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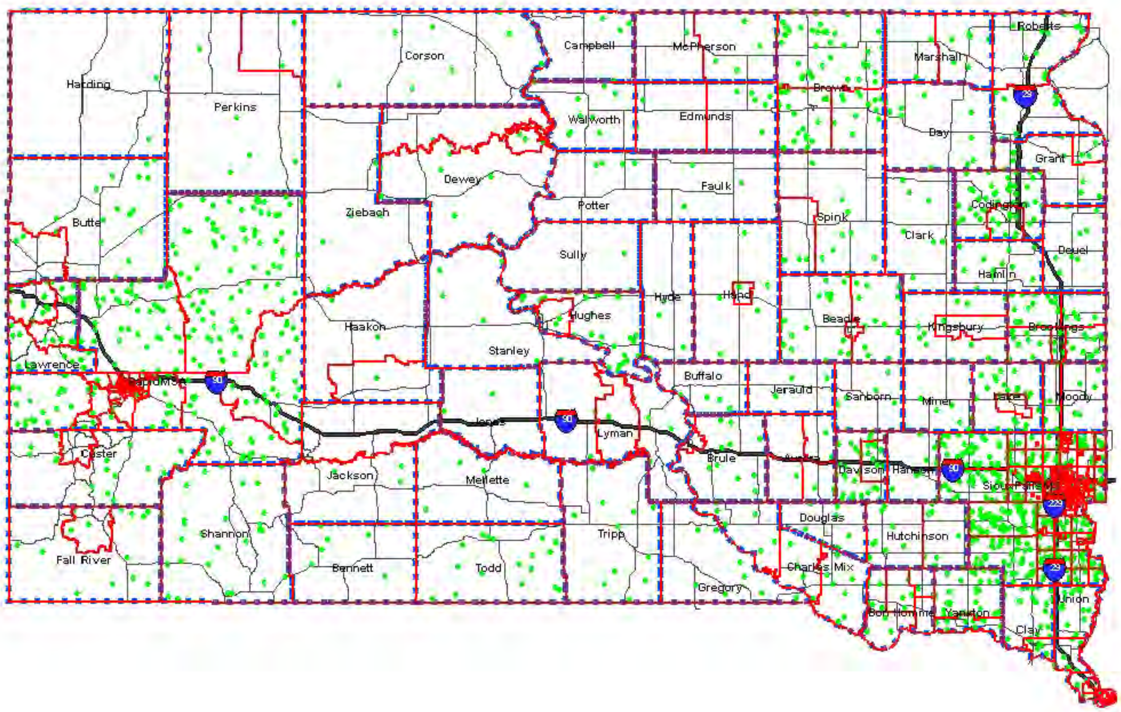

Review of Travel Demand Forecasting Requirements in the SDDOT

Study SD2006-06
Final Report

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DISCLAIMER

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16. Abstract
The purpose of this research study is to evaluate the most appropriate traffic forecasting tool that is most responsive to the needs of the South Dakota Department of Transportation (SDDOT). Like many other state agencies, the SDDOT has to do more with less funding for transportation infrastructure, operation, maintenance, and planning. The traffic forecasting functionality has to be tailored to SDDOT's needs and constraints while maximizing benefits.

The interviews of SDDOT stakeholders strongly emphasize the desire for a better forecasting approach than the current 20-year traffic forecasting procedure. The research team evaluated the uses/ needs of traffic forecasts at SDDOT against the availability of data, budget, and staff. While it is possible to build a statewide travel model (STM) of sketch planning type using available data, the applicability of such a model would fall short of meeting many of the identified uses and needs that are largely project specific. However, building a more robust 4-step STM that would satisfy many of the uses/ needs requires travel behavior data currently unavailable. Considering the advantages and disadvantages, the research team does not recommend a four-step statewide model at this stage. A more practical approach in the short-term is to enhance the current 20-year traffic forecasting procedure, use of GIS and transportation planning software, and staff training in travel demand forecasting. A sketch planning type STM is recommended in the short-medium term together with future enhancements that include a regional model option, and 4-step STM for passenger and freight.

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EXECUTIVE SUMMARY

1.1 PROBLEM DESCRIPTION

There are several reasons why a state might be interested in forecasting statewide or rural travel. These include (1) obtaining forecasts of rural, intercity, and long distance trips by passenger and freight; (2) supplementing urban travel forecasts; (3) developing project level forecasts in rural areas; and (4) satisfying mandated planning requirements—SAFETEA-LU mandates that several issues must be considered in statewide transportation plans.

Forecasts of rural and intercity travel are helpful in programming the sequence of projects and their associated costs, developing corridor preservation plans, establishing reconstruction and resurfacing strategies, and as valuable input into the overall assessments of the adequacy of the statewide transportation networks. Forecasts of freight travel are important for determining pavement thickness while passenger travel forecasts determine the future number of lanes.

Like many other state departments of transportation, the South Dakota Department of Transportation (SDDOT) is responsible for planning and maintenance of the state's transportation system. For SDDOT to effectively plan and maintain the state's transportation system, SDDOT needs planning tools to better understand travel patterns within the state and to better prioritize its limited resources.

The SDDOT has a 20-year traffic forecasting procedure that generates VMT forecasts at the county level. Since the traffic forecasting procedure was originally developed in 1999, it has not been validated. While the procedures adopted to derive these forecasting factors may still be valid and useful to some limited application, the SDDOT has recognized some shortcomings of the current forecasting procedure that include its inability to analyze from which land uses and location trips are generated, to which places trips are going, and which state routes trips are using. The inability of the current forecasting procedure to provide the desired analytical capabilities hinders the SDDOT from being able to analyze several planning needs, which include route diversion impacts prior to corridor improvements, corridor studies, site impact studies, and studies to identify the capacity and safety impacts associated with increased or diverted truck travel on state routes. The introduction of new intermodal facilities adjacent to highways creates opportunities for such diversion of truck trips.

The purpose of this research study is to enhance the current travel forecasting procedures to meet SDDOT planning needs. The challenge is to develop cost effective travel forecasting procedures with the desired analytical capabilities suitable to a rural state like South Dakota.

1.2 RESEARCH OBJECTIVES

This review of travel demand forecasting requirements in the South Dakota Department of Transportation has the following three objectives:

1. Determine the uses of and benefits of travel demand forecasting on a regional or statewide basis at the SDDOT.
2. Identify the level of travel demand forecasting functionality necessary to meet the needs of the SDDOT.
3. Determine the resources necessary to develop, maintain, and operate SDDOT travel demand forecasting capabilities on a regional or statewide basis.

The research team performed the following twelve research tasks to meet these objectives.

1.3 RESEARCH APPROACH

1. *Meet with the project's technical panel to review the project scope and work plan.*

   The research team's principal and co-principal investigators met with the Technical Panel in Pierre on April 16-17, 2007. During this time, the face-to-face interviews of stakeholders located in Pierre were conducted with the assistance of SDDOT Office of Research staff.

2. *Review and summarize existing research concerning travel demand forecasting for regional and statewide applications, including types of forecasts, methods, and data requirements.*

   The review examined both regional and statewide travel demand model approaches and applications. The focus of the review includes the objectives of the forecasting model, uses/applications of model (types of forecasts), model structure (particularly how freight is modeled), modes (automobile, commercial, others) model parameters, assumptions, data requirements, methodology, application software, GIS application, cost to implement and maintain, issues (model development, data, etc.), staffing, and training.

   To gain an understanding of how other state departments of transportation (DOTs) develop their travel demand forecasts, the research team surveyed 10 state DOTs: Arizona, Idaho, Iowa, Minnesota, Montana, Nebraska, New Mexico, North Dakota, Wisconsin, and Wyoming.

   To gain insights on regional models, travel demand models from the following 7 regional agencies were reviewed: Metropolitan Planning Organizations (MPO) of Rapid City, Sioux Falls (SECOG), and SIMPCO; Idaho Transportation Department (ITD) District 6 Travel Forecasting Methodology; Lincoln, Nebraska MPO Travel Demand Model; Travel Demand Model for the Eastern Colorado Mobility Study in Colorado; and Branson Transportation Model for the City of Branson in Missouri.

3. *Interview managers, traffic engineers, designers, planning staff, and other stakeholders within SDDOT to determine policies, requirements, uses, and benefits of travel demand forecasting.*

   The research team conducted interviews with SDDOT personnel in Pierre and those from regional offices. The research also interviewed staff from Metropolitan Planning Organizations (MPO) of Rapid City, Sioux Falls, and SIMPCO

4. *Identify processes and systems in SDDOT and other state agencies that have needs for travel demand forecasting.*

   The research team reviewed the regional models of Sioux Falls, Rapid City, and SIMPCO for model structure, data, modes, and other aspects of the models to better understand the interface of these urban/regional models to a forecasting model that encompasses the entire South Dakota state.

   The research team also reviewed the use of Geographic Information Systems (GIS) within SDDOT to identify how GIS can be effectively used as a tool for travel demand forecasting within SDDOT. Advances in GIS capabilities have made GIS a very powerful tool in planning and travel demand forecasting, in particular.

5. *Review and analyze SDDOT's existing travel demand forecasting process and identify and test a procedure to validate the forecasting factors.*

   The purpose of the review and analysis of the 20-year traffic forecasting procedure is to validate its applicability to South Dakota counties that have been experiencing growth in some areas while a decline in population in some other areas. The Technical Panel selected the following eight counties for the validation exercise: Brown County, Buffalo County, Clay County, Lawrence County, Meade County, Pennington County, Roberts County, and Todd County.

   Under this task, the input data and methodology were examined, and limitations and weaknesses of the procedure were identified. Statistical quality tests of linear regression models of historical VMT and county business data were examined. Relationship of population and employment as variables to predict VMT was also explored.

6. *Identify the type of economic, demographic, passenger, freight, or other data that could be used to develop regional and statewide travel demand forecasts, as well as the costs and other resources necessary to obtain the data.*

   The review of existing travel demand forecasting under Task 2, interviews under Task 3, and review of processes and systems under Task 4 provided valuable information as to the type of data needed for a statewide or regional SDDOT travel forecasting tool. Likewise, these tasks identified potential data sources.

7. *Prepare a technical memorandum that summarizes the work performed in Tasks 1-6 and provides recommendations on the most efficient process and resource needs to produce travel demand forecasts for the SDDOT. Discuss the costs, benefits, advantages, disadvantages, and feasibility of the recommended forecasting alternatives.*

   The research team summarized the work performed in Tasks 1-6 in a technical memorandum. A matrix comparing the costs, benefits, advantages, disadvantages, and feasibility of forecasting alternatives was prepared.

8. *Meet with the technical panel to review the technical memorandum and recommendations.*

   The research team discussed with the Technical Panel the Technical Memorandum prepared under Task 7.

9. *Based on SDDOT concurrence with the recommended travel demand forecasting process, develop a systems requirements document and implementation plan that addresses data collection and management, analytical tools, hardware, software, and necessary training, along with costs and implementation timeframes to either enhance the SDDOT's current travel demand forecasting process or establish a new process.*

   The purpose of this task is to develop a systems requirements document and establish cost estimates to implement the recommended, and SDDOT approved, travel demand forecasting process. The research team prepared a matrix of alternative analytical tools, software, and staffing.

10. *Meet with the technical panel to review and approve the recommended requirements document and implementation plan.*

    The BWR research team discussed the recommendations and implementation plan with the Technical Panel via a telephone conference. Comments and suggestions from the discussion were included in finalizing the research recommendations and the final research study report.

11. *Upon review and approval of the systems requirements and implementation plan by the technical panel, prepare a final report and executive summary of the research methodology, findings, conclusions, and recommendations.*

    The BWR research team prepared this final report as a summary of the research methodology employed on this project, the principal findings of the research, the conclusions drawn from the findings and the key recommendations for travel demand forecasting requirements in the SDDOT.

12. *Make an executive presentation to the SDDOT Research Review Board at the conclusion of the project.*

    At the conclusion of the research project, the research team presented the research findings and recommendations to the SDDOT Research Review Board. Comments and suggestions during the presentation were incorporated into the final report.

1.4 KEY FINDINGS

1.4.1 Perceived Needs at SDDOT

The stakeholders' interviews provided valuable information on traffic data that is key input to roadway geometric design, requirements for a roadway including number of lanes, ramps, interchanges, intersections, and signalization, pavement design, pavement management system, safety analysis, corridor studies, corridor preservation, regional and statewide planning, and other system level analysis.

Stakeholders expressed their desire for better, more robust and credible traffic forecasts. The existing SDDOT traffic forecasting process falls short of meeting traffic data needs of many DOT programs/divisions. The current reliance on a couple of very experienced staff for traffic data analysis and forecasting is highlighted as a potential area that SDDOT needs to address.

Perceived Needs for a Better Traffic Forecasting and Analysis Tool

Perceived needs that are not met in the current traffic forecasting process include:

- Identify corridors that should be targeted for preservation, capacity expansion, multi modal development, and corridors that are crucial to the state's long term economic growth;
- Identify bottlenecks that should be targeted for capacity expansion, multi modal development;
- Identify highway segments with safety improvement needs;
- Identify existing and forecast freight movement needs and data on truck traffic;
- Analyze traffic diversion from other routes to the expressway;
- Analyze the effect of a corridor improvement on parallel corridors;
- Obtain future year Annual Average Daily Traffic (AADT) for specific roadways;
- Obtain growth factors for corridors and for different areas of the state;
- Evaluate highway capacity of all state routes;
- Determine need for projects including traffic impacts, costs, environmental, and railroads; and
- Forecast level of service (LOS) in the urban fringe area (like Sioux Falls) on roadways with 500 to 6000 vehicles per day (vpd); identify the growth in those highways to

determine if growth has caused a drop in the LOS. Such a capability would provide a better way of assessing, for example, applications for an approach driveway in those urban fringe roadways.

Staff Skills and Training Needs

Stakeholders emphasize the need to increase the number of staff involved in traffic forecasting, as well as enhance SDDOT staff's skills and knowledge in the following:

- Use and application of the Institute of Transportation Engineers (ITE) trip generation procedures
- Process and manipulate Census data for use in transportation analysis
- Basic understanding of travel demand surveys and the application of survey data
- Understand general traffic forecasting theory and the process of traffic forecasting and modeling, including quick response method of analysis
- Understand the application of forecast data

Potential approaches for a better traffic forecasting capability at SDDOT that could meet many of the identified perceived needs are presented in Chapter 6 of the report.

1.4.2 Enhancements Needed to the Current 20-Year Traffic Forecasting Procedure

The 20-year traffic forecasting procedure was originally developed in 1999 and since then it has not been validated. The traffic forecasting factors were based on a county level analysis of vehicles miles of travel (VMT) and indirectly on county level business growth.

