10,851	51,445	21.09	
North of SH 123	Hays	Main	47,166	10,417	57,583	18.09	18.90
		Frontage	1,644	86	1,730	4.97	
		Total	48,810	10,503	59,313	17.71	
North of San Marcos	Hays	Main	60,770	11,482	72,252	15.89	17.40
		Frontage	259	46	305	15.08	
		Total	61,029	11,528	72,557	15.89	
North of Hays County Line	Travis	Main	66,566	12,580	79,146	15.89	15.80
		Frontage	3,450	289	3,739	7.73	
		Total	70,016	12,869	82,885	15.53	
South of Austin	Travis	Main	90,360	14,318	104,678	13.68	15.90
		Frontage	3,518	304	3,822	7.95	
		Total	93,878	14,622	108,500	13.48	
North of SH 71	Travis	Main	92,859	12,584	105,443	11.93	10.80
		Frontage	13,107	1,117	14,224	7.85	
		Total	105,966	13,701	119,667	11.45	
North of Colorado River	Travis	Main	138,366	16,506	154,872	10.66	9.80
		Frontage	22,196	2,042	24,238	8.42	
		Total	160,562	18,548	179,110	10.36	
South of FM 620	Williamson	Main	86,637	12,604	99,241	12.70	13.20
		Frontage	19,008	1,758	20,766	8.47	
		Total	105,645	14,362	120,007	11.97	
South of SH 29	Williamson	Main	62,935	10,875	73,810	14.73	16.60
		Frontage	-	-	-		
		Total	62,935	10,875	73,810	14.73	
South of Salado	Bell	Main	23,788	8,137	31,925	25.49	29.10
		Frontage	1,347	136	1,483	9.17	
		Total	25,135	8,273	33,408	24.76	

Because there were no existing toll roads in the Austin area from which travel and toll road usage data could be obtained, the consultants developed toll diversion models using information obtained from Stated Preference (SP) surveys[67] to predict how individual travelers would select between toll and non-toll alternatives. The toll diversion models were binary logit functions that estimated the percentage of trips between a particular origin-destination pair that will utilize the toll facility considering the time and costs savings associated with the tolled and non-tolled alternatives. Specifically, the logit function accounted for travel times on the toll road and the non-tolled alternatives, the toll cost, the driver's annual income, and any toll road or ETC bias. Different values were used for the Northwest Austin toll roads to account for the greater sensitivity to travel and cost values, because these toll roads were designed with non-continuous service roads. The toll diversion model was presented as the following equation:

$$\text{Toll Share} = 1/(1+e^{U})$$

Where:

Toll Share = Probability of selecting a toll road

e = Base of natural logarithm (ln)

$$U\ (\text{work}) = a*(Time_{TR} - Time_{FR}) + b*(Cost)/\ln(Inc)+C_{TR}+C_{ETC}$$

$$U\ (\text{non-work}) = a*(Time_{TR} - Time_{FR}) + b*(Cost)+C_{TR}+C_{ETC}$$

$Time_{TR}$ = Toll road travel time in minutes

$Time_{FR}$ = Non-toll road travel time in minutes

Cost = Toll in dollars

Inc = Annual income/1000

C_{TR} = Constant for toll road bias

C_{ETC} = Constant for ETC bias

a, b = Coefficients

The ETC bias term increases the probability of selecting a toll route due to perceived convenience. The SP data revealed ETC to have a perceived benefit of two to four minutes. The toll bias term reflects the reluctance to choose a toll road over a non-toll road. Analysis of the SP data revealed that 39 to 49% of the survey respondents consistently refused to select the toll road option regardless of the time savings offered. The consultants eliminated these responses in estimating the penalties associated with the use of toll roads, arguing that these negative responses were likely due to an anti-toll sentiment typical of areas where toll facilities were not present. The consultants estimated a weighted average value-of-time (VOT) for passenger cars of $12.06/hour for SH 130. It was anticipated that the VOT would be between 50 and 70% of the average wage rate in the region. URS validated the model with respect to time-of-day variations and changes in toll rates using a preliminary version of the SH 130 alignment and toll plan.

Table 4.30 illustrates the estimated traffic for SH 130 by time-of-day. Total peak-period auto traffic was estimated at 35.1% of total auto traffic and truck traffic at 30.2% of total truck traffic. The consultants compared these values to those obtained for similar toll facilities that have been constructed during the last several years in Florida. The values were found to be similar.

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[67] The SP surveys were used to estimate motorists' value-of-time, to identify any biases against toll roads, and to determine the perceived benefits from using electronic toll collection (ETC) transponders.

Table 4.30: Estimated Traffic by Vehicle Type and Time of Day (SH 130)

Vehicle Type	Time-of-Day	Traffic Volume	Peak Percentage (%)
Auto	Total Peak	490,309	35.1
	Off Peak	907,547	
	Total	1,397,851	
Truck	Total Peak	56,903	30.2
	Off Peak	131,713	
	Total	188,616	
Total	Total Peak	547,207	34.5
	Off Peak	1,039,260	
	Total	1,586,467	

The toll rate for SH 130 was calculated at approximately $0.105/ mile for the opening year (2006) and $0.147 by 2015 given various scheduled periodic increases. Expressing the latter value in 1997 dollars resulted in a toll rate of $0.088/mile ($1997)—a value found to be slightly lower than what was charged at recently constructed toll facilities. The toll elasticity value was calculated at -0.36, indicating that a 100% increase in the toll rate will result in a 36% reduction in total traffic. However, trucks were found to be more sensitive to toll increases, with a 100% increase in the toll rate resulting in a 61% reduction in truck traffic (see Table 4.31).

Table 4.31: Toll Elasticity by Time-of-Day

Vehicle Type	Time-of-Day	Traffic Volume		Time-of-Day	
		Base Toll	Doubled Tolls	Traffic Reduction (%)	Retained Traffic (%)
Auto	AM Peak	213,695	151,452	29.1	70.9%
	PM Peak	276,609	188,905	31.7	68.3
	Off Peak	907,547	605,916	33.2	66.8
	Total	1,397,851	946,273	32.3	67.7
Truck	AM Peak	29,063	11,698	59.7	40.3
	PM Peak	27,840	10,503	62.3	37.7
	Off Peak	131,713	51,268	61.1	38.9
	Total	188,616	73,469	61.0	39.0
Total	AM Peak	242,758	163,150	32.8	67.2
	PM Peak	304,449	199,408	34.5	65.5
	Off Peak	1,039,260	657,184	36.8	63.2
	Total	1,586,467	1,019,742	35.7	64.3

4.6.3 Socioeconomic Forecast

Two study areas were identified for SH 130 and the Northwest Austin elements (i.e., SH 45 and Loop 1), respectively. However, both areas were expected to experience rapid population and employment growth, as well as increasing congestion levels due to inadequate roadway infrastructure. The SH 130 study area comprised a 703 square mile area, which included areas south of central Williamson County, eastern Travis County, and northern Hays County. The Northwest Austin study area covered 142 square miles to the north of Travis County and southwest of Williamson County.

Historic trends illustrating population growth and employment patterns, residential development, commercial construction, household income, and other economic indicators were analyzed. Factors that were considered as potentially affecting regional population and employment growth included increased land values in primary employment areas, water and sewage capacity, attitudes to development, and increasing traffic congestion, as well as other indicators such as cost of living, and increasing income disparity.

Socioeconomic forecasts of population and employment data were assessed for each Traffic Analysis Zone (TAZ) included in the model. CAMPO's most recent population and employment forecasts completed in 1999—which included 1997 base year data and forecasts for the years 2007, 2015, and 2025—were used as the starting point.

Integra Joseph Farber & Co. evaluated the CAMPO forecasts and made required adjustments to better represent the expected growth patterns. The consultants adjusted the CAMPO forecasts using a three-stage process. *First*, current growth patterns and other information were collected to identify areas that will most likely be developed in the future. The information was collected through field surveys and interviews with city and county planning officials. The consultants also used zoning maps, local population forecasts, building permit information, planned roadway improvements, and aerial photographs. *Second*, population and employment forecasts for each traffic serial zone (TSZ) were compared with the collected data. *Finally*, if the comparison revealed that the forecasts were unreasonable, adjustments were made to the forecasts considering the information collected and using professional judgment. These adjustments ultimately resulted in a more conservative forecast at the TSZ level. Interim period forecasts (i.e., 2005, 2010, and 2015) were developed by interpolating between the CAMPO baseline and the forecast periods using assumed annualized growth rates.

The consultants also reviewed and compared the population forecasts produced by three other state agencies—i.e., the Texas State Data Center (SDC), the Texas Water Development Board (TDWB), and the Texas Comptroller of Public Accounts—with the CAMPO population control totals used. Finally, the year 2000 population figures—released by the U.S. Census Bureau in March 2001—were used to assess the CAMPO control totals.

In general, CAMPO's population and employment forecasts were found to be slightly optimistic but still reasonable. The population and employment estimates for Travis and Hays County provided by CAMPO were found to be reasonable, but Williamson County's population totals were replaced with the more conservative TWDB population forecasts. This subsequently required an adjustment to Williamson County's employment forecasts provided by CAMPO.

Table 4.32 summarizes the final population and employment control totals and the growth rate for each forecasting period by county.

Table 4.32: Final Population Control Totals by County, 1997-2025

Year	Travis County	Williamson County	Hays County	Total
Population				
1997	709,491	203,133	82,458	995,082
2000	812,280	249,967	97,589	1,159,836
2007	869,533	308,313	108,430	1,286,276
2015	1,029,114	427,875	136,086	1,593,075
2025	1,271,512	575,834	173,009	2,020,355
Annualized Growth Rates				
1997-2000	4.61%	7.16%	5.78%	5.24%
2000-2007	0.98 %	3.04%	1.52%	1.49%
2007-2015	2.13%	4.18%	2.88%	2.71%
2015-2025	2.14%	3.01%	2.43%	2.40%
2000-2025	1.81%	3.39%	2.32%	2.24%
Employment				
1997	440,346	54,604	31,018	525,968
2000	538,100	76,587	34,331	649,018
2007	503,806	104,206	31,441	639,453
2015	630,187	151,117	40,646	821,950
2025	808,023	200,569	53,058	1,061,650
Annualized Growth Rates				
1997-2000	6.91%	11.94%	3.44%	7.26%
2000-2007	-0.94%	4.50%	-1.25%	-0.21%
2007-2015	2.84%	4.76%	3.26%	3.19%
2015-2025	2.52%	2.87%	2.70%	2.59%
2000-2025	1.64%	3.93%	1.76%	1.99%

At the zonal level, the consultants noted that the employment and population densities assumed for some zones were higher than deemed reasonable. However, in general the consultant did not adjust these densities with the exception of a few zones where the density levels could not be justified. Specifically, the consultant determined that the population and employment forecasts were too high for most of the TSZ's along the SH 130 corridor, south of US 290. Although it is anticipated that SH 130 will result in development, it was argued that development will occur around the toll plazas and intersecting arterials—as opposed to along the corridor—due to the absence of frontage roads. Also, given the lack of existing residential and employment developments and the slow employment growth at the Austin-Bergstrom Airport, it was found reasonable to lower the population and employment forecasts in the area south of US 290. In contrast, several new construction projects have occurred in the area north of US 290 after the 1997 CAMPO forecasts were produced, which required an adjustment upwards.

Also, in the SH 45/Loop 1 study area, it was argued that the CAMPO forecasts underestimated the likely future population and employment growth in TSZ's along RM 620.

The consultants argued that this corridor has large areas of developable land and the road capacity to attract development. In contrast, along FM 1431 and Cedar Park, development did not occur as anticipated so that the population growth for TSZs located east of Leander and US 183 were lowered through the year 2015. East of US 183 and the TSZ along Parmer Lane, population and employment forecasts were increased.

After these adjustments to the individual TSZs,

> "the projected growth of the TSZ's population and employment were proportionately adjusted so that the sum of all TSZs was then equal to their respective proportion of the original study area control totals. Since the control totals for Williamson County were adjusted downwards (the Travis and Hays County control totals were not changed), the final control totals for each study area were lower, albeit proportional."

Table 4.33 illustrates the adjustments that were finally made to the control totals for each study area.

Table 4.33: Adjustments to the Control Totals of Each Study Area

	2007 Population	2007 Employment	2015 Population	2015 Employment	2025 Population	2025 Employment
SH 130						
CAMPO	432.543	193,900	590,557	291,395	871,877	436,447
Adjusted	420,511	190,064	555,277	297,151	754,267	400,362
Difference	-12,032	-3,836	-35,280	-12,244	-117,610	-36,085
% Change	-2.78%	-1.98%	-5.97%	-4.20%	-13.49%	-8.27%
SH 45/Loop1						
CAMPO	291,397	156,489	363,332	185,036	493,022	241,583
Adjusted	276,934	151,859	331,791	175,138	404,092	208,318
Difference	-14,463	-4,630	-31,541	-9,898	-88,930	-33,265
% Change	-4.96%	-2.96%	-8.68%	-5.35%	-18.04%	-13.77%
Total						
CAMPO	723,940	350,389	953,889	476,431	1,364,899	678,030
Adjusted	697,445	341,923	887,018	454,289	1,158,359	608,680
Difference	-26,495	-8,466	-66,871	-22,142	-206,540	-69,350
% Change	-3.66%	-2.42%	-7.01%	-4.65%	-15.13%	-10.23%

The consultant noted that adjustments were made to CAMPO's forecasted persons per household and employment by sector for some TSZs in the study area. However, the adjustments were described in general terms and no data were provided. CAMPO's methodology for forecasting median household incomes was judged appropriate.

Adjustments to population and employment forecasts outside of the study areas were reportedly treated similarly to the TSZs within the study area. In other words, after any adjustments, the share of population and employment in terms of the county control totals and the individual TSZs was preserved.

Finally, once the population and employment forecasts were adjusted at the county and TSZ level, the data was further adjusted at the traffic subarea level. Sixteen traffic subarea levels were defined. After calculating the subarea control totals, "*the growth of each TSZs future population and employment was proportionally adjusted to reach the new subarea control* *total."* A number of graphics were included in the T&R report to illustrate the base year and forecast period total population and employment by sub-area.

