MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH

2009-11

Post-Construction Evaluation of Forecast Accuracy

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Technical Report Documentation Page

1. Report No.	2.	3. Recipients Accession No.
MN/RC 2009-11		

4. Title and Subtitle	5. Report Date
Post-Construction Evaluation of Forecast Accuracy	February 2009
	6.
7. Author(s) Pavithra Parthasarathi and David Levinson	8. Performing Organization Report No.
9. Performing Organization Name and Address Department of Civil and Environmental Engineering University of Minnesota 500 Pillsbury Drive SE Minneapolis, MN 55455	10. Project/Task/Work Unit No. 11. Contract (C) or Grant (G) No. (c) 89261 (wo) 60
12. Sponsoring Organization Name and Address Minnesota Department of Transportation 395 John Ireland Boulevard, Mail Stop 330 Saint Paul, MN 55155	13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code

15. Supplementary Notes
http://www.lrrb.org/PDF/200911.pdf

16. Abstract (Limit: 200 words)

This research evaluates the accuracy of demand forecasts using a sample of recently-completed projects in Minnesota and identifies the factors influencing the inaccuracy in forecasts. The forecast traffic data for this study is drawn from Environmental Impact Statements (EIS), Transportation Analysis Reports (TAR) and other forecast reports produced by the Minnesota Department of Transportation (Mn/DOT) with a horizon forecast year of 2010 or earlier. The actual traffic data is compiled from the database of traffic counts maintained by the Office of Transportation Data and Analysis at Mn/DOT. Based on recent research on forecast accuracy, the inaccuracy of traffic forecasts is estimated as a ratio of the forecast traffic to the actual traffic. The estimation of forecast inaccuracy also involves a comparison of the socioeconomic and demographic assumptions, the assumed networks to the actual in-place networks and other travel behavior assumptions that went into generating the traffic forecasts against actual conditions. The analysis indicates a general trend of underestimation in roadway traffic forecasts with factors such as highway type, functional classification, and direction playing an influencing role. Roadways with higher volumes and higher functional classifications such as freeways are subject to underestimation compared to lower volume roadways/functional classifications. The comparison of demographic forecasts shows a trend of overestimation while the comparison of travel behavior characteristics indicates a lack of incorporation of fundamental shifts and societal changes.

17. Document Analysis/Descriptors	18. Availability Statement
Transportation demand forecasting, project evaluation, forecast accuracy	No restrictions. Document available from: National Technical Information Services, Springfield, Virginia 22161

19. Security Class (this report)	20. Security Class (this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	87	

Post-Construction Evaluation of Forecast Accuracy

Final Report

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February 2009

Published by

Office of Research Services
Minnesota Department of Transportation
Transportation Bldg
395 John Ireland Blvd
St Paul MN 55155-1899

Acknowledgements

The authors would first like to acknowledge the efforts of Michael Iacono, University of Minnesota, for conducting the initial groundwork necessary for this study. The authors would like to thank the following individuals for their invaluable assistance through the study: Gene Hicks, Mn/DOT; Tom Nelson, Mn/DOT; Mark Levenson, Mn/DOT; Bob Paddock, Metropolitan Council; Steve Wilson, SRF Consulting Group, Inc; and Steve Ruegg, Parsons Brinckerhoff. The authors would also like to thank Charles Rodgers, Minnesota Historical Society, for allowing a temporary return of the transportation records archived at the Minnesota State Archive to help with the data collection efforts. The authors would like to thank Allen Mattson and John Cook at the Facilities Management Office at the University of Minnesota for allowing the use of large format scanners and for their assistance in the scanning process. The authors also appreciate the guidance provided by Mark Filipi, Metropolitan Council; Steve Alderson, Mn/DOT (ret.); Brian Vollum, Mn/DOT (ret.); George Cepress, Mn/DOT (ret.); and other members of the Technical Advisory Panel (TAP). Finally the authors would like to thank Josh Potter and Anthony Jakubiak for their invaluable assistance with the data collection efforts without which this work would not have been possible.

Contents

List of Tables

List of Figures

Executive Summary

Travel demand forecasts are routinely used to dimension the construction of transportation infrastructure projects such as deciding roadway capacities, designing the length of station platforms in transit projects and so on. The evaluation of proposed transportation projects and their subsequent performance depends on the demand forecasts made in support of these projects, ahead of project implementation. The high cost of transportation projects, availability of limited resources, irreversibility of such decisions and associated inefficiencies make it essential to focus on the procedures used in forecasting in an effort to improve their accuracy.

There has been a recent revival of interest in evaluating the accuracy of project forecasts following project implementation in part due to recent books on large-scale infrastructure projects (Altshuler, A.A. and Luberoff, D, 2003; Flyvbjerg et al., 2003). While both the studies looked at the role of various technical analyses in project development, the role of travel demand forecasting and the inaccuracy of forecasts made in support of these projects have been of particular importance. The analysis conducted by Flyvbjerg et al. (2005) indicates major inaccuracies in the roadway and rail forecasts that cannot be explained by random variation.

Researchers have typically focused on either identifying and incorporating uncertainty/errors into the planning process or on improving the technical aspects of the traditional four-step transportation planning model. There hasn't been much focus on evaluating the accuracy of planning process by comparing project forecasts to actual traffic/ridership. Differences between actual and forecasted traffic/ridership, if evaluated, are usually explained away by uncertainties inherent in the planning process.

The goal of this research is to estimate inaccuracies in roadway traffic forecasts and also analyze the reasons for the presence of inaccuracies using data from the Minnesota Department of Transportation (Mn/DOT) and the Metropolitan Council. The forecast traffic data for the analysis was compiled from various Mn/DOT reports, namely, Transportation Analysis Reports (TAR), System Planning and Analysis Reports (SPAR) and Environmental Impact Statement (EIS), prepared in support of the various roadway projects in the region. The focus was on the metro area forecasts due to easy availability of actual traffic counts from Mn/DOT for the various years of analysis.

Analyses

Different types of analyses were conducted as part of this research project to estimate the inaccuracies in project forecasts. The first analysis was an illustrative analysis conducted to provide a macro level understanding of the database by estimating the inaccuracy as ratio of the forecast traffic to the actual traffic, collected for the forecast year. The average inaccuracy was estimated by different categories to better understand the data and underlying trends.

The quantitative analysis was conducted using a subset of the data to identify the factors influencing the inaccuracies in project forecasts. An ordinary least squares (OLS) regression model was developed formulating the inaccuracy in roadway forecasts as a function of certain relevant variables. The number of years between the year in which the forecast was prepared and the forecast year, project size, highway type, highway functional classification, roadway segment direction, year of report preparation and project status were used as relevant independent variables. The qualitative analysis consisted of a series of interviews with modelers to obtain their perspectives on Twin Cities modeling process and the factors that contribute to inaccuracies in the modeling process.

In addition, using the results of the qualitative analysis, macro-level analyses of model inputs were conducted to identify the reasons for the presence of inaccuracy in roadway traffic forecasts, an important objective of this study. This involved comparing forecasted to actual demographics, analyzing the changes in travel behavior using the travel behavior inventory (TBI) data and comparing the actual network to in-place networks.

Findings

The results from the Illustrative analysis indicated a trend of underestimation in roadway forecasts particularly in roadways of higher volumes and higher functional classifications. The quantitative analysis conducted using the OLS regression model identified the influence of the different variables on forecast inaccuracy. The inaccuracy ratio in the OLS model was influenced by the number of years between the report year and the forecast year, highway type, the functional classification of the roadway, the roadway segment direction, the year of report preparation and project status (existing/new facilities) while the project size didn't have any influence.

The interviews conducted with the modelers also provided a list of factors that might have contributed to inaccuracies in roadway forecasts. The inability of the model to understand and predict societal changes, the errors in socio-economic inputs that fed into the model and the differences in the actual and planned highway networks were provided as some of the main reasons for inaccuracies in project forecasts. Unlike the study by Flyvbjerg et al. (2005), political compulsions did not seem to play a big role in influencing model forecasts in the Twin Cities.

The comparison of demographic inputs indicated a trend of underestimation while the comparison of the TBI data indicated fundamental shifts in travel behavior, which weren't necessarily captured by the model. The comparison in the network inputs also indicated differences between assumed networks and in-place networks. The results from the macro-level comparison of model inputs (demographics, travel behavior and networks) highlighted the differences between forecasted and actual inputs that feed into the model forecasting process, contributing to overall forecasting error.

In summary, the analyses conducted in this study identified the presence of inaccuracies and indicated a trend of underestimation in roadway traffic forecasts. While it hasn't been possible to estimate the actual contribution of each model input to the overall inaccuracy, the results have helped identify the factors that play an influencing role.

Chapter 1

Introduction

Travel demand forecasts are routinely used to dimension the construction of transportation infrastructure projects such as deciding roadway capacities, designing the length of station platforms in transit projects and so on. The evaluation of proposed transportation projects and their subsequent performance depends on the demand forecasts made in support of these projects, ahead of project implementation. The high cost of transportation projects, availability of limited resources, irreversibility of such decisions and associated inefficiencies make it essential to understand and eliminate the causes of forecast inaccuracy.

While research efforts have focused on improving the technical aspects of a typical four-step transportation planning model, few studies have evaluated the model accuracy by comparing forecasts to actual traffic counts. Horowitz and Emslie (1978) compared the 1975 ADT forecasts, produced in 1968 and 1972, with the 1975 ADT measurements on 78 interstate highway segments. Their analysis indicated that the 1968 and 1972 forecasts over-estimated 1975 traffic volumes by 24% and 21% respectively. The authors concluded that the reliability of traffic forecasts shouldn't be taken for granted and extreme caution needs to be used in applying such forecasts to the determination of public policy.

Mackinder and Evans (1981) evaluated the predictive accuracy of transportation studies in Great Britain with a base year of 1970 or earlier. The authors focused on three different categories - urban studies, conurban studies and land use transportation studies. They used a sample set of thirty-one studies to evaluate the accuracy of forecasts for twelve different items of interest to transportation planners and policy makers. The twelve items considered for evaluation are: population, number of households, numbers of employed residents, employment, cars per household, household income, total number of highway trips, total numbers of public transport trips, total number of trips by both highway and public modes combined, total number of highway screenline trips, total number of highway cordon area trips, total number of highway through trips.

The evaluation of forecasts was done for each study area by comparing the forecast percentage change with the observed percentage change for each of the twelve items. The results indicated that the twelve forecast items considered for analysis were subject to large forecast errors. Specifically the highway and public transport trips were overestimated by a mean value of 41% and 32% respectively over a ten-year period but the forecasts didn't indicate a bias towards either mode. The authors felt that while the magnitude of forecast errors was large, it might not be critical if the transportation studies were used mainly for selecting different alternatives within a study area.

The Minnesota Department of Transportation (Mn/DOT) conducted a forecast accuracy study in the 1980s to measure the accuracy of the long range traffic forecasts produced between 1961 and 1964 for the Twin Cities Seven County Metropolitan area with a horizon year of 1980 (Page et al., 1981). The objective of the study was to measure of the historical accuracy of the long range traffic forecasts produced in the 1960s when computer based modeling was still in its infancy.

The accuracy was estimated by comparing the forecasts produced in the 1960s by the computer based forecasting model against the actual 1978 traffic counts collected. A total of 330 reports were utilized providing a database of 391 major roadway links of which 273 roadway links were used for direct comparison of traffic forecast to the traffic counts. Direct meaningful comparisons of the traffic forecasts against the actual counts couldn't be made for all 391 roadway links due to significant differences in the highway networks assumed at the time of preparing the forecasts and the actual network in place in 1980

The comparison of traffic forecasts against the traffic counts for the 273 links indicated a mean absolute percentage error of 19.52% with a percentage error range of +56.9% to -59.9%. Further the analysis indicated that traffic forecasts on 61.5% of the links were underestimated compared to the actual traffic counts and the forecasts were more accurate for higher volume roadways. The mean percent error dropped from 38.08% for the 0 to 9,999 count range to 9.58% for more than 80,000 count group. Conducting the similar analysis using all the 391 roadway link indicated a similar trend but the magnitude of underestimation and the percentage error range were much higher at 24.45% and +61.6 to -71.1%.

There has been a recent revival of interest in evaluating the accuracy of project forecasts following project implementation in part due to recent books on large-scale infrastructure projects (Altshuler, A.A. and Luberoff, D, 2003; Flyvbjerg et al., 2003). While both the studies looked at the role of various technical analyses in project development, the role of travel demand forecasting and the accuracy/inaccuracy of forecasts made in support of these projects have been of particular importance. This research follows on the current research interest using data from the Minnesota Department of Transportation (Mn/DOT) to estimate inaccuracies in roadway traffic forecasts and also analyze the reasons for the presence of inaccuracies.

The remainder of this report is organized as follows. The next section provides a brief review of relevant literature followed by a description of the data used for analysis. The illustrative, quantitative and qualitative analysis conducted in this study to estimate inaccuracies are then described. This is followed by a discussion on identifying reasons for the presence of inaccuracies in traffic forecasts. The report concludes with key findings from the study and provides recommendations to improve forecasts.

Chapter 2

Literature Review

While not many researchers have evaluated the accuracy of model forecasts by comparing the forecasted traffic to actual traffic, other approaches have been utilized to identify and quantify the errors in model forecasts and the factors influencing them. This chapter summarizes the various research approaches used to evaluate forecast inaccuracy and improve model forecasts.

2.1 Error/uncertainty in model forecasts

Research on improving model forecasts have traditionally focused on the errors/uncertainties present in the traditional four-step transportation planning model. Ashley (1980) developed an approach to quantifying the uncertainty in forecasting using the error structure in the traffic model. The sources of forecast error were subdivided into two distinct classes, each with their own specific characteristics: accuracy of the forecast exogenous input variables, accuracy of each of the individual sub-models.

The input errors were much easier to estimate using historic data sources compared to the model error sources. The model error is comprised of two parts which are not easily separable: calibration/estimation error and specification error. In addition the interaction of the different sources of model errors or the combined effects also have an effect on the traffic forecasts.

The uncertainty in a specific highway traffic model was estimated using Monte-Carlo simulation combining the information from the above mentioned error sources. The quantified uncertainty was then absorbed into the decision-making process using risk analysis to identify and quantify the risk associated with different ranges of forecasts. This approach was applied to a British highway project (Barfield By-Pass Project) to help illustrate the practical applications of explicit quantification and treatment of uncertainty and the usefulness of this approach in decision-making.

Gilbert and Jessop (1977) discussed the error and uncertainty in the transportation planning process with specific emphasis on the four-step model. Error refers to the imprecision arising from formal quantitative analysis, namely, sampling errors while uncertainty refers to subjectively quantified misgivings. The authors argued that the use of single point estimates of traffic forecasts was inadequate for the purposes of medium and long-term transportation planning. The authors utilized four types of forecasting models - short-term extrapolation, cross-sectional models, long-term trend estimation and Delphi-methods and scenario writing to indicate the use of ranges or probability estimates in improving traffic forecasts and the associated decision making process.

The authors also considered the relevance of error and uncertainty in the transportation planning process and identified methods to formally incorporate uncertainty into the planning process using approaches such as decision trees.

Clarke et al. (1981) expanded previous work on error and uncertainty in forecasting and scenario analyses to focus on the error and uncertainty in travel surveys. Travel surveys provide the main source of information on the resident trip patterns in a study area. Error and uncertainty in the travel survey step of the forecasting process could lead to systematic biases significantly affecting the model forecasts. The authors hypothesized that traditional home interview surveys typically underestimate the trips undertaken by the residents in the study area by about 10-15% which make it necessary to adjust the data to compensate. Further the conventional trip diary used as a survey instrument might have inherent weaknesses encouraging under-reporting of trip behavior. The authors examined the influence of the survey instrument by comparing the differences in reported trip behavior of the residents in Oxfordshire town of Branbury in Great Britain from two different survey instruments, namely the conventional trip diary and an activity diary.

The results confirmed their hypothesis with the activity diary providing significantly higher reported trip rates and travel times compared to the conventional trip diary. While the two survey instruments produced similar results for basic/compulsory trips, the discretionary trips and short distance walk/cycle trips showed statistically significant differences. This indicated that the conventional travel surveys produced a less complete picture of daily trip patterns resulting in insufficient attention being paid to non-work/school trip patterns and the usage of energy efficient walk/bike modes.

Talvitie et al. (1982) conducted an analysis of the total prediction error in a disaggregate mode choice model for work trips by using measures of average absolute error and root mean square error. The total prediction error in the mode choice model was considered to be made up of three components - model specification error, data aggregation error and transfer error. The model specification error arose due to omitted variables, model form and sampling errors of model parameters and estimated shares. The aggregation errors arose due to the usage of zonal averages instead of individual specific values and the transfer errors arose due to the usage of a model in another city. The data for model estimation came from the following sources: pre-BART data set collected in 1972, post-BART data collected in 1975, Baltimore, Maryland data set collected in 1977 and the Twin Cities data set collected in 1970.

The results indicated that the total prediction error in the mode choice model were pretty large and varied between 25%-65% of the predicted value with the Twin Cities data set showing the highest prediction error. The contributions of each of the three sub-components to the total prediction error in a mode choice model depend on the model transferability. The model transfer error dominated the error contribution if the model didn't transfer well while the aggregation error and model specification error contributed evenly to the total prediction error if the model transferred well. The results also indicated that market segmentation using income in this analysis didn't improve forecasting accuracy. The modal constants were determined to be the main indicators of the success of mode prediction indicating a need for further research in their estimation.

Pell and Meyburg (1985) suggested that the single point forecasts produced under the typical urban transportation planning model are subject to high uncertainty and quantification of the uncertainty is necessary for better decision-making. The study investigated the sources of uncertainty/errors in urban transportation forecasts and how the interaction between the various sources results in uncertainty of the final forecasts produced. The authors identified three distinct sources of uncertainty - model specification, model estimation and model inputs. Probability distributions were assumed for each of the error sources listed above and stochastic simulation was used to quantify the uncertainty in the travel forecasts arising from the various error sources.

Zhao and Kockelman (2002) investigated the stability of a traditional four-step travel demand model by simulating the propagation of uncertainty in a 25-zone network. The propagation of uncertainty in the model was accomplished by tracking the variation in model outputs due to variations in model inputs and parameters. The traditional four-step forecasting process was simulated by running the model 100 times using 100 different sets of inputs and parameter values with each forecasting run producing a set of link-level flows.

The results indicated that the average uncertainty increase in the first three steps of the forecasting process - trip generation, trip distribution and mode choice while the final traffic assignment step produces a decrease in average uncertainty. The results also indicate that uncertainty is compounded over the four stages of the forecasting process and the final flow uncertainties produced at the end of the forecasting process isn't lower than the input uncertainty. The results confirmed the thinking that modeling methods using point estimates might be biased and it is essential to recognize, quantify and incorporate the uncertainties present into the decision making process.

Hugosson (2005) developed a procedure to utilize the 'Bootstrap' method to estimate the sampling related uncertainty in a travel forecasting system. The 'Bootstrap' method is an analytical computer-based method that has been mainly used in econometrics to estimated standard errors, bias correction and test formulation. The basic idea is to create new samples called bootstrap samples from the original sample also referred to as the 'population' by drawing observations with replacements such that each observation has the same probability of being drawn. The sampling procedure is repeated several times and the parameters of interest are estimated for each of the bootstrap samples. Using these estimated parameters, estimates and other relevant statistical properties of the original estimated are calculated.

The Swedish National Travel Demand Forecasting System also called SAMPERS used to estimate private long distance trips was used as data for this study. The goal was to quantify the standards errors in the forecasts due to uncertainties in the sampling procedure used by the forecast system. Using the bootstrap method, the standard errors and confidence intervals of the total demand in origin-destination matrices and on link flows were estimated.

The results from the study indicated that the uncertainties are $\pm$10-15% in each of the analyzed levels - total demand on OD matrices and demand on links and train flows at a 5% risk level. The uncertainty in the value of time was slightly higher at $\pm$16% for cars and $\pm$23% for other modes.

Similar to Hugosson's work, de Jong et al. (2007) developed a method of quantifying uncertainty in traffic forecasts in The Netherlands using LMS, the Dutch national model system with a specific focus on the A16 motorway extension in the Rotterdam area. The input uncertainty and model uncertainty were considered separately and incorporated into the tour frequency and mode-destination choice modes in the LMS using probabilistic simulation approaches based on time series information and Monte Carlo simulation. A total of 100 LMS runs were carried out with half the run focusing on the reference 2020 model and the remaining 50 runs focusing on the reference 2020 model with the A16 motorway extension.

The results indicated substantial uncertainty margins in the total number of tours and kilometers by mode with the input uncertainty showing greater contribution to the errors compared to model uncertainty in both the reference 2020 scenario and reference 2020 scenario with the A16 motorway extension. In general public transport usage (bus/tram/metro/train) show greater input and model uncertainty compared to car usage and using a congestion feedback routine in modeling didn't affect the uncertainty in the number of tours and resulted in a very small decrease in variation in kilometers.

2.2 Theoretical approaches to evaluating forecasts

Mahmassani (1984) presented a theoretical framework to identify approaches to deal with uncertainty in urban transportation planning. Uncertainty arises in conjunction with any variable of relevance to the system, transportation in this case, and refers to the characteristic of the information available about the system. According to the author, the uncertainties present in an urban transportation environment can be grouped into the following categories:

- "The unknown", which refers to new and unforeseen situations
- "Occurrences of exogenous events" independent of the transportation system but affecting the environment in which the system operates
- "Randomness" in the values of measured or predicted impacts
- "Imprecision or vagueness" in the definition of criterion
- "Uncertainty" with respect to the preferential or normative basis of the evaluation process that decides the outcome of the decision-making process"

The approaches to incorporate the uncertainty in a transportation system were grouped into four categories:

- Reducing uncertainty by obtaining more information about the relevant variables
- Structuring the process using a sequential decision process conditional on prior decisions. Such a process will allow the decision maker to utilize the information available as the system evolves which will help avoid committing resources to irreversible actions and also become more responsive to changes.
- Design and evaluation criteria and guidelines, which refers to being flexible in designing and evaluating options available thus avoiding irreversible decisions
- Explicit evaluation procedures, which refers to evaluation tools such as sensitivity analysis that explicitly quantify and account for the presence of uncertainty

Niles and Nelson (2001) present a theoretical analysis for identifying the factors that increase the complexity in urban systems resulting in an increase of the uncertainty in traffic forecasts. The complexity in urban system arises from the diverse activity patterns of individual and households and by the dispersed nature of the destinations where the activities are carried out. The theoretical factors proposed by the authors that are likely to have a significant effect on urban system and associated travel can be categorized into three broad categories:

- "Technology applications" - refers to the advances in technology such as information technology and transportation technology that is likely to have a significant effect on travel patterns.

- “Environmental changes” - refers to the potential ”big picture changes” that affect the society as a whole such as the economy, physical environmental effects, energy supply and crime/terroris
- “Lifestyle shifts” - refers to changes in the individual lifestyles and their utilization of time and space such as personal time allocation changes, spatial use changes and institutional changes.
- “Institutional changes” - refers to changes in government policies, employer policies and other such organizational changes

2.3 Other factors influencing model forecasts

Daly and Ortuzar, J. de D. (1990) addressed the problem of the appropriate level of aggregation in a travel demand model by focusing on the mode choice and trip distribution procedures in the travel demand model. The goal was to determine the appropriate level of exogenous data aggregation in the disaggregate mode choice and destination choice models. Based on previous work, the errors that arise in a forecasting process were identified as: measurement, sampling, computational, specification, transfer and data aggregation errors.

According to the authors, a good model design provides an efficient allocation of modeling resources taking into account the cost of data collection, model estimation and forecasting. The authors acknowledged that the errors in a model arise from different sources and cannot be completely eliminated but a good model design will ensure that the errors present in the model are minimized as much as possible within the constraint of available resources.

The authors designed an experiment to assess the importance of data disaggregation and mode-destination choice integration using data from studies in Santiago, Chile. The results indicated that data aggregation affected the quality of the mode choice routine in the forecasting process. However data aggregation at the zonal level became more viable with the use of a joint mode-destination procedure in the forecasting process.