The review and analysis of the 20-year traffic forecasting procedure validated the applicability of the linear regression technique as a valid approach to develop 20-year county level VMT forecasts. The results of review and analysis also identified several shortcomings in the current procedure. These shortcomings include the issue of data integrity, the use of a single global approach, and the lack of relationship between county VMT and county business trend. County business data is indirectly used in adjusting the 20-year factors mainly for commercial categories.

Chapter 5 of the study report describes in details the limitations of the current 20-year traffic forecasting procedure, together with the recommendations to enhance it.

1.4.3 Travel Demand Forecasting Model Options for SDDOT

One of the objectives of this research study is to determine the uses and benefits of a statewide model. The interviews of SDDOT stakeholders strongly emphasize the desire for a better forecasting approach than the current 20-year traffic forecasting procedure. The research team evaluated the uses/needs of traffic forecasts at SDDOT against the availability of data needed to develop a robust model system for SDDOT, as well as other constraints such as budget, and staff availability.

While it is possible to build a statewide travel model using available data, the applicability of such a model would fall short to meet many of the identified uses and needs. The lack of travel behavior data to reflect rural tripmaking characteristics in South Dakota would be one significant shortcoming of a statewide travel model (STM). Geographical coverage with very low traffic dictates coarse or large traffic analysis zones, which practically limits, if not render worthless, the STM for project level analysis.

The review of needs and resources indicates that a statewide model development process for South Dakota is lacking the following:

- Foremost is funding constraint where there is very limited funding available for model development,
- Availability of primary data sources mainly on travel behavior data,
- The level of expertise of SDDOT staff is an issue, as well as shortfall in the number of staff, and
- There is no major new highway or project planned in the short-term, at least within the next three years, that will provide an impetus for model development.

Considering the advantages and disadvantages, the research team does not find the current and short-term need for travel forecasting to justify the substantial cost to build, maintain, and update a four-step statewide model that requires Origin-Destination data. Instead, a statewide model of sketch planning level type is recommended as a starting model following enhancements to the existing traffic forecasting procedures. As a practical statewide model option, demand estimation and link factoring can be readily developed using the enhanced 20-year traffic forecasting procedure and GIS networks.

1.5 RECOMMENDATIONS

The purpose of this research study is to evaluate the most appropriate travel demand forecasting tool that is most responsive to the needs of SDDOT. Like many other state agencies, the SDDOT has to do more with less funding for transportation infrastructure, operation, maintenance, and planning. The travel demand forecasting functionality has to be tailored to SDDOT's needs and constraints while maximizing benefits.

Figure ES-1 presents a schematic of the recommended changes to the current SDDOT traffic forecasting process. The recommendations are grouped into four general categories that correspond to implementation timeframes. For example, recommendation **R1** includes changes requiring immediate implementation. Proposed implementation timeframes for each recommendation are outlined in Table ES-2 on pages ES-17 to 18.

R1. Recommended Changes to the 20-Year Traffic Forecasting Procedure

A. Enhancements to the 20-Year Traffic Forecasting Procedure

B. Increase the Number of Staff Trained in Traffic Forecasting

C. Develop and Implement "Traffic Use Procedures" Guidelines

D. Develop a Database of Travel Forecasting Data

R2. Short-Medium-Term Enhancements

A. Use GIS for Simple Network and Land Use Mapping

B. Use of a Standard Transportation Planning Package for Simple Network and Mapping

C. Invest in National Household Travel Survey Add-on Sample

R3. Statewide Sketch Planning Model Option

R4. Future Enhancements

A. Regional Model

B. Freight/ Truck Statewide Model

C. Statewide Passenger Car Model

These recommendations are the most practical changes that can be implemented considering largely the SDDOT's budgetary constraint. The recommended changes represent an incremental process towards building a statewide travel forecasting capability at SDDOT when the need for one is justified.

According to NCHRP 358, many states found it useful to stage the development of the model, adjusting capabilities as the budget permitted. California, New Jersey, Ohio, Oregon, and Virginia are examples of states with a deliberate staging process—building a limited model to address immediate needs and expanding upon this model to address a greater range of issues.

A similar staging approach is followed by New Mexico and Iowa. Both states are currently in the development of their statewide models. New Mexico is starting with a simple network type passenger car model that would link to existing and proposed microsimulation and sketch planning tools. Iowa is starting with a 4-step passenger car and truck model.

The South Dakota DOT has a strong GIS capability with good coverage of the state highway and local roadway systems. The research team recommends making use of the Department's GIS to enhance travel demand forecasting and traffic analysis and transportation planning in general at SDDOT. Options to link GIS to a standard transportation software package for use in small-scale or project-level traffic analysis is also recommended. Future enhancements are also included.

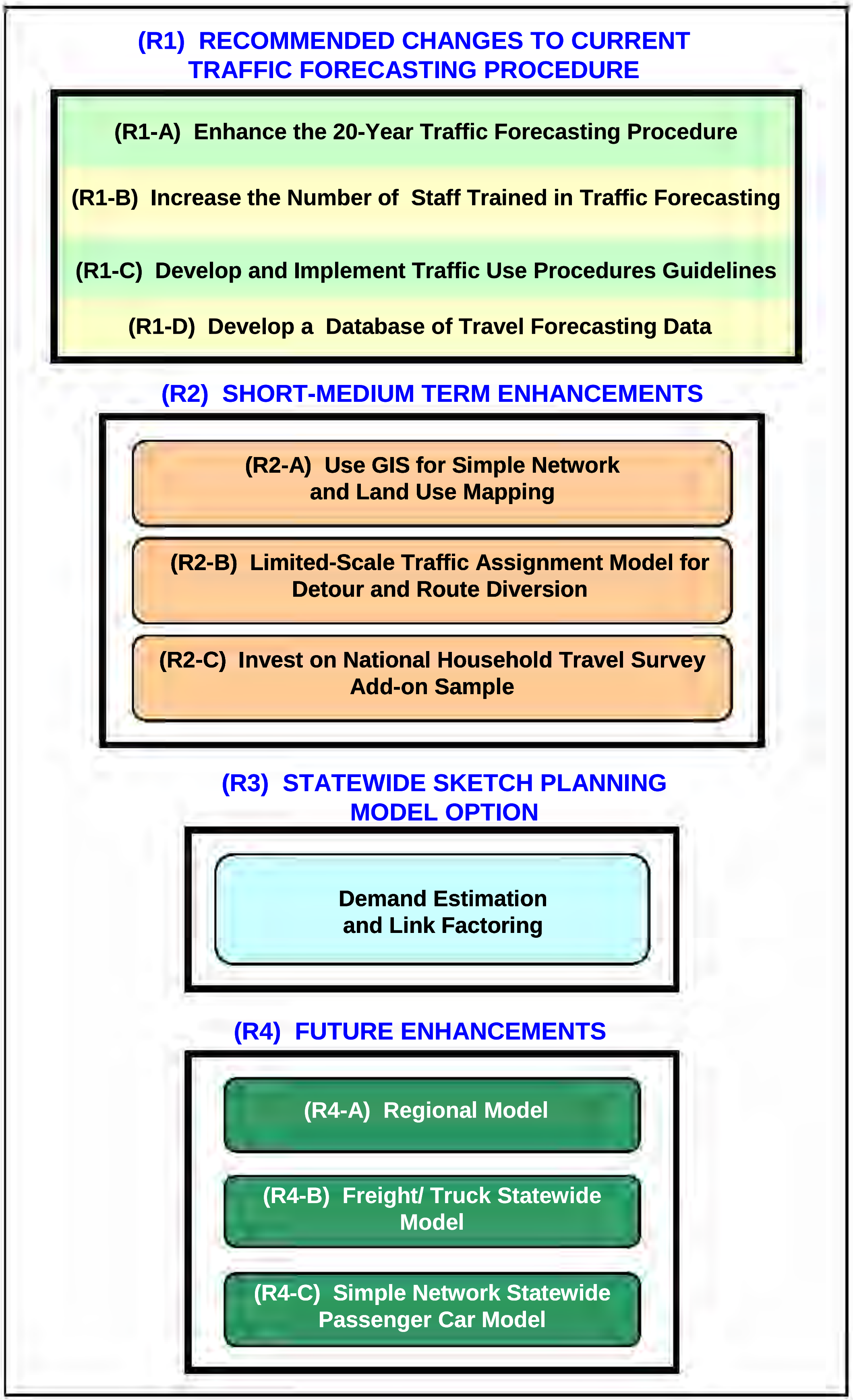

Figure ES-1 Recommended Changes and Enhancements to Current SDDOT Traffic Forecasting

1.5.1 Recommended Changes to the 20-Year Traffic Forecasting Procedure (R1)

R1-A Enhancements to the 20-Year Traffic Forecasting Procedure ()

The study recommends the following changes to enhance the current traffic forecasting process:

(1) Ensure data integrity

The detailed review and analysis of historical VMT data demonstrates the need to ensure a quality data set for use in the 20-year traffic forecasting procedure. It is imperative that historical VMT data should be reviewed to remove data outliers and make necessary adjustment for shifts in VMTs due to reclassification.

Apply the method outlined in Section 2.2.1 *(Method 3: Linear Projections of VMT by Functional Class, with Adjustments to Correct for Changes in Functional Class Categories)* to adjust the shifts in VMT due to reclassification. This method has been applied in this analysis to adjust for the interstate VMTs in Lawrence, Meade, and Pennington counties, as well as the statewide arterials and interstate VMTs.

(2) Year to use as a starting point for the regression analysis

After making the necessary adjustments to the historical VMT data, the starting year for the regression analysis should be reviewed. As shown in the historical VMT plots, some categories show sharp increases at some point and then moderating or leveling later. Typical of this trend is exhibited by Class 10-13 commercial where sharp increase in VMTs occurred in 1994. There are a couple of reasons for the sharp increase in VMT. After 1994, VMT has been calculated using HPMS data. Moreover, VMT data by county was not broken down by functional class until 1994. These changes in VMT calculation and aggregation have created some shifts, as exhibited by Class 10-13.

The regression analysis should use 1994 as a starting point rather than going back to 1986 for trucks. Starting year for other categories, such as *Other* class, should be reviewed as well.

(3) Apply different procedures to derive 20-year factors for VMTs

SDDOT should consider using different procedures to forecast VMTs based on the amount of historical and expected growth.

(a) Use constant growth rate in counties with only marginal increase in VMTs. Linear projection of VMT based on estimated growth factor (Method 1) outlined in Section 2.2.1 can be applied for categories such as Class 5-9 and *Other* class.

(b) Use linear regression or a combination of techniques. The technique used should be one that best fits the data. Use linear regression method for categories that exhibit a good linear fit. Use a combination of techniques, for example, a Moving Average to "smoothed" the data prior to applying a linear regression. Use other functions, for example an exponential function if this provides a better fit to the data. It is important, however, to ensure that the long term forecast is within reasonable expected growth.

(4) Aggregate categories

If appropriate, aggregate some categories to obtain a good linear fit. For example, Class 5-9 generally has poor linear fit. By combining the two commercial categories, an estimate for Class 5-9 can be derived. Aggregating data is a common practice. For example, it is common to start the VMT estimate at the statewide level since there is higher confidence in VMT data on the state highway system. Based on a statewide growth, estimate of growth at the county level is allocated based on population, or other socioeconomic data. Further, the VMT growth is allocated by functional class, for example interstate and non-interstate.

(5) Adjustment to the 20-Year VMT Factors

It is recommended not to apply the current adjustment approach. Ensure that a good linear fit exists; if not, use a different forecasting technique as outlined above.

(6) Explore socioeconomic explanatory variables

(a) Further explore the relationship of employment data and VMT, particularly for smaller counties. The present analysis indicated some significant relationship. Commercially available forecast socioeconomic data at a county level, for example, Woods & Poole economic data, is readily obtained at a modest cost. VMT projections using sound forecast socioeconomic data usually produce better factors.

(b) Explore the applicability of using total business pattern, particularly for larger counties. The results of analysis indicate that total business data has some significant relationship for some categories.

(c) Further explore the applicability of population as a variable in counties where a linear relationship exists. Population forecasts are more easily obtained than other socioeconomic data.

(7) Update the traffic forecasting annually using updated VMT and socioeconomic data.

(8) Develop standardized spreadsheet templates with graphic capability to facilitate analysis and interpretation of data trend.

R1-B Increase the Number of Staff Trained in Traffic Forecasting

As highlighted in the SDDOT stakeholders' interviews, there is a need to increase the number of staff with skills in traffic forecasting. Likewise, there is a need to provide training to enhance knowledge and skills in the following:

- Use and application of the Institute of Transportation Engineers (ITE) trip generation procedures

- Process and manipulate Census data for use in transportation analysis
- Basic understanding of travel demand surveys and the application of survey data
- Understand general traffic forecasting theory and the process of traffic forecasting and modeling, including quick response method of analysis
- Understand the application of forecast data

R1-C Develop and Implement "Traffic Use Procedures" Guidelines

In view of the recommended changes in the SDDOT traffic forecasting procedure and the desire to increase the number of Department staff who would be trained in traffic/travel forecasting, it is imperative for SDDOT to develop "traffic use procedures" guidelines. A "traffic use procedures" guideline would provide guidance on traffic data collection, processing and data editing procedures, outlining procedures on VMT adjustments and "smoothing" of historical VMT data, systematic guidelines for traffic forecasting, and thorough documentation.

The guidelines can also serve as a manual to facilitate training. Systematic guidelines for traffic forecasting can improve the development and documentation of a forecast to ensure accuracy and repeatability. Thoroughness of documentation ensures the quality of traffic forecasts with results repeatable and justifiable to others besides the responsible engineer. Standardize forecasting procedures and data sets ensure that forecasts are easier to review, interpret, and update.

R1-D Develop a Database of Travel Forecasting Data

Developing a database of travel forecasting data at SDDOT enables the Department to build incremental datasets that will be useful for developing regional models and later a statewide model. Such a database will serve as a repository of travel related information that can readily assist in various types of analysis and mapping. Information that can be stored in the travel forecasting database include, but are not limited, to the following:

- Socioeconomic data
- Data on travel characteristics
- Land use data, such as parcel level datasets
- Data collected and used in project-specific models or any non-MPO traffic models. A good example is the model developed for the City of Watertown
- Data on special trip generators or trip generation rates
- Traffic impact studies data
- Intersection controls and access management related data

1.5.2 Short-Medium-Term Enhancements (R2)

Other options to enhance travel demand forecasting and traffic analysis and transportation planning in general at SDDOT include the use of the Department's GIS capability. GIS can also be linked to a standard transportation software package for use in small-scale or project-level traffic analysis. A medium-term enhancement would be an investment to obtain good travel data from a household travel survey.