4.6.4 Roadway Network

Planned road construction and improvement projects were considered in the 2002 T&R forecast. The information was obtained from the CAMPO Long Range Plan and from jurisdictions in Austin, Round Rock, Cedar Park, Pflugerville, Williamson County, Travis County, CAMPO, and TxDOT. Of particular interest to the consultants were improvements to parallel routes that would either "compete" with turnpike elements or would "complement" turnpike elements by serving as "feeder" routes. Because none of the 2002 CTTP toll roads were scheduled to be open before 2007, 2005 was deemed inappropriate as a forecast year. Roadway network changes between 1997-2005 and 2005-2007 were thus combined. Tables 4.34 to 4.38 illustrate the major network changes that were accounted for in the T&R in different model evaluation time periods.

Table 4.34: Major Network Changes, 1997 - 2007

Roadway	Limits	Formerly	Improved Condition
SH 130	IH 35 (N)–US 183 (S)	Nonexistent	4-lane toll facility*
SH 45 N	Loop 1–SH 130	Nonexistent	4-lane toll facility*
	Loop 1 to Ridgeline	Nonexistent	4-lane toll facility*
Loop 1	SH 45–Shoreline Dr.	Nonexistent	6-lane toll facility*
	Shoreline Dr. –Duval Rd (south of Parmer Lane)	FM 1325, a 4-lane undivided major arterial	6-lane toll facility*
US 183	Lakeline Blvd.–McNeil Dr.	4-6 lane divided major arterial	6-lane freeway
	IH 35 (N)–SH 71	Generally, a 4-lane expressway	6-8 lane freeway
US 290	William Cannon Dr.–IH 35	4-6 lane divided major arterial	6-lane freeway
SH 71	IH 35 S–FM 973	6 lane expressway west of US 183, 4 lane divided major arterial east of US 183	6-lane freeway

Table 4.35: Major Network Changes, 2007-2010

Roadway	Limits	Formerly	Improved Condition
US 183	Davis Springs (A very Ranch) Rd.–Lakeline Blvd.	4-lane divided major arterial	5-lane divided major arterial
	Lakeline Blvd.–SH45 N	5-lane freeway	7-lane freeway
SH 45 S	IH35 S–US 183 S	Nonexistent	4-lane toll facility

Table 4.36: Major Network Changes, 2010-2015

Roadway	Limits	Formerly	Improved Condition
Parmer Lane	SH 195–FM 2243	2-lane undivided major arterial	4-lane divided major arterial
	Brushy Creek Rd.–New Hope Dr.	4-6 lane divided major arterial	6-lane expressway
US 183 Turnpike	N/of CR 276–New Hope Dr.	Nonexistent	4-lane toll facility
	New Hope Dr.–SH45 N	Nonexistent	6-lane toll facility
IH 35 HOV Lanes		Nonexistent	1 reversible peak direction HOV lane (AM/PM)
US 290 E	Johnny Morris Rd.–FM973	4-lane divided major arterial	6-lane freeway
US 290 W	Nutty Brown Rd. – William Cannon Drive	4-lane divided major arterial	6-lane freeway
US 183	SH71–FM 812	4-lane expressway/major arterial	6-lane freeway

Table 4.37: Major Network Changes, 2015-2020

Roadway	Limits	Formerly	Improved Condition
Anderson Mill Rd.	Its current end at Parmer Lane–IH 35 N	Nonexistent	4-lane divided major arterial
Braker Lane	Dessau Rd–Giles Lane	Nonexistent	4-6 lane divided major arterial
	Biles Lane–US 290 E	2 lane undivided – 4 lane divide arterial	4-6 lane divided major arterial

Table 4.38: Major Network Changes, 2020-2025

Roadway	Limits	Formerly	Improved Condition
Parmer Lane	SH 29 – Brushy Creek Rd.	4-lane undivided major arterial	6-lane divided major arterial/expressway
Howard Lane	Davis Springs (Avery Ranch) Rd. – McNeil Dr.	Nonexistent	4-lane divided major arterial
RM 620	SH 71 (W) – Anderson Mill Rd.	4-lane divided major arterial	6-lane divided major arterial/expressway
Loop 1 HOV Lanes	South of Parmer Lane – North of SH 45 (S)	Nonexistent	1 reversible peak direction HOV lane (AM/PM)
SH 71 (W)	RM 620 – US 290 (W)	6-lane divided major arterial	6-lane freeway
SH 71 (E)	FM 973 – Travis/Bastrop County Line	4-lane divided major arterial	6-lane freeway
SH 45 S Turnpike (Phase 2)	Loop 1 – IH 35 S	Nonexistent	4-lane toll facility
US 183 S	FM812 – FM 973	4-lane divided major arterial	6-lane freeway
	FM 973 – SH 130	4-lane divided major arterial	6-lane expressway

4.6.5 Northwest Austin Turnpike Elements Traffic & Revenue Forecast

Vollmer Associates was responsible for forecasting T&R for the Northwest Austin Turnpike elements (i.e., Loop 1 and SH 45). The consultants considered the opening dates of the various segments, the location of ramps, toll structure, toll plaza staffing needs, and toll rates in forecasting future T&R. Because the Northwest elements were constructed in phases, Vollmer assumed the following completion dates for each segment:

- Loop 1 element, Parmer Lane to the SH45 element (September 1, 2007),
- SH 45 element, Loop 1 to SH130 (September 1, 2007), and
- SH45 element, Loop 1 to Ridgeline, with 4-lane overpass over US 183 (December 1, 2007).

A closed barrier toll collection system is used for the Loop 1/SH 45 elements. This type of toll collection system utilizes both mainline toll barriers and ramp toll plazas to prevent non-toll traffic from using the roads. A mainline toll barrier is located on Loop 1 north of Merrilltown Road and on SH 45 west of Parmer Lane. There are two ramp toll plazas located on Loop 1 and five on SH 45. Mainline toll barriers and ramp plazas were located to ensure that all traffic entering or exiting the toll facility pay a toll.

Vollmer assumed that toll plaza staffing needs will be a function of the plaza type (i.e., mainline or ramp) and the estimated number of transactions. For the revenue forecasts, it was assumed that ramp locations with less than 5,000 average weekday transactions will not be staffed. All other ramps will be staffed sixteen hours per day. Mainline toll barriers were assumed to be staffed full time.

Table 4.39 illustrates the anticipated cash toll for passenger cars between 2007 and 2035. As is evident from Table 4.39, cash tolls are anticipated to increase by $0.25 in 2015, 2025, and 2035.

Table 4.39: Northwest Austin Turnpike Elements Passenger Car Cash Tolls (2007 to 2035)

Toll Location	Toll Direction	Auto Toll (dollars)			
		2007	2015	2025	2035
SH 45*					
West Mainline	East/west	$0.75	$1.00	$1.25	$1.50
Parmer/FM 734	To/from east	0.50	0.75	1.00	1.25
Howard Lane	To/from east	0.50	0.75	1.00	1.25
Greenlawn	To/from west	0.50	0.75	1.00	1.25
CR 170/Pflugerville Loop	To/from west	0.50	0.75	1.00	1.25
Arterial A	To/from west	0.75	1.00	1.25	1.50
East Mainline	East/west	0.75	1.00	1.25	1.50
Loop 1**					
Howard/Wells Branch	To/from south	0.50	0.75	1.00	1.25
Mainline	North/south	0.75	1.00	1.25	1.50
Shoreline Dr	To/from north	0.50	0.75	1.00	1.25

* Opens in 2007 except for the mainline west of the West Mainline Barrier, which will be completed by 2008.
** Opens in 2007.

For the Northwest Austin Turnpike elements, the consultants estimated that the average toll cost/mile for passenger cars paying cash, weighted by volume, would be $0.186 by the year 2008. Although it was noted that the toll rate is higher than on most turnpikes built in the 1950s, they were regarded comparable to the toll rates on more recently constructed and proposed turnpikes. The latter is due to higher right-of-way costs, higher construction costs, and higher operating and maintenance costs.

Vollmer also had to assume the market penetration for ETC users, who receive a 10% discount. The ETC market share (shown in Table 4.40) was based on a review of ETC usage at other U.S. toll facilities in areas of high commuter traffic. Market shares between model years were interpolated.

Table 4.40: ETC Market Share

Year	Auto share (%)	Truck share (%)
2007	30	25
2010	45	40
2015	65	50
2020	70	55
2025	75	60

The consultant forecasted average weekday traffic for 1997, 2005, 2007, 2010, 2015, 2020, and 2025—the years for which socioeconomic data were available. An annualization factor of 300 was used to convert average weekday traffic to annual traffic. Weekend traffic was assumed to be 50% that of weekday traffic. Gross toll revenues were calculated by multiplying the forecasted traffic by the prevalent toll structure, assuming that average truck tolls rates were 2.5 times that of passenger cars. The consultant also conducted screenline counts to determine whether the diverted toll traffic rates were reasonable when compared to nearby, parallel non-tolled routes.

Adjustments were made to the traffic model to account for a five-year ramp-up period. For the first four years of operation, the forecasted revenues were multiplied by 56%, 70%, 85%, and 95%, respectively to account for ramp-up. By the fifth year, traffic was assumed to have reached the levels forecasted so that no adjustments were made. The consultant also accounted for both intentional and unintentional toll evasion (see Table 4.41 for the adjustment percentages that were applied to the revenue forecasts).

Table 4.41: Toll Evasion on the Northwest Austin Area Turnpike Elements

Toll Plaza Type	Payment Type	Evasion, Leakage (%)
Mainline Plazas	Transponder	2.5
	Cash	5.0
Attended Ramp Plazas	Transponder	2.5
	Cash	5.0
Unattended Ramp Plazas	Transponder	2.5
	Cash	20.0

Table 4.42 provides the adjusted T&R projections for the Northwest Austin Turnpike elements from 2008 to 2042. Revenue beyond 2026 was estimated to grow at a rate of 2.9% initially and decline to 2% in the later years. The exception is in 2036 when toll rates were anticipated to increase.

Table 4.42: Traffic and Revenue Projections, FY 2008-2042
Northwest Austin Area Turnpike Elements
(Adjusted for Ramp Up and Toll Evasion)

Fiscal Year	SH 45		Loop 1		Total	
	Average Weekday Toll Transactions	Annual Revenue ($'000s)	Average Weekday Toll Transactions	Annual Revenue ($'000s)	Average Weekday Toll Transactions	Annual Revenue ($'000s)
2008	36,664	$7,600	39,535	$8,912	76,199	$16,511
2009	58,222	$12,234	53,025	$11,877	111,247	$24,111
2010	**74,121**	**$15,558**	**66,738**	**$14,859**	**140,859**	**$30,418**
2011	85,569	$18,345	73,759	$16,320	159,628	$34,665
2012	95,782	$20,407	78,775	$17,349	174,557	$37,757
2013	101,175	$21,504	79,908	$17,520	181,083	$39,024
2014	106,568	$22,601	81,041	$17,691	187,610	$40,292
2015	**111,962**	**$23,698**	**82,175**	**$17,861**	**194,136**	**$41,559**
2016	106,777	$30,791	79,638	$23,483	186,414	$54,274
2017	110,628	$31,853	81,250	$23,958	191,878	$55,811
2018	114,480	$32,914	82,862	$24,434	197,342	$57,348
2019	118,332	$33,975	84,474	$24,910	202,806	$58,885
2020	**122,184**	**$35,036**	**86,086**	**$25,385**	**208,269**	**$60,421**
2021	129,472	$36,917	88,320	$25,972	217,791	$62,890
2022	137,905	$39,071	90,761	$26,597	228,665	$65,668
2023	146,338	$41,226	93,202	$27,221	239,540	$69,447
2024	154,770	$43,380	95,644	$27,846	250,414	$71,226
2025	**163,203**	**$45,534**	**98,085**	**$28,470**	**261,289**	**$74,004**
2026	159,936	$56,749	96,774	$35,547	256,710	$92,295
2027	165,370	$58,677	98,799	$36,290	264,168	$94,967
2028	170,804	$60,605	100,823	$37,034	271,626	$97,639
2029	176,237	$62,533	102,847	$37,777	279,085	$100,310
2030	181,671	$64,461	104,871	$38,521	286,543	$102,982
2031	187,105	$66,389	106,896	$39,264	294,001	$105,654
2032	192,539	$68,318	108,920	$40,008	301,459	$108,325
2033	197,973	$70,246	110,944	$40,751	308,918	$110,997
2034	203,407	$72,174	112,968	$41,495	316,376	$113,669
2035	208,841	$74,102	114,993	$42,238	323,834	$116,340
2036	201,899	$86,885	112,505	$49,869	314,404	$136,754
2037	207,019	$89,088	114,451	$50,732	321,471	$139,820
2038	212,139	$91,292	116,398	$51,594	328,537	$142,886
2039	217,259	$93,495	118,344	$52,457	335,603	$145,952
2040	222,379	$95,699	120,290	$53,320	342,669	$149,018
2041	227,500	$97,902	122,236	$54,182	349,736	$152,084
2042	232,620	$100,105	124,182	$55,045	356,802	$155,150

4.6.6 SH 130 Element Traffic & Revenue Forecast

The T&R forecast for SH 130, which was divided into four segments, was conducted by URS Corporation. URS assumed that the three northern segments (i.e., Segments 1, 2, and 3) would be opened to traffic by September 2007. Segment 4, the southern part of SH 130, was assumed to be completed by December 2007. Also considered were the various segment upgrades and controlled-access improvements that were scheduled to occur once the initial 2002 Project bonds were retired or when new funding became available.

The toll collection system of SH 130 is also a closed barrier system to minimize non-toll traffic from using the toll road. Each segment of SH 130 was thus designed to have a single mainline barrier with express transponder lanes operating at highway speeds parallel to, but physically separated from cash lanes. These mainline barriers were to be located halfway between the principal interchanges at IH 35, SH 45, US 290, SH 71, and the US 183/SH 45 South junction. The use of ramp plazas in the principal interchanges was thus avoided, which allow for free flowing traffic. No frontage roads were provided along segments containing mainline barriers to prevent motorists from bypassing the mainline barriers.