Johnston and Ceerla (1996) looked at the impact of feedback in the trip distribution step on model forecasts. The authors noted that the lack of feedback in the trip distribution procedure results in forecasts that are biased in favor of the build alternatives (capacity enhancements) due to underprojections in the trip lengths induced by the added capacity, which in turn results in biased cost and emissions estimates. The authors utilized the Sacramento regional travel demand model to test two feedback procedures for different scenarios. The feedback procedures tested were -

- Partial Feedback (Conventional method) - Feedback of zone-to-zone travel time to the mode choice routine alone
- Full Feedback - Feedback of zone-to-zone travel times to both the mode choice and trip distribution procedure

The authors concluded that applying the full feedback routine to the travel demand model has a significant effect on the Vehicle Miles Traveled (VMT) and congestion delay forecasts and is more likely to accurately predict the travel, financial and economic effects of proposed projects. The full feedback procedure used in the Sacramento Regional Travel Demand model resulted in the no build scenario looking much better than the build scenario in terms of VMT, NOX and as good as the build scenario on CO emissions.

Chang et al. (2002) conducted a simulation study with eleven transportation analysis zoning structures and two types of network structure to test the effect of spatial data aggregation on travel demand model performance using the Idaho statewide travel demand model. The two networks differ in the level of detail with the first network consisting of all the interstates, principal arterials, minor arterials, major collectors in both the urban and rural areas and minor collectors in rural areas while the second network consists of only the major roads in the study area. The variations in zoning structure were incorporated by varying the Traffic Analysis Zones (TAZ) and the centroid locations in the study area.

The study found that models with smaller zonal structure generated shorter trip lengths, higher interzonal trips percentage, better estimated traffic volumes (V) to observed ground count ratios (A) and lower percentage root mean square error between V and A. The variation in network detail showed a negligible effect on the trip length or proportion of interzonal trips but impacted the percentage root mean square error between V and A. While the use of the detailed network resulted in lower percentage root mean square error between V and A for all variations in zonal structure compared to the less detailed network, the use of larger TAZs in the less detailed network resulted in lower percentage root mean square error values.

Rodier (2004) applied the model validation procedure to the Sacramento, California regional travel demand model to test the model accuracy, model prediction capabilities and the model representation of induced travel. The model calibration procedures used in the study involves comparing the model forecasts with observed data not utilized during the model development procedure. The Sacramento regional travel demand model forecasts estimated using 1991 data was compared against the year 2000 data to test the accuracy of the model over a 9-year period using simulation methods. The study concluded that the model captured about half of the estimated induced travel trips, modestly overestimated Vehicle Miles Traveled (VMT), Vehicle Hours Traveled (VHT) by 5.7%, 4.2% respectively and significantly overestimated Vehicle Hours of Delay (VHD) by 17.1%.

Another explanation for the underestimation seen in forecasts, specifically road forecasts, can be attributed to the non-incorporation of induced traffic into the model forecasting procedure (Noland, 2001). The theory of induced demand states that increases in highway capacity induces additional growth in traffic resulting in increased levels of vehicle traffic. From an economic perspective, the travel demand increases as the cost of travel decreases due to capacity improvements resulting in an elasticity of demand associated with travel (Noland and Lem, 2000).

Goodwin (1996) provided an average value for elasticity of traffic volume with respect to travel time of -0.5 in the short-term and upto -1.0 in the long-term based on a literature review of induced demand research. These elasticity estimates translate into an additional 10% of base traffic in the short-term and 20% in the long-term over the forecasts provided for an average road improvement, if traffic growth due to other factors is properly accounted. This is confirmed by a comparison of forecasted traffic and actual traffic counts taken a year after opening for 151 Department of Transport road projects in the United Kingdom. The actual traffic flows were on average 10.4% higher than forecast a year after opening. A similar comparison on 85 of the alternative or 'relieved' routes indicated that the observed flows were on average 16.4% higher than the traffic forecast .

While this discrepancy between the traffic forecast and actual traffic counts can be attributed to the errors in forecasting process (other than non-inclusion of induced traffic), the underestimation in traffic flows on the alternative routes that the capacity enhancement were expected to relieve points to the induced traffic error.

2.4 Evaluation of model performance

Flyvbjerg (2005) and Flyvbjerg et al. (2005, 2006) conducted one of the most comprehensive studies on inaccuracy in demand forecasts. This statistical study compared the forecast demand with the actual demand for a list of 210 projects between 1969 and 1998. The project list, worth U.S $59 billion, was compiled from projects located in 14 countries, both developed and developing, and included both transit (rail) and highway projects. The inaccuracy in travel forecasts was estimated as the difference between the actual forecast and the forecasted traffic standardized by the percentage of the forecasted traffic. Actual forecasts were usually counted from the first year of operations or opening year of the facility while the forecasted demand was obtained from the demand estimation produced at the time of decision to go ahead with the project.

The results from the estimation of inaccuracy indicated that forecasts produced for both rail and road projects were significantly misleading. The rail forecasts were highly inflated with passenger forecasts overestimated by two-thirds for 72% of all rail projects with an average overestimation of 106%. Inaccuracy in road projects weren't as high or one-sided as rail forecasts but 50% of the road projects showed a $\pm 20\%$ difference between actual and forecasted traffic. Further the inaccuracies in rail and road forecasts didn't improve over time with road forecasts showing greater inaccuracies towards the end of the 30-year study period.

For road projects the inaccuracy in forecasts showed a significant dependence, both directly and logarithmically, on the estimated number of vehicles with smaller projects tending to have the most inaccurate traffic forecasts. For rail projects, the inaccuracy in forecasts was significantly dependent logarithmically on the costs, with higher costs leading to greater inaccuracies.

Bain and Plantagie (2004) conducted a study on the accuracy of toll road forecasts focusing on optimism bias using a cross-sectional sample of 87 toll road projects. The forecasting performance of toll roads was measured as a ratio of the the actual end-of-year-one traffic to forecast traffic. The results indicated that toll-road forecasts overestimated year-one traffic by 20-30%. The ratio of the actual to forecasted traffic estimated indicated a mean of 0.76 and a forecasting error, given by the standard deviation of 0.26.

The study conclusions confirmed the findings of the earlier toll-road forecasts study conducted by the same authors in 2002 and 2003 using smaller data sets of 32 and 68 cross-sectional samples respectively (cited in the 2004 report). A subsample analysis of the current enlarged data set indicated that error range and the magnitude of optimism bias was reduced in toll road forecasts in countries where the toll roads were well established.

Bain and Polakovic (2005) revisited the toll-road study in 2005 by expanding their data set from 87 projects to 104 international toll-road, bridge and tunnel case studies to estimate the ratio of actual to forecast traffic for periods beyond year-one. The preliminary analysis indicated that there wasn't a systematic improvement in traffic forecasting accuracy beyond year-one with the magnitude of optimism bias and error in forecasts for years 2 to 5 constant and similar to the year-one findings. Further the mean of the actual to forecasted traffic ratio varied between 0.78 - 0.80 and the standard deviation indicating forecasting error varied between 0.22-0.25. Further disaggregation of the traffic forecasts by vehicle type indicated a high variability in truck forecasts which in turn contributed to the overall uncertainty.

The Federal Transit Administration (FTA) recently conducted a study to analyze the predicted and actual impacts of 21 recently opened major transit projects funded under the New Starts program (Lewis-Workman et al., 2007). This study was an extension of two prior studies - the 1990 Urban Mass Transportation Administration study and a 2003 FTA study, looking at projects that opened for revenue service between 1990 and 2002. The ridership analysis conducted as part of this study compared the forecast and actual average weekday boardings and indicated that slightly less than half (8 of 18) of projects completed between 2003 and 2007 have either achieved or have a good chance of exceeding 80% of the initial planning level forecasts.

2.5 Identifying reasons for forecast inaccuracies

Wachs (1992) provided some reasons for forecast inaccuracies by exploring the nature of ethical dilemmas in forecasting. Forecasts are part and parcel of policymaking and involve an inherent dilemma in circularity. Usually an investment in a system is made only after there is shown to be a 'need' for the investment. However to identify a 'need' forecasters need to make assumptions on future conditions. The future conditions are in turn dependent on current actions, which may or may not materialize thus negating the forecasts prepared.

Technical experts drawn from the ranks of social scientists, engineers and planners produce most forecasts used to justify investment decisions in transportation. However the complexity inherent in our government structure coupled with the limited resources available to policy makers places a huge burden on the forecaster to produce self-serving forecasts while attempting to be technically objective. Since the forecasting process is highly subjective producing consequences of great significance, it becomes pretty easy to play with the technical assumptions to produce self-serving forecasts.

In general very little attention has been paid to the role of forecasts in decision-making and most policy makers are only concerned with the final forecasts without having an understanding of the actual forecasting process and the underlying assumptions as long as the forecasts confirm with their particular preconceptions. Due to this inaccuracy in forecasts for public services are usually attributed to 'imperfect techniques' or 'imperfect data' and are never verified in the public arena nor attributed to the structure of decision making that invariably encourage unethical forecasting approaches.

Kain (1990) talks about the Dallas Area Rapid Transit's (DART) strategic misrepresentation of land-use and ridership forecasting in its campaign to get voters to support the planned 92-mile light rail transit system. According to the author, even though the required alternative analyses indicated that the proposed $2.6 billion rail system would carry only slightly more riders than an unimproved bus system, DART attempted to conceal that information and mislead voters about the significance of the unfavorable findings. Further the author argues that DART policy makers had a preconceived preference for a rail system even if the region's decreasing central business district (CBD), dispersed residential densities and high level of auto ownership weren't conducive to a rail system.

This report indicates that even if the forecasters at North Central Texas Council of Governments (NCTCOG) attempted to improve the forecasting methodologies and provide unbiased forecasts for the proposed light rail system, they were under tremendous pressure from DART to continuously revise their estimates. In addition DART also engaged in a misleading campaign aided by the media deflecting attention from the new reduced ridership estimates produced by NCTCOG. This report confirms Wachs's take on the ethical dilemmas that forecasters face wherein decisions taken are not completely objective and are governed by the preferences of the policy makers.

Similar to Kain's work in Dallas, Pickrell (1992) conducted a study assessing the accuracy of ridership forecasts and cost estimates for rail projects in eight US cities, namely, Washington, Atlanta, Baltimore, Miami, Buffalo, Pittsburgh and Sacramento. The comparison of the costs indicated an uniform trend of gross overestimation of rail ridership forecasts along with an underestimation of the rail construction costs and operating expenses in all the eight cities considered in the analysis.

The consistent underestimation of ridership forecasts and over estimation of costs suggests a poor utilization of public investment funds. The magnitude of the errors in rail forecasting combined with trend of increasing forecasting errors over time indicated that these errors can not be eliminated by merely incorporating technical changes, enhancing model sophistication and improving the accuracy of the model inputs.

According to the author, the transit planning process and the structure of the federal transit funding mechanism results in a playing field wherein local officials compete with each other for the limited federal grants using exaggerated forecasts, underestimated costs and overestimated benefits. Due to the limited resources available, the number of competing agencies and the funding structure in place, there is no incentive for the local officials (including the forecasters and consultants on their payroll) to produce unbiased forecasts. On the other hand the planning process is set up such that local officials actually encourage strategic misrepresentation in ridership forecasts and costs for new rail projects.

The author calls for a reduction in the forecasting horizon, acknowledging the presence of uncertainty inherent in forecasts used to justify project selection, restructuring the federal transit grant programs so as to transfer the risk of forecasting errors to the agency promoting the project, reforming the earmarking trends in state and local transit finance in addition to technical improvements in the modeling process to ensure forecast accuracy and reduce the optimism bias existent in transit studies.

Richmond (2001) conducted a comparison of rail ridership forecasts to actual ridership as part of his study on evaluating urban transit investments. The main goal of the study was to analyze the total transportation system impact of the new transit projects following project implementation and transit ridership was one of the parameters used to measure the impact of a transit project. Unlike the Pickrell study, the main consideration of this study was to analyze the contribution of the projects to the respective communities rather than focus on the accuracy of ridership forecasts.

Wholly new or modernized light rail projects in eleven US cities - Baltimore, Buffalo, Dallas, Denver, Los Angeles, Pittsburgh, Portland, Sacramento, San Diego, San Jose and St. Louis implemented between 1981 to 1996 were considered in addition to heavy rail developments in Miami (1984) and Los Angeles(1993) and Miami's People Mover(1986). For comparison purposes alternative approaches such as the busway/high occupancy vehicle (HOV) lane projects in Houston, Miami, Ottawa and Pittsburgh were incorporated into the study.

The analysis indicated that the impact of the new rail projects on increasing total transit ridership was minimal and actual ridership in most of the cities considered fell far short of the ridership forecasts available to the decision-maker at the time of deciding to go ahead with the project. In addition the capital cost estimates in most cases were higher than forecasts partly due to inflation, failure to understand the complexities of construction, design changes due to political reasons and other changes to the scale or design of the project. In some cases the project ridership did exceed the pre-opening ridership estimates but these estimates were invariably prepared well after the decision to go ahead with the project was made.

As part of the comprehensive research on forecast inaccuracy, Flyvbjerg (2005) asked project managers and researchers to identify causes for such significant differences in actual traffic and forecasted traffic. The two most important stated causes identified for inaccuracy in rail forecasts were ‘uncertainty about trip distribution’ and ‘deliberately slanted forecasts’. In case of road projects, the two most important stated causes for inaccuracy were ‘trip generation’ and ‘land-use development’. The inaccuracy of the forecasts highlight the need for identifying, quantifying and incorporating risk management strategies into planning projects but the one-sided overestimation seen in rail forecasts can not be attributed to simple uncertainties associated with many of the key input variables such as demographics, economic factors, technology and differences between assumed and implemented service plans.

When planners genuinely want to produce correct forecasts, the authors propose a new forecasting method called ‘reference class forecasting’ to improve the accuracy of traffic forecasts. The ‘reference class forecasting’ method was developed to compensate for cognitive bias in human forecasting and is considered to be more accurate than conventional forecasting. The methodology involves utilizing an ‘outside view’ rather than an ‘inside view’ wherein the ‘outside view’ is established using information from a class of projects similar to the project being considered. Utilizing the outside view allows the forecaster to focus on the outcomes by overcoming cognitive and organizational biases such as strategic misrepresentation, appraisal optimism.

In some cases, the authors hypothesize that planners and forecasters might be part of the problem of misrepresentation. Planners don’t have any incentive to produce correct forecasts and providing accurate forecasts might actually be counterproductive for the project under consideration. The structuring of the political funding process for transportation results in projects with greater misrepresentation getting funded for construction compared to projects with no misrepresentation. An institutional change in the way public projects get funded and a greater focus on transparency and accountability are essential to overcome the widespread misrepresentation in traffic forecasts.

Chapter 3

Data

The forecast traffic data relevant to this analysis was collected from the following Minnesota Department of Transportation (Mn/DOT) reports prepared in support of the various roadway projects.

- Transportation Analysis Reports (TAR)
- System Planning and Analysis Reports (SPAR)
- Environmental Impact Statement (EIS)

These reports with a horizon forecast year of 2010 or earlier focusing on the Twin Cities metro area were collected from various locations, namely, Mn/DOT Central Library, the Collection Department of the State Archives at the Minnesota Historical Society, MnDOT Office of Transportation Data and Analysis and the MnDOT Metro District Office (Roseville). The forecast reports were typically extremely brief in terms of the roadway networks, socio-economic inputs and other assumptions that went into creating the forecasts and in most cases the assumptions were just not provided. Further the reports didn't have any clear description of the actual roadway project and the need for the report. In general the forecast provided in the reports seem to be based on the outputs from the Twin Cities regional model altered by ground counts and turning movements taken in the study area.

The unavailability of forecast traffic data in electronic format necessitated the transfer of the reports into electronic format for use in the analysis. One of the problems of the electronic conversion of the reports was the nonstandard print formats of the forecast maps provided in the TARs and SPARs prepared in the 1970s through early 80s which required the use of special scanners. The special scanning facilities at the Facilities Management Office at the University of Minnesota were used for electronic conversion of these older forecast maps. The scanning facilities at the John R. Borchert Map Library at the University of Minnesota were used for the electronic conversion of the standard print format forecast maps and project reports prepares in the late 1980s through 1990s. A total of 211 reports were completely scanned into electronic format and are summarized in Table 1 in the Appendix.

Another important task relevant to the analysis was transferring the forecast traffic information from the numerous reports into an electronic database for use in the analysis. The following information identified as relevant to the analysis was compiled from the various project reports to ensure consistency in the data collection efforts:

1. Report Number
2. Report Description
3. Report Date
4. Forecaster responsible for the forecasts
5. Agency responsible for the forecasts
6. Horizon forecast year
7. Other years for which traffic forecasts are available
8. Type of forecast provided - daily traffic /peak hour traffic forecasts
9. Data sources as listed in the report
10. Forecast assumptions as listed in the report
11. Roadway name
12. Roadway location
13. Direction of forecasts - northbound, southbound, eastbound or westbound
14. Segment number or any other roadway identifier listed in the report
15. Forecast Traffic - Average daily traffic (ADT)/AM peak hour/PM peak hour forecasts
16. Actual traffic counts
17. Data source for actual traffic counts
18. Detector identifier used to obtain peak hour traffic counts

The actual traffic data used to estimate the inaccuracy in traffic forecasts was obtained from the traffic count database maintained by the Office of Transportation Data and Analysis at Mn/DOT. The data collection efforts for this research project was a pretty intensive and time consuming effort due to the lack of proper documentation and proper record keeping procedures. It is important to note here that the current MnDOT record keeping and archiving procedures are completely different and much more sophisticated from what was followed in the 1970s,1980s.

The final database consisted of 108 project reports resulting in a total of 5,158 roadway segments in the database and the actual traffic information was obtained for 2,984 of the 5,158 roadway segments. While there wasn't any definite selection criteria or rationale used to select project reports for transfer to the electronic database, care was taken to ensure that the project reports and EIS documents prepared in the 1980s or later for all the major freeways and highways in the metro area such as I-35E, I-35W, I-394, TH 100 etc. were included, based on the recommendations of the project Technical Advisory Panel (TAP).

The entire data collection process consisting of report collection, electronic conversion and database creation took about 9 months of the project time. The set of 268 reports that were identified as relevant to the study but couldn't be scanned and utilized in the analysis due to time and resource constraints are summarized in Table 2 in the Appendix.

Figure 3.1 shows the geographical locations of the various roadways in the Twin Cities metro area considered in this analysis.

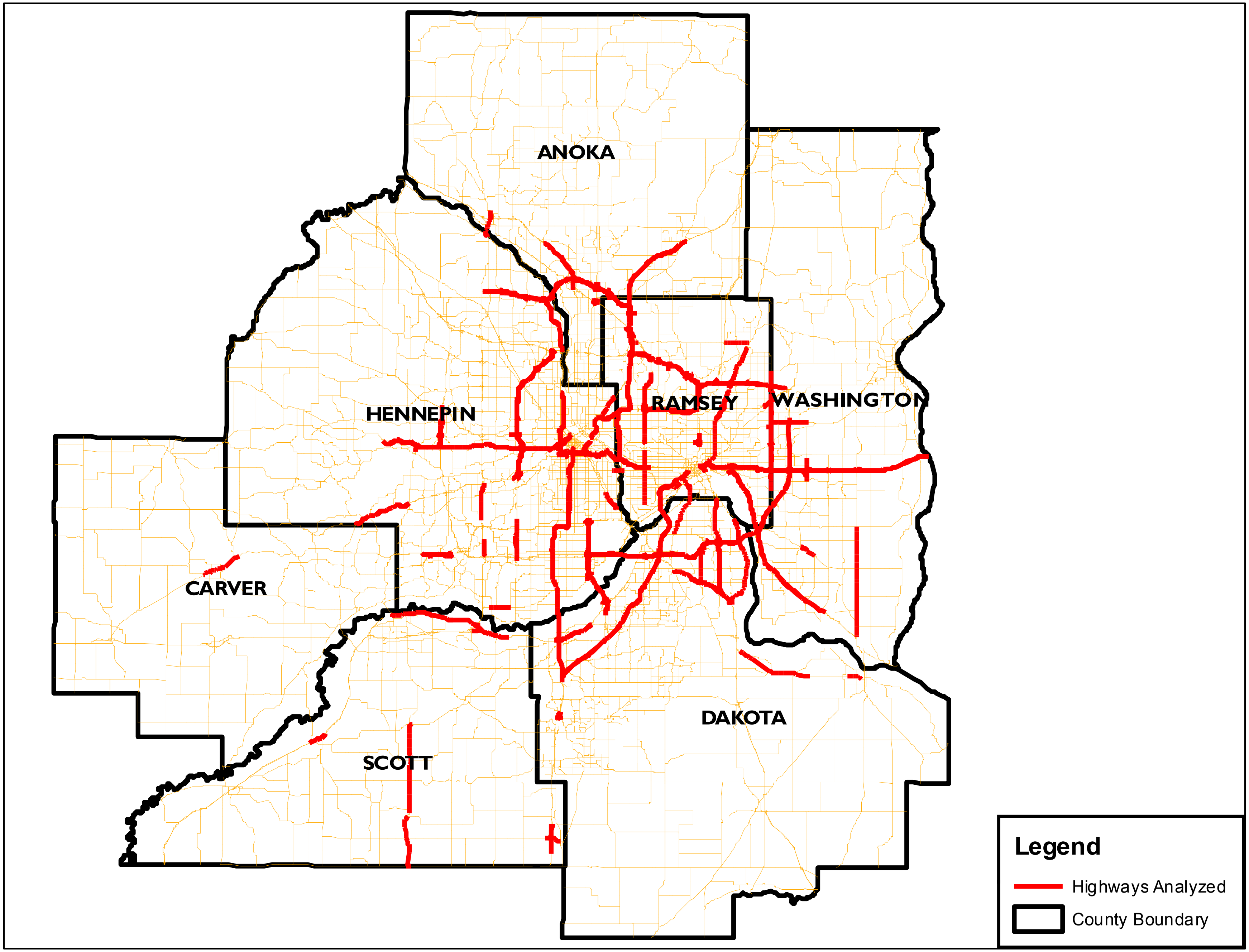

Figure 3.1: Geographical Location of Highways Analyzed

Chapter 4

Analysis

The evaluation of forecast inaccuracy in this study involves comparing the forecasted roadway traffic against the actual traffic, collected for the forecast year. The previous section provides a summary of the data collection efforts in this study. This chapter describes the three types of analyses conducted using the data to estimate the inaccuracy in roadway forecasts. The three types of analyses provide different approaches to estimating the inaccuracy in forecasts and identifying the factors influencing the forecasts.

4.1 Illustrative analysis

A scatterplot analysis of the actual traffic data to forecast traffic data using all the roadway segments in the database is provided in Figure 4.1. The target line in the scatterplot shows the ideal condition where the actual traffic data exactly matches the forecast traffic data. From a modeling perspective, it is ideal to have the points in the scatterplot as close to and evenly spread out from the target line as possible. In Figure 4.1, the majority of the data points in the scatterplot lie above the target line indicating a a trend of underestimation of forecast traffic with respect to the actual traffic data, especially for higher volumes.

Based on Bain and Plantagie (2004), the inaccuracy in traffic forecasts was estimated as a ratio of the forecast traffic to the actual traffic, collected for the forecast year. A ratio less than 1.0 indicates an underestimation in traffic forecasts while a ratio greater than 1.0 indicates an overestimation in traffic forecasts.

The estimated average inaccuracy by project is presented in Figure 4.2. The inaccuracy was estimated for each of the data points in the database with both forecast traffic and actual traffic information and then averaged by project to obtained the average inaccuracy. Table 4.1 compiles the projects analyzed and the estimated average inaccuracies for each project. The estimation of average inaccuracy shows that the average inaccuracy is less than 1.0 in 48% of the projects and the average inaccuracy is greater than 1.0 in 48% of the projects. The estimated average inaccuracy equals 1.0 in 4% of the projects (within $\pm$0.5%).