R2-A Use GIS for Simple Network and Land Use Mapping

The SDDOT GIS would provide a useful tool for many of the uses and needs identified by stakeholders. GIS mapping provides a handy tool for showing existing and future land use. Parcel level data would be very useful to show proposed developments, particularly commercial developments that would likely impact the state highway system. Demographics and socioeconomic data can be easily mapped over the highway system.

R2-B Use of a Standard Transportation Planning Package for Simple Network and Mapping

The strength in GIS capability at SDDOT can be augmented with a standard transportation planning software described in Chapter 6, Section 6.3, in the main report. GIS is very much at the heart of transportation planning tools providing links to data that drives the models. Figure ES-2 depicts an example using TransCAD that shows a map of mean travel time and mode of travel in South Dakota counties. Software packages have been developed to the point that they are more user-friendly than they were in the past, although knowledge and understanding of travel demand forecasting theory and modeling concept is required.

Area engineers would largely benefit from having a transportation software package to link with GIS. Such a tool would be handy for project level analysis and traffic impact studies. Once trained, area engineers and other SDDOT would be able to use the software package on limited or small-scale traffic assignment model for detour and route diversion analysis.

SDDOT already owns a TransCAD license, which is currently kept under Project Development.

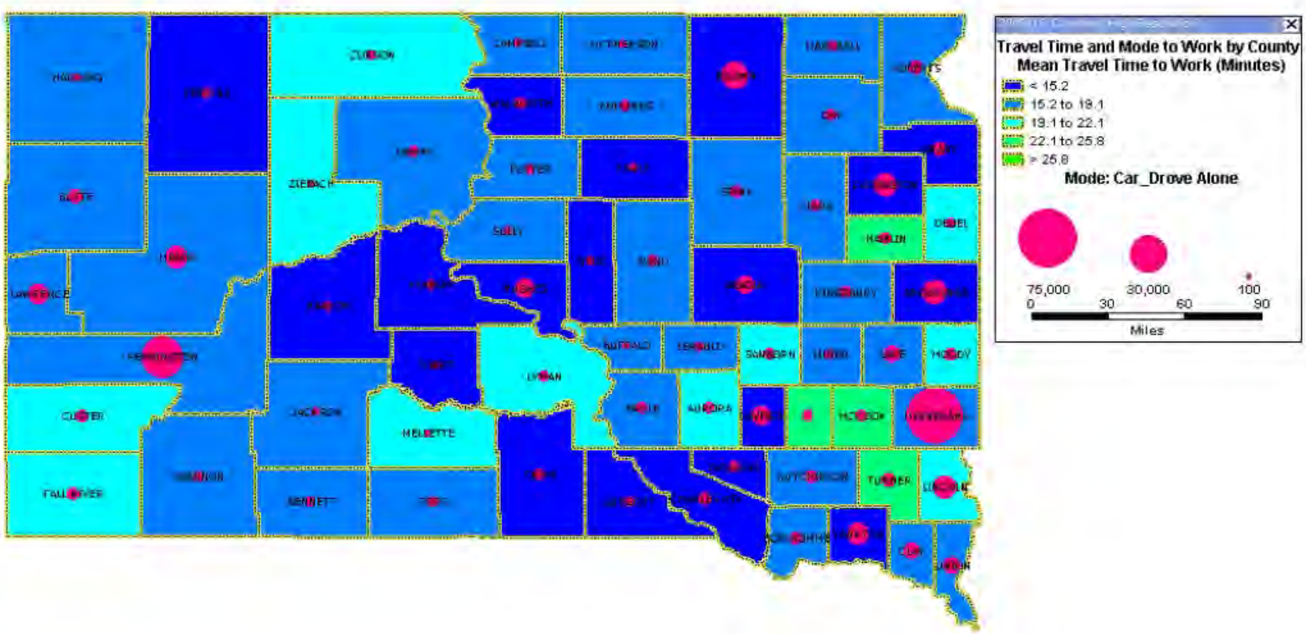

Figure ES-2 Example of the Use of TransCAD for GIS-Based Mapping/ Analysis

R2-C Invest in National Household Travel Survey Add-on Sample

The review of data availability and requirements for use in travel demand model development highlighted the need for good data on tripmaking characteristics of South Dakotan. An efficient approach to obtaining quality travel data from a travel survey is to purchase an add-on sample through the National Household Travel Survey. The 2008 add-on sample costs $175 per completed survey and requires a minimum of 1,500 samples.

The next NHTS schedule is fast approaching in 2008. It is not feasible to participate for this survey since sampling frame would need to be drawn and submitted to NHTS. It is already late for this coming 2008 survey schedule. However, NHTS has plans to conduct a more frequent survey than the current five-yearly interval. Considering budgetary constraint at SDDOT, the NHTS schedule appears fitting for SDDOT.

1.5.3 Statewide Sketch Planning Model Option (R3)

The review of data needs and available resources suggests that a demand estimation and link factoring approach can be developed as a statewide model option. The enhancements recommended to the 20-year traffic forecasting procedure would pave the way to extend the capability to incorporate socioeconomic and other potential explanatory variables. Population and employment are found to have some explanatory power for some categories in some counties. For those categories that do not show a good linear fit, aggregation of categories could be explored. Growth rates from population and employment data can also be assumed for those categories with marginal annual VMT growth.

Demand estimation and link factoring method was used in the Arizona DOT MoveAZ Plan. This method was used to update future HPMS travel forecasts. Factoring traffic volumes is less resource intensive than other approaches, but assumes that the underlying travel behavior in a region will not change. This approach is valid if the underlying trip distribution pattern is unlikely to change, if minimal changes in auto occupancy or mode split are expected, and if congestion on existing roads or the opening of new roads is not likely to result in a change in route choice. The VMT forecast for the MoveAZ Plan is based on population and employment forecasts as well as historical traffic counts.

1.5.4 Future Enhancements (R4)

Many states found it useful to stage the development of the model, adjusting capabilities as the budget permitted. In addition, experiences in many states and planning agencies indicate where many models were initiated because of a very specific issue or project that provides the impetus or triggers. Implementation of future enhancements suggested in Figure ES-1 would be largely driven on a needs basis. Table ES-1 below outlines potential triggers.

Table ES-1 Potential Triggers for Future Enhancements

Enhancement	Potential Triggers
Regional Model	• Future new major projects • Development pressures with regional impacts
Freight/ Truck Statewide Model	• Future expansion of ethanol plants • Capacity and safety impacts associated with increased or diverted truck travel on state routes that intermodal facilities adjacent to highways creates
Statewide Passenger Car Model	• Statewide long range planning requiring linkages with economic models • Corridor planning and bypass studies • Data on travel behavior and forecast socioeconomic data, and most importantly, funding availability

R4-A Regional Model

As outlined in Section 6.4.4, SDDOT could emulate the approach now being implemented at ITD District 6. To assist smaller communities in dealing with traffic growth in their areas, which could later pose problems with the state highway system, SDDOT could take the lead in coordinating regional transportation planning. The database set up as part of the recommended changes to traffic forecasting would allow SDDOT to build regional models when a need for it arises.

Future new major projects or development pressures with regional impacts would provide a strong catalyst for such a regional model.

R4-B Freight/ Truck Statewide Model

A simple network model approach applied in the Eastern Colorado Mobility Study and in the North Dakota DOT freight studies could be a potential model option for South Dakota when a need arises in the future to justify developing a statewide model for freight/ truck. Future expansions of ethanol plants would provide strong impetus for such a model. Likewise, the capacity and safety impacts associated with increased or diverted truck travel on state routes that intermodal facilities adjacent to highways creates would provide additional catalyst for a statewide freight/ truck model.

SDDOT could engage university research centers to develop a statewide freight/truck model similar to the freight studies undertaken by the Upper Great Plains Transportation Institute (UGPTI) for NDDOT. In developing the economic model to analyze, UGPTI has developed a simple network type model that includes trucks and passenger cars.

R4-C Statewide Passenger Car Model

Typical experiences in other states and planning agencies indicate that many models were initiated because of a very specific issue or project. For example, the need to evaluate corridor plans triggered the development of statewide models in Indiana and Missouri. Potential economic impacts associated with widening much of the state's two-lane highway system to four lanes provided the drive for the Montana statewide model. On the other hand, most statewide models were initiated because of a realization of system-wide forecasting needs. The need to evaluate and respond to air quality conformity analysis or system environmental impact statement provided impetus in other states for a statewide model. The Iowa DOT realized its needs for a statewide model as an important tool for forecasting auto and truck travel in the state, as well as other major planning efforts such as corridor analysis and policy evaluations.

When the need arises in the future to justify developing a statewide model for passenger car, a simple network model approach adopted by the New Mexico DOT could be implemented for South Dakota as a starting model. Impetus for developing such a statewide model may arise in response to the following needs:

- Corridor planning – assess the need for corridor level economic development studies and/ or intercity corridor and statewide planning. A need for a better forecasting tool for use in corridor planning is already a current issue identified by stakeholders.
- Bypass studies – stakeholders identified the need for a better forecasting tool for use in bypass studies.
- Respond to management and legislative requests for statewide travel statistics, as well as support for statewide system policy plans and investment analyses.
- Availability of good data on travel behavior and forecast data and most importantly, availability of funding.

1.6 IMPLEMENTATION PLAN

Table ES-2 summarizes the staffing requirements, opinions of cost, and implementation timeframes of the recommended changes to traffic forecasting at SDDOT.

Table ES-2 Staffing Requirements, Opinions of Cost, and Implementation Timeframes

Recommendation	Staffing Requirements	Opinions of Cost	Implementation Timeframe
(R1) Changes to the 20-Year Traffic Forecasting Procedure			
(R1-A) Enhancements to the 20-Year Traffic Forecasting Procedure	Implementation of the recommended changes to the current 20-year traffic forecasting procedure will not require new staff. However, more staff time from the Transportation Inventory Management program will be needed.	Staff time plus $400 if purchasing Woods & Poole socioeconomic data	Immediate
(R1-B) Develop and Implement "Traffic Use Procedures" Guidelines	This will only require staff time from the Transportation Inventory Management program.	Staff time	Immediate
(R1-C) Develop a Database of Travel Forecasting Data	This will require staff time from the Transportation Inventory Management program and the Bureau of Information and Telecommunications.	Staff time	Within one year and on-going
(R2) Short-Medium-Term Enhancements			
(R2-A) Use GIS for Simple Network and Land Use Mapping	This will not require additional staff, but will require more staff time largely from the GIS section.	Staff time	Within one year and on-going
(R2-B) Use of a Standard Transportation Planning Package for Simple Network and Mapping	This will not require additional staff, but will require more staff time. User of such standard transportation planning package is most strategically located under Project Development. The other option is the GIS section with supervision from a planner from Project Development.	$995 (annual software maintenance cost)	Within one year and on-going
(R2-A) Invest in National Household Travel Survey Add-on Sample	This will not require an additional staff, but would require staff time to devise the household survey sampling frame.	$262,500*	Medium-term that coincide with the next NHTS survey, most likely within the three to 5 years.

Recommendation	Staffing Requirements	Opinions of Cost	Implementation Timeframe
R3 Statewide Sketch Planning Model Option	This will not require additional staff, but will require more staff time from the Transportation Inventory Management program.	$25,000-$50,000	Short to medium-term
R4 Future Enhancements			
(R4-A) Regional Model	This will require an additional staff (0.25 to 0.5 FTE)	$150,000-$350,000	Long-term (not in the next 5 years)
(R4-B) Freight/ Truck Statewide Model	This will require an additional staff (0.50 to 1.0 FTE)	$150,000-$350,000	Long-term (not in the next 5 years)
(R4-C) Statewide Passenger Car Model	This will require an additional staff (0.50 to 1.0 FTE)	$$350,000-$600,000	Long-term (not in the next 5 years)

** This is only a minimum estimate based on the minimum of 1,500 samples required by NPTS. For a statewide sample, it will likely require more than the 1,500 minimum samples.*

1.0 INTRODUCTION

1.1 PROBLEM DESCRIPTION

There are several reasons why a state might be interested in forecasting statewide or rural travel. These include (1) obtaining forecasts of rural, intercity, and long distance trips by passenger and freight; (2) supplementing urban travel forecasts; (3) developing project level forecasts in rural areas; and (4) satisfying mandated planning requirements—SAFETEA-LU mandates that several issues must be considered in statewide transportation plans.

Forecasts of rural and intercity travel are helpful in programming the sequence of projects and their associated costs, developing corridor preservation plans, establishing reconstruction and resurfacing strategies, and as valuable input into the overall assessments of the adequacy of the statewide transportation networks. Forecasts of freight travel are important for determining pavement thickness while passenger travel forecasts determine the future number of lanes.

While planners in most sizable urban areas have the ability to forecast traffic levels in their communities, a large portion of travel in most states is rural. Thus, investigations of statewide or national transportation policies would be incomplete without forecasts on rural highways and other intercity transportation modes. Indicators (such as vehicle miles travel (VMT), air pollution emissions, tons of freight, and consumer surplus) require forecasts from both urban and rural areas. In addition, statewide forecasts can be helpful to urban area forecasts by providing information on through trips. In rural areas, the sizing of facilities in the design process requires accurate estimates of future travel.

Like many other state departments of transportation, the South Dakota Department of Transportation (SDDOT) is responsible for planning and maintenance of the state's transportation system. For SDDOT to effectively plan and maintain the state's transportation system, SDDOT needs planning tools to better understand travel patterns within the state and to better prioritize its limited resources.

The SDDOT has a 20-year traffic forecasting procedure that generates VMT forecasts at the county level. Since the traffic forecasting procedure was originally developed in 1999, it has not been validated. While the procedures adopted to derive these forecasting factors may still be valid and useful to some limited application, the SDDOT has recognized some shortcomings of the current forecasting procedure that include its inability to analyze from which land uses and location trips are generated, to which places trips are going, and which state routes trips are using. The inability of the current forecasting procedure to provide the desired analytical capabilities hinders the SDDOT from being able to analyze several planning needs, which include route diversion impacts prior to corridor improvements, corridor studies, site impact studies, and studies to identify the capacity and safety impacts associated with increased or diverted truck travel on state routes. The introduction of new intermodal facilities adjacent to highways creates opportunities for such diversion of truck trips.

The purpose of this research study is to enhance the current travel forecasting procedures to meet SDDOT planning needs. The challenge is to develop cost effective travel forecasting procedures with the desired analytical capabilities suitable to a rural state like South Dakota.

1.2 RESEARCH OBJECTIVES

This review of travel demand forecasting requirements in the South Dakota Department of Transportation has the following three objectives:

- Determine the uses of and benefits of travel demand forecasting on a regional or statewide basis at the SDDOT.
- Identify the level of travel demand forecasting functionality necessary to meet the needs of the SDDOT.
- Determine the resources necessary to develop, maintain, and operate SDDOT travel demand forecasting capabilities on a regional or statewide basis.