The toll rates at each of the four mainline barriers were identical, amounting to an initial rate of $1.50 upon opening of SH 130 and then raised every 10 years after 2015. However, the per-mile rate for each of the segments varied, because the segment lengths varied (see Table 4.43). The average mainline toll rate increase between 2007 and 2035 is equivalent to an average annual escalation rate of 3.1%, which is similar to the 3% annual inflation rate included in the CAMPO models.

Table 4.43: SH 130 Mainline Barrier Auto Tolls and Per-Mile Rates (2007 to 2042)

Seg-ment	Limits	Miles	Auto Toll (dollars)				Per-mile Rate (cents)			
			2007-2014	2015-2024	2025-2034	2035-2042	2007-2014	2015-2024	2025-2034	2035-2042
1	IH 35/SH 195 to SH 45	18.2	$1.50	$2.25	$3.00	$3.50	8.2	12.4	16.5	19.2
2	SH 45 To US 290	9.9	1.50	2.25	3.00	3.50	15.2	22.7	30.3	35.4
3	US 290 to SH 71	11.4	1.50	2.25	3.00	3.50	13.2	19.7	26.3	30.7
4	SH 71 to US 183/SH 45 S jct.	9.5	1.50	2.25	3.00	3.50	15.8	23.7	31.6	36.8
Total		49.0	6.00	9.00	12.00	14.00	12.2	18.4	24.5	29.6

The initial ramp toll was set at $0.50 upon the opening of SH 130. It was anticipated that ramp tolls would increase by $0.25 in 2015, 2025, and 2035.

The consultant used the *N minus 1* toll formula to establish the toll charged to vehicles with more than two axles, which translates into these vehicles being charged a multiple of the two axle base rate (see Table 4.44).

Table 4.44: SH 130 Turnpike Vehicle Classification and Toll Multiples

Number of Axles	Toll Multiple
2	1.0
3	2.0
4	3.0
5	4.0
6	5.0

According to URS, this toll structure (a) simplifies coin handling for toll collectors, (b) is more equitable than the straight per axle-rate charged to trucks, (c) increases toll plaza capacity and reduces operating expenses, (d) results in more revenue accountability, and (e) typically produces higher revenues.

URS forecasted average weekday traffic for the model years 2007, 2010, 2015, 2020, and 2025. Traffic forecasts for the intermediate years were interpolated and forecasts for the years beyond 2025 were extrapolated using a decreasing annual growth rate that declined to 2% by the year 2042. The traffic forecasts also accounted for ramp-up, the impacts of scheduled toll increases, as well as intentional and unintentional toll evasion and leakage. A screenline analysis conducted by URS revealed that traffic on IH 35 will continue be highest in the defined SH130 corridor. However, traffic on *"SH 130 will increase appreciably in relative terms"* as anticipated development occurs. Table 4.45 presents the traffic forecasts for SH 130 for the period 2008 to 2042.

Table 4.45: SH 130 Traffic Forecast

Fiscal Year	Average Weekday Toll Transactions by Segment				Total IH 35 - SH 183 N	Traffic Growth Rate (%)
	1	2	3	4		
	IH 35 - US 79	US 79 - US 290	US 290 - SH 71	SH 71 - SH 183 N		
2008	10,159	18,162	8,740	5,100	42,161	
2009	12,982	23,282	12,602	8,900	57,856	37.2
2010	**14,656**	**26,356**	**14,743**	**10,302**	**66,058**	**14.2**
2011	19,136	31,929	19,112	14,430	84,607	28.1
2012	21,534	36,257	21,723	16,290	95,804	13.2
2013	23,599	40,052	24,015	17,903	105,569	10.2
2014	24,999	42,725	25,635	19,012	112,371	6.4
2015	**26,399**	**45,398**	**27,255**	**20,121**	**119,173**	**6.1**
2016	23,821	40,042	22,434	14,575	100,873	-15.4
2017	25,500	43,146	24,348	15,958	108,953	8.0
2018	27,179	46,251	26,262	17,341	117,032	7.4
2019	28,858	49,355	28,176	18,724	125,112	6.9
2020	**30,536**	**52,459**	**30,090**	**20,107**	**133,192**	**6.5**
2021	33,508	57,367	32,956	24,803	148,634	11.6
2022	35,792	61,868	35,786	27,246	160,692	8.1
2023	38,077	66,368	38,617	29,689	172,751	7.5
2024	40,361	70,869	41,447	32,133	184,809	7.0
2025	**42,645**	**75,369**	**44,277**	**34,576**	**196,867**	**6.5**
2026	40,611	64,565	37,677	27,654	170,507	-13.4
2027	42,497	67,707	39,648	29,182	179,035	5.0
2028	44,382	70,847	41,617	30,709	187,555	4.8
2029	46,258	73,968	43,573	32,225	196,023	4.5
2030	48,116	77,055	45,504	33,720	204,395	4.3
2031	49,948	80,093	47,400	35,185	212,626	4.0
2032	51,745	83,066	49,248	36,610	220,670	3.8
2033	53,498	85,958	51,037	37,985	228,478	3.5
2034	55,199	88,751	52,755	39,298	236,004	3.3
2035	56,838	91,430	54,390	40,542	243,200	3.0
2036	54,290	87,354	51,987	38,764	232,395	-4.4
2037	55,675	89,587	53,321	39,761	238,344	2.6
2038	57,046	91,793	54,633	40,740	244,212	2.5
2039	58,422	94,007	55,951	41,723	250,104	2.4
2040	59,802	96,228	57,273	42,709	256,012	2.4
2041	61,185	98,453	58,597	43,696	261,931	2.3
2042	62,569	100,680	59,923	44,685	267,857	2.3

Revenue forecasts for SH 130 considered the toll structure previously discussed, as well as the following assumptions:

- 10% discount for transponder users, which resulted in an initial market share of 40% for auto users and 30% for truck users that increased to 60% for auto users and 50% for truck users by 2025,
- the aggregate toll multiplier for trucks was determined to be 3.1, which assumes a significant percentage of smaller trucks in the traffic mix,
- a seven-year ramp-up period was assumed based on the recent experience of new toll facilities that opened during the 1990s,
- an annualization factor[68] of 320 was assumed to convert average weekday traffic volumes to annual volumes, and
- a 2.5% toll evasion/leakage factor was assumed for the mainline plazas for transponder users and 5% for cash users, while a 2.5% factor for transponder users and a 15% for cash users was assumed for the ramp plazas (see Table 4.46). The difference between the mainline and ramp plaza factors were because the ramp plazas were assumed to be unattended at all times.

Table 4.46: Toll Evasion for SH 130

Toll Plaza Type	Payment Type	Evasion/ Leakage (%)
Mainline Plazas	Transponder	2.5
	Cash	5.0
Attended Ramp Plazas	Transponder	2.5
	Cash	15.0

Based on these assumptions, the consultant forecasted revenues for SH130 between 2008 and 2042 (see Table 4.47).

[68] This factor was developed considering actual data from two non-toll facilities in Austin and two suburban toll facilities in Florida, but was believed to be conservative.

Table 4.47: SH 130 Toll Revenue Forecast

Fiscal Year	Annual Toll Revenue (000) by Segment 1 IH 35 - US 79	2 US 79 - US 290	3 US 290 - SH 71	4 SH 71 - SH 183 N	Total IH 35 - SH 183 N	Revenue Growth
2008	$5,053	$6,839	$4,123	$2,470	$18,485	
2009	6,468	8,817	5,861	4,397	25,543	38.2%
2010	**7,314**	**10,032**	**6,856**	**5,074**	**29,275**	**14.6**
2011	9,082	12,529	8,825	7,065	37,502	28.1
2012	10,249	14,215	10,045	7,943	42,452	13.2
2013	11,261	15,690	11,118	8,698	46,767	10.2
2014	11,955	16,725	11,881	9,207	49,769	6.4
2015	**12,650**	**17,761**	**12,643**	**9,717**	**52,771**	**6.0**
2016	15,956	22,571	14,427	10,114	63,068	19.5
2017	17,159	24,393	15,701	10,990	68,242	8.2
2018	18,362	26,214	16,974	11,866	73,417	7.6
2019	19,566	28,036	18,248	12,741	78,591	7.0
2020	**20,769**	**29,857**	**19,522**	**13,617**	**83,766**	**6.6**
2021	22,968	32,753	20,274	15,880	91,874	9.7
2022	24,632	35,224	22,083	17,245	99,184	8.0
2023	26,296	37,695	23,892	18,611	106,493	7.4
2024	27,959	40,165	25,701	19,976	113,802	6.9
2025	**29,623**	**42,636**	**27,510**	**21,342**	**121,111**	**6.4**
2026	35,700	47,957	33,516	23,471	140,643	16.1
2027	37,358	50,291	35,269	24,768	147,687	5.0
2028	39,015	52,623	37,021	26,064	154,722	4.8
2029	40,664	54,941	38,761	27,350	161,715	4.5
2030	42,297	57,234	40,479	28,619	168,629	4.3
2031	43,907	59,491	42,165	29,863	175,426	4.0
2032	45,487	61,699	43,809	31,072	182,068	3.8
2033	47,028	63,847	45,400	32,239	188,515	3.5
2034	48,524	65,922	46,928	33,354	194,728	3.3
2035	50,041	68,027	48,477	34,484	201,030	3.2
2036	54,753	74,400	53,056	37,746	219,996	9.4
2037	56,150	76,344	54,417	38,717	225,628	2.6
2038	57,533	78,223	55,757	39,671	231,184	2.5
2039	58,921	80,110	57,102	40,628	236,761	2.4
2040	60,312	82,003	58,451	41,587	242,354	2.4
2041	61,707	83,899	59,803	42,549	247,958	2.3
2042	63,103	85,797	61,156	43,511	253,567	2.3

Finally, Table 4.48 illustrates the T&R percentages by vehicle type for SH 130. URS forecasted truck volumes to be approximately 10% of the traffic, but because trucks pay a higher toll rate, they would account for 24.2% to 28.9% of the total revenues. Also, truck transactions as a percentage were expected to decrease over time due to the increased sensitivity of truck trips to increased toll rates.

Table 4.48: SH 130 Transactions and Revenue Percentages by Vehicle Type

Vehicle Type	Percentage				
	2007	**2010**	**2015**	**2020**	**2025**
Auto Transactions	90	89.4	90.6	90.2	91.3
Truck Transactions	10	10.6	9.4	9.8	8.7
Total	100.0	100.0	100.0	100.0	100.0
Auto Revenue	72.4	71.1	74.3	72.9	75.8
Truck Revenue	27.6	28.9	25.7	27.1	24.2
Total	100.0	100.0	100.0	100.0	100.0

4.6.7 Summary of Other Assumptions and Project Revenue Forecast

In addition to the assumptions and adjustments listed in the preceding sections, the consultants also employed the following assumptions in forecasting the toll revenues for the CTTP:

- An annual inflation rate of 3% (compounded) over the forecast period was used.
- An adequate supply of gasoline will prevail during the forecast period, and the gasoline price will not increase above the 1980 peak, which, if adjusted for inflation, translates into a maximum of $2.50/gallon in current year prices.
- Increases in federal and state fuel taxes will also not result in pump prices exceeding $2.50/gallon.
- No radical change in travel modes (resulting in a shift away from private motor vehicle use) is anticipated.
- Normal economic conditions will prevail in Texas and the U.S. Therefore no major economic depression, national emergency, or prolonged fuel storage is anticipated.

Given all the disclosed assumptions, revenues were projected for the CTTP. These revenue forecasts are provided in Table 4.49.

Table 4.49: 2002 CTTP Revenue Forecast

Fiscal Year	Annual Toll Revenue ($'000)			Fiscal Year	Annual Toll Revenue ($'000)		
	Northwest Austin Area Elements	SH 130	Total		Northwest Austin Area Elements	SH 130	Total
2008	16,511	18,485	34,996	2026	92,295	140,643	232,938
2009	24,111	25,543	49,654	2027	94,967	147,687	242,654
2010	30,418	29,275	59,693	2028	97,639	154,722	252,361
2011	34,665	37,502	72,167	2029	100,310	161,715	262,025
2012	37,757	42,452	80,209	2030	102,982	168,629	271,611
2013	39,024	46,767	85,791	2031	105,654	175,426	281,080
2014	40,292	49,769	90,061	2032	108,325	182,068	290,393
2015	41,559	52,771	94,330	2033	110,997	188,515	299,512
2016	54,274	63,068	117,342	2034	113,669	194,728	308,397
2017	55,811	68,242	124,053	2035	116,340	201,030	317,370
2018	57,348	73,417	130,765	2036	136,754	219,996	356,750
2019	58,885	78,591	137,476	2037	139,820	225,628	365,448
2020	60,421	83,766	144,187	2038	142,886	231,184	374,070
2021	62,890	91,874	154,764	2039	145,952	236,761	382,713
2022	65,668	99,184	164,852	2040	149,018	242,354	391,372
2023	69,447	106,493	175,940	2041	152,084	247,958	400,042
2024	71,226	113,802	185,028	2042	155,150	253,567	408,717
2025	74,004	121,111	195,115				

4.6.8 Service Center Revenue Analysis

To minimize the number of toll violations, the TTA developed a program for the identification of violators and the collection of tolls and fees. The consultants[69] thus accounted for the additional revenues that this program—i.e., Violation Enforcement System (VES)—was expected to generate. The VES is to collect revenues from:

- unintentional toll evasions that result from equipment malfunction or problems with the electronic transponders.
- users that did not pay the toll, but that can be identified via video. In this case, a letter will be sent to the user to collect the required toll fee plus a $10 administrative fee.
- users who ignore the letter of violation. In this case, the user will receive a citation, assumed to be $100.

The consultants assumed that 10.8% of the violators will pay the toll, 3.6% will pay the toll plus the $10 administrative fee, and 0.8% will pay the toll plus the $100 citation. TTA will

[69] The consultants also reviewed the VES, the assumptions and methodology, and suggested several modifications.

also receive interest revenue accumulating from the electronic transponder deposits. The latter was estimated at 3% per year over the lifetime of the project. The service center revenue forecasted by the consultants is provided for selected years in Table 4.50.