The average inaccuracy was estimated by different categories to better understand the data and underlying trends. The inaccuracy on critical links, defined here as links with the highest actual traffic, is presented in Figure 4.3. This analysis was done to see if these links had greater accuracy compared to the other roadways in the project area. This analysis indicates a very clear trend of underestimation in the forecasts with 65% of the critical links showing an inaccuracy ratio of less than 1.0. 27% of the critical links have overestimated forecast traffic and only 8% of the critical links have forecast that match the actual counts (within $\pm5\%$).

A lookup table of the project identifier with the actual report number, used in Figure 4.2 and 4.3 is provided in Table 3 in the Appendix. The variation in estimated average inaccuracy and critical link inaccuracy by county is also provided in Figures 1 through 6 in the Appendix.

In addition average inaccuracy and critical link inaccuracy was also estimated for new and existing facilities in the database, classified based on the existence/non-existence of the concerned roadway at the time of report preparation, using information from the MnDOT construction project logs and consultations with MnDOT staff. The average inaccuracy for all existing roadway facilities, comprising of 77% of the projects in the database, was estimated to be 1.20 with the minimum and maximum inaccuracy varying between 0.01 to 8.94. The average inaccuracy for the new roadway facilities, comprising of 23% of the projects, was 0.95 with the maximum and minimum inaccuracy varying between 0.16 to 5.00.

Figures 7 through 9 show the estimated inaccuracies grouped by county for existing facilties and figure 10 shows the estimated inaccuracy for new facilities. Each figure is shown sorted by increasing order of average inaccuracy. Figure 7 shows the average inaccuracy and critical link inaccuracy for existing facilities in Anoka, Carver, Dakota and Hennepin counties. The average inaccuracy and critical link inaccuracy for existing facilities in Ramsey county are provided in figure 8 while figure 9 shows the variation in estimated inaccuracies for Scott and Washington counties.

The frequency distribution plot of the inaccuracies estimated for the various roadway data points in the database is presented in Figure 4.4. This estimation indicates a trend of underestimation with 56% of the total roadway points showing an inaccuracy ratio less than 1.0 and 44% of the total roadway points showing an inaccuracy ratio of greater than 1.0. The highest frequency of 24% is seen between the ranges of 0.75-1.0.

The average inaccuracy by roadway functional classification is presented in Figure 4.5. The roadway data point in the database with forecast traffic and actual traffic data was classified into one of five categories, based on the functional classification used in the Year 2000 Twin Cities Regional Travel Demand Model, provided below:

- Freeways
- Undivided Arterials
- Divided Arterials
- Expressways
- Collectors

The inaccuracy was estimated for each data point and then averaged by functional classification to obtain the inaccuracy by functional classification. Figure 4.5 indicates that freeways, with an inaccuracy ratio of less than 1.0, are subject to underestimation compared to the other roadways functional classifications, which seem prone to overestimation.

Figure 4.6 represents the average inaccuracy stratified by the count range. This stratification indicates that the higher volume roadways are subject to the problem of underestimation compared to lower volume roads which are more prone to overestimation. Roadways with volumes of 20,000 or less show an inaccuracy ratio of greater than 1.0 compared to the other higher count ranges which show an inaccuracy ratio less than 1.0. This result is in line with the inaccuracy by functional classification since freeways typically carry higher volumes of traffic compared to the other roadways.

The illustrative analysis was conducted to provide a macro level understanding of the database and indicates a trend of underestimation in roadway forecasts particularly in roadways of higher volumes and higher functional classifications.

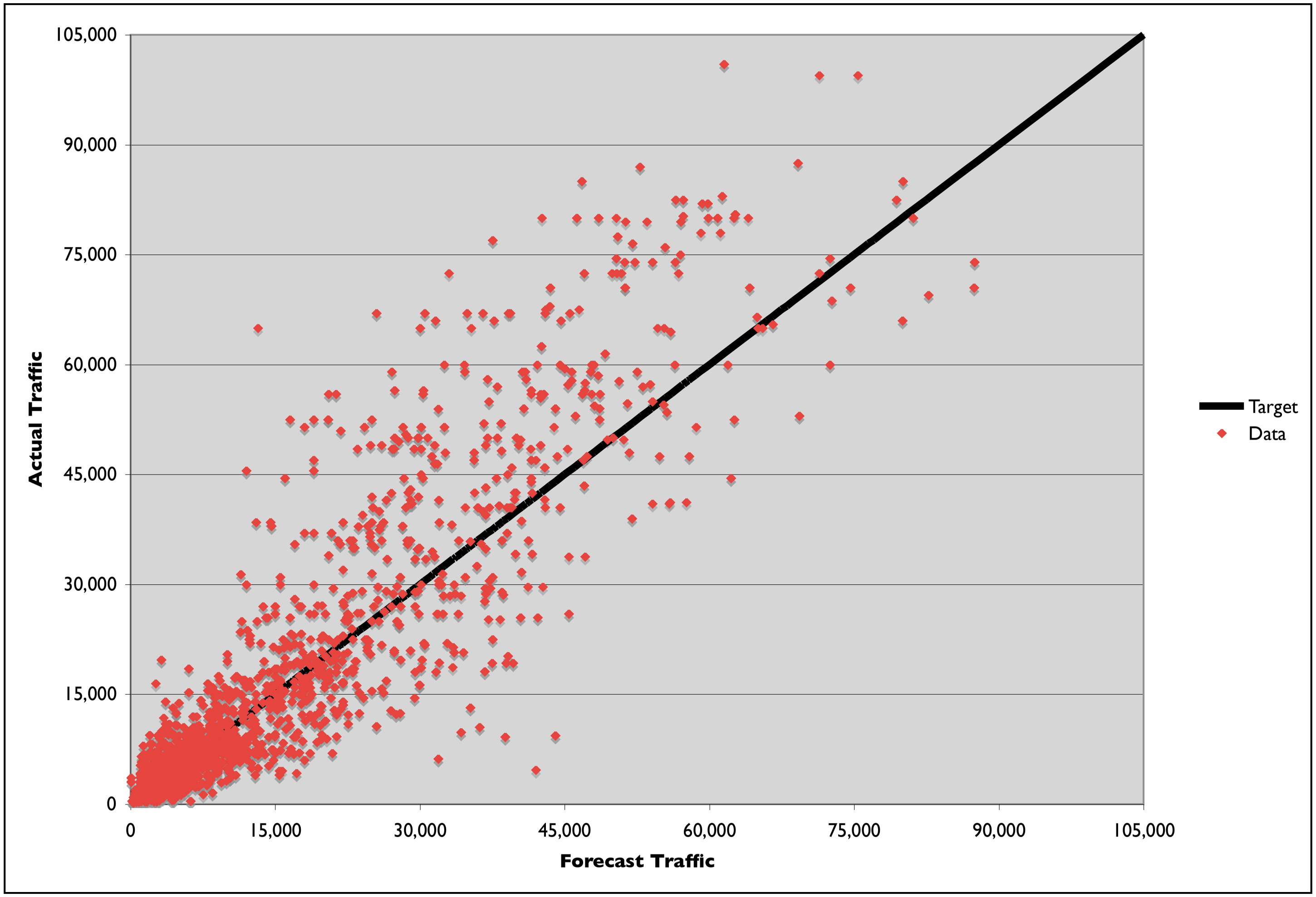

Figure 4.1: Scatterplot of Actual Traffic to Forecast Traffic

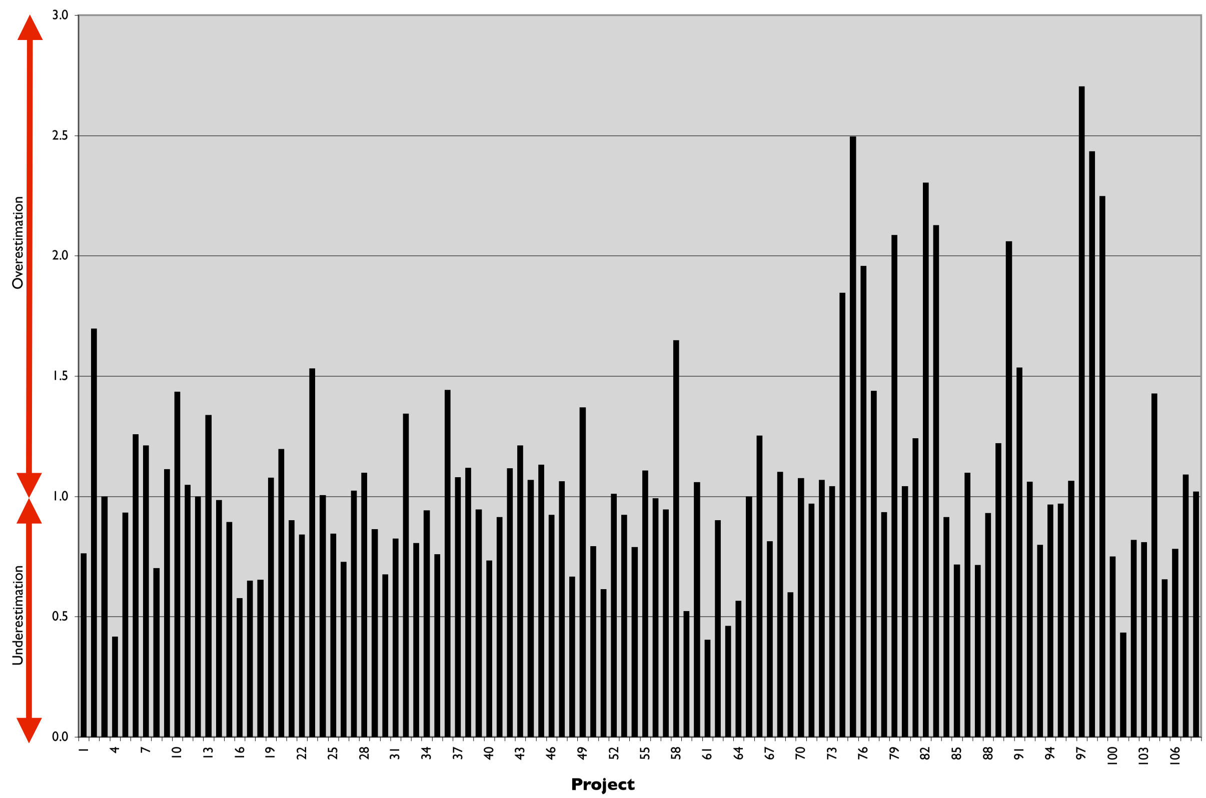

Figure 4.2: Estimated Average Inaccuracy by Project

Table 4.1: Summary of project reports in the database

Id	Report	Description	Report Year	Forecast Year	Number of Years	Total No. of Forecast Links	Total No. of Actual Traffic Links[1]	Avg Inaccuracy	Variance	Min. Inaccuracy	Max. Inaccuracy
1	SPAR-202	I-394-Third Ave Distributor from 13th Street N to Washington Ave	1978	2000	22	117	20	0.76	0.14	0.20	1.50
2	TA-M372B	Proposed New Alignments on TH 5 and County Road 30 from Birch Street to Isalnd View Road (Waconia)	1991	2010	19	48	14	1.69	2.01	0.89	5.00
3	TA-M329	PropTH 10/TH 610 from Prop TH169(Osseo By-Pass) to TH35W	1985	1987/2000/2010	15	157	56	1.00	0.10	0.55	1.94
4	TA-M335	CSAH 14 from CSAH 17 to East Carver County Line	1985	2003	18	3	3	0.41	0.01	0.33	0.51
5	TA-M336	TH35W From TH694 to Prop TH10	1985	2000	15	58	34	0.93	0.07	0.63	1.66
6	TA-M337	TH 100 from CSAH 10 to TH 394	1986	2000	14	92	58	1.25	0.13	0.91	2.88
7	TA-M343	Lake Street from W River Rd to Mississippi River Blvd	1986	2000	14	22	14	1.21	0.06	0.89	1.60
8	TA-M238	I 94: Tunnel to TH 51(Snelling Ave)	1979	2000	21	37	24	0.70	0.02	0.20	1.14
9	TA-M240	TH 55 - Pine Bend to Hastings	1980	2000	20	28	12	1.11	0.29	0.75	2.24
10	TA-M242	TH 120 from Lower Afton Road to TH 244	1980	2005	25	232	92	1.43	1.32	0.42	7.61
11	TA-M245	TH 13 - TH 35E Interchange Area	1980	2003	23	24	10	1.04	0.13	0.68	1.58
12	SPAR-208	TH 61, South of Warner Rd to the Washington County Line	1978	2002	24	36	12	1.00	0.05	0.55	1.17
13	SPAR-208A	TH 61, Intersection of Warner Rd and Burns Ave	1979	2002	23	18	10	1.33	0.23	0.92	1.90
14	SPAR-210	TH 36 - Lexington to Dale	1978	2003	25	24	14	0.98	0.06	0.70	1.31
15	SPAR-220	TH 51 at TH 212	1978	2002	24	12	8	0.89	0.01	0.79	1.10
16	SPAR-224	TH 35E - TH 35W to TH 110	1979	2000	21	52	44	0.57	0.02	0.32	1.00
17	SPAR-227	TH 94 - TH 35E Capitol Approach	1979	2002	23	31	16	0.65	0.01	0.46	0.80
18	SPAR-246	TH 35 and Crystal Lake Road	1980	2003	23	16	8	0.65	0.25	0.36	1.46
19	TA-M255A	TH 51 from Como to TH 36	1982	2004	22	120	32	1.07	0.05	0.64	1.51
20	TA-M286	TH 35 and Little Canada Road	1981	2005	24	28	14	1.19	0.15	0.71	1.69
21	SPAR-215	TH 494 from TH 36 to Mississippi River Bridge	1979	2003/1993/1983	24	76	50	0.90	0.11	0.38	1.97
22	SPAR-202A	I 394 - From TH 10-CSAH 15 in Wayzata to Washington Ave in Minneapolis	1978	2000	22	150	62	0.84	0.27	0.16	2.84
23	TA-M345	TH 7 - From TH 41 to TH 101	1986	2000	14	118	20	1.53	1.22	0.99	5.56
24	TA-M346	CSAH 1 - Nesbitt Ave to Yukon Ave	1986	2000	14	56	18	1.00	0.12	0.67	1.63
25	TA-M307	TH 394 - TH 100 to Washington Ave; TH 100 - Th 7 to TH 394		2000		158	82	0.84	0.15	0.38	2.07
26	TA-M253	Proposed TH 394 from West Junction (TH 101) to Junction Washington Ave (Dtwn Mpls)	1980	2000	20	100	26	0.72	0.12	0.16	1.50
27	TA-M253 Distributor Addendum	Year 2000 forecast in the vicinity of 3rd Ave	1982	2000	18	20	9	1.02	0.18	0.62	1.58
28	TA-M302	TH 169 Mississippi River Bridge - Anoka	1983	2005	22	56	16	1.09	0.15	0.48	1.68
29	TA-M207A	TH 94 and CSAH 13 (Woodbury Area)	1978	2003	25	8	8	0.86	0.10	0.65	1.38
30	TA-M289A	I-694/TH 61 No Build	1983	2005	22	12	8	0.67	0.02	0.57	0.87
31	TA-M309	TH5 - CSAH 4 To Ring Road (Prairie Center Drive)		2000		48	18	0.82	0.07	0.36	1.12
32	TA-M311	TH 56 From TH 52/55 To I-494	1984	2000	16	60	28	1.34	0.37	0.49	2.27
33	TA-M326	Washington County Forecasts For Selected Routes	1985	2000	15	106	102	0.80	0.21	0.31	3.23

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Table 4.1 – continued from previous page

Id	Report	Description	Report Year	Forecast Year	Number of Years	Total No. of Forecast Links	Total No. of Actual Traffic Links[1]	Avg Inaccuracy	Variance	Min. Inaccuracy	Max. Inaccuracy
34	TA-M358	TH 494 from TH 12 (394) to TH 55	1987	1990	3	28	10	0.94	0.01	0.87	1.04
35	TA-M298	TH50 - CSAH 5 & I-35 Ramps	1983	1987	4	16	8	0.76	0.06	0.47	1.10
36	TA-M308	TH 13 From I-35W To Cliff Road	1984	2000	16	32	18	1.44	0.64	0.63	2.80
37	TA-M296A	I-94/TH61/Etna Street	1983	2006	23	12	8	1.08	0.10	0.87	1.58
38	TA-M299	TH 280 - Interchanges between Kasota & County Road B	1983	2008	25	52	34	1.12	0.24	0.34	2.63
39	TA-M304	TH 694 from TH35E To TH 35W	1984	2008	24	48	34	0.94	0.02	0.69	1.44
40	TA-M301	TH 96 From I-35E To TH 61	1983	2008	25	72	28	0.73	0.04	0.40	1.11
41	TAS 3065A-14	TH 36 From TH 51 To TH 35E	1969	1985	16	40	38	0.91	0.07	0.32	1.40
42	TAS 3074B	TH 61 From Ramsey County Road C To Whitaker St In White Bear Lake	1967	1990	23	64	38	1.11	0.39	0.29	2.31
43	TAS 3074C-14	TH 61 At TH 36 and County Road C	1968	1985	17	14	14	1.21	0.13	0.84	1.87
44	TAS 3080	I-694 And White Bear Ave	1967	1986	19	8	8	1.07	0.01	0.92	1.16
45	TAS 3081	TH 51 - Jct TH 51 and Co Rd B2	1967	1985	18	28	22	1.13	0.14	0.45	1.91
46	TAS 3081A-14	TH 51 From TH 36 To Hamline Ave	1968	1990	22	36	26	0.92	0.11	0.67	1.96
47	TAU 3061A	TH 694 From TH35E To TH 36	1965	1986	21	22	18	1.06	0.15	0.44	1.83
48	TA-M300	TH 55 From Western City Limits To TH61	1983	2008	25	36	18	0.66	0.07	0.36	1.15
49	TAS 3066A-14	TH 94 Vicinity Of Sixth Street In St. Paul	1969	1985	16	15	10	1.37	0.24	0.81	2.16
50	TA-M292	Airport South Study (TH77, I-494, TH5)	1983	2000	17	176	102	0.79	0.08	0.26	1.69
51	TAU 3065	TH 36 at Hamline Ave	1963	1983	20	18	8	0.61	0.03	0.32	0.73
52	TAU 3066	TH 94 - Ninth and Broadway In St. Paul to West End of Bridges 6755/6756	1963	1983	20	14	12	1.01	0.18	0.63	2.28
53	TAU 3069	TH 94 - Pillsbury Street To Snelling Ave in St. Paul	1964	1984	20	8	6	0.92	0.00	0.88	0.94
54	TAU 3070	TH 35E - Maryland Ave Interchange	1964	1975	11	4	4	0.79	0.01	0.71	0.86
55	TAU 3073	TH35E - TH694 To North Ramsey County Line	1964	1985	21	24	24	1.10	0.05	0.71	1.54
56	TAU 3073A	TH 96 - TH35E to TH 61	1966	1985	19	26	10	0.99	0.15	0.54	1.45
57	TAU 3074	TH61 - From I-94 to TH 212	1964	1986	22	26	8	0.94	0.30	0.41	1.59
58	TAU 3074A	TH61 - From TH36 to .4 mi North Of County Road C	1965	1988	23	12	10	1.65	0.39	0.91	2.60
59	TAU 3075	TH8 - From Northeastern Junction Of I-35W to Stinson Blvd.	1964	1984	20	12	6	0.52	0.02	0.42	0.71
60	TAU 3076	Half Cloverleaf Interchange At TH 51 and County Road B-2	1964	1980	16	8	8	1.06	0.08	0.80	1.46
61	TAU 3077	TH 5 - Toronto Avenue to Banfil Street in St. Paul	1965	1985	20	22	6	0.40	0.04	0.21	0.64
62	TAU 3078	TH 280 - Kasota Ave Interchange, and West Frontage Rd, and Connecting Ramps	1965	1986	21	16	6	0.90	0.00	0.87	0.94
63	PSU3203A	TH101/13 - West City line of Shakopee to .21 miles West of City Line of Savage	1962	1982	20	10	10	0.46	0.00	0.38	0.51
64	PSU3203B	TH13 - TH101 West Of Savage To .75 Mi West Of I-35W	1962	1982	20	18	10	0.56	0.02	0.38	0.73
65	TAS3081B-14	TH51 - TH36 to Hamline Avenue	1969	1990	21	26	22	1.00	0.12	0.64	1.96
66	TAS3082-14	I-94 - From Mounds Boulevard To I-494/694	1968	1985	17	46	38	1.25	0.26	0.30	2.36
67	TAS3084-14	TH280 - From Franklin Avenue To NPRR Bridge	1968	1985	17	18	8	0.81	0.01	0.65	0.93
68	TAS3085-14	University Avenue - Park Street To Marion Street	1968	1985	17	26	14	1.10	0.11	0.68	1.76

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Table 4.1 – continued from previous page

Id	Report	Description	Report Year	Forecast Year	Number of Years	Total No. of Forecast Links	Total No. of Actual Traffic Links[1]	Avg Inaccu-racy	Variance	Min. Inaccu-racy	Max. Inaccu-racy
69	TAU3204A	TH13 - TH19 East Of New Prague to TH 282 North Of Lydia (Scott County)	1964	1988	24	60	16	0.60	0.08	0.34	1.12
70	TAU 3205	I-35 - From South Scott County Line to CMSTP&P Railroad	1963	1975	12	8	8	1.07	0.19	0.52	1.52
71	TAU 3223	TH10 - From Elk River To Big Lake	1963	1983	20	34	12	0.97	0.56	0.01	1.90
72	TAU 3451A	I-94 - From I-494/694 To .5mi East Of CSAH 19	1964	1989	25	18	14	1.06	0.14	0.74	1.63
73	TAU 3451B	I-94 - From .5Mi East Of CSAH 19 to the St. Croix River	1964	1989	25	32	18	1.04	0.43	0.52	2.32
74	SPARS 2	TH 212 - TH 120 to proposed CSAH 19, I-694 - Temporary TH 212 To County Road 68	1970	1985	15	26	12	1.84	0.85	0.84	3.20
75	SPARS 2A	TH 212 - TH 120 to proposed CSAH 19, I-694 - Temporary TH 212 To County Road 68	1970	1985	15	32	16	2.49	1.91	0.84	4.59
76	SPARS 3	TH52 - Pine Bend to Proposed TH 61 near Hastings	1970	1985	15	26	14	1.95	0.29	1.01	2.68
77	SPARS 4	TH 61 - From I-494 to County Road F	1970	1985	15	140	86	1.44	1.31	0.16	7.82
78	SPARS 15	TH 169 - From I-494 to CSAH 61	1970	1985	15	18	18	0.93	0.17	0.22	1.65
79	SPARS 16	TH 55 and 52- From TH 49 to TH 56	1970	1985	15	36	24	2.08	2.43	0.46	6.70
80	SPARS 17	TH 56 - From Linden Street to CSAH 26	1970	1985	15	38	22	1.04	0.25	0.63	2.48
81	SPARS 18	TH 56 - From Richmond St. to Grand Ave.	1970	1985	15	34	22	1.24	0.18	0.76	2.02
82	SPARS 19	I-494/I-694 - From Mississippi River to TH 212 (TH 5)	1970	1985	15	44	42	2.30	0.90	1.24	5.31
83	SPARS 32	TH 3 - From TH 52 and TH 55 to Salem Church Rd.	1970	1985	15	32	20	2.12	0.60	0.70	3.39
84	SPARS 33	TH 51(Snelling Ave.) - From I-94 to Pierce-Butler Route	1970	1990	20	40	28	0.91	0.08	0.49	1.57
85	SPARS 37	TH 10, Jct. TH 10 with TH 96 and I-35W with TH 96	1971	1985	14	16	16	0.71	0.04	0.24	0.92
86	SPARS 45	TH 51 (Snelling Ave.) - From TH 5 to Pierce Butler Route	1971	1985	14	80	63	1.09	0.16	0.51	2.04
87	SPARS 48	TH 169 - From TH 282 to TH 21	1971	1990	19	18	14	0.71	0.12	0.25	1.04
88	SPARS 49	TH 10 - From Egret Boulevard to University Ave. in Coon Rapids	1971	1985	14	20	16	0.93	0.16	0.32	1.44
89	SPARS 53	I-35E - From W. 7th St. to Kellog Blvd.	1971	1990	19	46	16	1.22	0.13	0.57	1.66
90	SPARS 60	TH 61 - From I-494 to County Road 19	1971	1985	14	50	36	2.06	2.21	0.62	6.92
91	SPARS 61	CSAH 18 - From Smetana Rd. to CSAH 3	1971	1975	4	64	26	1.53	0.76	0.52	3.44
92	SPARS 65	TH 10 - From Egret Blvd. to University Ave.	1971	1985	14	17	14	1.06	0.12	0.81	1.32
93	SPARS 69	TH 100 - From I-494 to Benton Ave.	1971	1985	14	44	21	0.80	0.03	0.59	1.17
94	SPARS 72	I-94 - From Dowling Ave. to TH 12	1971	1985	14	52	40	0.96	0.38	0.36	2.08
95	SPARS 73	TH 10 - Proposed Cloverleaf Junction for TH 65	1972	1985	13	8	8	0.97	0.02	0.85	1.14
96	SPARS 75	TH 52 - From Mendota Rd. to Annapolis St.	1972	1985	13	84	52	1.06	0.21	0.40	2.36
97	SPARS 75A	TH 49 (Dodd Rd.) - From TH 110 to I-35E	1974	1985	11	62	38	2.70	7.97	0.60	13.78
98	SPARS 77	TH 95 - From TH 61 to CSAH 18	1972	1992	20	16	16	2.43	0.62	1.24	3.50
99	SPARS 78	TH 55 - From 52nd St. to 44th St.	1972	1985	13	27	16	2.25	2.16	0.71	4.69