To meet these objectives, the research team conducted interviews with SDDOT personnel in Pierre and those from regional offices. The research also interviewed staff from Metropolitan Planning Organizations (MPO) of Rapid City, Sioux Falls, and SIMPCO.

The following section outlines the tasks undertaken by the research team to meet these objectives.

1.3 RESEARCH PLAN

To accomplish the above three objectives, twelve research tasks were defined. Below describes the tasks specified in the original request for proposal, together with the steps taken to perform them.

Task 1. Kickoff Meeting

Meet with the project's technical panel to review the project scope and work plan.

The research team's principal and co-principal investigators met with the Technical Panel in Pierre on April 16-17, 2007. During this time, the face-to-face interviews of stakeholders located in Pierre were conducted with the assistance of SDDOT Office of Research staff.

Task 2. *Review and summarize existing research concerning travel demand forecasting for regional and statewide applications, including types of forecasts, methods, and data requirements.*

The purpose of this review is to gain an understanding of how other state departments of transportation develop their travel demand forecasts. The review examined both regional and statewide travel demand model approaches and applications. The review focused on the following: objectives of the forecasting model, uses/applications of model (types of forecasts), model structure (particularly how freight is modeled), modes (automobile, commercial, others) model parameters, assumptions, data requirements, methodology, application software, GIS application, cost to implement and maintain, issues (model development, data, etc.), staffing, and training.

The research scope includes a review of statewide travel demand modeling practices at five other state DOTs with similar characteristics to South Dakota. States with similar rural characteristics as South Dakota that have operational statewide models are very limited. Montana DOT seems the only candidate. The research team decided to relax the requirement to include those DOTs in neighboring states that are currently developing or considering statewide models. Iowa DOT and New Mexico DOT are currently developing their statewide models while Minnesota DOT is currently undertaking a feasibility study assessing the need for a statewide model. In total, the research team surveyed 10 state DOTs: Arizona, Idaho, Iowa, Minnesota, Montana, Nebraska, New Mexico, North Dakota, Wisconsin, and Wyoming.

The research scope specifies seven regional models be included in the review, including the three Metropolitan Planning Organizations (MPO) of Rapid City, Sioux Falls (SECOG), and SIMPCO. Other four regional models reviewed include the Idaho Transportation Department (ITD) District 6 Travel Forecasting Methodology, Lincoln, Nebraska MPO Travel Demand Model, Travel Demand Model for the Eastern Colorado Mobility Study in Colorado, and Branson Transportation Model, City of Branson in Missouri.

The review of regional models focused largely on the following model elements: types of forecasts, types of modes, model input and validation data, sources of existing and forecast data, innovative modeling technique, model development cost when available, and limitations encountered in model development and suggested model enhancements.

In addition to the selected statewide and regional models, the following relevant sources were also consulted:

- 2004 Peer Exchange on Statewide Travel Demand Modeling, Transportation Research Circular E-C075
- NCHRP Synthesis 358: Statewide Travel Forecasting Models, TRB 2006
- Guidebook on Statewide Travel Forecasting, FHWA 1999
- Metropolitan Travel Forecasting: Current Practice and Future Direction, SR 288

Task 3. *Interview managers, traffic engineers, designers, planning staff, and other stakeholders within SDDOT to determine policies, requirements, uses, and benefits of travel demand forecasting.*

The research team streamlined the interview process by first mailing out a survey questionnaire to each stakeholder interviewee. The questionnaire was designed to include all pertinent information such as policies, processes, constraints, resources (data, staff, skills/trainings), requirements, uses, and benefits of travel demand forecasting. The questionnaire was submitted to the SDDOT Project Manager for comments/suggestions prior to the kickoff meeting, and before finally sending to each stakeholder.

The research team conducted face-to-face interviews of stakeholders located in Pierre during the kickoff meeting held in April 2007.

Task 4. *Identify processes and systems in SDDOT and other state agencies that have needs for travel demand forecasting.*

The interview with stakeholders in Task 3 provided valuable information in identifying processes and systems within SDDOT and MPOs (Sioux Falls, Rapid City, and maybe SIMPCO MPO for North Sioux City). Both Sioux Falls and Rapid City MPOs have developed and maintained regional travel demand models for their planning. The research team reviewed these regional models for model structure, data, modes, and other aspects of the models as part of Task 2. It is important to understand the interface of these urban/regional models to a forecasting model that encompasses the entire South Dakota state.

The research team also reviewed the use of Geographic Information Systems (GIS) within SDDOT to identify how GIS can be effectively used as a tool for travel demand forecasting within SDDOT. Advances in GIS capabilities have made GIS a very powerful tool in planning and travel demand forecasting, in particular.

Besides the interviews, the research team reviewed relevant planning documents to identify processes and systems within SDDOT and other state agencies that have needs for travel demand forecasting.

Task 5. *Review and analyze SDDOT's existing travel demand forecasting process and identify and test a procedure to validate the forecasting factors.*

The purpose of the review and analysis of the 20-year traffic forecasting procedure is to validate its applicability to South Dakota counties that have been experiencing growth in some areas while a decline in population in some other areas. The 20-year traffic forecasting procedure was originally developed in 1999 and since then it has not been validated. The traffic forecasting factors were based on a county level analysis of VMT and indirectly on business growth.

During the kickoff meeting, the Technical Panel selected the following eight counties for the validation exercise: Brown County, Buffalo County, Clay County, Lawrence County, Meade County, Pennington County, Roberts County, and Todd County.

Under this task, the input data and methodology were examined, and limitations and weaknesses of the procedure were identified. Statistical quality tests of linear regression models of historical VMT and county business data were examined. Relationship of population and employment as variables to predict VMT was also explored.

Task 6. *Identify the type of economic, demographic, passenger, freight, or other data that could be used to develop regional and statewide travel demand forecasts, as well as the costs and other resources necessary to obtain the data.*

The review of existing travel demand forecasting under Task 2, interviews under Task 3, and review of processes and systems under Task 4 provided valuable information as to the type of data needed for a statewide or regional SDDOT travel forecasting tool. Likewise, these tasks identified potential data sources.

Task 7. *Prepare a technical memorandum that summarizes the work performed in Tasks 1-6 and provides recommendations on the most efficient process and resource needs to produce travel demand forecasts for the SDDOT. Discuss the costs, benefits, advantages, disadvantages, and feasibility of the recommended forecasting alternatives.*

The research team summarized the work performed in Tasks 1-6 in a technical memorandum. A matrix comparing the costs, benefits, advantages, disadvantages, and feasibility of forecasting alternatives was prepared.

Task 8. *Meet with the technical panel to review the technical memorandum and recommendations.*

The research team discussed with the Technical Panel the Technical Memorandum prepared under Task 7.

Task 9. *Based on SDDOT concurrence with the recommended travel demand forecasting process, develop a systems requirements document and implementation plan that addresses data collection and management, analytical tools, hardware, software, and necessary training, along with costs and implementation timeframes to either enhance the SDDOT's current travel demand forecasting process or establish a new process.*

The purpose of this task is to develop a systems requirements document and establish cost estimates to implement the recommended, and SDDOT approved, travel demand forecasting process. The research team prepared a matrix of alternative analytical tools, software, and staffing.

Task 10. Technical Panel Review and Approval

Meet with the technical panel to review and approve the recommended requirements document and implementation plan.

The BWR research team discussed the recommendations and implementation plan with the Technical Panel via a telephone conference. Comments and suggestions from the discussion were included in finalizing the research recommendations and the final research study report.

Task 11. Final Report Preparation

Upon review and approval of the systems requirements and implementation plan by the technical panel, prepare a final report and executive summary of the research methodology, findings, conclusions, and recommendations.

The BWR research team prepared this final report as a summary of the research methodology employed on this project, the principal findings of the research, the conclusions drawn from the findings and the key recommendations for travel demand forecasting requirements in the SDDOT.

Task 12. Executive Presentation to Research Review Board

Make an executive presentation to the SDDOT Research Review Board at the conclusion of the project.

At the conclusion of the research project, the research team presented the research findings and recommendations to the SDDOT Research Review Board. Comments and suggestions during the presentation were incorporated into the final report.

1.4 REPORT ORGANIZATION

This report is organized into nine chapters and an executive summary.

Chapter 1 provides an introduction that outlines the purpose and objectives of the study.

Chapter 2 provides an overview of VMT estimation methodologies and travel demand modeling approaches.

Chapter 3 presents a summary of review of regional and statewide experiences in travel demand forecasting.

Chapter 4 presents the views gathered from interviews with SDDOT and MPO staff. The chapter summarizes the needs and benefits of a travel demand forecasting capability for South Dakota.

Chapter 5 presents the review, analysis, and validation of the current 20-year traffic forecasting procedure.

Chapter 6 presents the assessment of data, costs, and required resources for a travel demand forecasting capability in South Dakota.

Chapter 7 describes the recommended approach to travel demand forecasting in South Dakota.

Chapter 8 outlines the cost and implementation timeframes.

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2.0 AN OVERVIEW OF VMT ESTIMATION AND TRAVEL DEMAND FORECASTING APPROACHES

2.1 INTRODUCTION

This chapter outlines several approaches that have been applied for estimating baseline VMT and for forecasting future VMT in small urban and rural areas. It also presents potential travel demand forecasting approaches for consideration in South Dakota.

2.2 VMT ESTIMATION AND FORECASTING APPROACHES

In 1994, the Federal Highway Administration (FHWA) published a report entitled "Sample Methodologies for Regional Emissions Analysis in Small Urban and Rural Areas Final Report." The report provides information on sample methodologies and adjustment techniques for estimating VMT, which is a vital input for regional emissions analysis. Areas without travel demand forecasting models generally rely on calculations that involve spreadsheets to forecast future VMT. VMT forecasting methodologies described in the FHWA report range from very simple linear trend lines to more complex non-linear regression analyses. Sample methodologies are listed in Table 2-1 and details are outlined in subsequent sections.

The methodologies described in Table 2-1 were identified through FHWA research effort that involved a literature review and contacts with staff from over 20 State Departments of Transportation (DOTs) and metropolitan planning organizations (MPOs) that conduct conformity analysis (FHWA, 2004).

The current procedure to derive 20-year traffic forecasting factors for South Dakota is similar to Method 3 below. VMT factors are obtained by functional class. The current formulation, however, differs from Method 3 in that adjustments to correct for changes in functional class categories have not been performed to the historical VMT data set.

Table 2-1 Methodologies for Forecasting VMT without a Travel Demand Forecasting Model

Method 1	Linear projection of VMT based on estimated growth factor.
Method 2	Linear projection of total VMT, based on regression analysis of historic VMT data, apportioned by functional roadway class.
Method 3	Linear projections of VMT by functional roadway class based on historic VMT data, with *adjustments to correct for changes in functional class categories*.
Method 4	Linear projection of interstate VMT based on historic VMT data, and separate population-based forecast for non-interstate VMT.
Method 5	Analysis of anticipated VMT growth in each interstate corridor, and population-based forecast for non-interstate VMT.
Method 6	Separate regression forecasts by functional roadway class, based on VMT, population, and employment, with growth factor employing a decay function.

In selecting an appropriate approach, there are often tradeoffs to be made. Simple methods tend to have advantages in terms of data availability and ease of application, but may not be as technically robust. In contrast, methods that are more complex tend to have advantages in terms of being able to produce robust results for different circumstances and being sensitive to changes in transportation investments and other policies, but may be more time-consuming to apply and require greater investments in data collection. The advantages and limitations of each approach need to be weighed in terms of the availability of data and local understanding of conditions that influence the accuracy of an approach. Although complex methods may be more robust overall, simple methods may be most appropriate in cases where results are expected to be similar to those of a more complex method with less data collection and cost.

A linear projection of VMT may be appropriate if historical population trends are expected to continue and the road network is expected to remain largely the same. It would not be as appropriate, however, if the area is expecting much more rapid or slow growth than in the past, or if a major new highway facility is planned, which could bring in more through traffic.

Table 2-2 provides a summary comparing the applicability and limitations of each of the six methods in Table 2-1.

2.2.1 Method 1: Linear Projection of VMT based on Estimated Growth Factor

Description

Total VMT is projected to the future based on an estimated growth rate developed by planners. This growth rate may reflect historical growth, expectations for future growth using demographic or economic projections, or other factors as appropriate.

Method Applicability

This method is broadly applicable to virtually all areas without travel demand forecasting models. It is most appropriate when there are extremely limited resources for forecasting VMT, *or when future growth rates are not expected to follow historical patterns.*

Data Sources and Procedures

VMT projections are developed by applying an estimated VMT growth rate to a base-year estimate of VMT, developed from traffic counts and data on roadway extent. Regional planners develop the VMT growth rate based on historical information or expectations for future growth using demographic or other projections. Projected VMT is then apportioned to the functional classes in the same ratio as the most recent year of VMT data.

Limitations

- Methodology may not reflect future changes in factors that will influence VMT growth, such as population growth, economic growth, land use changes, and major new developments.
- Methodology does not reflect potential differences in travel growth rates on different types of roadways.
- Methodology is not sensitive to expected changes in transportation investments or policies. Any additional traffic growth associated with new facilities will need to be analyzed separately. Upgrades of facilities to higher classifications will not be reflected.

2.2.2 Method 2: Linear Projection of Total VMT, based on Regression Analysis, Apportioned by Functional Class

Description

This methodology uses a simple linear regression in order to forecast future total VMT for a jurisdiction, and then apportions the VMT to functional classes in the same ratio as the most recent year of VMT data. It is a simple method to project VMT using manual calculation procedures.

Method Applicability

This method is applicable to any area without a travel demand forecasting model. It is most appropriate for an area that is expected to maintain a stable rate of growth in population, economic activity, and vehicle travel.

Data Sources and Procedures

VMT projections are developed on a county basis based on the historical trend line (an ordinary least squares linear regression extrapolation of the latest ten years of data). The *statistical analysis uses total VMT in order to avoid issues associated with reclassification of VMT over time due to the expansion of urbanized boundaries and other functional class shifts.* Projected VMT is then apportioned to the functional classes in the same ratio as the most recent year of VMT data.

Limitations

- Methodology does not reflect factors that will influence future VMT growth, such as population growth, economic growth, land use changes, and major new developments. However, such items could be included in the regression analysis as an improvement to the existing methodology. As described above, *this method will not be very accurate for* *an area that is expecting a change in growth rate (either more rapid or slower) from the historical rate.*

- Methodology is not sensitive to expected changes in transportation investments or policies. Any additional traffic growth associated with new facilities will need to be analyzed separately. Upgrades of facilities to higher classifications will not be reflected.