Table 4.50: Customer Service Center Revenue Forecast (Selected Years)

Fiscal Year	Revenue ($'000)			Total Service Revenues ($'000)	Interest Earned On Tag Deposit ($'000)	Total CSC Revenues ($'000)
	Toll	Toll + $10 Fee	Toll + $100 Citation			
2008	190	700	1,390	2,280	80	2,360
2009	260	990	1,960	3,210	160	3,370
2010	320	1,250	2,470	4,040	230	4,270
2015	420	1,550	3,050	5,020	760	5,780
2020	700	1,920	4,670	6,290	1,000	7,290
2025	770	2,120	4,030	6,920	1,050	7,970
2030	1,050	2,300	4,240	7,590	1,050	8,640
2035	1,230	2,670	4,920	8,820	1,050	9,870
2040	1,510	2,890	5,210	9,610	1,050	10,660
2042	1,580	3,010	5,430	10,020	1,050	11,070

4.6.9 Sensitivity Analysis

The consultants also identified key variables and conducted a sensitivity analysis to determine how the forecasted T&R would change given reasonable changes in these key variables. The sensitivity analysis conducted is briefly summarized in this section.

Network Changes

The consultants removed two turnpike projects—i.e., US 183A and the eastern portion of SH 45 South—that are not part of the CTTP. The removal of US 183A will affect revenues on Loop 1, SH 45, and the northern sections of SH 130. It was argued that the removal of US 183A would increase the revenues on the CTTP, because the additional congestion would divert more users to Loop 1, SH45, and SH 130. In contrast, the removal of SH 45 South will result in a minor loss of revenue for the southernmost section of SH 130, which will partially offset the revenues gained in the northern sections. The results from removing these two turnpike projects are summarized in Table 4.51.

Table 4.51: Sensitivity Analysis to Network Changes

	Northwest Austin Area Elements	SH 130	Total CTTP
Revenue Difference from Base Case	+3%	+4%	+4%

Early Completion of Competitive Roadways

The consultants tested the revenue impacts resulting from the early completion of non-tolled alternatives to the CTTP. The completion of the facilities was assumed to occur in 2015 instead of 2020 and 2025. The facilities considered were:

- extension of Anderson Mill Road and Howard Lane,
- upgrading US 183 South,
- addition of IH 35 HOV lanes, collector-distributor roads, and express lanes, and
- widening of FM 973.

The anticipated revenue impacts are provided in Table 4.52.

Table 4.52: Effect of Early Completion of Competitive Roadways

	Northwest Austin Area Elements	SH 130	Total CTTP
Revenue Difference from Base Case	-2%	-5%	-4%

Socioeconomic Sensitivities

The consultants tested the revenue impacts associated with changes in the regional population and employment growth estimates, as well as changes in these growth estimates in the northwest area and SH130 corridor. The results are provided in this section.

Regional Growth Reduction

The consultants tested the impact on revenues if the regional population growth rate was 1.7% per year instead of 2.6% per year between 2000 and 2015. At the same time regional employment growth was also reduced from 2.5% to 1.3% per year. The impact on the 2015 revenues is illustrated in Table 4.53.

Table 4.53: Effect of Regional Growth Reduction

	Northwest Austin Area Elements	SH 130	Total CTTP
Revenue Difference from Base Case	-18%	-20%	-19%

Northwest Area Growth Reduction

The consultants tested the revenue impacts resulting from a reduced population growth rate of 1.7% per year (instead of 2.6% per year) and an employment growth rate of 1.6% per year (instead of 2.3% per year) in the Northwest Austin study area between 2000 and 2015. The rest of the metropolitan area was assumed to develop as forecasted in the base case. The revenue impacts are illustrated in Table 4.54.

Table 4.54: Effect of Northwest Area Growth Reduction

	Northwest Austin Area Elements	SH 130	Total CTTP
Revenue Difference from Base Case	-8%	-1%	-4%

SH 130 Corridor Growth Reduction

Similarly, the consultants tested the revenue impacts resulting from a reduced population growth rate of 2.1% per year (instead of 3.2% per year) and an employment growth rate of 2.5% per year (instead of 4.3% per year) in only the SH 130 corridor area between 2000 and 2015. The revenue impacts are illustrated in Table 4.55.

Table 4.55: Effect of SH 130 Corridor Growth Reduction

	Northwest Austin Area Elements	SH 130	Total CTTP
Revenue Difference from Base Case	-12%	-19%	-164%

Toll Diversion Coefficient Sensitivities

The two toll diversion coefficient tests that were conducted are summarized in this section.

Use of Northwest Elements Toll Coefficients for SH 130

In this case, the consultants used the toll diversion coefficients of the Northwest elements for predicting revenues on SH 130 and for the CTTP. The results are provided in Table 4.56.

Table 4.56: Revenue Change by Using Northwest Austin Area Coefficients for SH 130

	Northwest Austin Area Elements	SH 130	Total CTTP
Revenue Difference from Base Case	N/A	-13%	-7%

Use of Toll Coefficients for the 2002 Project Halfway Between the SH 130 Coefficients and Those from the Stated Preference Surveys

In this case, the consultants used cost coefficients in the toll diversion curves that were halfway between the values used for SH 130 and the values determined from the SP surveys. This resulted in a reduction in the VOT of potential users, which reduce their likelihood of using the toll roads; thereby impacting revenues (see Table 4.57).

Table 4.57: Revenue Change by Using 2002 Project Halfway Coefficients

	Northwest Austin Area Elements	**SH 130**	**Total CTTP**
Revenue Difference from Base Case	-9%	-22%	-16%

Sensitivity to Inflation Rates:

The revenue impacts of an inflation rate of 2.5% and 2.0% (instead of 3.0%) are illustrated in Table 4.58.

Table 4.58: Effect of Inflation Rate Change

Inflation Rate		**Northwest Austin Area Elements**	**SH 130**	**Total CTTP**
Revenue Difference from Base Case	2.5%	-2%	-5%	-4%
	2.0%	-4%	-10%	-7%

Traffic/Toll Elasticity and Rate Sensitivity

Toll elasticity is used to calculate the relative decrease in toll transactions (i.e., traffic) given an increase in the toll costs. Toll elasticity was defined as:

e = (percent change in volume*)/(percent change in toll**)
* Relative to the volume at the lower toll
** Relative to the lower toll

Values less than -0.1 are considered relatively inelastic, meaning that substantial increases in the toll rates do not result in significant reductions in the traffic. Values from -0.1 to -0.25 are considered to be moderately inelastic and values from -0.26 to -0.4 are considered to be moderately elastic. Values higher than -0.4, however, are relatively elastic, meaning that toll users are very sensitive to toll costs.

The model outputs revealed that usage of SH 130 was more sensitive to increases in tolls than the Northwest Austin Area elements. According to the consultants, the revenue of SH 45 would be maximized at a toll rate three times (i.e., $3.00) the base toll rate of $1.00 per barrier, producing about 1.5 times the base revenue. Loop 1 revenue would be maximized at about four times the base toll of $1.00, producing nearly double the base toll revenue. SH 130 revenue would be maximized at a toll level between one and two times the base toll.

4.6.10 Comparison between Forecast and Actual Data

Socioeconomics Factor: Differences in Forecast Population and Actual Population

Actual population data by county was obtained from the Texas State Data Center website and compared with the forecasted data used in the T&R report (see Table 4.59). From Table 4.59 it is evident that all three counties (i.e., Travis, Williamson, and Hays County) experienced higher annual population growth rates between 2000 and 2007 than what was forecasted in the 2002 T&R report.

Table 4.59: Actual and Forecasted Population by County

Year	Travis County		Williamson County		Hays County		Total|('000)	
	Forecast	**Actual**	**Forecast**	**Actual**	**Forecast**	**Actual**	**Forecast**	**Actual**
2007	869,533	947,215	308,313	370,616	108,430	139,699	1,286	1,458
Annualized Growth Rates (%)								
	Forecast	**Actual**	**Forecast**	**Actual**	**Forecast**	**Actual**	**Forecast**	**Actual**
2000-2007	0.98	2.22	3.04	5.79	1.52	5.26	1.49	3.32

Source: Texas Data Center, 2008

Difference in Forecast and Actual Roadway Network Change

Table 4.60 provides the anticipated and actual opening dates of the various CTTP elements. From Table 4.60, it is evident that most CTTP roads/segments opened to traffic prior to the scheduled dates. The only exceptions are SH 130, Segment 3 (US 290 to SH 71), which opened on September 6, 2007, five days later than scheduled, and SH 130, Segment 4 (SH 71 to US 183), which was scheduled to open on December 1, 2007, but which actually opened on April 30, 2008.

Table 4.60: Actual and Scheduled Opening Dates by CTTP Road/Segment

Road/Segment	Scheduled Opening	Actual Opening
Loop 1	9/1/2007	10/31/2006
SH 130, Segment 1, IH 35 to US 79	9/1/2007	12/13/2006
SH 130, Segment 2, US 79 to US 290	9/1/2007	10/31/2006
SH 130, Segment 3, US 290 to SH 71	9/1/2007	9/6/2007
SH 130, Segment 4, SH 71 to US 183	12/1/2007	04/30/08
SH 45, Loop 1 to SH 130	9/1/2007	10/31/2006
SH 45, US 183 to FM 620	9/1/2007	4/23/2007

Source: Central Texas Turnpike System (CTTS), 2008

Differences in Forecast ETC Share and Actual ETC Share

The 2002 T&R report assumed a 2007 ETC market share of:

- 30% for autos and 25% for trucks on Loop 1 and SH45, and
- 40% for autos and 30% for trucks on SH 130.

An analysis of actual 2007 transaction data obtained from PBS&J revealed an ETC market share of:

- 82% and 86% of total transactions on Loop 1 and SH45, and
- 79% of total transactions on SH 130.

From this data it seems that the ETC share was underestimated in the 2002 report.

SH130 Transaction Percentages by Vehicle Type

The 2002 T&R report forecasted that auto transactions would constitute 90% of the total transactions on SH 130 and that trucks would represent 10% of the transactions in 2007. An analysis of actual 2007 transaction data obtained from PBS&J revealed that autos represented 95% of total transactions in 2007 and trucks represented 5%. It thus seemed that the truck share was overestimated in the 2002 report.

Loop 1 and SH 45 Weekend Transactions

The 2002 T&R report assumed that weekend traffic on Loop 1 and SH 45 would be 50% that of weekday traffic in 2007. However, an analysis of actual 2007 transaction data obtained from PBS&J revealed that weekend traffic represented 25% and 26% of weekday traffic on Loop 1 and SH 45, respectively in 2007.

Toll Evasion and Service Center Fees

In the 2002 T&R report, the consultants assumed a 2.5% toll evasion factor for transponder users and a 5% evasion factor for cash payers traversing the mainline and attended ramp plazas on Loop 1 and SH 45. Toll evasion on the unattended ramp plazas were estimated at 2.5% for transponder users and 20% for cash users. Similarly, a 2.5% evasion factor for transponder users traversing the mainline and attended ramp plazas on SH 130 was assumed. However, an evasion factor of 5% and 15% for cash payers traversing the mainline and attended ramp plazas, respectively, on SH 130 was assumed. Based on data provided by TTA, Samuel (2009) calculated that toll evasion (i.e., unpaid tolls) amounted to 2.94% of CTTS toll revenue for the period January 2007 to May 2009. Although difficult to compare with the numbers included in the T&R report, unpaid tolls on the CTTS seems to be problematic. Samuel reported that by the end of June 2009, approximately 140,000 vehicle owners failed to have paid nearly $3.2 million in tolls.

Samuel (2009) also documented the procedure adopted by TTA to collect unpaid tolls. The procedure is quite different from the VES program assumed in the service center revenue analysis section of the T&R forecast. TTA is using video tolling or "Pay by mail" to generate a bill for unpaid toll plus TTA charges a $1.00 administrative fee. Two invoices reflecting these charges are sent within 45 days to the user. If TTA does not receive the money by day 75 $5.00

is added to the bill. TTA will waive half the fees if the user pays the bill and opens a TxTag account at the same time. At day 112 the unpaid bills are sent to a collection agency, which adds a $25 fee. At day 200 the non-payer can be taken to the Justice of the Peace Court. The differences between the VES program and the actual enforcement program adopted by TTA are illustrated in Table 4.61.

Table 4.61: Anticipated and Actual Violation Enforcement Procedures

Violation Enforcement System (T&R Report)		**Violation Enforcement Procedures (TTA)**	
Procedure	**Payment Due ($)**	**Time Period to Settle Payment**	**Payment Due ($)**
Payment on receipt of violation letter	10	Within 45 days	1
Payment on receipt of citation resulting from ignoring letter of violation	100	By day 74	5
		By day 112	25
		By day 200	Taken to Court

Source: 2002 TTA Bond Document, Samuel, 2009

Other Assumptions

The 2002 T&R report assumed an annual inflation rate of 3% per year. According to the Texas Comptroller's Office (2009), the annual inflation rate between 2002 and 2007 was between 1.5% and 3.7%.

Table 4.62: Actual Inflation Rate (2002-2007)

	2002	**2003**	**2004**	**2005**	**2006**	**2007**
CPI (1982-1984=100)	178.9	183.1	187.4	193.5	200.6	205.3
Annual Percentage Change (%)	1.5	2.4	2.3	3.3	3.7	2.3

Source: Texas Comptroller's Office, 2009

The consultants also assumed that gasoline would remain in adequate supply and that the current year price of gas would never exceed $2.50/gallon during the forecast period. However, according to the U.S. Energy Information Administration (2009), in 2007 the price of gas reached $2.77/gallon and in 2008 the price of gas peaked at $3.21/gallon.

Finally, the consultants assumed that normal economic conditions will prevail in Texas and the U.S. Therefore no major economic depressions were assumed. However, in late 2008, the U.S. economy contracted and entered into a recession that still prevailed at the time this report was published.