Continued on next page

Table 4.1 – continued from previous page

Id	Report	Description	Report Year	Forecast Year	Number of Years	Total No. of Forecast Links	Total No. of Actual Traffic Links[1]	Avg Inaccuracy	Variance	Min. Inaccuracy	Max. Inaccuracy
100	TAS3562C	TH 55 - From Kimball to 3.5 Mi. SE of Jct. TH 25 in Buffalo	1967	1990	23	98	56	0.75	0.12	0.17	1.73
101	TAS3562D	TH 55 - From Kimball to 3.5 Mi. SE of Jct. TH 25 in Buffalo	1967	1990	23	50	14	0.43	0.07	0.19	0.90
102	FEIS New U.S. Hwy 10	New U.S. Hwy 10 - Between Egret Boulevard and I-35W	1987	2000	13	52	44	0.81	0.07	0.39	1.22
103	FEIS TH 3	TH 3 - (Is actually TH 52) - From Jct. TH 55 to Jct. I-494	1987	1990	3	40	36	0.81	0.28	0.23	2.09
104	FEIS TH 77/I-494	TH 77/I-494 - From E. 86th St. to E. 70th St. and from 12th Ave. S. to 34th Ave. S.	1987	1990	86	128	126	1.42	0.87	0.74	8.94
105	FEIS I35E	From TH 110 (Dakota County) to I-94 near downtown St. Paul	1982	2006	24	18	18	0.65	0.04	0.36	1.06
106	DEIS TH 610/TH 252	TH610/TH252 - From I-94 in Maple Grove to TH 10 in Coon Rapids/From I-94 in Brooklyn Center to TH 610 in Brooklyn Park	1981	2000	19	82	74	0.78	0.18	0.19	2.14
107	FEIS US-12/I-394	US-12/I-394 - From between SR-101 and I-94	1982	2000	18	294	250	1.09	0.30	0.39	2.87
108	20-Year Plan For District 9	I-35W - From I-35E to TH 49	1989	2010	21	18	16	1.02	0.07	0.64	1.35

[1] Average Annual Daily Traffic(AADT)

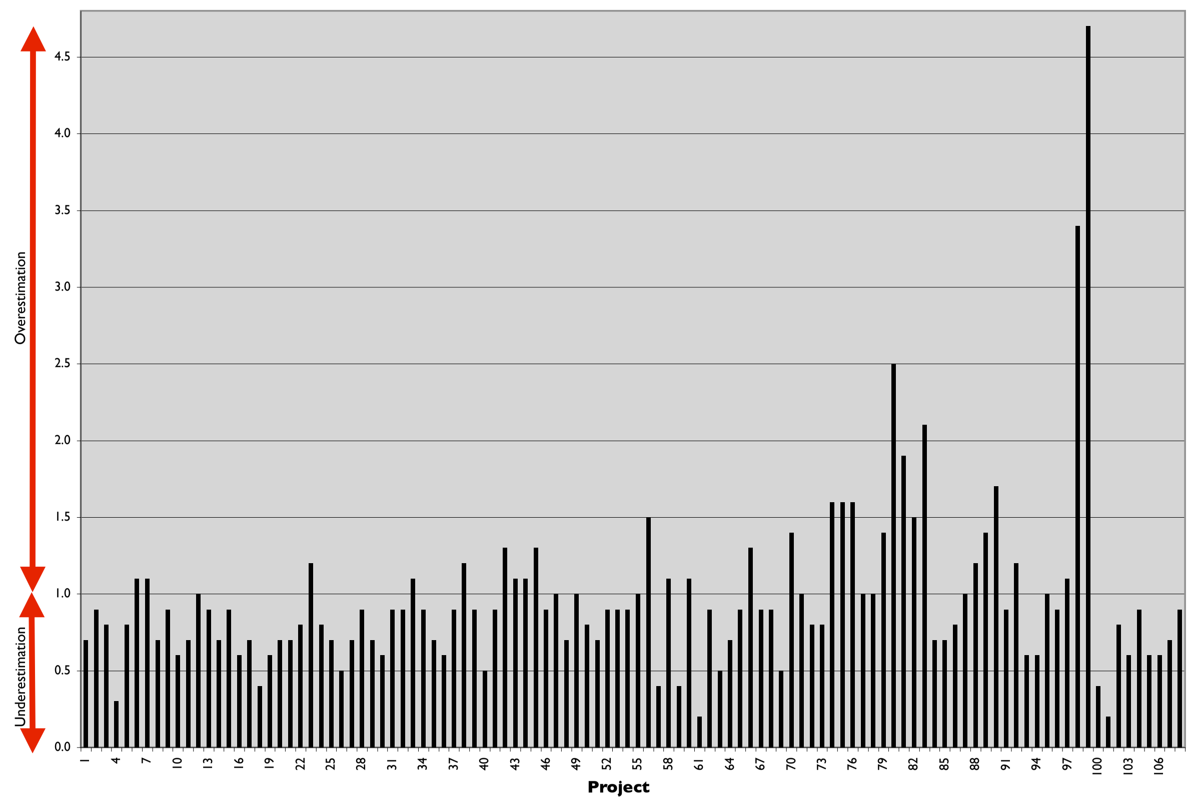

Figure 4.3: Estimated Inaccuracy on Critical Links by Project

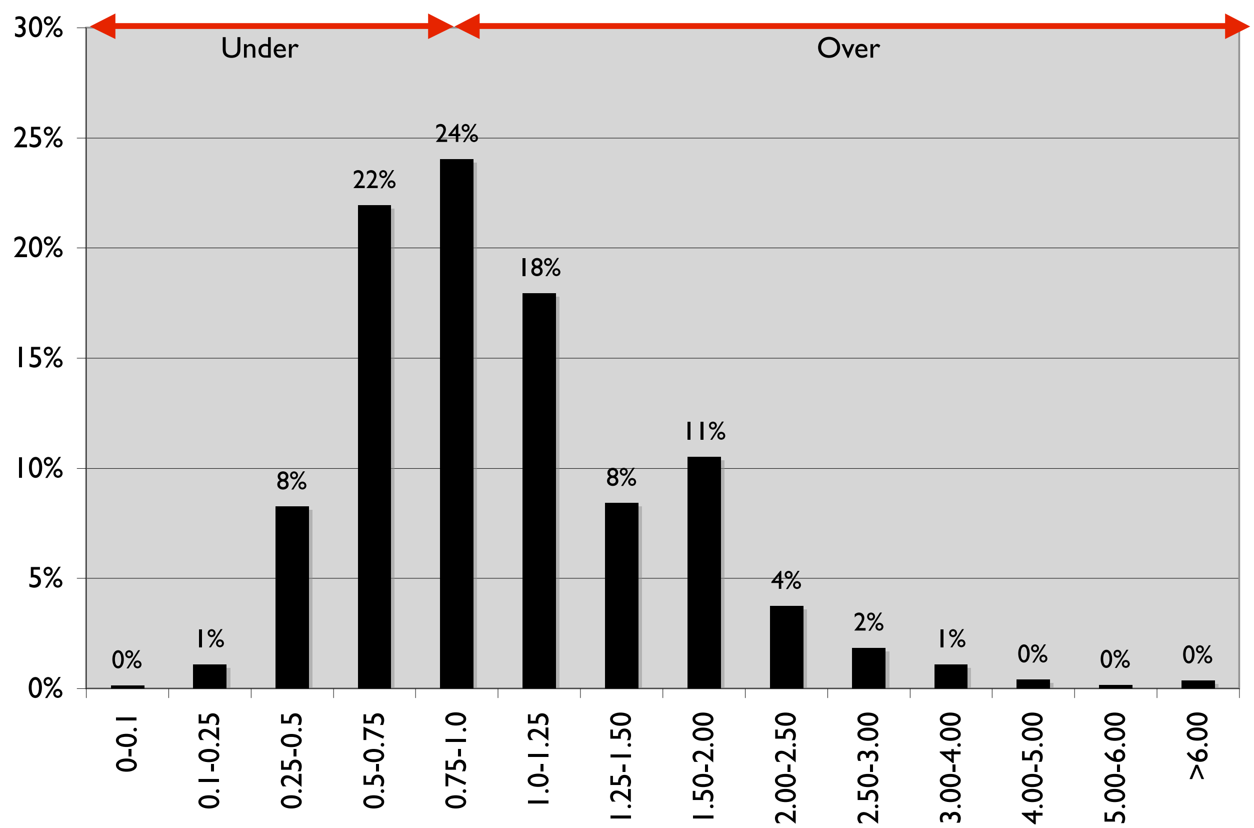

Figure 4.4: Frequency Distribution Plot of Average Inaccuracy

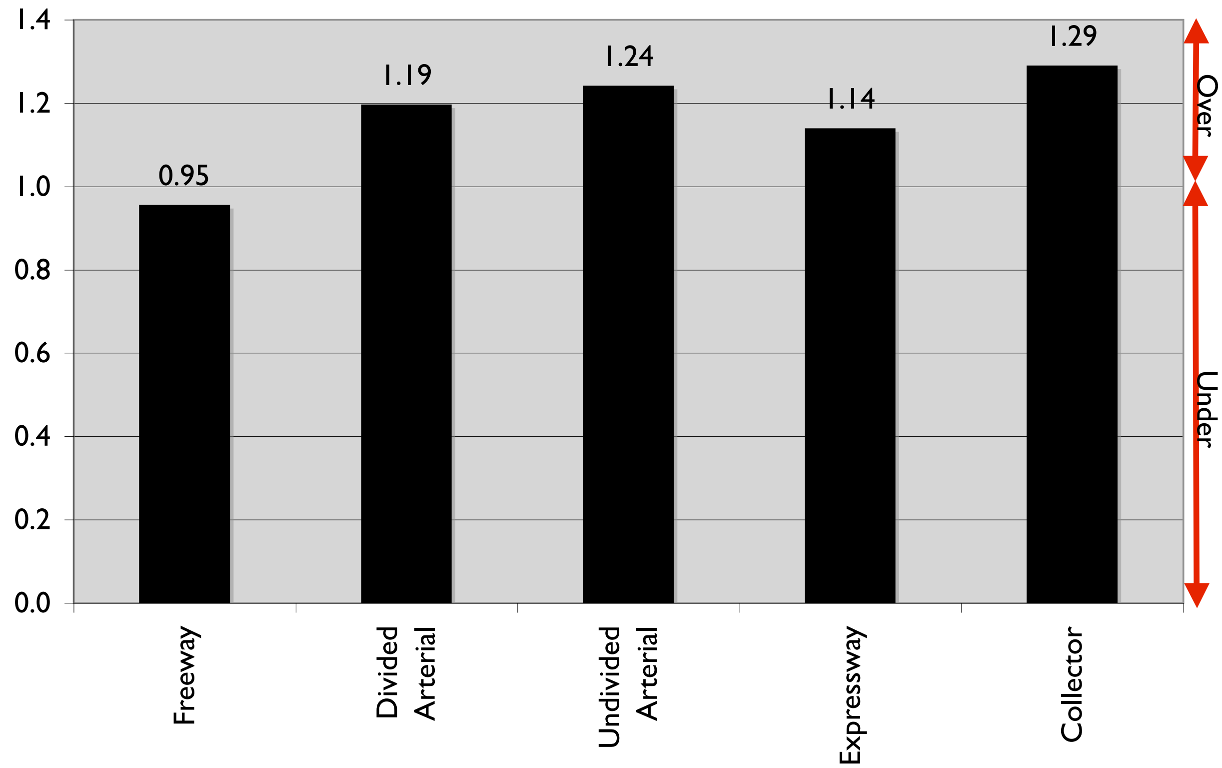

Figure 4.5: Estimated Average Inaccuracy by Highway Functional Classification

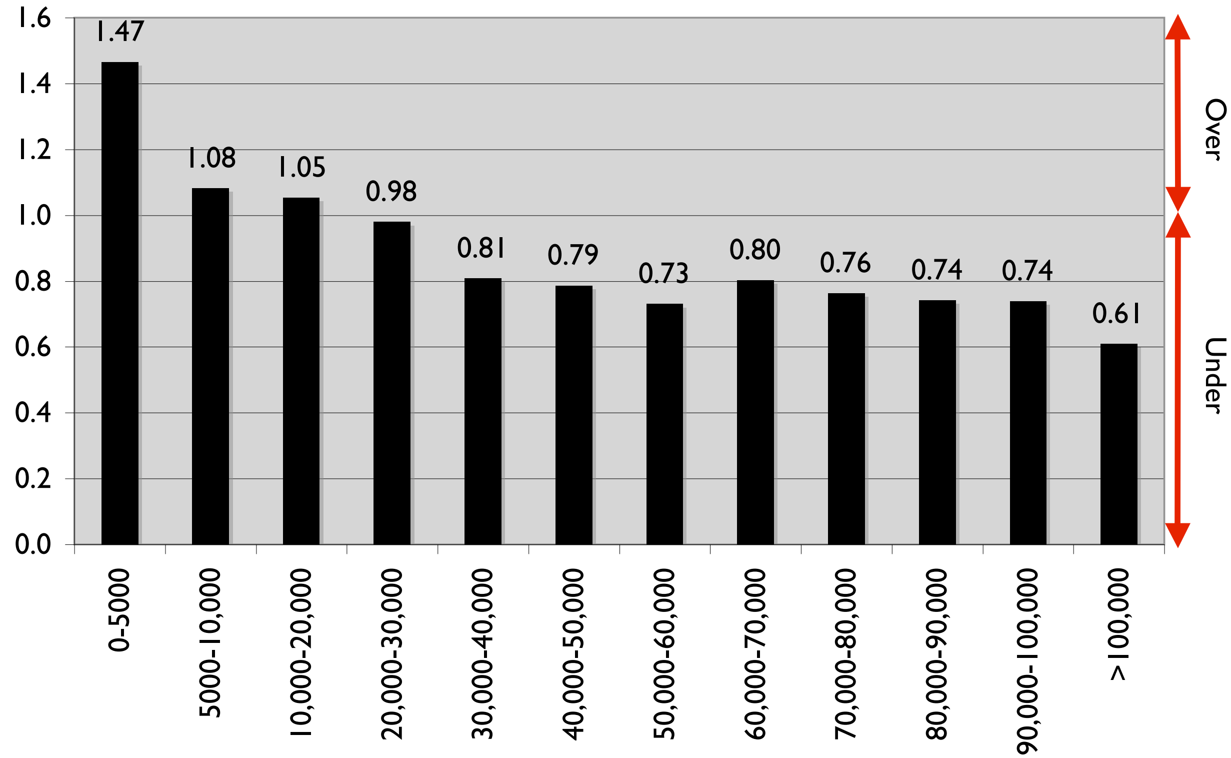

Figure 4.6: Estimated Average Inaccuracy by Counts

4.2 Quantitative analysis

As part of this quantitative analysis, a model was developed formulating the inaccuracy in roadway forecasts as a function of certain relevant variables. The quantitative analysis used the same data as the Illustrative analysis except that it focused only on the inaccuracies on the main roadway in each project and didn't consider the side streets or other roadways in the project for which forecasts had been provided. The following additional information was collected for each of the main highway data points with both forecast traffic data and actual traffic data.

- Number of years between the year in which the report was prepared and the forecast year
- Forecast Vehicle Miles Traveled (VMT) or Vehicle Kilometers Traveled (VKT) by project
- Highway Type
- Highway Functional Classification
- Roadway segment direction
- Decade of report preparation
- Project status (existing/new facility) at the time of report preparation

The forecast traffic provided on each main roadway segment was multiplied with the segment length, measured as part of this analysis. This estimated forecast VMT or VKT on each main roadway segment was then summed up by project to obtain a measure of project size.

The main roadways were separated into two roadway types: radial and lateral. Roadways that radiate directly from downtown Minneapolis or St. Paul that could be used as a way to get direct access to the downtowns were classified as radial roadways. The other roadways that did not provide a direct access to the downtown were classified as laterals. For example, in the Twin Cities region, highways such as I-394, I-94, I-35W, I-35E were classified as radial highways and roadways such as TH 100, TH 169, TH 51 were classified as lateral highways.

The highway functional classification was the same as the one used in the Illustrative analysis and has already been described above in detail. The segment direction was based on the roadway direction with respect to the central cities of Minneapolis and St. Paul. The following segment direction classification was used in this analysis:

- East
- Middle
- Middle North
- Middle South
- North
- Northeast
- Northwest

- South
- Southeast
- Southwest
- West

In addition, each project was classified into one of the following four time categories based on the year in which the report was prepared.

- 1960-1970 - refers to reports prepared between 1961 and 1970
- 1970-1980 - refers to reports prepared between 1971 and 1980
- 1980-1990 - refers to reports prepared between 1981 and 1990
- After 1990 - refers to reports prepared after 1990

The main highways in the database were also categorized into existing or new facilities as described above in the Illustrative analysis.

As mentioned above, the inaccuracies in the forecasts were measured as a ratio of the forecast traffic to actual traffic. A simple ordinary least squares (OLS) regression model was estimated using the roadway segments that had complete information for all the variables considered in the analysis. The basic functional form of the model estimated is given below:

$$I = f(N, H, F, V, D, T, S) \tag{4.1}$$

where,

- I = Inaccuracy ratio estimated as forecast traffic divided by actual traffic
- N = Number of years between report year and forecast year
- H = Highway type
- F = Functional Classification
- V = Project size measured in VMT or VKT
- D = Segment Direction
- T = Time variable representing decade of report preparation
- S = Roadway status.

The results of the analysis are provided in Table 4.2. Table 4.3 presents the results of the analysis in metric units. The results indicates the factors that influence the inaccuracies in roadway forecasts. A variable which is positive and significant can be expected to increase the inaccuracy ratio indicating overestimation while a variable which is negative and significant can be expected to decrease the inaccuracy ratio resulting in underestimation. The variables that have a significant influence (positive or negative) are highlighted in bold in Table 4.2 and 4.3 .

We can see that the the increase in the number of years between the report year and forecast year results in underestimation of traffic forecasts. Radial highway are more prone to underestimation compared to lateral highways in the region. The functional classification of the roadway doesn't play an influencing role except for expressways which are subject to overestimation with respect to freeways.

Compared to roadways located between the cities of Minneapolis or St. Paul, roadways located in the middle south (between Minneapolis and St. Paul), southwest, northwest and west direction show a trend of underestimation while roadways in the east, northeast and southeast directions show overestimation in traffic forecasts.

The reports prepared in the decade between 1970 and 1980 seems to have produced overestimated forecasts compared to the base decade of 1960-1970 but the other time categories do not play an influencing role on forecast inaccuracy. The roadway status (existing/new) at the time of report preparation influences the inaccuracy in forecasts with new facilities being more prone to underestimation in forecasts compared to the existing roadway facilities. The size of the roadway project does not seem to have an influence on the inaccuracy in forecasts.

The quantitative analysis was conducted to go beyond the illustrative analysis and identify factors that contribute to the underestimation/overestimation in traffic forecasts. While the estimated model was a simple OLS model, the results confirm that the inaccuracy in traffic forecasts is influenced by many factors and also shows the type of influence that each of the variables have on forecast inaccuracy.

Both the illustrative analysis and quantitative analysis utilize the actual traffic counts to compare against the forecast traffic. It is important to note that in both these analysis, the actual ground traffic counts need not be 100% accurate and are subject to their own set of data collection errors. Hence the inaccuracy estimates measured here might vary based on the errors present in the actual traffic information.

4.3 Qualitative analysis

Similar to the analysis used by Flyvbjerg et al. (2005), the qualitative analysis involved interviewing modelers in the Twin Cities who have had experience working with the Twin Cities travel demand models. The goal was to obtain their perspectives on the modeling process which might provide some useful insights into reasons for inaccuracies in forecasting.

A total of seven people were interviewed in this process and the interviews were conducted between May - June 2008. The interviewees varied in terms of their actual hands-on experience with the models and ranged from modelers who were actually involved in the technical development of the model to planners whose expertise was limited to using the results from the model for various roadway projects. The interviews were conducted with both private sector consultants and employees of public agencies and were conducted in person, via email and over the phone.

Each of the interviewee were asked the standard set of five questions, which are provided below:

1. Your understanding of the possible sources of error in the Twin Cities models?

2. With the current expertise in modeling that we have, what could have be done differently with the model development in 1970s, 1980s?

Table 4.2: Results from OLS Regression (English Units)

Variable	Coefficient	Std. Error	t	P> $\|t\|$
Number of years*	-0.034	0.004	-9.560	0.000
Project VMT	0.000	0.000	-1.430	0.153
Radial highway type*	-0.108	0.033	-3.330	0.001
Collector	-0.112	0.226	-0.500	0.619
Divided Arterial	0.047	0.057	0.830	0.407
Expressway*	0.097	0.043	2.270	0.024
Undivided Arterial	0.031	0.049	0.640	0.523
East*	0.264	0.082	3.230	0.001
Middle North	-0.036	0.073	-0.490	0.624
Middle South*	-0.348	0.105	-3.320	0.001
North	-0.113	0.072	-1.560	0.119
Northeast*	0.552	0.077	7.200	0.000
Northwest*	-0.193	0.087	-2.220	0.027
South	-0.056	0.071	-0.780	0.434
Southeast*	0.358	0.070	5.140	0.000
Southwest*	-0.162	0.079	-2.050	0.041
West*	-0.154	0.083	-1.860	0.063
Rept year between 1970-1980*	0.111	0.042	2.610	0.009
Rept year between 1980-1990	0.064	0.047	1.350	0.177
Rept year after 1990	0.278	0.220	1.260	0.207
New Facilities*	-0.125	0.039	-3.220	0.001
constant	1.639	0.088	18.630	0.000
Number of obs	1275			
R-squared	0.251			
Adj R-squared	0.238			
Root MSE	0.503			

* indicates significant at 90% level

Table 4.3: Results from OLS Regression (Metric Units)

Variable	Coefficient	Std. Error	t	P> $\|t\|$
Number of years*	-0.034	0.004	-9.560	0.000
Project VKT	0.000	0.000	-1.430	0.153
Radial highway type*	-0.108	0.033	-3.330	0.001
Collector	-0.112	0.226	-0.500	0.619
Divided Arterial	0.047	0.057	0.830	0.407
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Rept year between 1970-1980*	0.111	0.042	2.610	0.009
Rept year between 1980-1990	0.064	0.047	1.350	0.177
Rept year after 1990	0.278	0.220	1.260	0.207
New Facilities*	-0.125	0.039	-3.220	0.001
constant	1.639	0.088	18.630	0.000
Number of obs	1275			
R-squared	0.251			
Adj R-squared	0.238			
Root MSE	0.503			

* indicates significant at 90% level

3. How does the Twin Cities model compare with other models that you have worked with or had an opportunity to look at?

4. How would you respond to criticisms against modeling? - Many people argue that the most models underestimate/overestimate the traffic forecasts and hence it is not worthwhile to be spending time, money and efforts on modeling

5. Have there been instances on political compulsions influencing the model forecasting in the Twin Cities?

A brief summary of the responses from the interviews are provided below and the complete interviews are presented in the Appendix.