2.2.3 Method 3: Linear Projections of VMT by Functional Class, with Adjustments to Correct for Changes in Functional Class Categories

Description

This methodology uses separate simple linear regressions in order to forecast future VMT for each roadway functional classification. In order to account for changes in road classifications over time, minor changes are "smoothed" by adjusting the VMT on a particular functional class for each year in proportion to any changes made in functional class mileage.

Method Applicability

This method is applicable to any area without a travel demand forecasting model. It is most appropriate for an area that is expected to maintain a stable rate of growth in population, economic activity, and vehicle travel.

Data Sources and Procedures

VMT forecasts are developed based on a linear regression for each functional class of roadway. However, in order to use historic data to conduct a linear regression by functional class, adjustments need to be made to correct for minor changes in functional class categories (associated with changes due to system upgrades).

Minor changes are "smoothed" by adjusting the historic annual VMT for a particular functional class in proportion to any subsequent changes made in functional class mileage (due to roadway upgrades). Per the equation below, this is done by multiplying VMT for each year by the ratio of mileage in the functional class in the current year to mileage in the VMT estimate year (for example, if current mileage on urban arterials is 105% of mileage in a historic year, due to system upgrades, VMT on urban arterials in the historic year will be multiplied by 1.05 in order to get an adjusted VMT estimate).

For each roadway functional class, for each historic year:

$$VMT_{adjusted-historic-year} = VMT_{historic-year} \, x \, \frac{FunctionalClassMiles_{current-year}}{FunctionalClassMiles_{historic-year}}$$

This effectively adjusts the older VMT for a given functional class to account for roadways that have since been shifted into that functional class. Per the equation below, functional class VMT totals must then be adjusted to ensure that total VMT for each year does not change as a result of these adjustments. The VMT sum for each year is calculated, and the ratio of the original VMT sum to the new VMT sum is multiplied by the adjusted VMT value for each functional class.

For each roadway functional class, for each historic year:

$$VMT_{corrected-historic-year} = VMT_{adjusted-historic-year} x \frac{VMT(All-Roadways)_{unadjusted-historic-year}}{VMT(All-Roadways)_{adjusted-historic-year}}$$

To avoid problems caused by larger discontinuities in historic trends by functional class (for example, due to changes in the definition of a functional classification at a particular time), linear regressions are conducted in a manner so they do not span such discontinuities. In other words, if a major jump takes place in 1990, the regression may disregard all data prior to 1990.

The procedures discussed above may be conducted at the statewide level in order to develop projected growth rates for each functional class that can then be applied at the local level.

Advantages

- Accounts for differences in growth rates on different types of roadways.
- Accounts for historical changes in road network, and can adjust for concerns about local links with sparse data.

Limitations

- Methodology does not explicitly account for factors that will influence future VMT growth, such as population growth, economic growth, land use changes, and major new developments. As a result, it will not be very accurate for an area that is expecting a significant change in growth rate (either more rapid or slower) from the historical rate.
- Methodology is not sensitive to expected changes in transportation investments or policies. Any additional traffic growth associated with new facilities will need to be analyzed separately. Future upgrades of facilities to higher classifications will not be reflected.

Example Application

Ohio Department of Transportation (DOT) uses travel demand forecasting models for many small urban areas. Where there is no travel demand forecasting model, Ohio DOT has used this procedure to forecast VMT. In this case, VMT estimates were only believed to be accurate at the statewide level, not the local level. As a result, the procedures for estimating future VMT growth rates were conducted at the statewide level for all functional classes in order to maintain consistency. The statewide growth rates were then applied to estimates of VMT by functional class for the area being analyzed.

2.2.4 Method 4: Linear Projection of Interstate VMT and Population-based Forecast of Non-Interstate VMT

Description

This methodology separates out non-Interstate and Interstate VMT. The rationale is that non-Interstate VMT typically relates closely to population whereas Interstate traffic in rural and small urban areas involves predominantly through-traffic that is not closely correlated with local population growth. Interstate VMT is estimated based on historical trend line, while non-Interstate VMT is estimated based on a regression to predict non-Interstate VMT per capita, which is applied to projected population.

Method Applicability

This method is applicable to small urban and rural areas, where Interstate highways make up a substantial proportion of VMT, and where population growth patterns may not reflect historical trends.

Data Sources and Procedures

Interstate VMT is projected using linear regression based on historic traffic volumes. Non-Interstate VMT is calculated by multiplying projected population by projected non-Interstate VMT per capita. Projected population can be taken from the MPO or state agency responsible for population projections. Non-Interstate VMT per capita is forecast based on a linear regression using historic estimates of VMT per capita for non-Interstate travel at the county level. This forecast recognizes that the amount of daily travel per person has increased historically and is likely to continue to increase. The resulting estimate of non-Interstate VMT is then apportioned to the functional classes in the same ratio as in the most recent year of data (also see Method #5 below for an alternative methodology for estimating non-interstate VMT).

Advantages

- Relatively simple approach yet accounts for most important roadway classification issues.
- Use of per capita VMT provides better sensitivity to key factors that affect non-Interstate travel than methods that simply use historical VMT as the independent variable.

Limitations

- Methodology does not fully reflect factors that will influence future non-Interstate VMT growth.
- Methodology is not sensitive to factors affecting Interstate VMT growth rate.
- Methodology is only somewhat sensitive to expected changes in transportation investments or policies.

Example Application

The approach has been used by the South Carolina Department of Transportation in Cherokee County.

2.2.5 Method 5: Corridor-based Analysis of Interstate VMT, Population-based Forecast for Non-Interstate VMT

Description

This method is similar to methodology #4, but uses professional judgment and a corridor-by-corridor analysis of historic growth and anticipated growth in each corridor in order to estimate the growth rate for Interstate VMT rather than relying solely on linear projection of historic data. It also utilizes a slightly different approach for estimating non-Interstate VMT, relying heavily on statewide VMT data rather than county level data.

Method Applicability

This method is applicable to small urban and rural areas, where Interstate highways make up a substantial proportion of VMT, and where historical growth in Interstate VMT may overestimate future growth, (this may be the case if historic growth has been especially rapid, and limited highway capacity constrains the level of future growth). It also is most applicable in locations where population growth patterns may not reflect historical trends.

Data Sources and Procedures

Interstate VMT is projected using data on historic trends, but is assumed to decline somewhat based on limitation in highway capacity or other factors. A corridor-by-corridor analysis is conducted of historic VMT growth in order to develop an initial annual growth rate. An adjusted annual growth rate is then developed for purpose of projections based on professional understanding of the anticipated pace of traffic growth in each corridor.

An estimate of non-Interstate VMT is developed using an approach similar to the one described in methodology #4, which relies on projections of population and per capita VMT. However, in this case, statewide growth in non-Interstate VMT is estimated using statewide VMT data from HPMS and state population estimates. First, a linear regression is developed to predict statewide non-Interstate VMT as a function of population, based on historic data, as follows:

$$NonInterstateVMT = a * Population + b$$

The base year non-Interstate VMT is then subtracted from the future year projection to calculate the projected growth in non-Interstate VMT. This statewide VMT growth is then allocated to the counties based on a combination of county population change and a projected increase in per capita VMT, as described below:

1. First, projected VMT per person is calculated for the analysis year by dividing the non-Interstate VMT calculated in the regression equation by the population projection in the analysis year.
2. The resulting estimate of VMT per capita is then multiplied by the base-year county population estimate in order to estimate future-year VMT associated with the existing population for the analysis year.
3. The county-level VMT estimates are then summed for the state to obtain the estimated statewide VMT associated with the existing population.
4. The difference between the resulting statewide VMT total (representing VMT associated with the base year population) and the forecasted total (from the regression analysis) is then calculated to obtain the estimated VMT due to population growth.
5. The VMT associated with population growth is then allocated to the county level based on each county's proportion of statewide population change between the base year and the forecast year. For example, if a county is responsible for 5% of the estimated population growth, then 5% of the VMT associated with population growth would be allocated to the county.

The resulting estimate of county-level non-Interstate VMT is then allocated to each functional class in the same proportion as in the HPMS baseline year.

Advantages

- Relatively simple approach yet accounts for most important roadway classification issues.
- Use of per capita VMT provides better sensitivity to key factors that affect non-Interstate travel than methods that simply use historical VMT as the independent variable.
- Use of statewide data helps to avoid potential inaccuracies associated with county-level VMT estimates.

Limitations

- Methodology does not fully reflect factors that will influence future non-Interstate VMT growth.
- Use of estimated or assumed growth rates can introduce bias.
- Methodology is only somewhat sensitive to expected changes in transportation investments or policies.

Example Application

The approach has been used by the Kentucky Transportation Cabinet (KYTC) in locations where there is not a travel demand forecasting model.

2.2.6 Method 6: Separate Forecasts by Functional Class based on VMT, Population, and Employment, with Growth Factor Employing a Decay Function

Description

This methodology involves developing separate forecasts of VMT by functional class. A unique aspect of this method is that it takes into account employment as a factor that influences VMT, and does not use a linear regression function. It employs a decay factor based on an assumption that future traffic growth will slow in the future compared to historic rates of growth. Estimates are adjusted to reflect current year HPMS VMT estimates.

Method Applicability

This method is applicable to small urban and rural areas without a travel demand forecasting model. *It is particularly useful where there are significant differences between travel characteristics by road classification, and when there is empirical evidence of a declining trend in VMT growth.*

Data Sources and Procedures

VMT forecasts for each county and functional class are based on traffic data and growth factors that reflect historic correlations between VMT and population and employment for each county and functional class. The growth factor employs a decay function assuming that VMT growth will taper off. Estimates are adjusted to reflect current year HPMS VMT estimates.

Advantages

- Methodology accounts for additional factors that influence VMT growth.
- Approach accounts for differences in VMT growth rates on different roadway functional classifications.

Limitations

- Use of estimated or assumed growth rates (decay function) can introduce bias.
- Resource and data requirements are the highest among the alternatives examined for areas without a travel demand forecasting model.

Example Application

The approach has been used by the Pennsylvania Department of Transportation for all areas where there is not a travel demand forecasting model.

Table 2-2 Comparison of VMT Forecasting Methods

VMT FORECASTING METHOD	METHOD APPLICABILITY	LIMITATIONS
Method 1 Linear projection of VMT based on estimated growth factor.	• Broadly applicable to virtually all areas without travel demand forecasting models. • Most appropriate when there are extremely limited resources for forecasting VMT, *or when future growth rates are not expected to follow historical patterns.*	• Methodology may not reflect future changes in factors that will influence VMT growth, such as population growth, economic growth, land use changes, and major new developments. • Methodology does not reflect potential differences in travel growth rates on different types of roadways. • Methodology is not sensitive to expected changes in transportation investments or policies. Any additional traffic growth associated with new facilities will need to be analyzed separately. Upgrades of facilities to higher classifications will not be reflected.
Method 2 Linear projection of total VMT, based on regression analysis of historic VMT data, apportioned by functional roadway class.	• Applicable to any area without a travel demand forecasting model. • Most appropriate for an area that is expected to maintain a stable rate of growth in population, economic activity, and vehicle travel.	• Methodology does not reflect factors that will influence future VMT growth, such as population growth, economic growth, land use changes, and major new developments. However, such items could be included in the regression analysis as an improvement to the existing methodology. • This method will not be very accurate for an area that is expecting a change in growth rate (either more rapid or slower) from the historical rate. • Same as bullet 3 of Method 1.
Method 3 Linear projections of VMT by functional roadway class based on historic VMT data, with *adjustments to correct for changes in functional class categories*.	• Same as Method 2 **Advantages** • Accounts for differences in growth rates on different types of roadways. • Accounts for historical changes in road network, and can adjust for concerns about local links with sparse data.	• Methodology does not explicitly account for factors that will influence future VMT growth, such as population growth, economic growth, land use changes, and major new developments. As a result, it will not be very accurate for an area that is expecting a significant change in growth rate (either more rapid or slower) from the historical rate. • Same as bullet 3 of Method 1.

Table 2-2 Comparison of VMT Forecasting Methods (continued)

VMT FORECASTING METHOD	METHOD APPLICABILITY	LIMITATIONS
Method 4 Linear projection of interstate VMT based on historic VMT data, and separate population-based forecast for non-interstate VMT	• Applicable to small urban and rural areas, where Interstate highways make up a substantial proportion of VMT, and where population growth patterns may not reflect historical trends. **Advantages** • Relatively simple approach yet accounts for most important roadway classification issues. • Use of per capita VMT provides better sensitivity to key factors that affect non-Interstate travel than methods that simply use historical VMT as the independent variable.	• Methodology does not fully reflect factors that will influence future non-Interstate VMT growth. • Methodology is not sensitive to factors affecting Interstate VMT growth rate. • Methodology is only somewhat sensitive to expected changes in transportation investments or policies.
Method 5 Analysis of anticipated VMT growth in each interstate corridor, and population-based forecast for non-interstate VMT	• Applicable to small urban and rural areas, where Interstate highways make up a substantial proportion of VMT, and where historical growth in Interstate VMT may overestimate future growth, (this may be the case if historic growth has been especially rapid, and limited highway capacity constrains the level of future growth). • Most applicable in locations where population growth patterns may not reflect historical trends. **Advantages** • Same as Method 4 • Use of statewide data helps to avoid potential inaccuracies associated with county-level VMT estimates.	• Methodology does not fully reflect factors that will influence future non-Interstate VMT growth. • Use of estimated or assumed growth rates can introduce bias. • Same as bullet 3 of Method 4.
Method 6 Separate regression forecasts by functional roadway class, based on VMT, population, and employment, with growth factor employing a decay function.	• Particularly useful where there are significant differences between travel characteristics by road classification, and when there is empirical evidence of a declining trend in VMT growth. **Advantages** • Methodology accounts for additional factors that influence VMT growth. • Approach accounts for differences in VMT growth rates on different roadway functional classifications.	• Use of estimated or assumed growth rates (decay function) can introduce bias. • Resource and data requirements are the highest among the alternatives examined for areas without a travel demand forecasting model.

2.3 TRAVEL DEMAND FORECASTING APPROACHES

This section presents potential travel modeling approaches for consideration in South Dakota. The approaches described below are directly quoted from the report commissioned by the New Mexico Department of Transportation that presents potential statewide model options for New Mexico (NMDOT, 2007).