Comparison of Forecasted and Actual Transactions and Revenue

The consultants included T&R forecasts for the period 2008 to 2042 in the 2002 T&R report, while actual transaction and revenue data is available for 2007 and 2008. The result is that only the forecasted and actual data for 2008 could be compared (see Tables 4.63 and 4.64).

Table 4.63: Forecasted and Actual Transactions (2008)

Toll Road	Actual Transactions	Forecasted Transactions	Difference (Transactions)	Difference (%)
Loop 1	54,770	39,535	15,235	39
SH 45	91,057	36,664	54,393	148
SH 130	58,267	42,161	16,106	38
System	204,094	118,360	85,744	72

Note: In calculating the figures, revenue and transaction data by collection type was rounded to the nearest hundred.
Source: Actual transaction data and cash revenues were obtained from CTTS 2008 Transaction Report (2009).

Table 4.64: Forecasted and Actual Revenue (2008)

Toll Road	Actual Revenue ($)	Forecasted Revenue ($)	Difference (Revenue)	Difference (%)
Loop 1	10,822,600	8,912,400	1,910,200	21
SH 45	16,982,500	7,599,600	9,382,900	123
SH 130	18,370,000	18,484,800	(114,800)	-1*
System	48,905,800	34,996,800	13,909,000	40

Note: Forecasts were based on all 49 miles of SH 130 being open and tolled. Full tolling on Segment 4, however, did not materialize until September 2008. However, revenue projections in the last two quarters of 2008 surpassed projections for the time period.
Source: Actual transaction data and cash revenues were obtained from CTTS 2008 Transaction Report (2009).

From the tables above, it is evident that the 2002 T&R report underestimated the transactions and revenue generated by the CTTS in 2008.

4.7 Concluding Remarks

The research attempted to replicate and extend the work conducted previously by financial analysts at S&P and J.P Morgan. However, a replication of the work done by S&P was hampered by the fact that the analysts did not describe the research method in any detail. For example, S&P noted the use of initial forecasts, but it is unclear whether the forecasts were transactions, daily traffic, or annual traffic. Also, it is unclear if the facility opened in segments what was regarded as the first year of operation, i.e., the opening of the first section or the opening of the whole road? The researchers attempted numerous times to meet with the analysts to clarify the methodology, but were unsuccessful. Furthermore, the analysis was also complicated by the lack of information and specificity included in the T&R reports.

4.7.1 Data Sourcing

Oftentimes the data used were not sourced.[70] This introduced some concerns about an apples-to-apples comparison when comparing, for example, population and employment growth rates to the forecasted values included in the T&R reports. In a number of cases historical growth rates could be obtained from a reputable government agency, such as the Bureau of Economic Analysis or Statistics Canada, but it was not clear whether this was the original data source. A lack of data also prevented the verification of certain assumptions that were documented in the T&R report. For example, actual trips generated from specific land uses could not be verified because origin and destination information are not available from the transaction data.

4.7.2 Embedded Assumptions

Even T&R studies dated 2007 that provide a significant amount of well-sourced data are often not explicit about the assumptions embedded in the T&R approach. Vague statements, such as "*historical demographic and economic trends are assumed to continue into the future*" were standard in many of the T&R reports. The actual rates assumed were often not provided and it is unclear how, or even if, some of these values—i.e., motor vehicle registration trends—are used in the forecasting process.

4.7.3 Lack of Specificity

T&R consultants typically estimate the number of transactions and revenue for the base year and for selected future modeled years. The annual transaction and revenue numbers for the non-modeled years are then obtained through interpolation or extrapolation. For example, Halcrow only provides toll usage numbers for three years, and explains that the non-modeled year's forecasts were estimated using simple interpolation. Simple linear interpolation was used in an effort to replicate the values provided by Halcrow (see Table 4.28). However, it is evident from the values obtained that simple linear interpolation was not used by the consultant. Furthermore, broad statements, such as repeat or replicate the process, can be very misleading. On a number of occasions when the research team attempted to replicate a calculation, different results were obtained from what was included in the T&R report.

70 However, the newer T&R reports source data substantially better than the earlier studies done in the 1980s.

Table 4.65: Halcrow and Interpolated Users/day

Year	Users/day	
	Halcrow	Interpolated
2002	286,600	261,330
2003	303,800	282,660
2004	322,200	303,990
2005	340,200	325,320
2006	358,100	346,650
2007	375,800	367,980
2008	394,500	389,310
2009	414,300	410,640
2010	433,600	431,970
2011	453,300	453,300

Source: 407 International Bond Issuance, 1999

4.7.4 Revenue Emphasis

The analysis was also complicated by the fact that, especially in the case of the earlier studies, the emphasis seems to be on revenue estimation as opposed to toll demand estimation. This is reasonable to the extent that these T&R studies are often reviewed to determine the bonding capacity of the facility, but it further reduces the transparency of the calculations. For example in the Houston case study, the T&R consultant only provided ADT values for a limited number of years and annual revenue values. In this case, there was no discussion about the annualization factors used to estimate either annual volume or revenue. Although the research thus did not reveal any optimism bias in the forecasting of toll road usage, this was partly attributable to a lack of forecasted toll usage data.

4.7.5 Key Variables

In general there is little discussion, if any, about the key variables that could introduce uncertainty into T&R forecasting. The exception is the Halcrow study that was done for the private concessionaire in the bidding for the 407 ETR. This T&R study was by far the most detailed—even when compared with the newer 2002 WSA's Westpark T&R study and the 2002 Central Texas Turnpike Project T&R Forecast—and included both an extensive sensitivity and risk assessment. The next chapter summarizes the research team's findings in terms of areas that require an improved understanding to enhance the reliability of T&R forecasts.

Chapter 5. Traffic and Revenue Forecasting Uncertainties

> "Current professional practices and procedures were used in the development of these findings. However, there is considerable uncertainty inherent in future traffic and revenue forecasts for any toll facility. There may sometimes be differences between forecasted and actual results caused by events and circumstances beyond the control of the forecasters. These differences could be material. Also, it should be recognized that traffic and revenue forecasts in this document are intended to reflect the overall estimated long-term trend. Actual experience in any given year may vary due to economic conditions and other factors" (Wilbur Smith Associates, 2007).

As the statement from WSA indicates, there are some inherent uncertainties in the forecasting of T&R for tolled facilities. This research study conducted an extensive review of four mature toll roads and the Central Texas Turnpike Project (CTTP). A number of the T&R reports reviewed were thus quite dated. For example, the T&R studies reviewed for Orlando was conducted in the mid-1980s and early 1990s with the result that the 1986 T&R did not provide any forecasted transactions and only forecasted revenues for six years for the northeastern segment and for four years for the southwestern segment. This might have been standard at that time, but made the replication of the S&P methodology impossible. These older T&R reports also listed very few model input assumptions—for example, only population growth in the case of the 1986 T&R for the northeastern and southwestern segment of the Eastern Beltway in Orlando. However, based on the case studies reviewed, there seems to be no evidence to point to a systematic optimism bias in T&R forecasts.[71] Nonetheless, this chapter of the report identifies a number of areas that requires an improved understanding to enhance the reliability of T&R forecasts.

5.1 Traffic Forecasting Model

There seems to be a general consensus in the literature that the models adequately perform their function and that unreliability stems from the inputs into those models. Most stakeholders interviewed agreed that the problems with toll forecasting performance stems from the application of the models, not the models themselves. The exception is Halcrow. Halcrow acknowledged that their model introduces some errors, but the consultant is not sure about what they are or the impact that they have. Model errors and the estimation methods adopted must have an impact on the T&R forecasts, but the issue is that the extent of the model error is largely unknown in the industry.

All the T&R consultants interviewed noted that the travel demand models developed by regional planning bodies or MPOs for long-range planning are typically used as the starting point when conducting toll traffic forecasts. These models are aggregate models and each T&R

[71] As mentioned earlier, the data on toll usage was largely insufficient to draw any conclusions about optimism bias from. However, the forecasted revenue data were more comprehensive and did not point to any optimism bias (see Appendix B to E). Although revenues were overestimated on all four segments of the Orlando Eastern Beltway (i.e., the northeastern segment, the southwestern segment, the southern connector, and the Seminole Expressway), the Hardy toll road (1984), and the Westpark Tollway, revenues were underestimated on the 407 ETR, the Hardy toll road (1994), the Sam Houston West, East, and South Tollways, the HCTRA system, SH190 Segments I to V in Dallas, and the CTTP. In the case of the West Belt Tollway, revenues were slightly over-predicted in the first 10 years of the road's operation, but subsequently revenues exceeded forecasts.

consultant has a proprietary approach to adapt the inputs from these models, as well as the models to conduct corridor types of analysis. The models and their structure was not the focus of this research, but it is questionable whether these regional travel demand models are sensitive enough to model commuter and trucker's responses to the tolls charged. For example, tolling introduces several complicating factors, the most notable being the cost of the trip. In travel demand models, a particular route will be chosen if it is superior in generalized cost terms—approximate to be the cost of time plus toll paid. However, cost is perceived differently depending on the individual's economic and personal flexibility. Individuals who have a low value of time (VOT) may choose to use non-tolled routes, in spite of delays. Others may have a threshold of resistance to paying a toll. Because of the unpredictability of such behavior in a mixed tolled/non-tolled system, the modeling of route choice is problematic when using traditional travel demand models. Also, the embedded growth assumptions—while conducive to planning—may not be sufficiently conservative to support debt repayment on the toll route.

5.2 Model Input Assumptions

Forecasting uncertainty also result from inferior data or incorrect model assumptions. T&R forecasts are a function of numerous assumptions regarding national, local economic, and local demographic growth, the willingness of road users to pay tolls, the estimated time savings, and ultimately the implicit value placed on time by potential toll road users. In conducting a detailed review of the selected case studies, all input assumptions were reviewed, but special attention was given to the following input assumptions: economic growth, demographic projections (e.g., income, population, employment), fuel, expected traffic growth rates, land use and future development, VOT, and transportation network changes that have contributed to/or detract from the toll road.

An analysis of the model input assumptions and their impact on the forecasted T&R were, however, often hampered by poor data sourcing, a lack of documentation on how and, in some instances even if, analyzed data variables were included in the T&R process, and a lack of documentation in terms of identifying the key *"driving"* variables in the analysis and the impact of changes in these variables on T&R forecasts. In some cases this prevented the verification of assumptions and an assessment of the impacts on forecasts.

5.2.1 Economic and Demographic Factors

Optimistic or pessimistic future year economic growth assumptions, inflated population and employment growth, and development and land use scenarios that never transpire impact T&R forecasts. In an interview with URS, it was stated that T&R forecasts are particularly sensitive to assumptions about economic growth and land use, because it has an impact on the demand for the facility and thus usage of the facility. URS mentioned that one of the first questions they wish to answer when forecasting usage of a toll road is "What is the demand?" (personal interview with URS, 2008)

Population forecasts are said to impact trip generation in a zone, while employment forecasts impact trip attraction to a zone. There is a general perception that the MPO forecasts, and consequently their models, tend to be overly optimistic. This is partly because these model outputs are used to motivate for federal funding. However, each MPO is different and caution should be applied in assuming that all MPO models are overestimating travel demand. For example, the North Central Texas Council of Governments (NCTCOG) in Dallas/Fort Worth is often conservative in their estimates (personal interview with North Central Texas Council of

Governments, 2008). T&R consultants also typically employ independent consultants to verify the estimates of the MPOs.

The research findings also pointed to substantial uncertainty surrounding the use of historical growth rates to predict future employment and population growth rates. In all the case study examples, either employment or population or both were under or over predicted. Yet, with the exception of the Halcrow and the CTTP reports, no other T&R study reviewed attempted to determine the impact on the forecasted T&R attributable to changes in the assumed employment and population growth rates.

It is recognized that the prediction of future economic, population, and employment growth is extremely difficult. These variables can be influenced by unpredictable occurrences, such as security issues (e.g., post 9/11), legislation, the price of fuel (e.g., Houston was severely affected by the oil crises), etc. Of more concern is the vague statements, such as "*historical demographic and economic trends are assumed to continue into the future*" that were standard in many of the T&R reports. The actual rates assumed and included in the models were often not provided.

Land development and land use assumptions also introduce uncertainty into the T&R process. For example, planned land development around a corridor can be delayed until the road is built. This land use lag can result in less traffic demand in the first years, aggravating the ramp-up period (personal interview with URS, 2008). URS reported to err on the conservative side in forecasting land use developments in the Seminole Expressway corridor. Similarly, Vollmer assumed delays in the construction and thus opening of various facilities that were under construction at the time of Vollmer's T&R report for the Southern Connector. For example, Vollmer assumed for 9 of the 21 developments that were under construction in the considered corridor that:

> "only 80 percent of the first phase of each development would be completed as scheduled with the remaining 20 percent completed with the second phase…The developments used for vehicle trip generation were reduced in size to reflect 80 percent of the development scheduled for completion after 1995, 70 percent after 2000, and 60 percent after 2005."

Nonetheless, revenues were overestimated on all four segments of the Orlando eastern bypass (i.e., the northeastern segment, the southwestern segment, the southern connector, and the Seminole Expressway). It is also not clear how the land use assumptions affected the estimation of the revenues.

Finally, some T&R reports included a review of various factors, such as the trends in new building permits and residential housing activity (i.e., number of homes sold and the amount of time houses are on the market), age distribution of the population, vehicle registration trends, and number of visitors. It is, however, unclear how this information is incorporated into the T&R forecasting approach, if at all, and the impact of changes in these variables.

5.2.2 Inflation

In most of the T&R studies reviewed, it is unclear how inflation is treated. Most of the T&R studies do not indicate whether values are in nominal or real dollars. The exception again is Halcrow who estimated all values in real (constant) dollars. The values in the 2007 T&R study that supported the acquisition of SH121 were provided in nominal (current year) dollars. In this T&R study, the Consumer Price Index (CPI) was used as a measure of inflation. The T&R study tabled the historical CPI for all urban consumers between 1967 and 2006. However, the two different inflation rates assumed for the DNT and SH121 did not resemble the past growth rates calculated. Furthermore, no justification for the two adopted rates was provided.