While each interviewee provided different reasons for inaccuracies in traffic forecasts, the inability of the model to understand and predict fundamental societal changes was the most often stated reason. The change in the labor force participation of women was one of the commonly quoted examples of the model's inability to properly account for travel behavior. Other factors such as increases in mobility, auto ownership, influence of the internet and technology on travel were also provided as examples of model's inability to understand and incorporate societal changes.

Another very important reason often provided by the interviewees were the errors in the socio-economic inputs that fed into the model along with the locational distribution of forecasted demographics. The development of socio-economic forecasts used in the older models was done exclusively by the Metropolitan Council without any input from the local communities. The involvement of the local communities in the 1990s helped correct this error to a certain extent. However the modeling process ran into the issue of aggressive forecasting by the local communities without any thought as to where the growth needs to be alloted or any understanding of ways to meet the infrastructure requirements of the forecasted population and employment. It is only in the last 8-10 years that communities have started to understand the importance of realistic socio-economic forecasts. The difference between the planned and actual highway networks was also provided as another reason for inaccuracy in forecasts.

The technical and computational limitations in the older models made it difficult for modelers to track errors, conduct sensitivity tests etc. to ensure the reasonableness and accuracy of their forecasts. The complicated nature of the models also resulted in modeling being limited to a select few individuals which meant lesser discussions and fewer people looking at the model forecasts to ensure reasonableness.

From a technical standpoint, the trip distribution model came in for criticism since it was felt that there still wasn't a good understanding of the basic trip patterns in the region. Other technical aspects of the model that came in for criticism were the the over importance given to home based work (HBW) trips compared to other purposes, traditional focus on principal arterials with little importance to assignment on collectors/minor arterials, inability of the model to handle peak spreading and the assumption of a fixed percentage of daily traffic for the peak periods and the handling of special generators, especially big ones such as the Mall of America.

The interviewees mostly agreed that political compulsions had not been a major factor in influencing the traffic forecasts in the Twin Cities compared to other regions. Some of the interviewees indicated that private consultants were more likely to be face pressure from the clients compared to public agency employees in terms of model input assumptions such as roadway capacities, socio-economic inputs. Public agencies in the Twin Cities do not necessarily face political pressure but sometimes there is a “push” to use existing or expected assumptions which need not be confirmed by the data in hand.

Most interviewees were also unanimous in their agreement for the necessity of using models in forecasting. The view of the interviewees was that criticisms against the use of modeling in forecasting arise when the model results are used by policy makers without an understanding of the science/process behind the numbers, the application of a macro level model to a micro level study area without adequate analysis and the lack of understanding that models are best used for highlighting differences between various scenarios rather than providing absolute numbers. The interviewees also argued that models needed to be looked at as just one of the tools to help in the decision making process and other factors need to be taken into account. Use of other techniques such as growth rates would work only in few scenarios and models are absolutely essential to forecasting the future.

Chapter 5

Understanding Reasons for Forecast Inaccuracy

One of the primary objectives in this research was to test for the presence of inaccuracy in roadway traffic forecasts using Twin Cities data. Another important objective of this research was to identify the reasons for the presence of inaccuracy in traffic forecasts. Such an analysis would ideally involve looking at the input assumptions (roadway network, socio-economic forecasts, trip rates etc.) that went into creating the forecasts for each of the projects in the database. The difficulties encountered in the data collection efforts of this research project combined with the minimal documentation provided in each project report and the inability to obtain the actual model files from the 1970 and 1980 models have highlighted the in-feasibility of such an approach.

Rather than attempt to collect the input information for each of the project reports in the database, it was decided to collect input information that might have been used in the regional travel demand model to prepare forecasts. As indicated above in the data section, most forecasts in the database seem to have been prepared based on the regional travel demand models modified by ground counts and turning movements. So comparing model inputs to actual numbers might help shed light on the reasons for forecast inaccuracy.

5.1 Comparison of demographic inputs

The errors in the socio-economic inputs that feed into the model along with the locational distribution of forecasted demographics was identified as an important reason for forecast inaccuracy under the qualitative analysis. Some of the interviewees indicated that the demographic forecasts were overoptimistic especially in the 1970s and governed by the Metropolitan Council's growth objective of "4 million by the year 2000".

Table 5.1 provides a comparison of demographic forecasts to the actual numbers, estimated as an inaccuracy ratio. The demographic forecasts were prepared by Metropolitan Council for the 7-county metro in March 1975 for future years 1980, 1990 and 2000 and utilized in the respective regional travel demand models. The actual Census demographics for Minnesota were obtained from the datanet hosted at the Minnesota Land Management Information Center (LMIC) and the National Historical Geographical Information System (NHGIS)(Land Management Information Center, 2008; Minnesota Population Center, 2008).

Table 5.1: Comparison of Demographic Forecasts

Average Inaccuracy estimated using 1975 Metcouncil forecasts			
County	**1980 Population**	**1990 Population**	**2000 Population**
Anoka	1.08	1.01	0.93
Carver	1.02	1.19	1.04
Dakota	1.17	1.19	1.19
Hennepin	1.10	1.08	1.06
Ramsey	1.12	1.17	1.22
Scott	1.02	1.04	0.89
Washington	1.11	1.27	1.22
Total 7-county	**1.11**	**1.12**	**1.10**

The comparison indicates a trend of overestimation in demographic forecasts with all counties showing an inaccuracy ratio of greater than 1.0 except for the year 2000 forecasts for fast growing suburban Anoka and Scott counties. The results from the comparative analysis indicates the presence of errors in the demographic forecasts used in the travel demand models which could contribute to the inaccuracy in the roadway forecasts.

5.2 Comparison of travel behavior inputs

Another component of the modeling process that could contribute to the overall inaccuracy in traffic forecasts is the trip generation/travel behavior component. The regional travel demand models used in the Twin Cities are typically based on the Travel Behavior Inventory(TBI) survey. The TBI is a comprehensive travel survey conducted in the Twin Cities area, conducted jointly by the Metropolitan Council and Mn/DOT about every 10 years. The travel characteristics estimated from the TBI are used to update the regional travel demand model for forecasting purposes (Metropolitan Council of the Twin Cities Area., 2003).

Since it wasn't possible to obtain the actual model files from the 1970s and 1980s, it was decided to look into the TBI data for an understanding of the travel behavior characteristics used in the models to produce forecasts. Table 5.2 provides a summary of the TBI data from 1949 to 2000. It can be seen that the average home-based work (HBW) trip length, trips per capita and trips per household show an increasing trend while the auto occupancy and persons per household show a decreasing trend.

The models were developed based on the actual TBI data for the base year and typically used similar travel characteristics for the forecast year. So a 1990 traffic forecast prepared using the 1970 travel demand model would use travel characteristics from the 1970 TBI for the base year traffic and characteristics similar to 1970 TBI for 1990 traffic forecasts. The 1970 model used to prepare 1990 traffic forecasts would most likely not have incorporated the following changes between 1970 and 1990, given below:

- A 40% increase in home-based work (HBW) trip lengths
- A steep increase in trip making characteristics - a 43% increase in trips per capita, a 14% increase in trips per household, a 39% increase in women labor force participation

- A 22% decrease in persons per household combined with a 9% increase in workers per household
- A 10% decrease in HBW auto occupancy and a 14% decrease in overall auto occupancy

The inability of the travel demand models to incorporate such fundamental shifts in travel behavior could be another important reason for inaccuracy in traffic forecasts.

Table 5.2: Summary of TBI Data

Variables	**1949 TBI**	**1958 TBI**	**1970 TBI**	**1982 TBI**	**1990 TBI**	**2000 TBI**	**1990 - 1970 TBI**	**2000 - 1970 TBI**
HBW Average Trip Length: Miles	na	na	6.57	8.11	9.2	11.4	40%	74%
HBW Average Trip Time: Minutes	na	na	19.8	na	21.2	25.6	7%	29%
Trips Per Capita	1.78	2.45	2.72	3.37	3.9	4.2	43%	54%
Trips Per Household	na	7.52	8.88	9.08	10.12	10.3	14%	16%
Persons Per Household	na	na	3.27	2.68	2.56	2.46	-22%	-25%
Workers Per Household	na	na	1.3	1.38	1.42	na	9%	na
Auto Occupancy: HBW	1.12	1.12	1.19	1.15	1.07	1.05	-10%	-12%
Auto Occupancy: Overall	1.55	1.57	1.5	1.3	1.29	1.35	-14%	-10%
Percentage of Women in Labor Force*	na	na	48.8%	60.0%	67.8%	72.5%	39%	49%

Source: 2005 Twin Cities Transportation System Performance Audit

5.3 Comparison of highway network inputs

Another possible reason for the inaccuracy in roadway traffic forecasts could be the differences between the assumed highway network and the actual in-place network. Most roadway projects have a long time gap between the planning stage and actual construction/implementation stage magnified by delays encountered during roadway construction. In addition the roadway alignment usually goes through many changes and the initially analyzed alignment might be very different from the actual in-place alignment. In some cases, roadways assumed to be completed by a certain forecast year might end up not being constructed at all.

Since it was not possible to identify the roadway network assumptions for each project report in the database, it was decided to conduct a macro-level analysis by comparing the network assumptions from the Transportation Policy Plans (TPP) and other comprehensive plans against the actual year of roadway construction. The TPP is prepared by the Metropolitan Council as part of the comprehensive development guide also called the Regional Development Framework (RDF) for the Twin Cities seven-county metropolitan area. The TPP describes the transportation policies and plans that the Metropolitan Council plans to implement between the plan's adoption year and the plan's forecast year to meet the regional goals of the RDF. The Metropolitan Council's current 2030 Transportation Policy Plan was approved and adopted by the council on December 15, 2004 (Metropolitan Council of the Twin Cities Area., 2004).

Table 5.3 provides a comparison of the roadways identified in the 1976 RDF and expected to be completed by 1990 against the actual year of construction of each roadway. These highway network assumptions would have been used in the regional travel demand models to produce forecasts for 1990 and later.

The rows highlighted in bold in Table 5.3 are highways that did not get completed by 1990 and in some cases ended up not being built at all. For example, the I-335 alignment, proposed in the 1976 RDF, between I-94 and I-35W, has been eliminated from consideration by Mn/DOT and there are currently no plans to construct this section. Similarly the section of Northtown Corridor between I-94 and US 169 has still not been completed even though it was identified to be completed by 1990.

The differences between assumed networks and planned networks arise due to many factors, namely, construction delays, funding issues, public opposition, shift in regional planning goals etc., but such differences between the assumed networks and in-place networks contribute to inaccuracy in project forecasts.

This macro-level analysis indicates that the inaccuracies in roadway forecasts arise from different sources, some of which have been described above. While the difficulties in data collection limited the type of detailed analysis that could have been conducted, the results highlight the differences between forecasted and actual inputs that feed into the model forecasting process resulting in forecast errors.

Table 5.3: Comparative Analysis of Highways Identified in the 1976 Regional Development Framework

Highways	**From**	**To**	**Actual Year Built**
I-35E	West Seventh Street	I-94	1984-1991
I-35E	I-35	State Highway 110	1981-1985
I-94 (Mpls)	US 12	57th Ave N	1980-1982
I-494	State Highway 5	I-494	1982-1986
US 10	Ramsey Co Rd J	State Highway 47	1990
US 169/212	**I-494**	**State Highway 41**	**1994-1996**
US 169 (W River Rd)	86th Ave N	Northtown Corridor	1983
US 169/ State 101 (Shakopee Bypass)	US 169	State Highway 13	1976-1980
Co Rd 18 (Hennepin)	**5th Street S**	**Minnetonka Blvd**	**1994**
Co Rd 62 (Hennepin)	**Co Rd 18**	**I-494**	**1985-1986**
Northtown Corridor	**US 169**	**I-94**	**Not built yet**
Northtown River Crossing	**US 10**	**US 169**	**1998**
LaFayette Expressway (52)	**I-494/State Highway 110**	**State Highway 55/52**	**1985-1994**
I-335	**I-94**	**I-35W**	**Control Section eliminated in 1979**

* The above listed highways were identified in the 1976 RDF as new facilities expected to be constructed to complete the 1990 Metropolitan highway system

Chapter 6

Recommendations and Conclusions

The objective of this study was to estimate the inaccuracy present in roadway forecasts and identify the reasons for inaccuracy using Minnesota data. The illustrative analyses conducted as part of this research indicated a trend of underestimation in roadway forecast especially in higher volume roadways and higher functional classification such as freeways. The quantitative analysis conducted here using a simple OLS model shed light on the factors influencing forecast inaccuracy and the type of influence that each variable has on the overall traffic inaccuracy. Variables such as the number of years between the report year and forecast year, highway functional classification, roadway direction, year of report preparation and roadway status seem to influence the forecast inaccuracy.

The qualitative analysis conducted helped identify the reasons for inaccuracy in traffic forecasts from a modeler's perspective. The errors in model inputs such as demographic forecasts, trip making characteristics and network differences contributes to the total inaccuracy in roadway forecasts though the exact contribution of each of these inputs to total forecast inaccuracy is difficult to estimate with the data available. The changes in modeling methodologies over time such as the use of capacity constraints, improvements in equilibrium assignment techniques, mode choice routines have also contribute to the differences in roadway traffic forecasts prepared over the various years.

The data collection efforts on this research project turned out to be much more laborious and time consuming effort than anticipated. The unavailability of the data in electronic format, lack of proper documentation, record keeping and data archiving procedures complicated the data collection process and subsequent analyses. Many of the older model files were in paper format and had been thrown away over the years with changes in office locations and individuals involved in modeling.

One of the most important recommendation that can be provided, based on this study, is the absolute necessity for agencies to incorporate better record keeping and data archiving procedures. Such an approach would make it easy to look back at the modeling process (inputs, assumptions, technical methods) utilized and conduct various types of analysis (sensitivity analysis, backcasting procedures) to investigate the reasonableness of traffic forecasts.

The long-term and complicated nature of forecasting process makes it difficult to anticipate changes and control for errors in model forecasts. In some cases, factors outside the control of the planning agency such as the current worldwide financial crisis, threats to national security influence the travel patterns of individuals but aren't necessarily easy to predict and incorporate.

The improvements in technology, internet usage and rising gas prices contribute to changes in the way people travel and make residential and employment decisions. Most modelers interviewed as part of this research acknowledged the lack of a proper understanding of travel behavior and trip distribution could be possible sources for model errors. The impact of fundamental societal changes on traffic forecasts and the dependence of irreversible infrastructure decisions on these forecasts makes it imperative for modelers to better understand them and incorporate them rather than blindly utilizing existing trends into the forecasting process.

It is also essential for non-modelers/decision makers in charge of funding decisions to obtain a better understanding of the forecasting process. Most interviewees acknowledged that a basic understanding of the science behind the forecasts, limitations and applicability of traffic forecasts would go a long way in diffusing criticisms against modeling.

Further a shift in thinking from using absolute numbers in making infrastructure decisions to using ranges would definitely improve the forecasting process. An acknowledgement of the inherent uncertainties in the modeling process along with a sensitivity analysis using ranges to show the variation in traffic forecasts with changes in the various inputs would certainly help the forecasting and decision making process.

References

Altshuler, A.A. and Luberoff, D (2003). *Mega-Projects: The Changing Politics of Urban Public Investment*. Washington, D.C.; Cambridge, MA: Brookings Institution Press ; Lincoln Institute of Land Policy.

Ashley, D. (1980). Uncertainty in the context of highway appraisal. *Transportation Research 9*, 249–267.

Bain, R. and M. Plantagie (2004). Traffic forecasting risk: study update 2004.

Bain, R. and L. Polakovic (2005). Traffic forecasting risk study update 2005: through ramp-up and beyond.

Chang, K.-T., Z. Khatib, and Y. Ou (2002). Effects of zoning structure and network detail on traffic demand modeling. *Environment and Planning B 29*, 37–52.

Clarke, M., M. Dix, and P. Jones (1981). Eror and uncertainty in travel surveys. *Transportation 10*, 105–125.

Daly, A. J. and Ortuzar, J. de D. (1990). Forecasting and data aggregation: theory and practice. *Traffic engineering & control. 31*(12), 632–643.

de Jong, G., A. Daly, M. Pieters, S. Miller, R. Plasmeijer, and F. Hofman (2007). Uncertainty in traffic forecasts: literature review and new results for The Netherlands. *Transportation 34*(4), 375–395.

Flyvbjerg, B. (2005). Measuring inaccuracy in travel demand forecasting: methodological considerations regarding ramp up and sampling. *Transportation Research Part A 39*(6), 522–530.

Flyvbjerg, B., N. Bruzelius, and W. Rothengatter (2003). *Megaprojects and Risk: An Anatomy of Ambition*. United Kingdom: Cambridge University Press.

Flyvbjerg, B., M. Holm, and S. Buhl (2005). How (in) accurate are demand forecasts in public works projects? *Journal of the American Planning Association 71*(2), 131–146.

Flyvbjerg, B., M. Holm, and S. Buhl (2006). Inaccuracy in traffic forecasts. *Transport Reviews 26*(1), 1–24.

Gilbert, D. and A. Jessop (1977). Error and uncertainty in transport models. *Transportation models: proceedings of Seminar G, PTRC Summer Annual Meeting, University of Warwick, United Kingdom, June 1977*.

Goodwin, P. (1996). Empirical evidence on induced traffic. *Transportation 23*(1), 35–54.

Horowitz, J. and R. Emslie (1978). Comparison of measured and actual traffic volumes on urban interstate highways. *Transportation Research 12*, 29–32.

Hugosson, M. (2005). Quantifying uncertainties in a national forecasting model. *Transportation Research Part A 39A*(6), 531–547.

Johnston, R. and R. Ceerla (1996). Travel modeling with and without feedback to trip distribution. *Journal of transportation engineering 122*(1), 83–86.

Kain, J. (1990). Deception in dallas: strategic misrepresentation in rail transit promotion and evaluation. *Journal of the American Planning Association 56*(2), 184–196.

Land Management Information Center (2008). Datanet. Accessed May 2008.

Lewis-Workman, S., B. White, S. McVey, and F. Spielberg (2007). *The Predicted and Actual Impacts of New Starts Projects - Capital Costs and Ridership*. Washington, D.C: Federal Transit Administration and Vanasse Hangen Brustlin, Inc.

Mackinder, I. H. and S. E. Evans (1981). *The predictive accuracy of British transport studies in urban areas*. Crowthorne, Berkshire, United Kingdom: Transport and Road Research Laboratory.

Mahmassani, H. (1984). Uncertainty in transportation systems evaluation: issues and approaches. *Transportation planning and technology 9*(1), 1–12.

Metropolitan Council of the Twin Cities Area. (2003). *2000 Travel Behavior Inventory home interview survey : data and methodology.* St. Paul, MN: Metropolitan Council.

Metropolitan Council of the Twin Cities Area. (2004). *2030 Transportation Policy Plan.* St. Paul, MN: Metropolitan Council.

Minnesota Population Center (2008). National Historical Geograhic Information System. Accessed May 2008.

Niles, J. and D. Nelson (2001). Identifying uncertainties in forecasts of travel demand. Accessed October 2007.

Noland, R. (2001). Relationships between highway capacity and induced vehicle travel. *Transportation Research Part A 35*(1), 47–72.

Noland, R. and L. Lem (2000). Induced travel: A review of recent literature and the implications for transportation and environmental policy. *Appraisal of Road Transport Initiatives: Proceedings of Seminar D, European Transport Conference*.

Page, J., M. Levenson, and B. Stewart (1981). *Twin Cities forecasting accuracy study*. St. Paul, MN: Minnesota Dept. of Transportation.

Pell, C. and A. Meyburg (1985). Sources of error and their implications for uncertainty in urban transportation planning forecasts. *64th Annual Meeting of the Transportation Research Board*.

Pickrell, D. (1992). A desire named streetcar: fantasy and fact in rail transit planning. *Journal of the American Planning Association 58*(2), 158–176.

Richmond, J. (2001). A whole-system approach to evaluating urban transit investments. *Transport Reviews 21*(2), 141–179.

Rodier, C. (2004). Verifying accuracy of regional models used in transportation and air quality planning: case study in Sacramento, California, Region. *Transportation Research Record 1898*, 45–51.

Talvitie, A., Y. Dehghani, and M. Anderson (1982). An investigation of prediction errors in work trip mode choice models. *Transportation Research A 16*, 395–402.

Wachs, M. (1992). Ethical dilemmas in forecasting for public policy. *Public Administration Review 42(6)*, 562–567.

Zhao, Y. and K. Kockelman (2002). The propagation of uncertainty through travel demand models: An exploratory analysis. *The Annals of regional science. 36*(1), 145–163.