Each option includes descriptions of structure, purpose, products, and the level of effort necessary to apply and maintain each system. It includes a description of a set of basic tools and progresses with descriptions of more sophisticated and complex models. Each option presented considers strengths and weaknesses, data requirements, model components, model calibration needs, and future forecasting processes (including training). The options considered include:

- Demand Estimation and Link Factoring
- Simple Network Models
- Basic Four-Step Transportation Models
- Integrated Freight and Passenger Four-Step Transportation Models

More advanced and complex approaches, such as activity-based models, are not included here as these approaches would not likely be applicable for South Dakota. Chapter 6 outlines the evaluation of potential statewide modeling approaches to meet the uses and needs of various divisions/ programs within SDDOT.

2.3.1 Demand Estimation and Link Factoring

This option is a sketch planning technique that focuses on the estimation of travel demand without developing a full network-based, four-step transportation model. The analysis is accomplished by pivoting off of known values of the dependent variable (e.g., VMT) and its relationship to one or more independent variables (e.g., population or employment). It is the simplest of the approaches and can be implemented with existing spreadsheet software (e.g., Microsoft Excel). It only provides a high-level (county or urban area) estimate of total demand for travel.

Such sketch planning models are not network or trip based and, therefore, transportation networks, trip generation, distribution, mode choice, or travel assignments are not performed. This option provides only aggregate values for travel demand and can be used to support the development of state transportation plans. If, for example, a state DOT has an existing estimate of VMT by functional class based on traffic counts, and has an estimate of population and employment growth at the county level, this option could be used to forecast future aggregate VMT by functional class.

This option can provide aggregate information about the transportation system, and can be used in the early stages of transportation system analysis to develop a conceptual understanding of performance.

2.3.2 Simple Network Models

Simple network models distill the relationship between socioeconomic activity and the transportation system into a set of basic parameters used to forecast and report travel demand. These models rely on readily available data, modeling parameters, GIS-based and regionally-based network characteristics, and the use of standard travel model software.

This option considers the development of shortcuts to impute values for missing or scarce data items. One such shortcut often developed as a component of this option is an origin-destination matrix estimation (ODME). This estimation technique builds the statistically most likely trip table consistent with observed traffic counts, and is used as a substitute for travel parameters normally derived from primary survey information in more sophisticated models (through the use of trip generation and distribution models).

Simple network models are trip based and, therefore, can produce limited versions of the outputs (e.g., network traffic volumes, origin and destination movements) associated with more complete modeling options (e.g., basic four-step models). Although similar structures can be created to estimate aggregate travel for other modes (rail, air etc.), simple network models typically do not include a mode choice component.

Models of this type can be calibrated with observed data (travel times, traffic counts, commodity flows), but most often the travel behavior parameters contained within the systems are "asserted" or borrowed from other locations or studies. Therefore, although this type of model can be validated using traffic counts, the lack of rigorous data inputs means that precise refinement of the validation is not typically feasible.

Because much of the travel behavior captured in this type of model is derived from traffic counts and other direct observations of the state transportation system, modeling would be confined to the state with external stations represented by traffic counts to capture trips entering and leaving the state.

2.3.3 Basic Four-Step Transportation Models

Models are continually adapting, changing and improving with new research advances, as well as demands placed upon them. The traditional and sequential "four-step process" is still used in the majority of planning purposes. The steps that are generally considered part of the four-step sequential process include: trip generation, trip distribution, mode choice and traffic assignment.

1. Trip generation defines how many trips will be produced;

2. Trip distribution defines what routes the trips use;
3. Mode choice defines what means of transport will be used (passenger car, bus, passenger rail, air travel, freight rail, truck, etc.); and
4. Trip assignment defines what routes will be used by the various modes of travel.

Basic four-step travel models represent the current state of the practice in statewide model development and application. These models are comprehensive and, therefore, more costly and data intensive than options previously presented. Statewide versions of this modeling option are similar to their urban counterparts, typically developed by MPOs.

Basic four-step modeling captures and analyzes trip-based travel. Although information can be obtained about a variety of transit modes, the emphasis is on highway travel, with information on other modes developed for refining highway results. This type of architecture would be applied to model person trips by trip purpose (e.g., work- or business-related travel, non-work travel, leisure travel, external trips) and freight transport in terms of vehicle trips or commodity types.

Basic four-step models provide statewide forecasts of freight and passenger highway vehicle trips on a route-by-route basis and can be used to generate transit usage. Such a model could be used to select and prioritize projects at a conceptual systems planning level. These models would allow the SDDOT to answer questions, at least in general terms, concerning the return on investment from various transportation infrastructure alternatives.

These models can effectively integrate with and support urban models (e.g., forecasting external station volumes based on state demographic and economic growth as opposed to simple extrapolation of historical trends). A statewide model can also be used to coordinate urban models by depicting the relationships of the urban areas with the overall state transportation system. Urban models also benefit when a statewide model can provide estimates or forecasts of travel for intercity project improvements to major intercity highway corridors that influence urban travel, but are not captured within the scope or scale of the urban models.

2.3.4 Integrated Freight and Passenger Four-Step Transportation Models

Advanced state of the practice in statewide modeling typically goes beyond simple applications of the basic four-step model process to involve a more thorough examination of many of the underlying factors that address travel behavior. A multimodal travel demand model (multimodal system) covering the entire state would incorporate statewide networks for roads, rail, and air travel. These models typically move beyond highway systems to examine a fully integrated multimodal transportation system, including highway and non-highway passenger travel, freight commodity flows, and trade-offs of rail versus truck movements.

A multimodal system would provide the ability to analyze passenger and freight travel within a state. Models of this type can be used to forecast trip generation, trip distribution, and mode choice for all passenger and freight trips within the state, and provide highway and other mode assignments and demand forecasts. However, commodity-based freight analysis also allows for additional analysis not available in models that capture only vehicle trips. The use of commodity flows as an input in the modeling process and as a performance variable allows economic impacts to be calculated and incorporated into the analysis. The value of goods being carried and the economic impacts to the state are among the kinds of assessments that can be made with this level of analysis. Products possible with a commodity-based model would include the ability to conduct economic policy analysis and productivity growth studies, as well as detailed cost benefit analysis.

As suggested in the *Guidebook on Statewide Travel Forecasting* (FHWA, 1999), multimodal systems most often require a full "four-step" model that considers passenger modes, such as auto, intercity bus, conventional rail, high-speed rail, and air; freight modes, such as truck, rail, water, and air; passenger travel purposes, such as commuter, business, and recreation; freight commodities, such as lumber, machinery and agricultural products; time of day splits; functional classifications; intermodal transfers; and future growth or changes in industry and population.

Table 2-3 Comparison of Travel Demand Forecasting Approaches

ATTRIBUTE	DEMAND ESTIMATION AND LINK FACTORING	SIMPLE NETWORK MODELS	BASIC FOUR-STEP MODELS	INTEGRATED FREIGHT AND PASSENGER FOUR-STEP MODELS
Platform	Spreadsheet	Standard modeling package (TransCAD, Cube/TP+, VISUM)	Standard four-step travel model software	Standard travel modeling software with macros to analyze commodity flows, econometric data, and other desired performance measures
Zonal Variables	Basic county demographics	State or U.S. Census data on demographics at the county or subcounty level	Detailed socioeconomic variables from the U.S. Census, sample data collected from primary travel surveys, and supplemental data from state sources	Available socioeconomic data from the U.S. Census, state and regions, sample data from special travel behavior surveys, and supplemental primary data collection
Network Variables	Highway network attributes and aggregate travel demand data	Basic highway system geography and attributes (functional class, distance, speed limits, traffic counts by location)	Available highway network geography and attributes (functional class, distance, speed limits, traffic counts by location), and roadway capacities, signalized intersections, and geographic data	Available highway system geography and attributes (functional class, distance, speed limits, traffic counts). Roadway capacities, signalized intersections, highway and freight intermodal variables, network attributes for rail and air, operational plans, track alignment, grade crossing and operational signals, and signals, locations of intermodal terminals
Model Components Incorporated	Not a network-based, four-step model	Trip generation and trip distribution are synthesized, mode choice is not employed (some aggregate data can be used), and traffic assignment	Traditional four-step modeling methods, including trip generation, trip distribution, mode choice, and trip assignment	Same components as basic four-step methods

Table 2-3 Comparison of Travel Demand Forecasting Approaches (continued)

ATTRIBUTE	DEMAND ESTIMATION AND LINK FACTORING	SIMPLE NETWORK MODELS	BASIC FOUR-STEP MODELS	INTEGRATED FREIGHT AND PASSENGER FOUR-STEP MODELS
MODEL CALIBRATION / VALIDATION	Volume checks at state, county, and MPO boundaries	Typically coarse with trip vectors or other factors used to adjust biases in the base year. These same factors are then applied to the travel forecast	Generally from available or computed information (counts, travel times, commodity flows, passenger rail, or transit flows) and special surveys (household, vehicle intercept, workplace, on-board transit) depending on the sophistication of the models	Available or computed data allowing for calibration and validation by trip purpose and market segment for each passenger or freight mode
FORECAST VARIABLES	Readily available forecasts at the county level from state and/or reasonably priced commercial sources	Readily available forecasts at the county level or below from state and/or reasonably priced commercial sources	Available socioeconomic forecasts at the county level or below may be supplemented with forecasts from accessible and reasonably priced commercial sources	Available socioeconomic forecasts supplemented with forecasts from costly commercial sources
FORECAST DATA RELIABILITY	Reliable for broad travel demand forecasting (e.g., VMT and AADT) but with limited applicability for network evaluations	Reliable for link-level and system level travel demand analysis but with limitations because future passenger forecasts are based on socioeconomic growth without detailed four-step modeling	Reliable for link-level and system travel demand analysis	Reliable for link-level and system travel demand analysis
PRODUCT	Aggregate system wide travel demand forecasts	Route-level traffic forecasts and system performance, such as VMT, Vehicle Hours of Travel (VHT), and energy consumption	Traffic forecasts by route segment and system performance measures, such as VMT and VHT. Statistical basis for comparing the costs and non-economic benefits of projects and aggregate information about non-highway mode market share and demand	Roadway segment passenger and freight forecasts by mode and vehicle type, system performance measures, such as VMT and VHT, link by link non-highway passenger travel and freight transport forecasts (person trips or commodities), tabulations of economic productivity and cost effectiveness, and integrated features for tradeoff analysis

Table 2-3 Comparison of Statewide Travel Demand Forecasting Approaches (continued)

ATTRIBUTE	DEMAND ESTIMATION AND LINK FACTORING	SIMPLE NETWORK MODELS	BASIC FOUR-STEP MODELS	INTEGRATED FREIGHT AND PASSENGER FOUR-STEP MODELS
ANALYTICAL FRAMEWORK	Conceptual analysis and rudimentary state transportation planning support	Used for systems planning, system performance, project analysis, rudimentary alternatives testing or scenario-based planning, analyzing the magnitude and distribution of STIP projects, and identifying potential deficiencies	Highway systems planning, system performance forecasts, deficiency identification, support LRTP and STIP prioritization, link to HPMS and VMT forecasting, support alternatives analysis and scenario-based planning, links with simulation models and economic models (HERS-ST and REMI)	Comprehensive multimodal freight and passenger systems planning, transportation system performance forecasts and system deficiencies, prioritize projects for the STIP, support a multimodal LRTP, perform rigorous project-level highway and non-highway/freight and passenger alternatives analysis, and provide the framework for economic analysis of projects
COSTS	Ranges from $25,000 to $75,000 depending on sophistication and needs	Ranges from $150,000 to $450,000 depending on sophistication, needs, and data collection (proprietary data purchase)	Ranges from $350,000 to $600,000 (or more) depending on sophistication, needs, data collection	Ranges in the $600,000 to $1,000,000 (higher) and could cost significantly higher; and
LEVEL OF REQUIRED TRAINING	Low	Low to moderate	Moderate to high	Very high

Source: New Mexico Multimodal Study: Travel Modeling Approach – Task E Report prepared by New Mexico Department of Transportation

3.0 Review of Regional and Statewide Travel Demand Forecasting

Task 2. Review and summarize existing research concerning travel demand forecasting for regional and statewide applications, including types of forecasts, methods, and data requirements.

3.1 INTRODUCTION

One of the objectives of the research study is to determine the resources necessary to develop, maintain, and operate travel demand forecasting capabilities for South Dakota on a regional or a statewide basis. To glean an understanding of methods, data requirements and associated costs required in developing and maintaining a travel demand model, the research scope included a review of regional and statewide travel demand forecasting applications. The following sections present the review findings.

3.2 REGIONAL APPLICATIONS

3.2.1 Models Reviewed

The research scope specifies seven regional models be included in the review, including the three Metropolitan Planning Organizations (MPO) of Rapid City, Sioux Falls (SECOG), and SIMPCO. The full list of seven regional models reviewed includes:

1. Rapid City Travel Demand Model
2. Sioux Falls Travel Forecasting Model
3. SIMPCO Travel Demand Model
4. Idaho Transportation Department (ITD) District 6 Travel Forecasting Methodology
5. Lincoln MPO Travel Demand Model, Nebraska
6. Travel Demand Model for the Eastern Colorado Mobility Study, Colorado
7. Branson Transportation Model, City of Branson, Missouri

The review of regional models focuses largely on the following model elements: types of forecasts, types of modes, model input and validation data, sources of existing and forecast data, innovative modeling technique, and model development cost if available. Limitations encountered in model development and suggested model enhancements are noted when available.

The Transportation Research Board (TRB) has recently released its study findings on "Metropolitan Travel Forecasting: Current Practice and Future Direction" in Special Report 288

(TRB, 2007). Sixty percent of all MPOs responded to the survey of modeling practice among MPOs. Relevant information from this Special Report 288 is referred to in this review of regional models whenever applicable.

Rapid City Travel Demand Model

The following are salient features of the Rapid City MPO travel demand model. More information about the model is presented in Section 4-3 as responses to interviews of MPO staff.

- The Rapid City MPO travel demand model follows a 3-step process that is implemented in TransCAD software package.
- The model deals only with the auto mode and estimates daily or 24-hour vehicular traffic.
- The Rapid City MPO planning area is divided into 210 internal zones plus 16 external stations. "Census blocks" is used as the unit or "building-block" for TAZ structure.
- Roadway network is based on GIS street centerline from the Rapid City MPO. The street centerline files included coverage for all streets, roads, and highways in Pennington County.
- The Rapid City MPO maintains an extensive database of socioeconomic data at the parcel level through their GIS. The base year land use categories included single family residential, multi family residential, manufacturing, military, retail, drive-through retail, office/service, medical, school/public, and motel/hotel. Special traffic generators were also identified for 22 TAZs, which included National American University, museums, SDSM&T, Storybook Island, Ellsworth Air Force Base, Rushmore Mall, and the Regional Airport.
- Three trip purposes (Home Based Work, Home Based Non-Work, and Non-Home Based) were defined for trip generation.
- Trip rates were developed based on several sources including NCHRP Report No. 187, NCHRP Report No. 365, and the ITE Trip Generation Manual.
- For model validation, data from the US Census Bureau was utilized to validate HBW trip productions and trip length frequency. Traffic counts were used to validate modeled volumes. Criteria established under NCHRP No. 365 and NCHRP No. 255 were used.
- The Rapid City MPO has developed 2025 land use projections for both residential and non-residential uses utilizing neighborhood plans at the TAZ level.
- Recommended enhancements to improve model performance include finer TAZs, better trip generation rates, and development of time-of-day parameters, which requires the collection of more hourly traffic counts.