WSA uses the inflation rates forecasted by the state (e.g., Texas Comptroller) in their forecasts. However, it is assumed that the relationship between income and inflation is constant. In other words, income and VOT are assumed to increase at the inflation rate. In reality, income can increase at a higher or lower rate than the inflation rate. The toll escalations adopted can also be at a higher or lower rate than the inflation rate, but in general WSA try and keep the rate at which VOT and the toll rate increases constant. All revenues are forecasted in nominal dollars (personal communication with Wilbur Smith Associates, 2008).

5.2.3 Value of Time

Value of time (VOT) is important regardless of whether toll traffic is modeled in mode choice, network assignment, or when estimating a diversion rate. According to the T&R consultants interviewed, forecasts for VOT are highly dependent on the history of tolling in the area, level of congestion, and income of potential users. Without an existing toll road or toll system in the area, this value is based on stated preference surveys, demographic information, and time savings calculations. However, stated preference surveys do not always provide accurate estimates. WSA noted VOT does not follow a normal distribution and is often heavily skewed toward one extreme (personal interview with Wilbur Smith Associates, 2007).

Despite the acknowledged importance of the VOT assumptions, only the Halcrow report addressed VOT explicitly. In all the other T&R reports, the assumptions about VOT are not revealed. Halcrow tested the impact of a 25 percent higher and 25 percent lower VOT on the forecasted traffic volumes for years 2001 and 2011. The results in Table 5.1 illustrate the importance of VOT in determining toll road usage. It is clear that uncertain VOT assumptions can lead to large differences in forecasted traffic volumes (especially if VOT was overestimated).

Table 5.1: Percent Change in Value of Time

		AM Peak		Inter-Peak	
		+ 25%	-25%	+ 25%	-25%
Percent Change in Revenue	2001	10.30	-17.50	5.40	-27.50
	2011	4.10	-12.80	2.10	-28.40

However, in the case of the 407 ETR, it seems that the consultants vastly underestimated the VOT and the Toronto motorists' willingness to pay to use the toll road. Despite the very aggressive toll rate schedule implemented by the private concessionaire, toll traffic is still increasing on the road.

5.2.4 Truck Usage

The literature suggests tremendous uncertainty surrounding truck usage of toll roads. In general, truck modeling is not a focus of the local MPO planners. This is in part due to the fact that MPOs gather little data—current or historical—about truck usage in an area. The lack of data is compounded by the fact that little is known about the behavioral responses of different truck user categories to tolling (Krieger, 2007), as well as the cost structures of these different user categories and the associated impact on trucker's decisions to use toll roads.

Trucks are believed to have a different VOT than the average motorist, and within the trucking community, different market segments have different reactions to tolling. For instance, an owner-operator might be less willing to pay a toll if it cuts into his bottom line. However, if the owner can pass the toll cost onto the shipper, he might be more willing to incur the cost to benefit from a significant time savings.

The T&R consultants interviewed stated that the emphasis placed on forecasting truck traffic depends on the toll road's characteristics. If the planned toll road is in an urban area and non-toll alternatives are available, less emphasis might be placed on the truck analysis. However, if it is an inter-city route or an urban bypass around a congested urban area, then the analysis effort will typically increase. In none of the case studies reviewed was truck usage of toll roads discussed or analyzed in detail.

In general, it has been assumed that the historical truck percentage of traffic volume will apply to the toll road (or at least be similar) (Knorring and Kornhauser, 2005). In most T&R studies, truck usage is thus estimated as a percentage of the toll transactions. For example, WSA's 1998 T&R report for the 407 ETR stated that:

> "freight traffic is not explicitly modeled as a separate class (it forms 7 percent of current [407 ETR] trips) but the extra revenue generated by these vehicles is taken into account in the revenue estimates (through increases to assumed toll rates in the revenue calculations)."

This assumption seems to be overly simplistic given the lack of understanding of trucker's behavioral responses to toll roads. A more rigorous consideration of the factors that influence the usage of particular toll roads are required to ensure a more robust forecasting of truck toll road use.

5.2.5 Ramp-Up

Some feel that the road will always be playing catch up if it experienced a difficult ramp-up period, i.e., an underestimation of both the duration and use of toll roads during the ramp-up period (personal interview with Jim Ely, 2008). Others have argued that concerns about the difference between forecasted and actual toll road usage often stems from the undue focus on the ramp-up period. The ramp-up period is particularly uncertain, often exhibiting a higher degree of variability and unpredictability than the later operating years. According to Halcrow:

> "Ramp up represents the inertia of drivers to route changes; that is some drivers tend to stay on a tried and tested route even when a shorter or quicker alternative is possible, and only drift over to a the new route gradually over time" (407 International Bond Issuance, 1999).

The ramp-up period is assumed to have ended when the road's traffic growth is in line with the area-wide traffic growth rates (Bain, 2002). Historically, the ramp-up factor has been based on experiences with similar types of facilities and a T&R consultant's professional judgment, leading to *"spotty"* results and the inability to adequately predict ramp-up.

In an interview with URS (2008), it was noted that the ramp-up factor is a function of the road's characteristics, location, marketing efforts, payment collection type, the transponder penetration rate in the area, the area's transportation network, signage to the road, ramp-up for similar types of facilities, and most importantly professional judgment (personal interview with URS, 2008). For example, ramp-up is thus forecasted differently for a beltway road than for a road that is strongly integrated into the area's existing highway network. However, it is not clear how each of these variables impact the ramp-up factor. It is suspected that professional judgment is the dominant factor in deciding the length of the ramp-up period and the usage during this period. Usually, the ramp-up factor is expressed as a certain percentage of the volume or transactions (given no ramp-up).

5.2.6 Planned Capacity Enhancements

Trommer (2006) and Kerali (2005) reported that steady state assumptions in models assume no changes to the transportation network in terms of both the extent and capacity of the system. Improvements to competing non-tolled alternatives or other substitute services are thus largely ignored. The findings of this research do not support the findings of Trommer and Kerali. The extent to which transportation network changes were considered is less clear from the T&R studies for Orlando. However, the T&R study did at a minimum consider the impact of an access road to the airport on the northeastern and southwestern segments of the Orlando bypass. Also, it is not clear if and how the widening of US59 and the improvements to I45 were considered in the T&R forecasts for the Hardy toll road as these improvements definitely contributed to the Hardy toll road not meeting forecasted traffic volumes. In the newer studies, the T&R consultants assumed certain network improvements (e.g., additional toll, non-toll, and transit capacity) for the modeled years. These network improvements are usually obtained from the MPOs and state DOTs. However, the T&R studies did not specifically document or list the capacity improvements that were modeled.

5.2.7 Gas Prices

Higher gas prices impact transportation demand and are typically a factor in the mode choice and network assignment steps of the travel demand model. Few T&R studies mention the price of gas. WSA included an assumption that gas prices will remain reasonable, but did not provide any values. It is, however, clear from the revenue patterns on several toll roads that during periods of increasing gas prices—as were experienced in the early and late 1970s—that toll road usage slowed or even decreased. A similar pattern is observed during periods of economic downturn as was experienced in the early and late 1990s. The impact of gas prices on toll road usage is an area that needs a more detailed review and understanding.

5.2.8 Toll Collection System

It is often argued that in addition to the time savings associated with not needing to stop, an electronic tag makes the user less sensitive to the toll rate charged and thus would impact toll road usage positively. For example, for the 407 ETR, WSA (and subsequently Halcrow) predicted ETC usage, but it is not clear to what extent this factor impacts toll usage forecasts. The impact of ETC on toll road usage is an area that needs a more detailed review and understanding.

5.2.9 Annualization Factors

As indicated before, an annualization factor is a value that is used to convert daily traffic volumes and revenues to annual values. From the Halcrow T&R study, it can be concluded that the annualization factor is a function of the variation in traffic volume, vehicle characteristics, and transponder usage by time-of-day, day-of-week, and season. An annualization factor thus attempts to balance these differences out and allow daily volumes to be converted to annual volumes. Ultimately revenue is estimated on an annual, not daily, basis. In the research team's comparison of estimated annual trips using the annualization factor and the actual annual trips, it appeared that the estimates using the annualization factor resulted in an over prediction of the actual annual trips by almost 5 percent. This would also result in an overestimation of the revenue. However, there is little discussion of the annualization factor, how it is determined, or the rationale for adjusting the factor.

5.3 Political Environment

5.3.1 Political Champion

Most of the toll roads reviewed had a champion—sometimes a political champion—who aggressively pursued the construction of the road often over decades. The Eastern Beltway champion was the OOCEA chairman Jim Greene, for which the OOCEA portion of the road was eventually renamed. The construction of the initial 43-mile (69-km) central section of Highway 407 was championed by the Rae government—in particular Deputy Minister of Transport George Davies. In the case of the Southern Connector (a section of Orlando's Eastern Beltway), a group of influential landowners lobbied successfully for its construction. In the case of the Southern Connector Extension, the Disney theme park played a pivotal role. In this case, Disney acquired the land in the area and contributed (together with three other land owners) almost half of the funding towards the completion of the Southern Connector Extension.

Many times these champions raised public awareness about the toll road's key role in the city's transportation system, mediated among the habitually feuding stakeholders, sometimes motivating the passage of new legislation to allow tolling, and in Davies's case developed Ontario's first large scale infrastructure project and their first major PPP. Without these champions many toll roads would never have been constructed. On the other hand, political support for the construction of a toll road could potentially result in an inadequate consideration of the risks associated with the project.

5.3.2 Political Risk

The literature noted that the vulnerability of toll road projects to changing political circumstances is often underestimated. The 407 ETR provides an example of how politics can influence the decision to privatize a facility and the operation of a facility. Table 5.2 provides a timeline for the various governments that were involved in the construction and leasing of the 407 ETR.

Table 5.2: Governing Parties of Ontario

Leader	Party	In Power		Action on Highway 407
		From	To	
David Peterson	Liberal	-	1990	Construction breaks ground on small section of 407
Bob Rae	New Democrats	1990	1995	Built central section, Announce RFP for two extensions in March 1995
Mike Harris	Conservatives	1995	2003	Leases out Central section and two extensions for $3.1 billion
Dalton McGuinty	Liberal	2003	n/a	Began litigation against the private concessionaire over multiple issues

Source: Mylvaganam and Borins, 2004

The Rae government's first attempt at entering into a PPP was non-partisan and an attempt to best serve the public. There seem to be little evidence of politics motivating the decision to construct a toll road apart from providing the public with an alternative to the congested Highway 401. The second privatization attempt was handled by the Harris government, which leased the 407ETR for 99 years for the highest market value at the time. The lease length was discussed, but the lease amount did not seem to be a concern at the time. However, when the road was subsequently valued by S&P at between $8 and 13 billion in late 2003, the new governing party (McGuinty) objected (Mylvaganam and Borins, 2004). Concern was raised that the Harris government valued the asset inaccurately. As mentioned before, the asset was leased for the highest value at the time—higher than the lease price determined by the government (based on the T&R report from WSA). The higher value of the asset was partly the result of the large revenues the road has generated, and the higher revenue levels are directly related to the higher toll rates implemented by the private concessionaire. If the road was managed by the OTCC—a public agency—a much less aggressive toll rate policy would probably have resulted in a lower market value though it is unclear how much lower.

This alludes to the point that the flexibility of public authorities, such as the NTTA and HCTRA, in setting toll rates can be inhibited by public pressure and political opposition. For example, HCTRA failed to raise toll rates on the Westpark tollway despite the facility experiencing severe congestion during peak hours. A similar situation is experienced on sections of the DNT. The failure to identify or at least contemplate the political risk surrounding the toll setting authority structure laid out in the toll agreement and the flexibility to increase or index tolls—i.e., the number and magnitude of toll increases assumed throughout the duration of the concession—does impact both the usage and actual revenues generated by the facility. However, it also points to the fact that, when attempting to calculate the value of an asset up for lease, different revenue models and approaches should be an important component of future T&R reports. A number of T&R consultants interviewed mentioned that they often used conservative estimates to account for project risk. However, in the case of the 407 ETR it was felt that WSA's conservative estimates impacted the lease amount the government obtained for the road (personal communication with George Davies, 2008). A method for valuing toll assets up for lease is, however, largely absent.

5.4 Concluding Remarks

This chapter of the report identified a number of variables and areas that require an improved understanding to ensure more reliable T&R forecasts for toll roads. It is clear that forecasting variables, such as population growth, land use, employment, VOT, and inflation are very complex and severely influenced by external factors and unforeseen occurrences beyond the control of the T&R consultants. Nonetheless, there is a general lack of transparency concerning the assumptions, estimated values, and modeling methods used by T&R consultants that prevent a clear understanding of the key variables impacting T&R forecasts. Better notation of the key variables influencing T&R forecasts, the data sources used, the implicit assumptions, and the limitations of the modeling methods used are positive steps the T&R industry could take. The next chapter includes specific recommendations to enhance a stakeholder's understanding of the T&R process and to facilitate an informed evaluation of the important variables that introduce uncertainty into the forecasts.