Appendix A: Data

Table 1: List of Scanned Project Reports

Id	Report No	Id	Report No	Id	Report No	Id	Report No	Id	Report No	Id	Report No
1	PSU3203A	41	TA-M298	81	TAU 3076	121	TA-M241	161	TA-M368B	201	TAU 3453
2	PSU3203B	42	TA-M299	82	TAU 3077	122	TA-M253A	162	TA-M369	202	TAU 3455
3	SPAR-202	43	TA-M300	83	TAU 3078	123	TA-M255	163	TA-M370	203	TAU 3456
4	SPAR-202A	44	TA-M301	84	TAU 3205	124	TA-M278A	164	TA-M372	204	TAU 3457
5	SPAR-208	45	TA-M302	85	TAU 3223	125	TA-M295	165	TA-M372A	205	TAU 3458
6	SPAR-215	46	TA-M304	86	TAU 3451A	126	TA-M315	166	TA-M373	206	TAU 3459
7	SPAR-227	47	TA-M308	87	TAU 3451B	127	TA-M316	167	TA-M374	207	TAU 3459-14
8	SPARS 15	48	TA-M309	88	TAU3204A	128	TA-M317	168	TA-M375	208	TAU 3459A-14
9	SPARS 16	49	TA-M311	89	SPAR-202 HOV	129	TA-M319	169	TA-M376	209	TAU 3557A
10	SPARS 17	50	TA-M326	90	SPAR-221	130	TA-M323	170	TA-M379	210	TAU 3560
11	SPARS 18	51	TA-M329	91	SPARS 1	131	TA-M323A	171	TA-M380	211	TAU 3561
12	SPARS 19	52	TA-M335	92	SPARS 1A	132	TA-M324	172	TA-M381		
13	SPARS 2	53	TA-M336	93	SPARS 1B	133	TA-M325	173	TA-M383		
14	SPARS 2A	54	TA-M337	94	SPARS 38	134	TA-M327	174	TA-M385		
15	SPARS 3	55	TA-M343	95	SPARS101	135	TA-M328	175	TA-M386		
16	SPARS 32	56	TA-M358	96	SPARS102	136	TA-M329A	176	TA-M387		
17	SPARS 33	57	TA-M372B	97	SPARS104	137	TA-M329B	177	TA-M388		
18	SPARS 37	58	TAS 3065A-14	98	SPARS106	138	TA-M329R	178	TA-M390		
19	SPARS 4	59	TAS 3066A-14	99	SPARS109	139	TA-M330	179	TA-M391		
20	SPARS 45	60	TAS 3074B	100	SPARS110	140	TA-M333	180	TA-M393		
21	SPARS 48	61	TAS 3074C-14	101	SPARS112	141	TA-M334	181	TA-M393A		
22	SPARS 49	62	TAS 3080	102	SPARS113	142	TA-M338	182	TA-M394		
23	SPARS 53	63	TAS 3081	103	SPARS117	143	TA-M340A	183	TA-M395		
24	SPARS 60	64	TAS 3081A-14	104	SPARS118	144	TA-M342	184	TA-M399		
25	SPARS 61	65	TAS3081B-14	105	SPARS119	145	TA-M348	185	TA-M402		
26	SPARS 65	66	TAS3082-14	106	SPARS123	146	TA-M349	186	TAS 3079		
27	SPARS 69	67	TAS3084-14	107	SPARS124	147	TA-M350	187	TAS3083-14		
28	SPARS 72	68	TAS3085-14	108	SPARS132	148	TA-M350A	188	TAS3083A-14		
29	SPARS 73	69	TAS3562C	109	SPARS139	149	TA-M351	189	TAS3453A-14		
30	SPARS 75	70	TAS3562D	110	SPARS79	150	TA-M352	190	TAS3460-14		
31	SPARS 75A	71	TAU 3061A	111	SPARS80	151	TA-M353	191	TAS3460A-14		
32	SPARS 77	72	TAU 3065	112	SPARS82	152	TA-M354	192	TAS3460B-14		
33	SPARS 78	73	TAU 3066	113	SPARS83	153	TA-M355	193	TAS3561A		
34	TA-M207A	74	TAU 3069	114	SPARS86	154	TA-M356	194	TAS3562A		
35	TA-M242	75	TAU 3070	115	SPARS86A	155	TA-M357	195	TAS3562B		
36	TA-M245	76	TAU 3073	116	SPARS89	156	TA-M360	196	TAU 3063A		
37	TA-M253	77	TAU 3073A	117	SPARS90	157	TA-M363	197	TAU 3071		
38	TA-M289A	78	TAU 3074	118	SPARS93	158	TA-M365	198	TAU 3223A		
39	TA-M292	79	TAU 3074A	119	SPARS97	159	TA-M367	199	TAU 3451C		
40	TA-M296A	80	TAU 3075	120	SPARS99	160	TA-M368A	200	TAU 3451D		

Table 2: List of Unscanned Project Reports

Id	Report No	Id	Report No	Id	Report No	Id	Report No	Id	Report No
1	Planning Survey Unit File 3031	61	Planning Survey Unit File 2018	121	TAU 2418	181	TA-M307	241	MSU 199 - 20199
2	Traffic Analysis Unit File 3059	62	Planning Survey Unit File 2021	122	TAU 2419A	182	TAR-M280	242	TAU 367
3	TAU 3059	63	TAU 2022	123	TAU 2419B	183	TA-M307A	243	TAU 429
4	TAU 3059A	64	TAS 2022A-14	124	TAS 2420	184	TA-M345	244	TAS 530-14
5	TAS 3059B-14	65	TAU 2023	125	TAS 2420A	185	TA-M346	245	PSU 617
6	TAS 3059C-14	66	TAU 2024	126	TAU 2459	186	TA-M339	246	PSU 628
7	TAS 3059D-14	67	TAU 2025	127	Planning Survey Unit File 2465	187	TA-M340	247	PSU 628
8	TAS 3059E-14	68	TAU 2026	128	TAU 2465	188	Twin Cities Forecasting Accuracy Study	248	TAU 628
9	TAU 3060	69	TAU 2027	129	TAU 2465A	189	Year 2000 Highway System Forecast Analysis	249	TAU 628
10	Planning Survey Unit File 3055	70	TAU 2028	130	TAU 2465B	190	TH 212 Traffic Forecasts - I-494 to Noewood/Young America	250	TAU 628A
11	Planning Survey Unit File 3056	71	TAU 2029	131	Planning Survey Unit File 2466	191	SPAR M-181	251	TAU 628B
12	TAU 3056	72	TAU 2030-14	132	TAU 2466A	192	SPAR M-207	252	TAS 628C-14
13	TAU 3056A	73	Planning Survey Unit File 2148	133	Planning Survey Unit File 2467	193	SPAR M-2078	253	TAU 629A
14	TAU 3056B	74	TAU 2150	134	TAU 2467A	194	SPAR M-210	254	TAS 638-14
15	TAS 3056C-14	75	TAS 2150A-14	135	TAU 2467B	195	TH 61 - Addition to M-208A	255	TAS 643A-14
16	TAU 3057	76	TAS 2151-14	136	TAS 2467C-14	196	SPAR M-220	256	TAS 645-14
17	Traffic Analysis Unit File 3058	77	Traffic Analysis Unit File 2193	137	TAS 2467D-14	197	SPAR M-224	257	TAS 671
18	TAU 2706-A	78	TAU 2196	138	TAU 2468A	198	SPAR M-225	258	TAU 760A
19	TAU 2707	79	TAU 2197	139	TAU 2468B	199	TA M-235		
20	TAU 2707A	80	TAU 2198	140	TAS 2468C-14	200	TA M-236		
21	TAU 2708	81	TAU 2198A	141	Traffic Analysis Unit File 2469	201	TA M-246		
22	TAU 2769	82	TAU 2198B	142	TAU 2469A	202	TAR M-277		
23	Planning Survey Unit File 2783	83	TAU 2199	143	TAU 2472	203	TA- 286		
24	TAU 2571B	84	TAU 2291A	144	TAU 2472A	204	TA M299A		
25	TAS 2492-14	85	Planning Survey Unit File 2302	145	TAU 2472B	205	TA M299A		
26	TAS 2493-14	86	TAU 2303	146	TAU 2472C	206	TA-M300A		
27	TAS 2494-14	87	TAU 2303A	147	TAU 2472D	207	Traffic Analysis Reports Transferred to the State Archives		
28	TAS 2494A-14	88	TAU 2303B	148	TAU 2472E	208	TA-M313		
29	Traffic Analysis Unit File 2512	89	TAU 2303C-14	149	TAU 2472F	209	TA-M314		
30	TAU 2513	90	TAS 2303D-14	150	TAU 2472G	210	TA-M347		
31	TAU 2514	91	TAU 2304A	151	TAS 2472H-14	211	TA-M350A		

Continued on next page

Table 2 – continued from previous page

Id	Report No	Id	Report No	Id	Report No	Id	Report No	Id	Report No
32	TAU 2514A	92	TAS 2304B-14	152	TAS 2472I-14	212	TA-M368-B		
33	TAS 2515	93	Planning Survey Unit File 2305	153	TAU 2470	213	TH 610 - Before/After Traffic Study		
34	TAS 2515A	94	Planning Survey Unit File 2306	154	TAU 2470A	214	TA-M198		
35	TAU 2473	95	TAU 2307	155	TAU 2471	215	SPAR M-207		
36	TAU 2473A	96	TAU 2308	156	TAU 2471A	216	TA-M238		
37	TAU 2473-14	97	TAU 2308A	157	TAU 2471B	217	TAR 240		
38	TAU 2474	98	TAU 2309	158	TAU 2471C	218	TAR M-242		
39	TAU 2474A	99	TAU 2310	159	TAU 2471D	219	TAR M-245		
40	TAU 2474B	100	TAU 2310A	160	TA-M307	220	TAR M-253		
41	TAU 2474C	101	TAU 2310B-14	161	TA-M339	221	TAR M-255A		
42	TAU 2474D	102	TAU 2310C-14	162	TA-M306	222	TA-258		
43	TAU 2474E	103	TAU 2310D-14	163	TA-M267	223	TA-M68-A		
44	TAU 2474F-14	104	TAU 2311	164	The Twin Cities Metropolitan Area Year 2000 Highway Network Forecasting Model Update	224	SPAR 160		
45	TAU 2475	105	TAU 2312	165	Year 2000 Highway Network Screenlines (The Minneapolis-St. Pual Metropolitan Region	225	SPAR 162		
46	TAU 2476	106	TAU 2312A-14	166	TH 610 Traffic Study	226	SPAR 165		
47	TAU 2476B-14	107	TAU 2313	167	Minnesota Department of Transportation District 5 20 Year Plan	227	SPAR 166		
48	TAU 2477	108	TAS 2313-14	168	TH 610 and TH 169 Route Location Study (First Level Evaluation of Alternatives)	228	SPAR 169		
49	TAU 2479	109	TAU 2314	169	2000R Travel Demand Forecast Update (1981)	229	SPAR 170		
50	TAU 2480	110	TAS 2314B-14	170	Disrict Nine 20 Year Plan	230	SPAR 171		
51	TAU 2481	111	TAS 2315	171	DEIS TH 10 - From Hanson Blvd. in Coon Rapids to I-35W in Mounds View	231	SPAR 172		
52	TAU 2481B	112	TAS 2316-14	172	EIS 35E- in Dakota County from South Jct. I35 to Jct. TH 110	232	SPAR 173		
53	TAS 2486	113	TAS 2317-14	173	EIS I-494 - From 24th Ave. in Bloomington to the Mississippi River in St. Paul	233	SPAR 178		
54	TAS 2487	114	TAS 2318-14	174	FEIS New U.S. Hwy 10 - Between Egret Boulevard and I-35W	234	SPAR 179		
55	TAS 2488	115	TAS 2319-14	175	FEIS TH 3 - (Is actually TH 52) - From Jct. TH 55 to Jct. I-494	235	SPAR 179A		
56	TAS 2489	116	Traffic Analysis Unit File 2411	176	FEIS TH 77/I-494 - From E. 86th St. to E. 70th St. and from 12th Ave. S. to 34th Ave. S.	236	SPAR 184		

Continued on next page

Table 2 – continued from previous page

Id	Report No	Id	Report No	Id	Report No	Id	Report No	Id	Report No
57	TAS 2490	117	TAU 2411A	177	FEIS I35E- From TH 110 (Dakota County) to I-94 near downtown St. Paul	237	SPAR 186		
58	TAS 2491	118	TAU 2411B	178	DEIS TH 610/TH 252 - From I-94 in Maple Grove to TH 10 in Coon Rapids/From I-94 in Brooklyn Center to TH 610 in Brooklyn Park	238	MSU 14 - 20014		
59	TAS 2491A-14	119	TAU 2411C	179	FEIS US-12/I-394 - From between SR-101 and I-94	239	MSU 34 - 20034		
60	TAS 2491B-14	120	TAU 2411D	180	20-Year Plan For District 9 - I-35W - From I-35E to TH 49	240	MSU 80 - 20080		

Appendix B: Illustrative Analysis

Table 3: Lookup Table to be Used Along with Figure 4.2 and Figure 4.3

Id	Report		Id	Report		Id	Report
1	SPAR-202		37	TA-M296A		73	TAU 3451B
2	TA-M372B		38	TA-M299		74	SPARS 2
3	TA-M329		39	TA-M304		75	SPARS 2A
4	TA-M335		40	TA-M301		76	SPARS 3
5	TA-M336		41	TAS 3065A-14		77	SPARS 4
6	TA-M337		42	TAS 3074B		78	SPARS 15
7	TA-M343		43	TAS 3074C-14		79	SPARS 16
8	TA-M238		44	TAS 3080		80	SPARS 17
9	TA-M240		45	TAS 3081		81	SPARS 18
10	TA-M242		46	TAS 3081A-14		82	SPARS 19
11	TA-M245		47	TAU 3061A		83	SPARS 32
12	SPAR-208		48	TA-M300		84	SPARS 33
13	SPAR-208A		49	TAS 3066A-14		85	SPARS 37
14	SPAR-210		50	TA-M292		86	SPARS 45
15	SPAR-220		51	TAU 3065		87	SPARS 48
16	SPAR-224		52	TAU 3066		88	SPARS 49
17	SPAR-227		53	TAU 3069		89	SPARS 53
18	SPAR-246		54	TAU 3070		90	SPARS 60
19	TA-M255A		55	TAU 3073		91	SPARS 61
20	TA-M286		56	TAU 3073A		92	SPARS 65
21	SPAR-215		57	TAU 3074		93	SPARS 69
22	SPAR-202A		58	TAU 3074A		94	SPARS 72
23	TA-M345		59	TAU 3075		95	SPARS 73
24	TA-M346		60	TAU 3076		96	SPARS 75
25	TA-M307		61	TAU 3077		97	SPARS 75A
26	TA-M253		62	TAU 3078		98	SPARS 77
27	TA-M253 Distributor Addendum		63	PSU3203A		99	SPARS 78
28	TA-M302		64	PSU3203B		100	TAS3562C
29	TA-M207A		65	TAS3081B-14		101	TAS3562D
30	TA-M289A		66	TAS3082-14		102	FEIS New U.S. Hwy 10
31	TA-M309		67	TAS3084-14		103	FEIS TH 3
32	TA-M311		68	TAS3085-14		104	FEIS TH 77/I-494
33	TA-M326		69	TAU3204A		105	FEIS I35E
34	TA-M358		70	TAU 3205		106	DEIS TH 610/TH 252
35	TA-M298		71	TAU 3223		107	FEIS US-12/I-394
36	TA-M308		72	TAU 3451A		108	20-Year Plan For District 9