Sioux Falls Travel Forecasting Model

In 2001, The City of Sioux Falls decided to develop a new travel demand model. The new model area extended beyond the city limits to cover the Sioux Falls MPO planning area. Thus, the expanded model area covers the City of Sioux Falls, the northern half of Lincoln County and all of Minnehaha County, with the exception of the northwest quarter. The following are salient features of the City of Sioux Falls travel demand model. More information about the model is presented in Section 4-3 as responses to interviews of MPO staff.

- The Sioux Falls travel demand model follows the 4-step approach with an additional "time of day" element that defines AM peak (7:00-9:00), PM peak (4:00-6:00) and Off-peak for all other times. The model is developed using the TP+/Viper software package.
- The model area is divided into 570 internal zones plus 12-15 external stations. The TAZ structure is based on Census geography.
- Roadway network is based on the City's GIS street centerline.
- Land use data include group housing, population, households, average household size, average autos per household, employment (industrial, office, retail, and other), transit service, and school enrollment (primary, secondary and university). Employment includes full and part-time jobs.
- Trip purposes defined for trip generation include; Home Based Work, Home Based School, Home Based Shopping, Home Based Other, Non-Home Based, Truck (heavy trucks), and Commercial (delivery, service, tradesmen, taxis, government vehicles, all light and medium duty vehicles not used for personal uses).
- Trip rates were developed based on stratification of household size and auto ownership. Trip productions and trip attractions models use values from the NCHRP Report No. 365.
- The mode choice model splits the total person trips into trips by travel mode. The Sioux Falls model defines the following travel modes: drive alone, carpool (any vehicle with more than one occupant), transit, and non-motorized (walk/bike).
- For traffic assignment, the Sioux Falls model performs three separate assignments: AM peak, PM peak, and off-peak.
- The Sioux Falls model made extensive use of generic travel parameters and coefficients due largely to budget and data constraints. Recommended enhancements to improve model performance include external survey, time of day parameters (more hourly traffic count data), and vehicle classification data to update the truck and commercial trip models.

SIMPCO Travel Demand Model

Salient features of the SIMPCO MPO travel demand model include:

- The SIMPCO MPO travel demand model follows a 3-step process that is implemented in TransCAD software package.
- The model deals only with the auto mode and estimates daily or 24-hour vehicular traffic.
- The SIMPCO MPO planning area is divided into 180 internal zones plus 21 external stations.
- Roadway network is based on TIGER data.
- Three trip purposes (Home Based Work, Home Based Non-work, and Non-home Based) were defined for trip generation.

ITD District 6 Travel Forecasting Methodology

The Idaho Transportation Department District 6 contracted a consultant to develop a traffic forecasting methodology for District 6 that was completed in May 2007. The ITD District 6 encompasses nine counties, which is entirely covered in the model. The travel forecasting methodology provides the District with the capability to specify a forecast year for any segment in the state system and get a future year Average Annual Daily Traffic (AADT) and Design Hour Volume (DHV). Elements of the forecasting procedure included the following:

- The ITD District 6 forecasting is a pragmatic approach in that it applies different procedures to forecast future traffic volumes on roadway segments depending on the amount of growth expected in the area where the segment is located.
  (a) If the expected growth were average or less than average, traffic forecasts would be based on trend line forecasting from historical traffic counts.
  (b) If growth were expected to be higher than average growth, land use forecasts would be used as the basis for creating growth rates.
- For areas where there is high growth but no local model is available, a simplified methodology using the available land use forecasts to create a growth rate were used. Appropriate trip generation rates were used to generate total daily vehicle trips for the mix of land use in each year that land use data or forecasts were available.
- For areas where there are no land use forecasts available or where no significant local growth is anticipated, trend line forecasting from traffic counts were used. A trend line forecasting method is appropriate when the future growth rate is expected to be similar to the historical rate, and is most frequently used in areas with relatively low growth rates. To apply this method, linear regression analysis has been performed using historical AADT traffic count data obtained from the ITD Traffic Survey and Analysis Section.

- Where travel models developed by local agencies exist, the models would be used to produce the land use based growth rates.
- If a local model were not available, a consistent procedure would be used to estimate growth in travel based on the expected growth in population and employment.
- The methodology does not represent a full travel forecasting model, but is instead a database management tool that uses available data to produce forecasts. As the methodology is applied for studies, additional information can be added to the database that supports the methodology. By developing the framework for consistent forecasting, the data gained from each corridor study or update will not be lost but will be stored in a way that makes it useful for future forecasting efforts. This process would allow the evolution of a procedure and database that could eventually become a full-scale travel model for the nine-county district.
- The forecasting tool is GIS-based that is linked to Excel spreadsheets to perform analytical computations. The GIS system is designed to be compatible with other GIS work being developed for the District. The District's GIS roadway databases were utilized to establish the forecasting network.

One important outcome of establishing the ITD District 6 forecasting methodology is fostering better communication and coordination among District staffs, local planners, and community stakeholders.

ITD District 6 commissioned a consultant to undertake the initial study that reviewed the needs in the district and established the travel forecasting methodology. The contract for the study was $75,000. ITD District 6 has retained the consultant that developed the travel forecasting methodology to maintain and update the model. There is no regular maintenance and update cost to the consultant. Update to the model would be carried out whenever the model is used and new data is available. In May 2007, ITD District 6 entered another contract for the consultant to update corridor plans for state roads. The contract involves developing population and employment forecasts that will be updated in the travel forecasting database. The cost for this new contract is $60,000.

Lincoln, Nebraska MPO Travel Demand Model

The City of Lincoln and Lancaster County (Lincoln MPO) has developed a travel demand model as a planning tool for addressing current and future transportation demand in the region. Elements of the Lincoln MPO model included the following:

- The Lincoln MPO travel demand model adopts a 4-step process in TransCAD software platform.
- The study area is divided into 560 TAZ that includes 32 external stations.

- Model street networks were "conflated" to reflect true geographic and link distances.
- The Lincoln model estimates daily vehicle trips and has the ability to model non-auto modes of transportation such as walking and bicycling. For this reason, person trips were used as the trip generation variable.
- Trip purposes include: Home Based Work, Home Based Shop, Home Based Recreational, Home Based Other, and Non-Home Based.
- The Lincoln Model has 12 land use categories: multi family dwelling units, single family dwelling units, general retail, shop retail, office, service, industrial, park, elementary, secondary, college, and university. Special traffic generators that include airport, prison, mall, medical center, university main campus, heavy industrial and low retail/ office/ service are also considered.
- Trip generation rates for non-residential uses were based on ITE Trip Generation 7th Edition, which were further refined based on four area types defined in the Lincoln model. Residential trip rates were based on the 2001 National Household Travel Survey (NHTS) for Des Moines, MAPA Omaha Council Bluffs, and Mid-America Regional Council. Additionally, trip rates for the rural area were developed using the Lancaster County survey.
- For mode split model component, the auto and non-auto shares were estimated based on data from the 2001 NHTS.

Travel Demand Model for the Eastern Colorado Mobility Study

In 2001, the Colorado Department of Transportation (CDOT) commissioned the Eastern Colorado Mobility Study. The purpose of the study was to evaluate the feasibility of improving existing and/or constructing future transportation corridors and intermodal facilities to enhance the mobility of freight services within and through eastern Colorado. The study area includes all of eastern Colorado, extending to the I-25 corridor on the west and Colorado's borders on the north, east and south.

To generate passenger car and truck travel forecasts for the Eastern Colorado Mobility Study, a **Simple Network Model** for passenger cars using ODME techniques and a more rigorous approach for freight forecasting was developed. Though the model encompassed half of the State, it was used in a statewide modeling context to assess freight diversions and freight transportation infrastructure needs. Modeling elements included the following[1]:

- Transportation network was developed from Colorado DOT GIS for rural regions of eastern Colorado and from available regional models for the urban front range of the study area (Colorado Springs, Denver, and North Front Range-Fort Collins).

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1 Modeling elements list is largely quoted from the New Mexico Multimodal Study: Travel Modeling Approach Task E Report.

- Origin-destination matrix for passenger cars were developed for the region using basic four-step modeling in rural eastern Colorado, statewide traffic counts, and “seed” or initial travel matrix developed from the regional models.
- TRANSEARCH commercially available data was purchased for the entire State and processed into truck trip tables by vehicle type and commodity type.
- Passenger and freight models were integrated to generate trip assignments within TransCAD travel modeling software.
- Integrated models were linked to the ITS Deployment Analysis System (IDAS) to evaluate the performance and benefit/cost impacts of the potential freight infrastructure improvement strategies in eastern Colorado.
- Trip assignments and analytical tools were also used to assess the truck diversion impacts of I-25 and those associated with the Ports to Plains.
- The model was used to analyze the Colorado to Texas and Heartland expressway (Denver to North Dakota) corridors and to evaluate freight infrastructure improvements to existing state highways in eastern Colorado.
- The cost to develop the model for the Eastern Mobility Study was $250,000.

According to the New Mexico Multimodal Study, CDOT has been discussing the potential implementation of a full statewide model to support their policy and planning initiatives, but has yet to commit to developing this system. The work conducted for the Eastern Colorado Mobility Study provides a framework and available dataset that could be used by CDOT to develop this full statewide model.

Branson Transportation Model

Branson, Missouri has a small population of approximately 5,000; however, an estimated 7 million people visit Branson each year to enjoy music shows, shopping malls, golf courses, lake activities, and camping. Traffic patterns in Branson are, therefore, typical of other large travel destinations located in semi-rural areas such as national parks. While travel is oriented toward commuting trips in the morning and afternoon peak hours in most cities, different travel patterns exist in Branson. Individual entertainment activities and the tourist season itself have great influence on travel patterns, resulting in Branson displaying the following travel pattern characteristics:

- Traffic typically peaks on the weekend.
- Weekday traffic is typically only 80 percent of the volume likely to be experienced on the weekend.
- In the summer, traffic is 10 to 15 percent higher than volumes in fall and winter.

- Peaks in the traffic volumes throughout the day correlate with the show schedules for the theaters on Route 76.

During the peak tourist season, Branson is plagued by delays and congestion. The City of Branson decided to develop a long-range comprehensive transportation plan to guide their efforts in addressing the transportation deficiencies in the region. The goal of the transportation plan was to develop a roadmap tailored to the unique characteristics of Branson that can be used both immediately and over the course of the next 20 years. In conjunction with the Branson Comprehensive Transportation Plan (BCTP) that was completed in 2001, the Branson Transportation Model (BTM) was developed. In early 2006, the BTM was updated to include transit modeling capability for use in the Branson Transit Study. Elements of the updated BTM included the following:

- The updated Branson Transportation Model is a 4-step model; a mode choice model was developed and incorporated into a new transit model, which was used for evaluating future transit alternatives.
- A survey of Branson employees, visitors, and attractions was carried out to define travel patterns in the study corridor and to identify trip generation rates for use in the travel demand model. The survey results were used to help establish trip rates for estimating trip distribution, as well as in establishing external and internal trips in the Branson Transportation Model.
- Based on survey data, **separate trip generation models** were developed for “visitors” and “employees.” For **visitors**, a hotel generation model was developed to properly account for visitor trip productions, by converting hotel rooms to number of visitors. A *Daily Visitor Trip Rate by Purpose* (Hotel, Theater, Shopping, Restaurants, and Other) was created, based on the visitor trip logs collected from the visitor trip surveys. For **employees**, a separate trip generation methodology was developed because their trip making is also significant in the corridor and because their travel patterns differ from those of the tourists. An *Employee Trip Rate by Purpose* (Work Based Shopping, Work Based Restaurant, Work Based Work Related, and Work Based Other) was created based on the data collected with the Employee Travel Surveys. The number of employees within the study area were identified by using an InfoUSA generated list.
- A mode choice model was developed to determine an acceptable mode split (ratio of highway to transit trips) within the study area. The three modes designated for study are: auto trips; transit trips by walk to bus; and walk / bus access to a fixed-guideway system that runs almost exclusively down State Route 76. The mode choice components to calculate the utility values needed include walk to transit times, highway and transit vehicle travel times, transit wait times, access and egress, auto operating costs, and transit fare cost.

- Model validation is a key component in the development of a suitable model to forecast transit ridership. Since Branson does not currently have regular bus service operating within the study area, a comprehensive array of transit models used in other tourist-based markets that have applied for FTA New Starts funding was reviewed, including Las Vegas, the Orlando area, Miami/South Florida, and Tampa Bay. Multiple transit-related parameters from these tourist community models were evaluated to ensure that the Branson model includes appropriate sensitivities to the introduction of transit, as well as changes in transit characteristics. The following parameters relating to transit usage and mode choice were reviewed and incorporated into the Branson model, as appropriate: *mode bias constants; auto operating costs; access to transit coefficients; wait and transfer time coefficients; and transit fare coefficients*.

3.2.2 Review Findings

The regional models indicate that no two models are alike. The model purpose, data availability, and budget largely influence the type and structure of the model system. The Eastern Colorado Mobility Study and the ITD District 6 travel forecasting methodologies demonstrate some simplified approaches to model larger, but less urbanized, communities. The ITD District 6's pragmatic approach could be emulated in some regions in South Dakota. The Branson experience provides a good example of modeling a tourist destination region. However, a similar approach may not be suitable yet for regions in South Dakota as the level of tourist influx is not of that same order of magnitude as Branson. The cost of conducting corridor surveys could be prohibitive.

3.3 STATEWIDE APPLICATIONS

3.3.1 Selected State DOTs

The research scope includes a review of statewide travel demand modeling practices at five other state DOTs with similar characteristics to South Dakota. States with similar rural characteristics as South Dakota that have operational statewide model is very limited. Montana DOT seems the only candidate. The research team decided to relax the requirement to include those DOTs in neighboring states that are currently developing or considering statewide models. These state DOTs are Iowa DOT and Minnesota DOT. Iowa DOT have completed their assessments for need and specification of a statewide travel model (STM) and now on Phase II development stage of the STM through consultant contracts. Minnesota DOT is currently undertaking a feasibility study assessing the need. It has completed its survey and some of the results are cited in this review. Other state DOTs whose model systems could be potential model for SDDOT are included in this review. The New Mexico DOT is currently developing its statewide model while Arizona DOT has been employing a sketch planning tool. The Wisconsin experience of integrating urban travel models with a statewide model serves an example of potential alternative for South Dakota that could be looked at while the North Dakota freight studies that developed a simple network model provides a good example for a starter freight model for South Dakota. The unsuccessful attempts by the Idaho Transportation Department and Wyoming DOT are also included to gain insights into pitfalls in a statewide model.