Chapter 6. Recommendations and Future Work

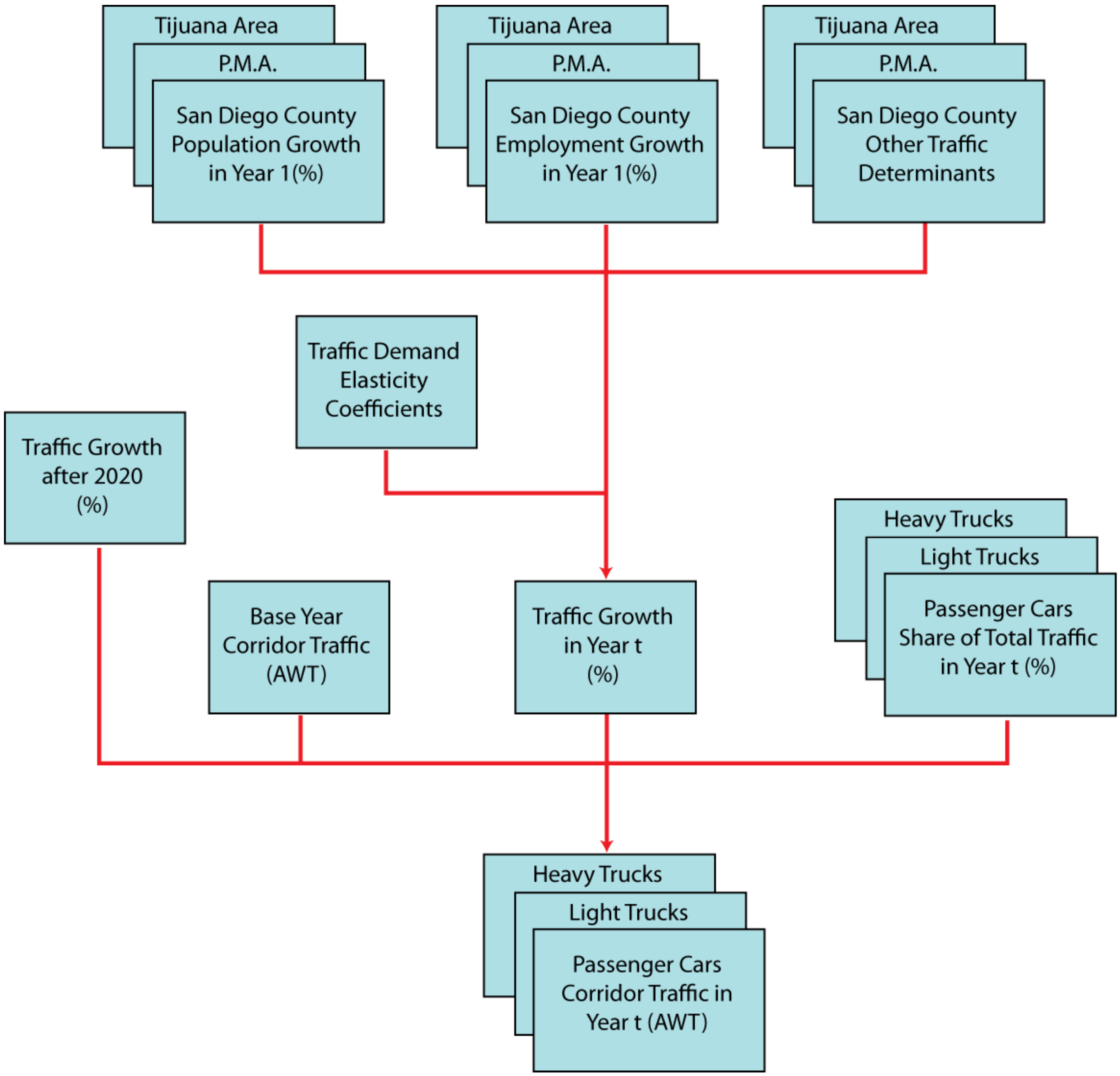
Although a detailed review of the case studies included in this research effort provided no evidence of a systematic optimism bias in toll revenue forecasts, a number of variables and areas that require an improved understanding to enhance the reliability of T&R forecasts for toll roads were discussed in Chapter 5. As mentioned before, the research was hampered by the lack of information and specificity included in the T&R reports. There is a general lack of transparency concerning the assumptions, estimated values, and modeling methods used by T&R consultants that prevent a clear understanding of the key variables impacting T&R forecasts. This chapter provides specific recommendations to address some of the concerns about data and data sourcing, the identification of key variables and how they are considered in the T&R forecasts, the limitations of the modeling methods used, and the sensitivity of T&R forecasts to changes in key variables.

6.1 Recommendations

6.1.1 Schematics of the T&R Methodology

A key issue seems to be that there are no standards for T&R reports in terms of the data and analysis that have to be included in the T&R study. As indicated before, T&R studies thus reveal little information about the T&R forecasting approach—it is considered proprietary by the T&R consultants—when and how various variables impact the analysis, the assumptions, or the estimation methods adopted. Without a better understanding of the modeling approach, and when and how variables are considered in the analysis, little more can be achieved but to note the general effect (overestimation or underestimation) of the T&R forecast and to rely on the explanations of the T&R consultants as to the reasons for discrepancies between actual and forecasted values.

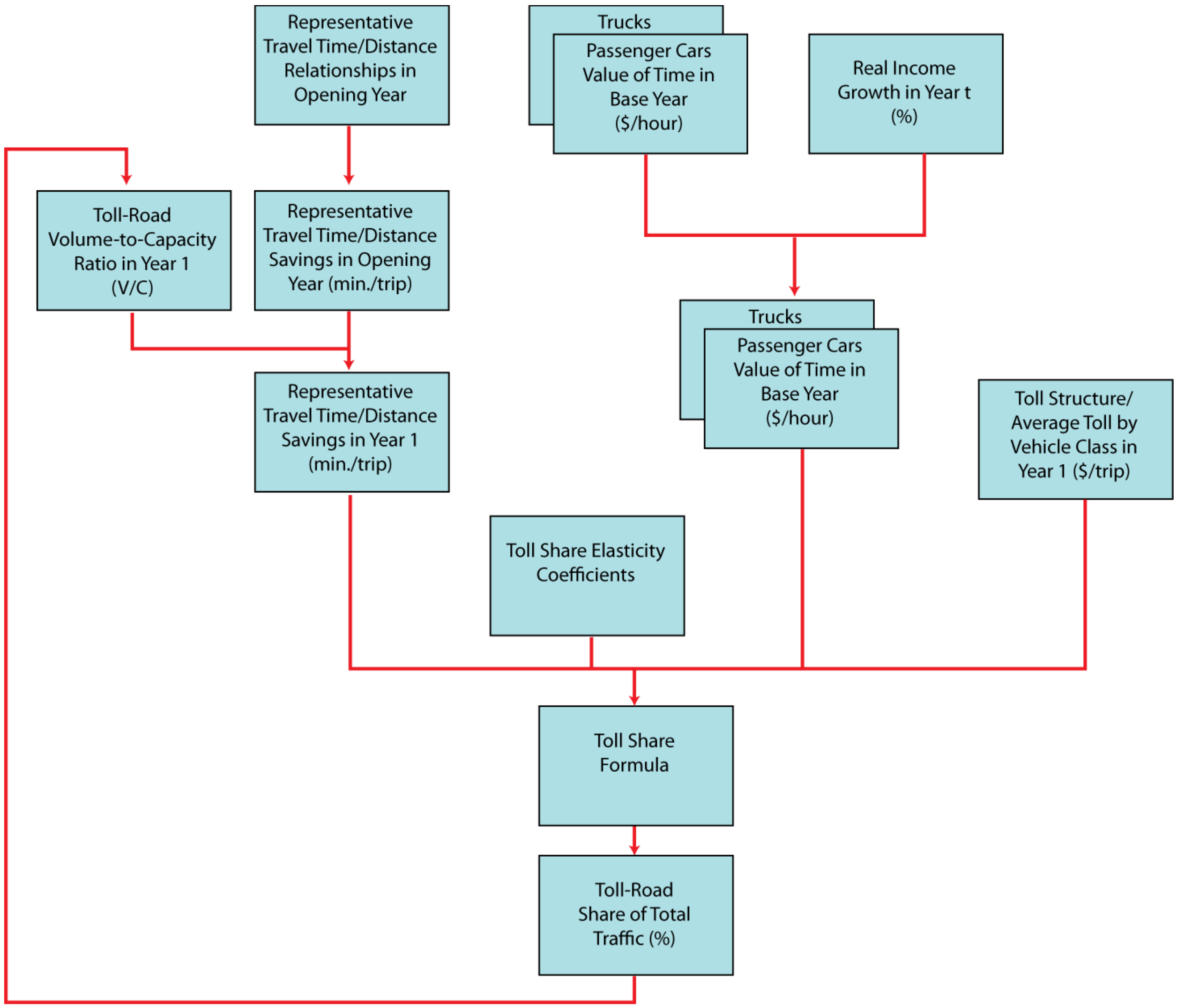
It is thus recommended that the "black box" approach to T&R forecasting be mediated by a more detailed accounting of the variables, assumptions, and estimation methods employed. A positive first step is to provide a schematic of the T&R approach—see a simplistic example prepared by HDR: HLB Economics in Figure 6.1 to illustrate the concept—detailing the various variables considered, their interaction with other variables, and when these variables are considered in the T&R modeling process.



Source: HDR: HLB Decision Economics Inc., 2003

Figure 6.1: Schematic of Travel Demand Forecasting

Figure 6.2 provides a schematic of the variables that are considered in estimating the toll share or diversion rate to the toll road.



Source: HDR: HLB Decision Economics Inc., 2003

Figure 6.2: Toll Share Estimation

Flow charts are critical to assessing the factors that introduce uncertainty. It is further recommended that each variable be subsequently discussed in terms of the data sources used (see section below), the factors that impact the variable—e.g., VOT is a function of household income, inflation, time savings accrued, etc.—and the various implicit assumptions surrounding the estimation of the variable. In this regard, the schematic in Figure 6.2 clearly demonstrates that the diversion rate to the toll road is a function of the travel time savings, a toll share elasticity coefficient, VOT, and the toll schedule. Many times when forecasts are updated or revised, it is not clear what inputs changed, why the results are different, or even what the underlying concerns with the previous estimate were. A schematic would help clarify at least the inputs, while more detailed documentation of the reasoning employed and assumptions (see below) would enhance the understanding of the process.

6.1.2 Model Methods and Limitations

The T&R studies reviewed—with the exception of one WSA report for HCTRA—did not provide any information about the trip distribution methods (e.g., growth factor model, gravity model), mode choice, or the network assignment methods that were used to forecast toll road usage. A better understanding of the methods used is required to evaluate the uncertainty the model introduces. To illustrate this point the traditional four step model typically employs static traffic assignment (see Chapter 3). However, static traffic assignment (STA) employs a number of simplifications that introduces uncertainty in traffic forecasting:

- STA requires that the origin-destination traffic matrix be converted from aggregate values (e.g., daily, weekly, monthly, or annual volume) to peak-period values to simulate a *"worst-case scenario."* The peaking factor, which estimates maximum hourly traffic demand, could be a major source of uncertainty.
- STA assigns the peak-period estimated traffic to the network in a single assignment. Existing traffic prior to the assignment and unassigned traffic that did not reach their destinations in the analysis period are ignored. In reality, traffic arrivals and departures are continuous, and traffic already on the network impacts the demand and behavior of traffic entering the network. Furthermore, because the peak period in most urban networks could extend from around 6:00 a.m. to 10:00 a.m. and 3:00 to 7:00 p.m., a single assignment is prone to significant error.[72]
- STA is weak in handling mode choice, route choice, trip timing, and the effect of tolls on travel behavior. Tolls are typically converted to an equivalent time penalty, i.e., the toll is divided by an average value of time to calculate equivalent minutes. The toll road user thus trades the toll for the assumed delay on non-tolled routes. However, all of these factors depend on individual decisions, and, instead of using utility functions, STA uses averages that may compound errors.

The model structure and estimation methods adopted are thus believed to contribute to the uncertainty of T&R forecasts. At a minimum, it should be required from the T&R consultants to specify the methods used, as well as the potential limitations and variability that the method introduces when modeling toll road usage.

6.1.3 Data and Assumptions

Data Collection

Forecasting uncertainty also results from inferior data. It is clear from this research that data is an important component of the T&R forecasting process. Most the T&R consultants interviewed conduct origin destination surveys, traffic counts, and stated preference surveys, and verify economic and demographic data (usually through an independent consultant) to supplement the information obtained from local planning agencies. However, the data sources used and the surveys are not always very well documented.

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[72] The use of dynamic traffic assignment (DTA) models is widely considered an improvement over the use of STA. A comparison of the results from STA and DTA with actual traffic indicates that DTA produces more reliable results.

A key input into the T&R studies of the 407 ETR was the *"Transportation Tomorrow Survey."* This extensive travel survey has been conducted every five years since 1986 in the Greater Toronto Area (GTA). The 1986, 1991, and 1996 surveys were used by WSA in their analysis. Information on household location, size, type, and car ownership was gathered, as well as information about individuals within the households including their age, sex, employment status, and number of driving licenses. More importantly, the survey records important trip details, such as origin, destination, trip purpose, trip time, and trip mode. The 1986 survey was a sample of 4.2 percent of the households in the GTA. The 1991 survey was an update of the 1986 survey and focused only on the areas that had experienced significant growth in the preceding five years. The 1996 survey included areas outside the GTA. The 1996 was a full survey—i.e., not an update—and included 115,000 interviews, representing a 5 percent sample of the households in the survey area (Urban Transportation Research Advancement Centre, 2008). The *"Transportation Tomorrow Survey"* information is used by the MTO to *"update previous trip tables for the GTA transportation model"* and evaluate *"peak and inter-peak periods"* (407 International Bond Issuance, 1999).

TxDOT also has an extensive travel survey program. For example, TxDOT together with HGAC and HCTRA are planning extensive travel surveys in the Houston-Galveston area:

- External Station Surveys at 33 sites,
- Household Surveys of 5,700 households in the H-GAC region,
- Work Place / Special Generators Survey at 500 businesses,
- Commercial Vehicle Surveys, and
- Toll Road Travel Behavior & Customer Satisfaction Surveys.

Given that the HGAC area had an estimated 1,865,000 households in 2005, the 5,700 household surveys mentioned would represent less than 0.3 percent of the households (compared to the 5 percent household survey sample for the GTA). The reliability of T&R forecasting would be substantially improved given increased resources for data collection and transparent surveys in urban areas.

No significant truck traffic analysis was conducted in any of the reviewed case studies. The literature revealed that in the case of a number of toll roads, arguments of the growing need for just-in-time deliveries or higher willingness to pay for business travel because of the VOT savings has not resulted in the truck numbers forecasted. Truckers seem to make irrational decisions at times, making the trucking company's behavioral response to tolls particularly difficult to predict. For example, an owner operator may perceive their VOT savings much lower than a fleet manager whose decisions are likely based on more careful analysis and who dictates the route drivers should be taking. Truck surveys and a much more in-depth analysis of trucking patterns and preferences are needed to gain a better understanding of the behavioral responses of truckers to tolling in an area.