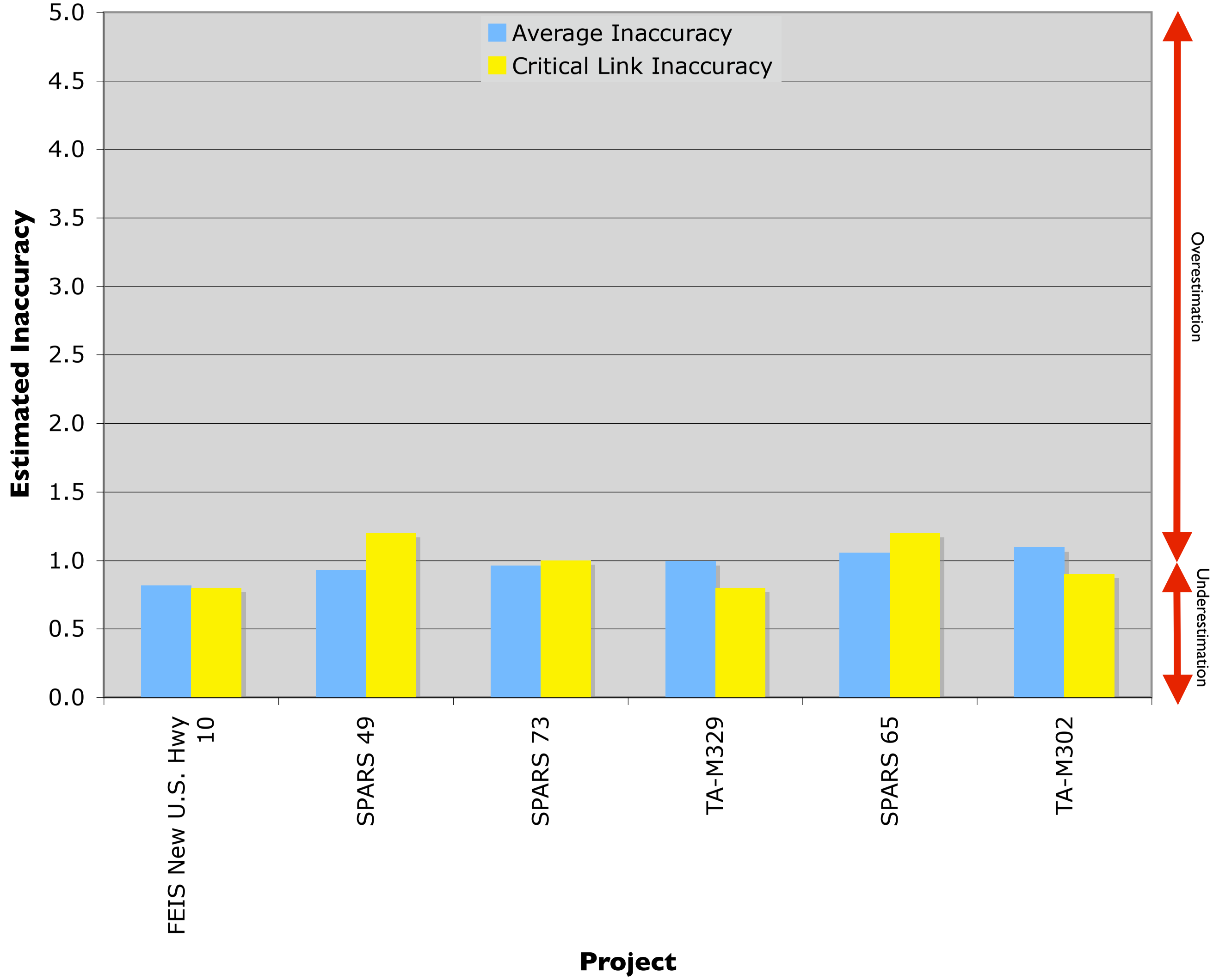

Figure 1: Estimated Inaccuracy - Anoka County

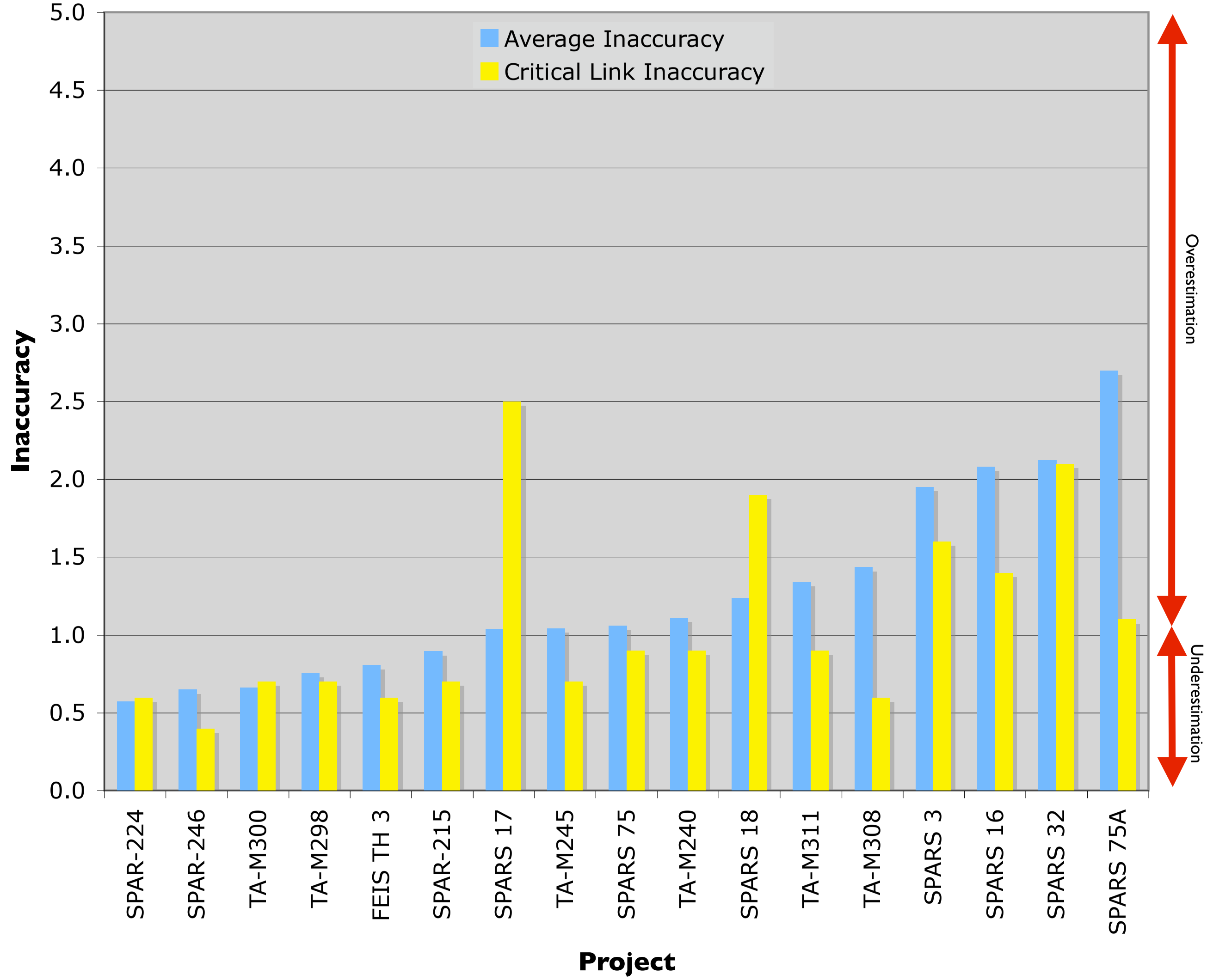

Figure 2: Estimated Inaccuracy - Dakota County

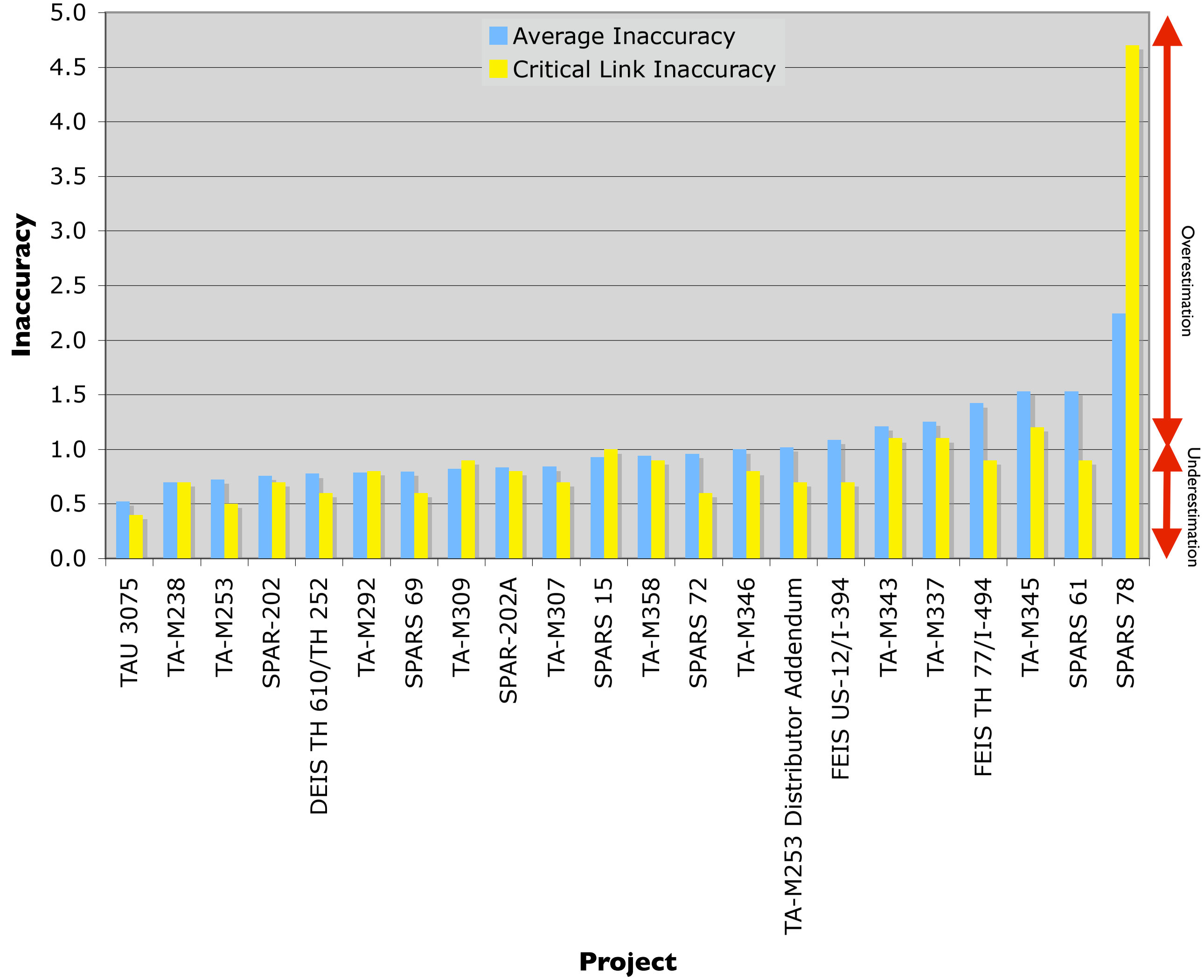

Figure 3: Estimated Inaccuracy - Hennepin County

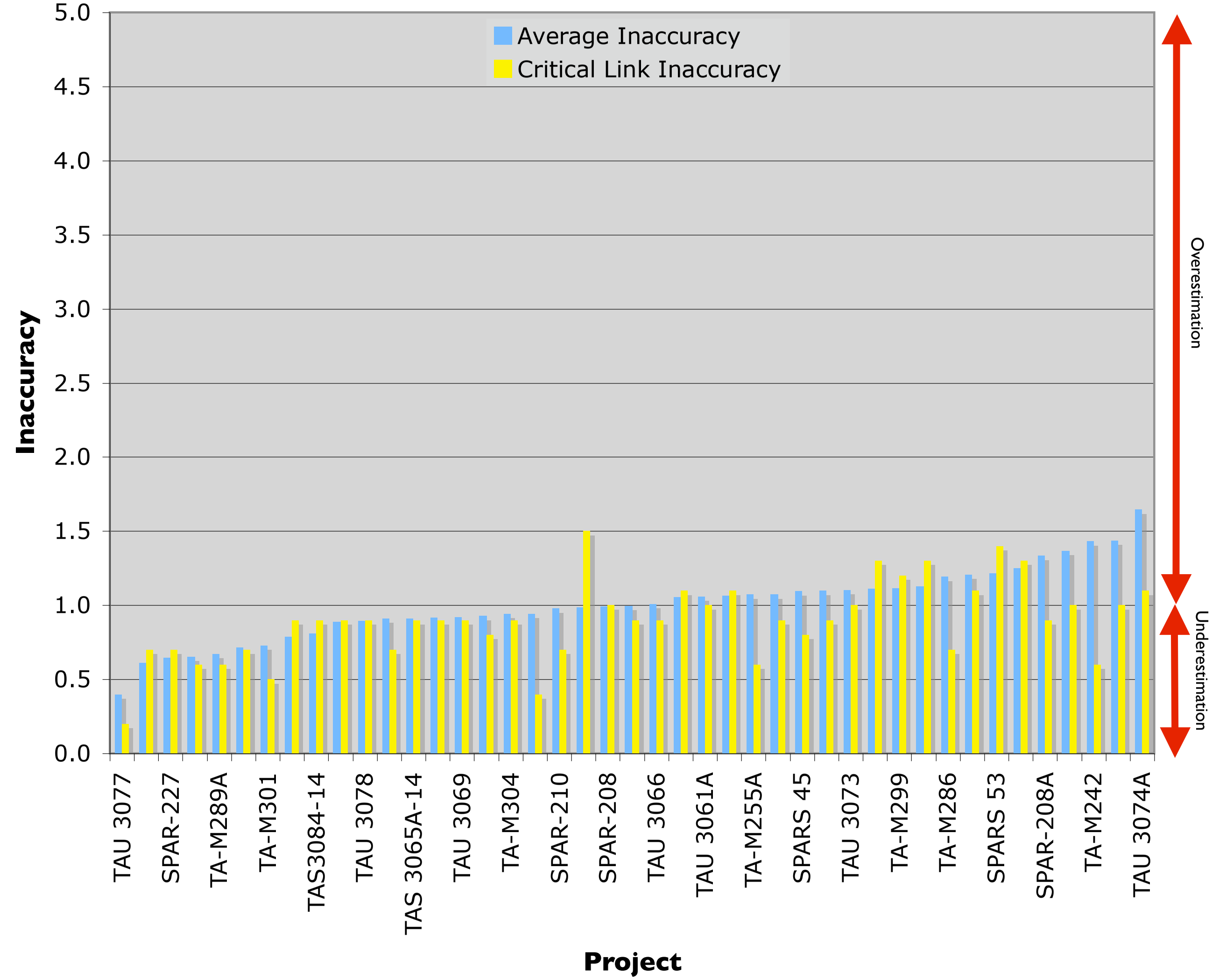

Figure 4: Estimated Inaccuracy - Ramsey County

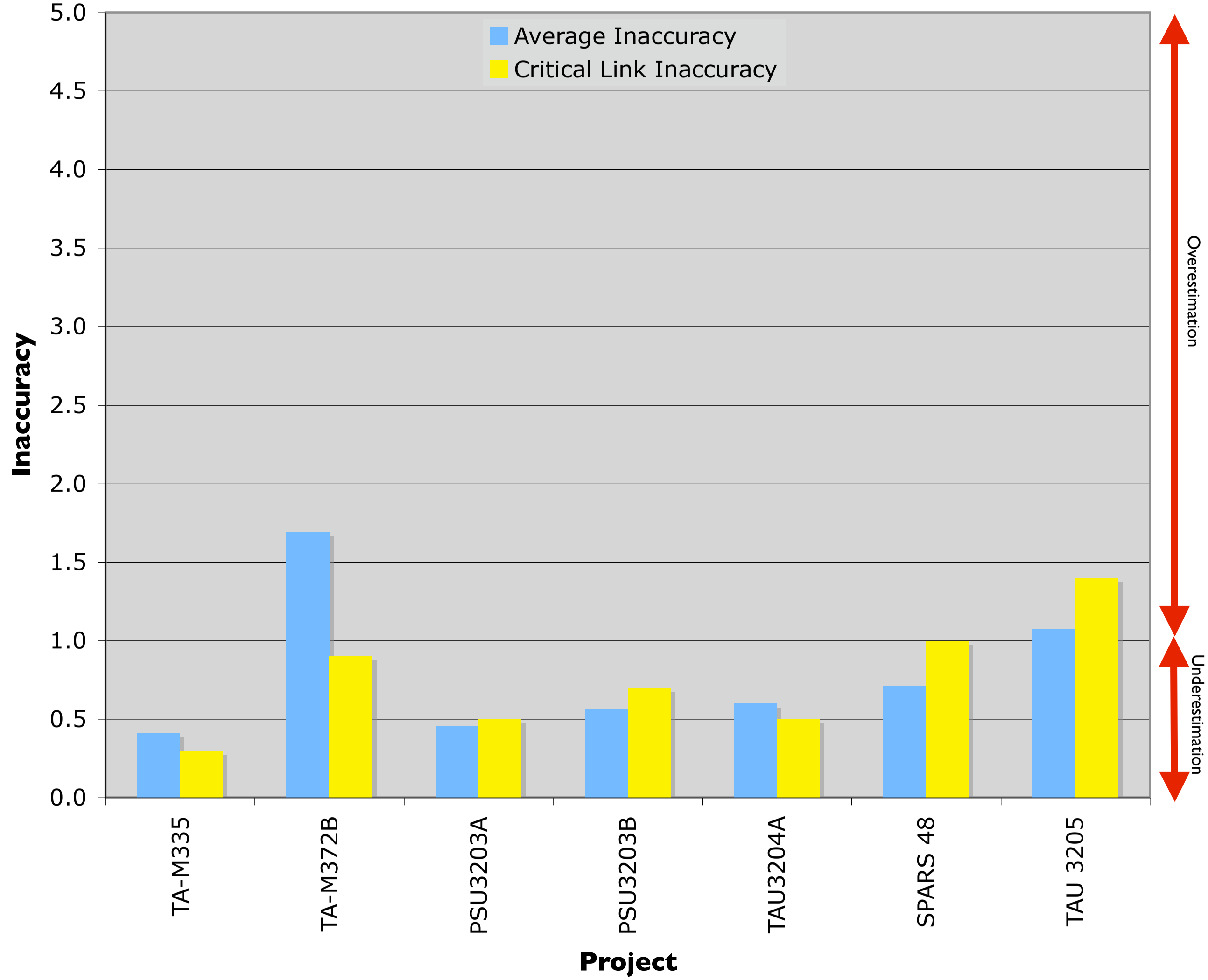

Figure 5: Estimated Inaccuracy - Scott & Carver County

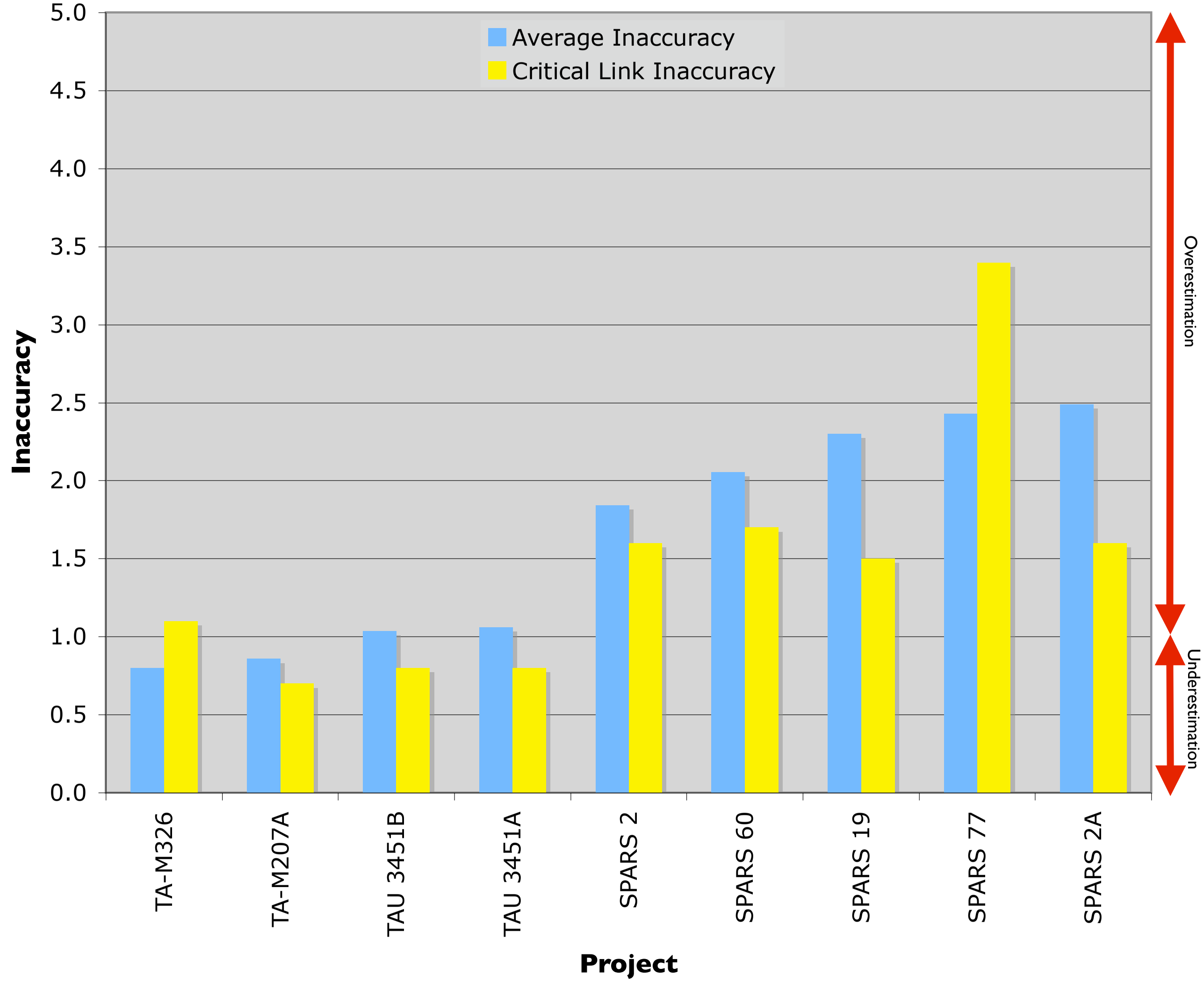

Figure 6: Estimated Inaccuracy - Washington County

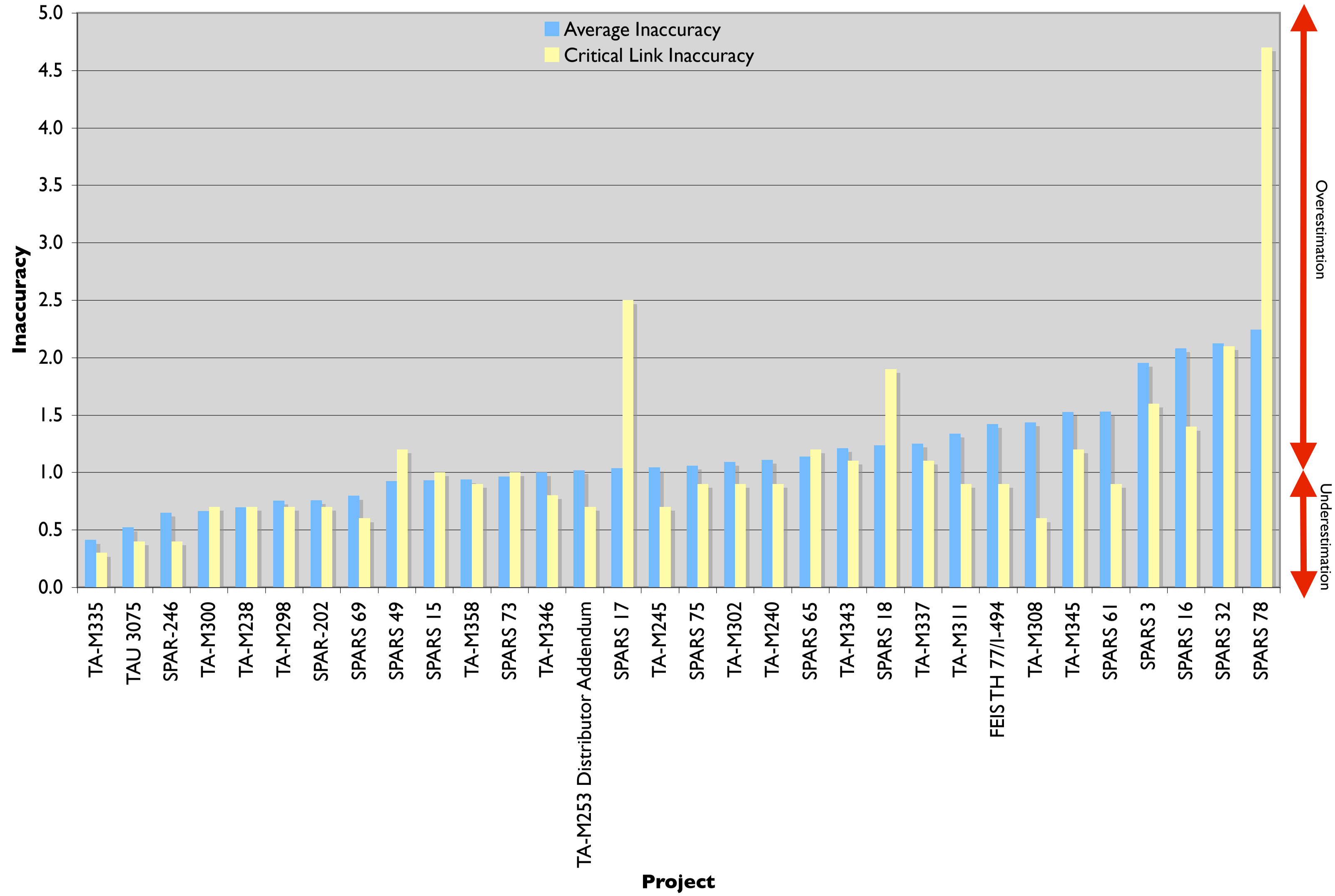

Figure 7: Estimated Inaccuracy for Existing Roadway Facilities - 1[1]

[a]Using data on existing facilities in Anoka, Carver, Dakota and Hennepin counties

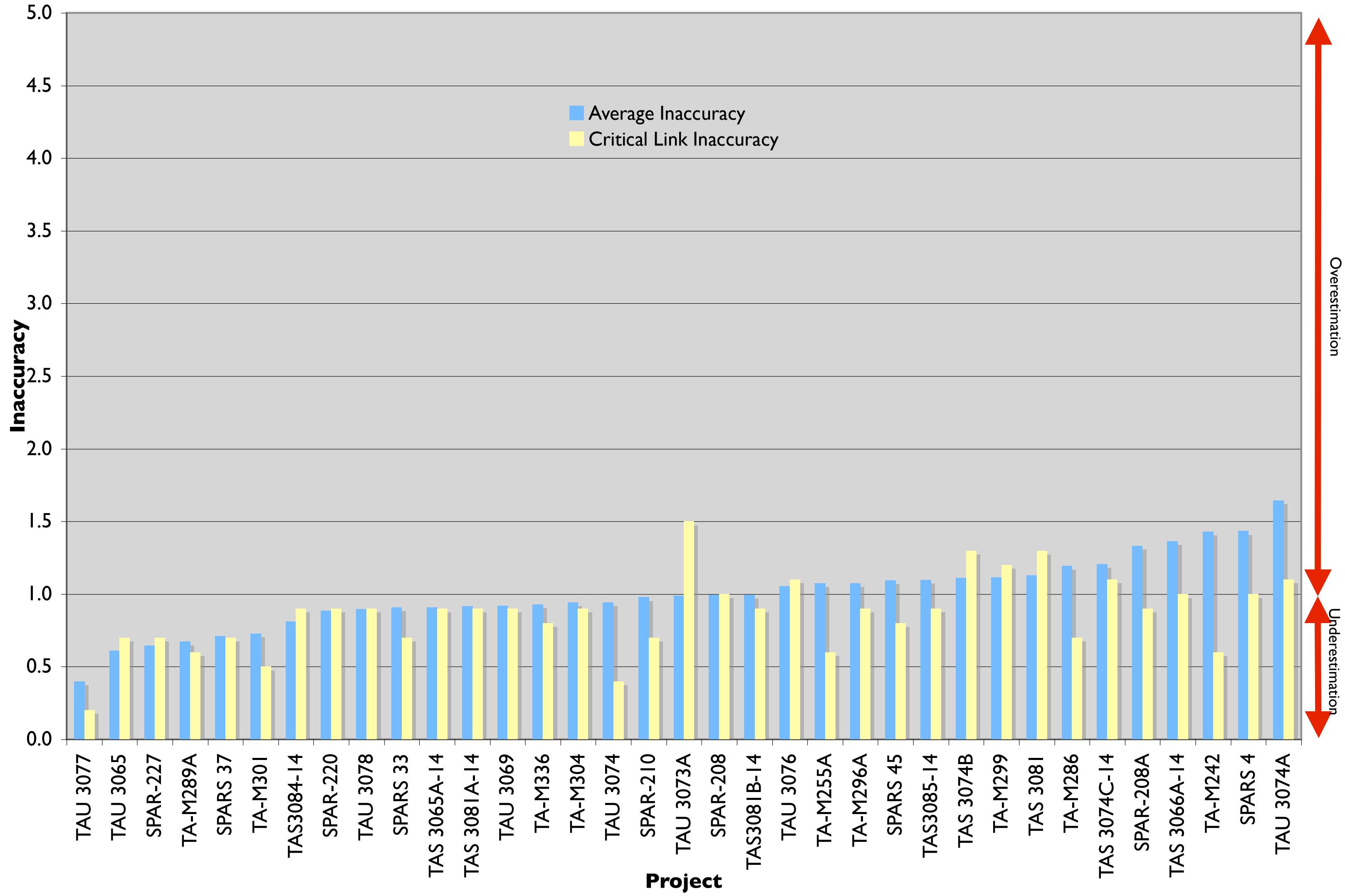

Figure 8: Estimated Inaccuracy for Existing Roadway Facilities - 2[2]

[b]Using data on existing facilities in Ramsey county

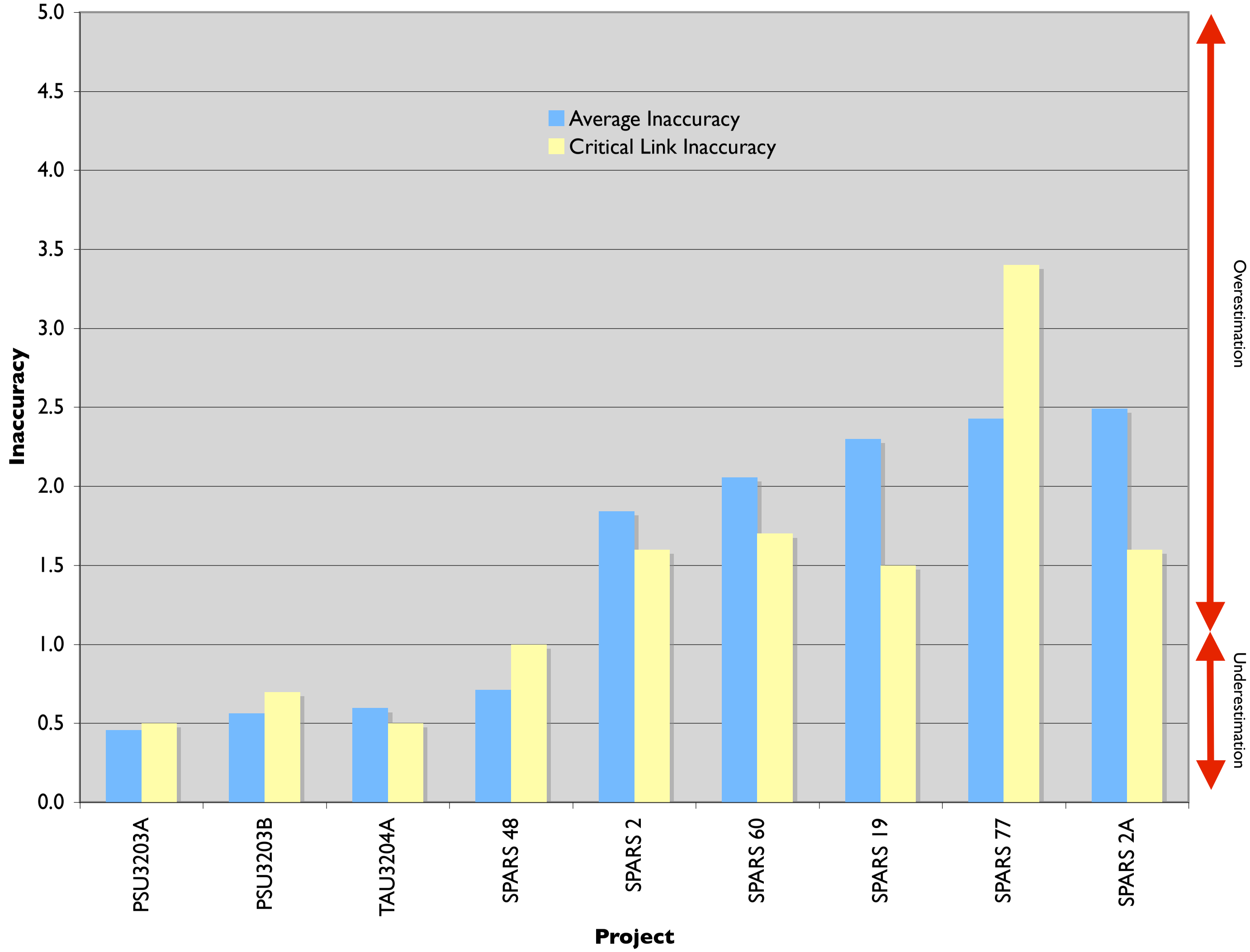

Figure 9: Estimated Inaccuracy for Existing Roadway Facilities - 3[3]

[c] Using data on existing facilities in Scott and Washington counties

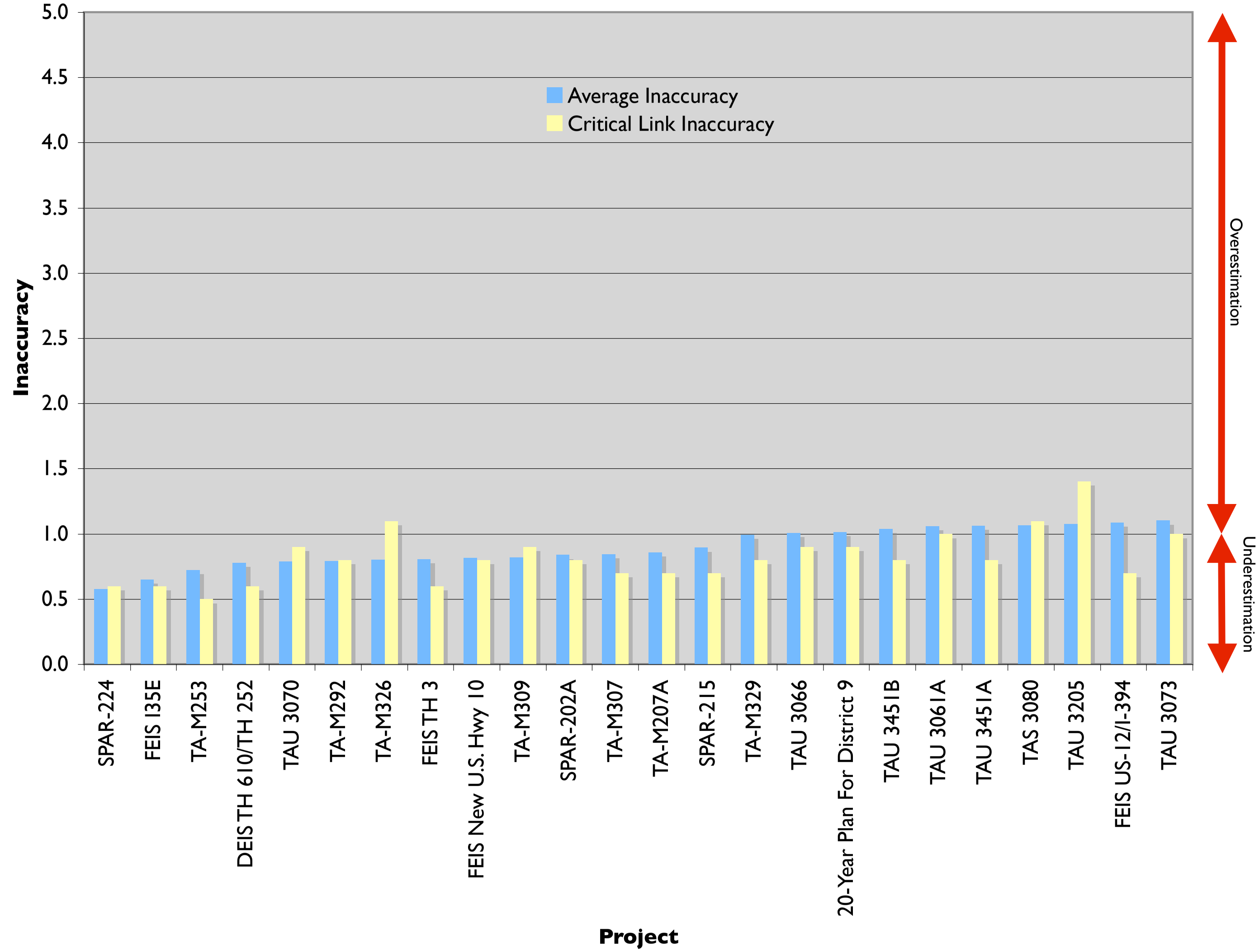

Figure 10: Estimated Inaccuracy for New Roadway Facilities[4]

[d]Using data from on new facilities from all counties in the Twin Cities metro area

Appendix C: Qualitative Analysis

Interviews Conducted

Interview with Respondent A on May 7th, 2008

Respondent A currently works for an private consulting firm in the Twin Cities region with over 25 years experience in model development and forecasting.

Question 1: Your understanding of the possible sources of error in the Twin Cities (TC) model? The errors in the TC model could be from the following sources:

1. The usage of a a static/fixed time of day model. The current model is based on the 2000 TBI and assumes that a fixed percentage of the overall traffic occurs during the peak period which could affect the results such as over estimation of peak hour demand on highway facilities. Further the model does not account for peak spreading even though travel behavior surveys and census data confirms this trend.

2. The inability of historical and current models to recognize fundamental changes in travel behavior over time such as participation of women in the work force, influence of internet and technology on travel, increases in gas prices, retiring baby boomer generation etc. Even though the model is recalibrated once every 10 years it is difficult for models to incorporate such changes.

3. Trip distribution model - The travel demand model developed in 1990 used K-factors to model the different travel patterns in the region (ex. trips traveling east and west between Minneapolis and St. Paul). The 2000 model uses a destination choice model rather than K-factors. However the basic problem is that we do not understand the basic trip patters in the region due to which we are forced to use such factors to replicate the actual travel patterns.

4. The traditional over importance given to home-based work (HBW) trips in the models compared to other trip purposes. Even though current models have corrected this bias, it might have played a role in the forecasts produced in 1970s and 80s.

5. Trip attraction rates - The trip generation rates used in the model are fine but the trip attraction rates are always a little fuzzy. The trip attraction rates and the use of special generators are a big source of errors in models. For ex. forecasting for a development like the Mall of America can be very difficult for the model to handle.

6. Airport Trips - A survey of trip rates per enplanement was conducted in the 1990s and the rates in the current model are based on the 90s survey . Many changes have happened or happening in the airline industry which makes it imperative for us to revisit the airport trip rates used. Ex. NWA-Delta merger which will affect the enplanements at the MSP airport.

7. The current model includes the collar counties while the previous models covered only the seven county area. The previous model might not have replicated the trips from the ring collar counties to the core area which might have caused errrors

Question 2 : With the current expertise in modeling that we have, what could have be done differently with the model development in 1970s, 1980s?

The advances in modeling in the 1970s and 1980s were definitely less compared to the 1990s. For example. the current model has a destination choice component which was just not there in the previous models. Further market stratification by peak and offpeak travel was not covered in the previous models. However there are still some items that haven't yet been resolved even in the current models, for example, peak spreading. We would need a time based survey to incorporate this component into the model.

Question 3: How does the Twin Cities model compare with other models that you have worked with or had an opportunity to look at?

The TC model is definitely on par in fact better than average in comparison to other comparable regional models. The TC model has good sets of trip purposes and markets incorporated into it and was used to support ridership forecasts for transit projects in the Twin Cities, ex. Hiawatha, Central Corridor which indicates that the model was subject to FTA scrutiny and met the stringent FTA requirements.

However the TC model lags behind models in regions such as New York, Denver, Columbus and Sacramento which are tour/activity based models and are way ahead of the TC model in that respect. We could make the shift to a activity based model using the information from the past travel surveys conducted in the area but the shift isn't likely to happen any time in the future due to many reasons.

Question 4: How would you respond to criticisms against modeling? - Many people argue that the most models underestimate/overestimate the traffic forecasts and hence it is not worthwhile to be spending time, money and efforts on modeling.

Models provide a systematic way of assessing different alternatives and it is important to treat models to see changes rather than absolute numbers. A good model will provide us with information on travel patterns that wasn't expected. Further models help in maintaining neutrality and provide a level playing field for funding such as the FTA new starts program.

Question 5: Have there been instances on political compulsions influencing the model forecasting in the Twin Cities? For example - many transit forecasts show overestimated ridership and underestimated costs due to political pressures.

There hasn't been instances of political compulsions in the Twin Cities compared to other areas. Most pressures in modeling come from lack of proper understanding of the modeling process.

Email exchange with Respondent B on May 20th, 2008

Respondent B worked at a public agency in the Twin Cities and is now retired.

I believe the weakest part of travel demand forecasting and largest source of error is the forecast/input for the aggregate as well as distribution/location of future population/households/employment. The regional totals for the forecast year may be off and I urge you to take a look at the history of changing forecasts for regional demographics for the Twin Cities. In the early 70s the population forecast was 4 million by the year 2000. Revisions in the aggregate forecast for demographics change every few years. An equally large source of error for transportation forecasts may be the forecast locational distribution of those demographics. These too have been subject to numerous revisions over time. And the forecasting of the locations of people, housing, and jobs have traditionally been influenced by political ”correctness”. With two central cities, forecasts in the Twin Cities area have tended to be influenced by this more than those for other metropolitan areas.

So, I don’t think the errors in forecasts can really be ”fixed” by changes to the travel demand model (generation, distribution, mode choice, assignment). There may be little tweaks/embellishments that can be made to make each or all of these components. But, if the demographic forecasting can not be improved significantly, improvements to the travel demand model will offer very little improvement to forecast accuracy.

The new generations of models, in my opinion, have little chance of improving the accuracy of travel demand forecasts. They may be more elegant and based more on individual travel behavior, but without more accurate demographic forecasts, they will not provide forecasts that are anymore accurate. Therefore, I continue to believe that a very important component of the travel demand forecasting business should be the range of error intrinsic in the forecast. And, transportation project capacities should be more strongly influenced by factors other than the travel demand forecast.

I believe the second largest source of errors in travel demand forecasts, these days, is in the hourly values. In the old days the models yielded only daily values and the forecaster used his/her judgement to develop peak hour values. The current and previous version of the Twin Cities model yields outputs for periods in the day. And, the values for periods are based on the proportions observed in the model’s base/calibration/validation year.

As daily volumes increase on a road segment or a collection of segments, the observed proportion(s) that occur in the peak hour/hours decrease. This is a primary theme running through the guidelines we developed for travel demand forecasts for the Metro District... Basically, what the guidelines do is force the transportation forecaster to look at the outputs from the model and subject the raw model results to checks for reasonableness.

Interview with Respondent C on May 23rd, 2008

Respondent C currently works for a local planning agency in the Twin Cities with over 30 years experience and was involved in model development of the older regional models.

Question 1: Your understanding of the possible sources of error in the Twin Cities (TC) model?

The socio-economic TAZ file was developed totally ”in-house” based on available acres. There was no input from the communities unlike the current trend.

The earlier regional forecasts had optimistic population numbers. Further the trip generation used per capita trip rate to define regional totals which did not anticipate or incorporate labor-force participation rates.

The focus in the models were primarily on principal arterials and the assignments on minor arterials/collectors were of little consequence.

The earlier models were also more difficult to run and had more limitations due to computing capabilities. The IT people ran the model as such and the forecaster just got a stack of outputs. It was very difficult to identify errors in such situations.

Question 2 : With the current expertise in modeling that we have, what could have be done differently with the model development in 1970s, 1980s?

The older models could have definitely used more community involvement and greater interaction between MnDOT and the MPOs which wasn't the case. Modeling in the 70s was done by a select few and there was no opportunities to discuss any modeling issues which could have helped the modeling community. The current expertise in modeling has definitely helped modeling in general. The older models also took much longer to run due to which error tracking was a much bigger effort worsened with not many modelers available to work with the models unlike today.

Question 3: How does the Twin Cities model compare with other models that you have worked with or had an opportunity to look at?

I can't necessarily say if the TC model is better than other models. The TC model used to be on the UTPS platform until the 1990s. Towards 1990, MnDOT was dissatisfied with the Metcouncil forecasts (problem of underestimation). The calibration/validation of the model was out of date as the model had been calibrated in 1972 but was still used in the 90s with newer trip generation rates to produce forecasts. Due to the issues, the model was recalibrated in the 90s to improve model performance.

Question 4: How would you respond to criticisms against modeling? - Many people argue that the most models underestimate/overestimate the traffic forecasts and hence it is not worthwhile to be spending time, money and efforts on modeling.

As modelers we hear criticisms against modeling but there is nothing that can be done. There is no other way to get future traffic other than using models. Using growth rates alone to predict the future wasn't easy since the freeways opened to traffic in different years and traffic patterns have changed so much with the interstate construction.

Using models along with growth rates might have worked but not using the model wasn't - There is no other alternative.

Question 5: Have there been instances on political compulsions influencing the model forecasting in the Twin Cities? For example - many transit forecasts show overestimated ridership and underestimated costs due to political pressures.

There was no political compulsions as such but there was a push to use ”forced” assumptions about auto operatings costs vs. transit fares especially after the 1970s Oil Embargo. During the oil embargo, there was a major shift to transit and rideshare (ex. 3M started a vanpool program during that time). Assumptions in modeling were governed by this shift due to which the focus in modeling in the 1980s was to force assumptions to lessen the difference between auto and transit. The expectation was that the shift to transit and trip reduction would continue into the future and the model was made to produce forecasts along this line.

Phone interview with Respondent D on May 23rd, 2008

Respondent D worked for a public agency in the Twin Cities and is now retired.

Question 1: Your understanding of the possible sources of error in the Twin Cities (TC) model?

1. The difference between the planned highway network and actual in-place network resulted in the actual traffic differing from the forecasts
2. Modeling using computers was a new concept and was done using mainframe computers. These mainframe models didn't have the robustness of current day models . Error tracking was extremely difficult in these models since the modeler had to go through many pages of modeling output to track them.
3. Too many variables in the older models - While the error in each of the individual variables was minor on its own, the sum total of all these minor errors added to the magnitude of the total error.
4. Demographic forecasts prepared by the MetCouncil and fed into the models weren't necessarily forecasted accurately due to which the forecasts produced by the models were also off.
5. In general models don't account for real variation in inputs such as gasoline prices, parking costs.
6. Models traditionally have focused on downtown/work trips and haven't focused on the work areas in other locations such as Eden Prairie and Bloomington.
7. Modeling doesn't address the variation in travel times - modelers still use just a point forecast rather than a range to describe their outputs.

Question 2 : With the current expertise in modeling that we have, what could have be done differently with the model development in 1970s, 1980s?

Older models could have been simpler for sure. They were just too complicated with too much data to sift through which made it extremely difficult to work with.

Question 3: How does the Twin Cities model compare with other models that you have worked with or had an opportunity to look at?

No answer

Question 4: How would you respond to criticisms against modeling? - Many people argue that the most models underestimate/overestimate the traffic forecasts and hence it is not worthwhile to be spending time, money and efforts on modeling.

People need to understand that modeling is just a small portion of the entire process. Modeling provides us a tool to understand the growth that can be expected.

To criticize just the model in the entire process is dumb but to based the entire process on just the model outputs alone is dumber. You definitely need to look other things and not use the model alone to guide investment decisions.

Question 5: Have there been instances on political compulsions influencing the model forecasting in the Twin Cities? For example - many transit forecasts show overestimated ridership and underestimated costs due to political pressures.

Modelers at MnDOT or the Metcouncil do not have this problem of having to alter the forecasts under political compulsions. In my experience consultants are more likely to get the models to suit their client needs such as creating model forecasts indicating the need for a 10-lane freeway. This is one of the reasons that MnDOT and Metcouncil insist on the basic parameters not being altered to analyze different scenarios.

On another note, the land use component in the model hasn't been adequately addressed - For ex. areas like Burnsville are growing at such a rapid rate. The problem in incorporating land use properly into the model is that growth is governed by zoning regulations and market forces which are difficult to understand and predict. Further zoning guidelines are also subject to political compulsions which thus indirectly affect the model forecasts.

Interview with Respondent E on May 27th, 2008

Respondent E worked for a public agency in the Twin Cities and is now retired.

Question 1: Your understanding of the possible sources of error in the Twin Cities (TC) model?

The main source of error comes from a change in basic behavior patterns which can mean that a model calibrated to past conditions is faulty. In my experience the best example is the change in household behavior that accompanied the movement of women into the labor force.

A second source is poor network representation, all or nothing trip distribution models that are not sensitive to network capacity limitations perform poorly in estimating future link volumes.

The procedural errors usually happen when people try to use the regional model and networks at the detailed/micro level without adequate analysis and expect the model to produce reasonable numbers.

Further there are data collection errors in the home interview surveys that feed into the regional travel demand model. The 1980 regional plan didn't allow adequate money to conduct a zone level TBI study. Hence the 1980 TBI was conducted at the district level compared to the 1970 and 1990 TBI which were conducted at the zonal level.

Another source of error could be from data coding errors also called "Oops I got gravy on my tie error"

Question 2 : With the current expertise in modeling that we have, what could have be done differently with the model development in 1970s, 1980s?

We could have had much better trip distribution models. Trip generation never was a serious problem if you could determine future conditions such as car ownership or household size but trip distribution to networks without a capacity control feature led to poor link volume estimates.

Question 3: How does the Twin Cities model compare with other models that you have worked with or had an opportunity to look at?

I have always understood the Twin Cities models to be equal or better than the models in other major urban areas. There were two reasons. First the data collected in the twin cities, both travel and land use information, was of high quality compared to other areas. We just had very competent research teams. Second we always worked with one of the best modeling consultants in the nation. His name was Gordon Schultz and he worked on our models in 1970, 1980, 1990 and 2000

Question 4: How would you respond to criticisms against modeling? - Many people argue that the most models underestimate/overestimate the traffic forecasts and hence it is not worthwhile to be spending time, money and efforts on modeling.

I believe that modeling, even if it results in major challenges, is an effective way to put data and issues on the table. Those who criticize models provide an opportunity to let the modelers and the project planners clarify and explain their analysis. If the critics are just trying to block the project they at least give the project planners an opportunity to bring out facts about the demand for the project and to quantify costs and benefits which requires the use of models. Then it is possible to discuss the range of accuracy. Depending on assumptions models always have the potential to over or underestimate travel. That is no reason not to model. Your doctor can misread your blood tests but is that a reason to tell him not to take a sample and have it analyzed? The critics who tell you not to do the analysis because there is a margin for error plus or minus are guilty of introducing even worse error into the evaluation. Simulation works and those who are trained to use it are key members of the engineering team. That is how!!

Question 5: Have there been instances on political compulsions influencing the model forecasting in the Twin Cities? For example - many transit forecasts show overestimated ridership and underestimated costs due to political pressures.

Yes there have been but I do not feel that I can validate any such stories that I have heard. When I was in charge of regional modeling we used several quality control criteria such as historical trends in overall person trip rates to validate our answers. No one associated with the models at the Metropolitan Council ever let politics effect the published model results.

Interview with Respondent F on May 30th, 2008

Respondent F works for a private consultant in the Twin Cities and has had over 25 years experience in the field of travel demand modeling and forecasting.

Question 1: Your understanding of the possible sources of error in the Twin Cities (TC) model?

1. The techniques used in modeling in the 1970s and 1980s were much more rudimentary. Further modelers didn't have the resources necessary to translate the understanding of travel behavior to modeling.

2. Societal changes such as women in the workforce, auto ownership (autos/hh), increases in level of mobility/access have been difficult to understand and forecast. Specifically the labor force participation of women has been a big change that wasn't just expected

3. Trip Distribution - Our understanding of trips distribution wasn't necessarily good and even now modelers don't have a complete understanding of where and how trips get distributed

4. Computing limitations made it difficult to cycle through a forecast, conduct sensitivity tests etc. to check the reasonability and confirm your comfort in the forecasts produced.

5. Due to the difficulties in modeling, there was a lot more dependence on using growth rates

Question 2 : With the current expertise in modeling that we have, what could have be done differently with the model development in 1970s, 1980s?

The current PC based approach providing increases in computing speed, access to modeling tools has been the biggest change in modeling. This has provided a better blend of modelers with good technical expertise and people that have a better sense of the actual travel patterns which has helped modeling.

In the olden days very few people were involved in modeling which meant very few eyes looking at the model forecasts. Nowadays with the improvement in modeling expertise and computing capabilities, the number of people working on model is much higher. More modelers get together to look at the forecasts and discuss it which in turns help produce better forecasts.

Question 3: How does the Twin Cities model compare with other models that you have worked with or had an opportunity to look at?

The TC model definitely has many similarities with other urban area models and I would rate the TC model in the middle of comparable urban area models.

It is definitely not cutting edge but is as good as any other region. Cities like San Diego are ahead of the curve and have moved to activity based models but I am not sure if these models are going to be way better compared to our models. Activity based models are definitely more complicated and difficult to run which again reduces the accessibility of the models.

Compared to other regions, TC model is much more independent since we have different consultants working on the model ensuring a good product.

Question 4: How would you respond to criticisms against modeling? - Many people argue that the most models underestimate/overestimate the traffic forecasts and hence it is not worthwhile to be spending time, money and efforts on modeling.

The problem/criticisms against modeling mainly arise when people/decision makers over depend on the actual numbers and don't look beyond them nor try to get an understanding of the science behind the numbers. People/decision makers love/need numbers and usually use the model to back them up.

We are a engineering based profession and modeling provides a tool to base the designs on. The challenge for modelers is to come up with a good defensible number.

Highway projects typically cost millions of dollars and models provide the projections used to justify the project. It would be wrong to make such huge investments without giving due diligence to the technical assessment of the project.

However modelers need to constantly look at tools to improve our forecasts and find the right scale of the confidence in the model forecasts.

Question 5: Have there been instances on political compulsions influencing the model forecasting in the Twin Cities? For example - many transit forecasts show overestimated ridership and underestimated costs due to political pressures.

I can think of one time where the way the project was being conducted could have been perceived that way. It definitely wasn't a direct pressure from the client on our team but we knew that the client faced pressure from a political person.

Modelers normally get hard questions when the results don't come out the way it is expected but the hard questions work to our advantage since we can look deeper into the model to see why that is the case. This helps produce a better model.

Modelers have to sometimes bend a certain way but usually it is in the context of **NOT** affecting the decision.

There is a constant battle between consultants and clients in deciding the model inputs. Modelers in this situation become frontline defenders of programs like comprehensive plans, TIP etc. The modeler needs to let the client know that the input assumptions suggested isn't in line with approved plans.

Interview with Respondent G on June 23rd, 2008

Respondent G works for a local planning agency and has been involved in transportation planning and travel demand modeling in the Twin Cities for over 20 years.

Question 1: Your understanding of the possible sources of error in the Twin Cities (TC) model?

1. Input socio-economic (SE) data:

   Prior to the 90s, the SE forecasts were prepared exclusively by MnDOT and Metcouncil with no local knowledge. After the 90s, communities started getting involved in preparing the SE data. However the process was still very localistic and done without much thought. Communities were also really aggressive in their forecasts without consideration to infrastructure requirement of the forecasted population and employment. Metcouncil didn't have much control over the communities in this respect and could only ensure that the forecast met the control totals.

   It is only in the last 8-10 years that communities have started to back off from the aggressive growth plans and also realize that where the growth is alloted to in the area is important.

2. Modeling expertise

   Prior to 1990, the models ran a simple all or nothing assignment. The 1990 model moved away from this by moving to a peak/offpeak model. The peak periods were handled separately but everything outside the peak period was grouped into an offpeak assignment which was for all practical purposes an all or nothing assignment. In the current model we have improved to an hourly model but still the diurnal factoring is set. We are hence not able to account for factors like peak spreading which can be expected to affect forecasts produced.

Question 2 : With the current expertise in modeling that we have, what could have be done differently with the model development in 1970s, 1980s?

The all or nothing assignment which was used in the 1980s and 1990s could have definitely been done differently

Question 3: How does the Twin Cities model compare with other models that you have worked with or had an opportunity to look at?

The TC model did push the envelope previously but currently the model is getting antiquated. The model is definitely not state of the art and we are starting to fall behind a little bit compared to other regions. For ex, we do not have a mechanism to account for peak spreading; there is no encouragement or support to shift to activity base

Question 4: How would you respond to criticisms against modeling? - Many people argue that the most models underestimate/overestimate the traffic forecasts and hence it is not worthwhile to be spending time, money and efforts on modeling.

Nobody ever makes a decision based on models alone, other factors are always taken into account. The model is just a tool and it is important for us to understand it strengths and weaknesses.

People who criticize models do not understand what the model is good for. It is best to use the model to understand changes due to changes in the inputs. Modelers try to create a model that best replicate existing conditions but there are errors in the existing counts, input SE data which contributes to the model error. All forecasters will acknowledge that the forecasts are off but it is the best we can do given the information we have. We need to understand that there will always be a margin of error in a model and it is important to acknowledge, understand and address it in order to use the model forecasts.

Decision makers using the model expect too much from the model. Further they love actual numbers and will not use ranges. People also talk about just using growth rates which can work if nothing is going to change in terms of land use and other inputs. However when the land use and trip generation changes are significant, growth rates are not going to cut it and we need an actual model. Growth rates can at best be used for forecasting on local streets but beyond the local streets level, roadway traffic is governed more by land use changes which can't be handled by growth rates alone.

Question 5: Have there been instances on political compulsions influencing the model forecasting in the Twin Cities? For example - many transit forecasts show overestimated ridership and underestimated costs due to political pressures.

There isn't much of political compulsions dictating model forecasts in the Twin Cities. However while conducting the 2000 TBI the technique used to develop trip generation rates for the core county and ring counties produced trip rates that weren't realistic especially for the ring where the geocoding was bad. We ended up not using the technique however I think we might be missing something. We went with the trip generation rate that we think should be there and the TBI data wasn't confirming our thinking. But in this case more than political compulsion the idea was to use a rate that we though was realistic.