Data Sourcing

In many of the T&R studies reviewed, the data were not adequately sourced and vague statements such as "*historical demographic and economic trends are assumed to continue into the future"* were standard in many of the T&R reports. In many T&R studies, the actual rates assumed and included in the models were not provided. At a minimum T&R consultants should reveal the data sources used to enable a stakeholder to evaluate the reliability of the data sources and to verify the data included in the T&R reports. As mentioned earlier, on a number of occasions when the research team attempted to replicate a calculation, different results were obtained from what was included in the T&R report. One explanation could be that the T&R consultant used a different data source than the research team.

Document Assumptions

The calculation of factors, such as the ramp-up factor, the annualization factor, and the ETC factor involves a number of assumptions, but none of the T&R studies reviewed disclosed any of the underlying assumptions. For example, ramp-up characteristics are reported to be determined by the road's characteristics, location, marketing efforts, payment collection type, the existing transponder penetration in the area, the area's transportation network, ramp-up experienced on similar facility types, signage to the road, and most importantly professional judgment (personal interview with URS, 2008). However, it is not clear how each of these considerations impact the ramp-up factor and it is suspected that professional judgment is the dominant consideration.

Also, professional judgment seems to dominate many of the included assumptions. Vollmer, for example, assumed that only 80 percent of planned developments will materialize. This represents a 20 percent difference between planned and assumed developments, which is only one of the input values. It is even less clear, without a better documentation of the rationale for these assumptions, if discrepancies in assumptions are compounded or whether they balance each other out.

These types of assumptions and the assumptions underlying calculated factors impact the reliability of forecasted toll road usage, but are often not discussed in any detail. Furthermore, many of the T&R reports did not provide the estimated values for the factors calculated. All assumptions and the calculated factor values should be clearly documented in the T&R study.

6.1.4 Sensitivity of Key Variables

The more recent T&R studies usually include some form of limited sensitivity analysis of a few key input parameters, such as the demographic forecasts or VOT. Usually three different demographic scenarios reflecting the base case, a low and a high growth scenario are developed and the impact on transactions and revenues determined. However, this section of the T&R study is usually a very brief section, only highlighting the variables that were considered, the scenarios, and the results.

An increased application of sensitivity analyses is recommended to identify key driving variables and their impact on forecasted toll road usage (and ultimately revenues). For example, optimistic and overstated assumptions about potential users' estimated VOT given estimated time savings can introduce significant uncertainty in the T&R forecasts. It is thus recommended that T&R consultants identify the key variables that introduce uncertainty in the T&R forecasting process through sensitivity analysis using a range of input values. Also, it is recommended that the tested values of the key variables be graphed against the transactions and revenues for the modeled years to illustrate the impact graphically.

6.1.5 Assessing Forecasting Risk

Macro Level

At the macro level, S&P developed a traffic forecasting risk index to judge the potential reliability of toll traffic and revenue forecasts produced (see Table 6.1). While toll T&R forecasts thus provide a sense of the general magnitude of potential demand, a Traffic Risk Index provides a means to determine the certainty that these returns will be generated at a broad macro level. This is a very general tool that can be used in an initial evaluation of a toll facility.

Table 6.1: Traffic Risk Index

Project Attributes	**More Reliable**	**Less Reliable**
	0 1 2 3 4 5	6 7 8 9 10
Tolling regime	• Shadow tolls	o User paid tolls
Tolling culture	• Toll roads well established—hence data on actual use is available	o No toll roads in the country—uncertainty over toll acceptance
Tariff escalation	• Flexible rate setting/escalation formula, no government approval	o All tariff hikes require regulatory approval
Forecast horizon	• Near-term forecasts required	o Long-term (30+ year) forecasts required
Toll-facility details	• Facility already open • Estuarial crossing • Radial corridors into urban areas • Extension of existing road • Alignment: strong rationale (including tolling points and intersections) • Alignment: strong economics • Clear understanding of future highway network • Stand-alone (single) facility • Highly congested corridor • Few competing roads • Clear competitive advantage • Only highway competition • Good, high-capacity connectors • Active competition prevention (e.g., traffic calming, truck bans)	o Facility at the very earliest stages of planning o Dense, urban networks o Ring-roads/beltways around urban areas o Greenfield site o Confused/unclear road objectives (not where people want to go) o Alignment: strong political o Many options for network extensions exist o Reliance on other proposed highway improvements o Limited/no congestion o Many alternative routes o Weak competitive advantage o Multimodal competition o Hurry-up-and-wait! o Autonomous authorities can do what they want
Surveys/data	• Easy-to-collect (laws exist)	o Difficult/dangerous to

Project Attributes	More Reliable						Less Reliable				
	0	1	2	3	4	5	6	7	8	9	10
collection	• Experienced surveyors • Up-to-date • Locally calibrated parameters • Existing zone framework (widely used)						collect o No culture of data collection o Historical information o Parameters imported from elsewhere (another country?) o Develop zone framework from scratch				
Users: private	• Clear market segment(s) • Few, key origins and destinations • Dominated by single journey purposes (e.g., commute, airport) • High income, time-sensitive market • Tolls in line with existing facilities • Simple toll structure • Flat demand profile (time-of-day, day-of-week, etc.)						o Unclear market segments o Multiple origins and destinations o Multiple journey purposes o Average/low-income market o Tolls far higher than the norm—extended ramp-up? o Complex toll structure (local discounts, frequent users, variable pricing, etc.) o Highly seasonal and/or "peaky" demand profile				
Users: commercial	• Fleet operator pays toll • Clear time and operating cost savings • Simple route choice decision-making • Strong compliance with weight restrictions						o Owner-driver pays toll o Unclear competitive advantage o Complicated route choice decision-making o Overloading of trucks is commonplace				
Micro-economics	• Strong, stable, diversified local economy • Strict land-use planning regime • Stable, predictable population growth						o Weak/transitioning local/national economy o Weak planning controls/enforcement o Population forecast dependent on many exogenous factors				
Traffic growth	• Driven by/correlated with existing, established and predictable factors • High car ownership						o Reliance upon future factors, new developments, structural changes, etc. o Low/growing car ownership				

Source: Bain and Wilkins, 2002

Individual Project Level

At the individual project level, a comprehensive risk analysis is recommended in assessing the impact of all key assumptions and variable values on T&R forecasts. Typically, a risk assessment involves the following steps:

- identify the key input variables that impact the forecasts (e.g., from a sensitivity analysis),
- provide a minimum and maximum value for each key input variable, as well as the probability distributions for each of them, and
- simulate various scenarios using, for example, the Monte Carlo method.[73]

This will provide a range of forecasted T&R values within given confidence intervals instead of a point estimate (i.e., the *"expected outcome"*) that is now the standard in T&R forecasts. These confidence intervals enable the analyst to quantify the uncertainty in the forecast. The impacts of assumptions regarding changing conditions in the economy, political climate, regional development, and flexibility to raise toll rates can all be tested in a risk assessment.

Only one T&R study reviewed—Halcrow's T&R study for 407 ETR—included a risk analysis. The objective of Halcrow's risk analysis was to quantify the level of uncertainty associated with specific variables[74] within a reasonable range of values: *"The overall objective is thus to identify ranges of revenue levels, with confidence limits, taking account of variation in key socio-economic, land use development, and other variables."* In the case of the Halcrow's risk analysis, the analysts identified the lowest and highest possible value for each key variable and simulated various scenarios that could possibly occur by selecting various values for each variable within their possible ranges. The scenarios were evaluated using the Monte Carlo method. Halcrow generated revenue levels for 10,000 possible scenarios. Halcrow did this for the three model years, i.e., 2001, 2011, and 2021. The resulting distributions for these scenarios were *"effectively display[ed] as a normally distributed profile"* where the *"mean and median for each distribution are very similar in each case."*

Although risk assessment is regarded a positive step and recommended, a number of issues had been raised concerning the risk assessments conducted by T&R consultants, i.e., (a) the values identified are mainly based on the T&R firms' judgment or *"expert opinion,"* (b) probability distributions are often set as normal (even if this is unrealistic), and (c) the ranges are based on vague sources (Lam and Tam, 1998). Also, in many cases the variables are not independent. For example, the Monte Carlo simulation could select a high economic growth value and a low land use development value in a single scenario. This particular scenario has an equal probability of occurring and thus being included in the final range of revenues regardless of the fact that the likelihood of this scenario (in practice) is much less than one where economic

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73 Monte Carlo Simulation is a technique that allows the user to input variables in a model and receive outputs as probability distributions. The values for input variables are considered as ranges or probability distributions. Then, using a random number generator, the input values are randomly selected from the given distributions and entered into the model. The process is repeated many times and the results are reported as probability distributions from which conclusions about likely outcomes can be drawn.

74 Halcrow conducted a risk assessment of the following key variables: GDP growth, socio-economic growth, VOT, tolls charged, the differences between the WSA and Halcrow models, traffic generation (i.e., induced trips), unbillables, and model errors.

growth and land use are either both high or low. However, new simulation techniques are available that could account for potential dependencies and the latter concern should thus not be used to dismiss risk assessments.

6.1.6 Independent Socioeconomic Consultants

Most T&R firms interviewed either used an independent socioeconomic consultant or conduct an independent in-house review of the demographic and economic forecasts obtained by the MPOs in an effort to overcome concerns about optimistic economic growth and land use predictions. When contracting a consultant, the goal is typically to use an independent firm not associated with the MPO, county, or city. However, this perceived objectivity has to be traded off against a firm's knowledge of the area and experience working in the area. Nevertheless, an independent firm acts as a peer review or a due diligence effort and is an effort to improve the credibility of the T&R forecasting process.

The details surrounding any revisions to the MPO figures have not been documented in the case study T&R reports reviewed. The exceptions are the T&R for the 2002 CTTP and the investment grade T&R study conducted by WSA in support of the bond issuance for the SH121 project. The latter includes the detailed report prepared by the independent applied economics research firm as an appendix to the T&R. This report details the methodology and rationale for revising the MPO numbers obtained from the NCTCOG, as well as the revised numbers. It is recommended that these types of reports and analyses are included in all T&R studies.

6.1.7 Link between Traffic Forecasts and Revenue Forecasts

T&R consultants usually assume a certain rate schedule when conducting T&R forecasts—in some of the older documents these rate schedules were not provided. In some T&R studies, scenarios assuming different rate schedules were tested and toll sensitivity curves were developed to estimate optimum toll rates considering the impact on traffic and the associated revenue generated. In general the toll rate schedule is an input from the owner or the bidder of the facility.[75] Traffic levels are then forecasted based on these set toll rates and revenues are directly calculated from these traffic levels. However, when attempting to calculate the value of an asset up for lease, different revenue models and approaches should be an important component of future T&R reports. This will require an improved understanding of users' (both passenger cars and trucks) choice processes concerning a tolled route—i.e., value of time, income levels in the area, various toll schedules, time saved, distance saved, etc.—and the development of models that can adequately account for individual preferences. In the case of the 407 ETR, it is felt that WSA's conservative estimates impacted the lease amount the government obtained for the road (personal communication with George Davies, 2008).

6.2 Future Research

All the case studies reviewed were commuter routes with multi-axle vehicles representing a very small percentage of the traffic or transactions. With the exception of the NTTA, none of the toll road owners or operators embarked on surveys/studies to characterize the users of their system and none have attempted to differentiate between passenger car and truck users' responses to tolls. Also, the only marketing scheme identified was the opening of toll road

[75] Often it also erred on the conservative side and was set at less than the revenue maximizing levels.

segments for a period without charging tolls. These non-tolled periods serve as a marketing promotion for the road. In addition, marketing efforts in general were limited to the distribution of electronic toll collectors at mall kiosks and sporting events, and the sponsoring of sporting events. One of the reasons for these limited marketing campaigns can be that most of the toll roads are operated by public agencies. The 407 ETR and the NTTA also promote the benefits of using the toll road by indicating the cost savings that would have accrued to the user if the transaction was paid via a transponder instead of video imaging and cash, respectively.

The research team also reviewed the literature on the characteristics of toll road users, the NTTA's mystery driver program, and worked with the TTA in the design and administration of a telephone survey to both toll road and non-toll road users in Central Texas. The survey included a number of questions that will assist the research team to distinguish the travel behavior and characteristics of commuters, business travelers, and travelers on personal business/recreational travelers. Also, information was gathered about the respondents' education, income, age, gender, vehicle ownership, and ethnicity. An analysis of the survey data will be reported in a subsequent research report.

A detailed review of the literature was also conducted regarding truck usage of toll roads and the cost structures of the trucking industry by market segment. The literature revealed that local trucker's costs could be significantly increased by congestion. For long-haul truckers, Knorring et al. (2005) found that cost/benefit was a significant factor in their route decision-making. Truckers will choose to pay a toll only if it makes business sense, e.g., the rates paid by the shipper allows the trucking company to recover the increased operating costs associated with using the toll or the savings in operating costs (time, fuel, etc.) exceed the additional cost imposed by the toll. In general though, far fewer studies have been conducted to understand and characterize the trucking industry's response to tolls and most of the information on truck cost structures is outdated. The American Trucking Association has undertaken a study to obtain better information on trucking costs. The results of this study will be useful to inform the objectives of this research effort. Furthermore, the research team has interviewed the Texas Motor Transportation Association and HEB to inform the development of a questionnaire that will be administered to a number of trucking companies operating in Texas to obtain an improved understanding of the different trucking market segments,[76] their cost structures, and proclivity to use toll roads.

Based on the survey results for passenger vehicles conducted in Central Texas and the trucking survey, the research team will identify the factors that drive toll road usage for each of the user categories/market segments. The results of both these surveys can be used to inform the development of effective measures and strategies to market toll roads to different user categories and ultimately increase toll road usage.

[76] The trucking industry can be categorized based on service area (i.e., local, regional, and long-haul) or vehicle characteristics (i.e., light, medium, and heavy trucks) or ownership (i.e., private companies or owner-operators).

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