Below is the final list of state DOTs included in this review. The order by which the states are listed below corresponds to the types of statewide model where the simplest type (demand estimation and link factoring) is presented first.

1.	Arizona	Operational	6.	Wisconsin	Operational
2.	Montana	Operational	7.	North Dakota	Operational (Freight only)
3.	New Mexico	Under development in 2007	8.	Minnesota	Feasibility study
4.	Iowa	Under development in 2007	9.	Idaho	None
5.	Nebraska	Dormant	10.	Wyoming	None

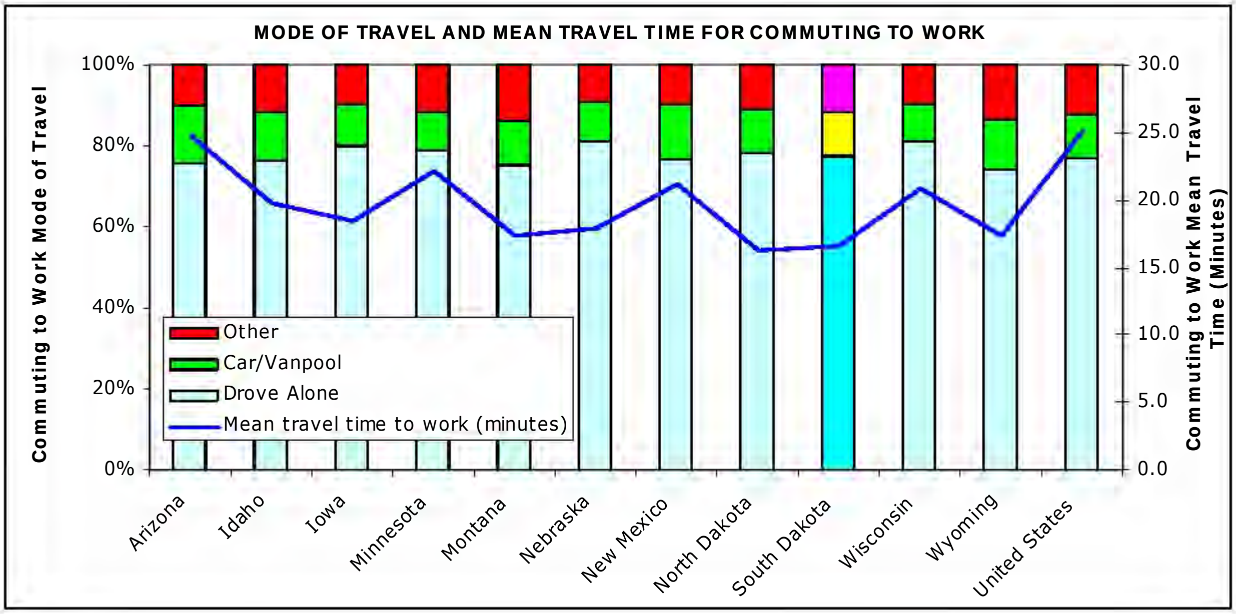
3.3.2 State Quick Facts Comparison

Comparison of some geographic, demographic, roadway mileage, and travel statistics are presented in Table 3-1 and Figures 3-1 and 3-2. South Dakota is a close second to Montana in terms of percent rural state trunk miles. With respect to population, it is third behind Wyoming and North Dakota. In terms of population density, it comes a close 4th behind North Dakota. Travel time to work remains relatively shorter at 16 minutes via the private automobile. Total highway vehicle miles over a five-year period from 2000 to 2005 has gone down slightly for South Dakota, compared to other states.

Table 3-1 Quick Facts for Selected States

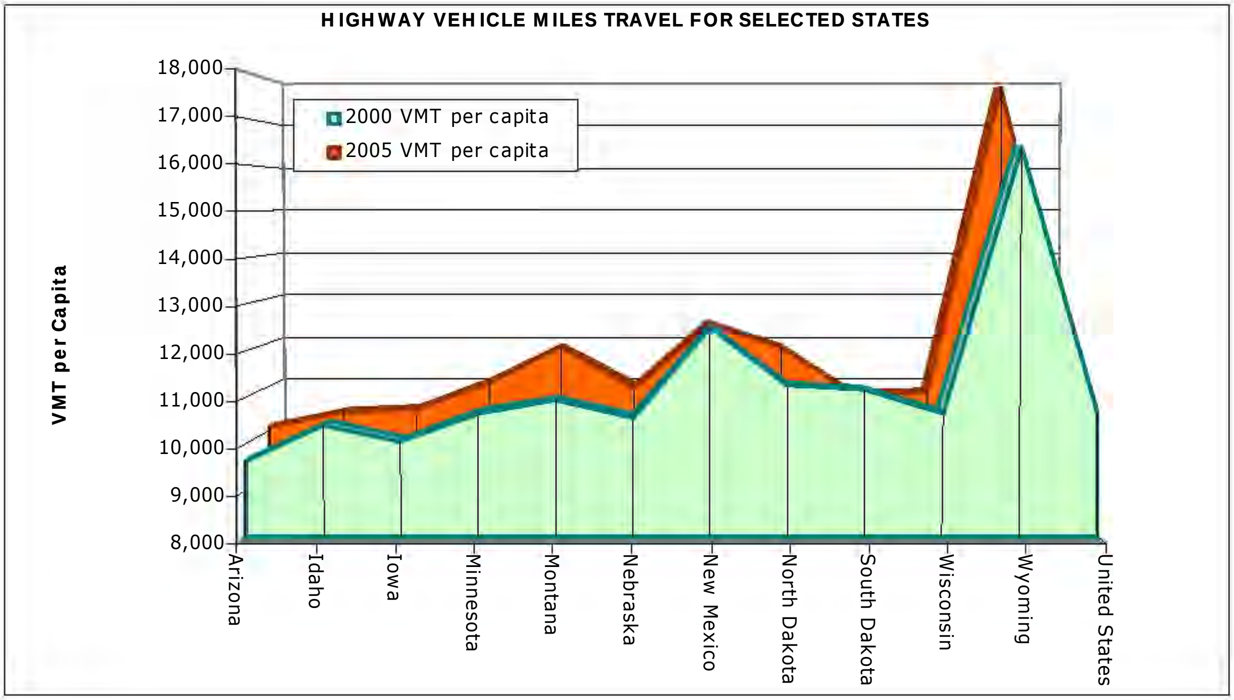
	South Dakota	Arizona	Idaho	Iowa	Minnesota	Montana	Nebraska	North Dakota	New Mexico	Wisconsin	Wyoming	USA
Geographic												
Land Area[1], sq. miles	75,885	113,635	82,747	55,869	79,610	145,552	76,872	68,976	121,356	54,310	97,105	3,537,438
Land Area Rank in the U.S.[1]	16	6	11	23	14	4	15	17	5	25	9	N/A
Person per square mile[2] (2000)	9.9	45.2	15.6	52.4	61.8	6.2	22.3	9.3	15	98.8	5.1	79.6
Demographic[2]												
Population (2006 Estimate)	781,919	6,166,318	1,466,465	2,982,085	5,167,101	944,632	1,768,331	635,867	1,954,599	5,556,506	515,004	299,398,484
Households (2000)	290,245	1,901,327	469,645	1,149,276	1,895,127	358,667	666,184	257,152	677,971	2,084,544	193,608	105,480,101
Average Household Size (2000)	2.50	2.64	2.69	2.46	2.52	2.45	2.49	2.41	2.63	2.50	2.48	2.59
Median Household Income (2000)	$39,265	$43,696	$40,509	$42,865	$51,202	$35,574	$42,166	$39,233	$37,838	$46,142	$43,785	$44,334
Roadways-Rural miles[3] (2001)												
Interstate	629	996	526	635	681	1,135	437	531	892	581	826	33,061
Other Principal Arterial	2,184	1,129	1,653	2,038	2,579	2,620	2,252	2,088	1,752	2,610	1,958	83,292
Minor Arterial	10	0	9	3	1	0	0	0		81	0	1,961
Major Collector	3	8	0	0	2	0	0	0		1	0	714
Minor Collector	0	0	0	0	0	0	0	0		0	0	21
Local	0	0	0	0	0	0	0	0		0	0	44
Total	2,816	2,133	2,188	2,676	3,263	3,755	2,689	2,619	2,644	3,273	2,784	119,093
Percent Rural Miles	96.24%	78.62%	92.40%	84.10%	82.36%	96.95%	90.42%	96.18%	89.66%	77.58%	94.34%	73.96%
Roadways-Urban Miles[3] (2001)												
Interstate	49	172	85	147	231	56	45	41	108	164	87	13,411
Other Freeways & Expressways	0	132	0	0	146	0	17	0	11	175	3	7,971
Other Principal Arterial	61	258	87	339	313	62	222	63	186	571	77	18,998
Minor Arterial	0	16	7	19	4	0	0	0	0	23	0	1,124
Collector	0	2	1	0	4	0	1	0	0	8	0	287
Local	0	0	0	1	1	0	0	0	0	5	0	133
Total	110	580	180	506	699	118	285	104	305	946	167	41,924
Percent Urban Miles	3.76%	21.38%	7.60%	15.90%	17.64%	3.05%	9.58%	3.82%	10.34%	22.42%	5.66%	26.04%
GRAND TOTAL	2,926	2,713	2,368	3,182	3,962	3,873	2,974	2,723	2,949	4,219	2,951	161,017

Sources:
1. http://en.wikipedia.org/wiki/List_of_U.S._states_by_area
2.http://quickfacts.census.gov/qfd/index.html
3.http://www.fhwa.dot.gov/ohim/hs01/hm41.htm



Source: U.S. Department of Commerce, U.S. Census Bureau, American Community Survey, and BWR (http://www.census.gov/acs/www/ as of Oct. 12, 2006)

Figure 3-1 Mode of Travel and Mean Travel Time to Work in Selected States



Source: U.S. Department of Commerce, U.S. Census Bureau, American Community Survey, and BWR (http://www.census.gov/acs/www/ as of Oct. 12, 2006)

Figure 3-2 Highway Vehicle Miles Per Capita in Selected States

3.3.3 Overview of Selected Statewide Experience

Arizona DOT Experience

The Arizona DOT completed a long-range transportation plan, referred to as MoveAZ, in December 2005. ADOT developed a variety of analytical tools to support MoveAZ, including the development of a statewide sketch planning tool. This model considered the Demand Estimation and Link Factoring option and consisted of the following elements:

- VMT forecasts by state, county, and functional classification were developed using population, employment, and traffic trend data;
- VMT forecasts were mapped to the transportation network in ADOT's statewide GIS and the State's HPMS (which contained a full sample of roadway segments in Arizona) to update the AADT for both base and forecast years;
- AADTs were adjusted to balance roadway volumes at county borders and urban-rural boundaries;
- Truck percentages in the HPMS were updated to reflect realistic travel on specific interstate corridors (I-10, I-40, I-8, I-19, and I-17); and
- GIS and HPMS were integrated with HERS-ST and other analytical tools to assess the transportation performance of corridors across the State and used to support the project prioritization and selection process for the MoveAZ Plan.

ADOT's statewide sketch planning tool has been used to support the MoveAZ Plan and various regional and system studies currently underway in the State. ADOT also has considered, but has not committed to, the development of more rigorous statewide models to support an update to MoveAZ and other statewide planning and policy initiatives. The ADOT statewide sketch planning system was developed for approximately $75,000 as part of the overall Arizona LRTP.

This type of modeling system can be applied in South Dakota DOT as an enhancement to the current 20-year traffic forecasting process. SDDOT already has the historical VMT by functional class by vehicle types at the county level. As detailed in Chapter 5, the current 20-year forecasting process can be extended to incorporate population and other socioeconomic variables that have valid influence to the annual growth or decline in VMT. The review and validation in Chapter 5 explored the applicability of population and employment as variables to estimate future travel forecast.

This sketch planning type of modeling system would support the development of the state's LRTP, regional studies, and other system elements.

Montana Statewide Travel Model

The Montana Department of Transportation (MTD) commissioned a highway reconfiguration study in the early 2000s. The main purpose of the study was to assess the potential economic impacts associated with widening much of the state's two-lane highway system to four lanes. The statewide model was a Simple Network Model that includes a series of integrated and unique benefit/cost models. To augment the statewide model, models that are more rigorous were developed to assess freight movements. Elements of this statewide model included the following:

- Transportation network developed from MTD GIS encompassing the entire State and implemented using TransCAD travel modeling software;
- Origin-Destination matrix for passenger cars were developed for the region using basic four-step modeling for trip generation and trip distribution, and statewide traffic counts;
- TRANSEARCH data was purchased for the entire State and processed into truck trip tables by vehicle type and commodity type;
- Passenger and freight models were integrated to generate trip assignments within TransCAD travel modeling software;
- REMI data were purchased and formatted to represent economic conditions across the State; and
- The Highway Economic Analysis Tool (HEAT), a unique set of benefit/cost and economic tools, was developed with a GIS-based user interface that was integrated with the statewide model and analysis tools to assess the impacts of systems and corridors.

MTD is currently using HEAT and the statewide model to assess statewide plans and policies, as well as system and corridor impacts associated with transportation, economic, environmental, and program (assets such as bridge, pavement, and safety).

The cost to develop the MTD modeling system was approximately $500,000. This cost included the development of the Highway Economic Analysis Tool (HEAT) designed to link to the statewide travel model system to test and prioritize corridor improvements across the state.

This modeling system could be a potential model for South Dakota DOT as a next better approach than a sketch planning type tool (demand and link factoring). The simple network model could provide the capabilities required for long-range and policy planning, performance-based corridor evaluations, statewide systems planning, and other analytical tools. One important consideration would be the cost to develop such a model system. The MTD modeling system cost was around $500,000. This sum, however, included an economic model. Thus, it will cost less to develop such a system for South Dakota if no other sub models are included.

New Mexico DOT Statewide Travel Model

Development of the New Mexico DOT statewide travel model is currently underway through consultants. The recommended model approach is a simple network model as a starting *core model* for the STM and develop enhancements to the model over time by layering on additional components (such as a freight model or intercity rail model), as the Department becomes familiar with the modeling system and begins to use the model for analysis and planning.

Figure 3-1 depicts the recommended New Mexico DOT statewide travel model currently being develop using the VISUM travel model software. The five key components to the proposed modeling system are outlined below:

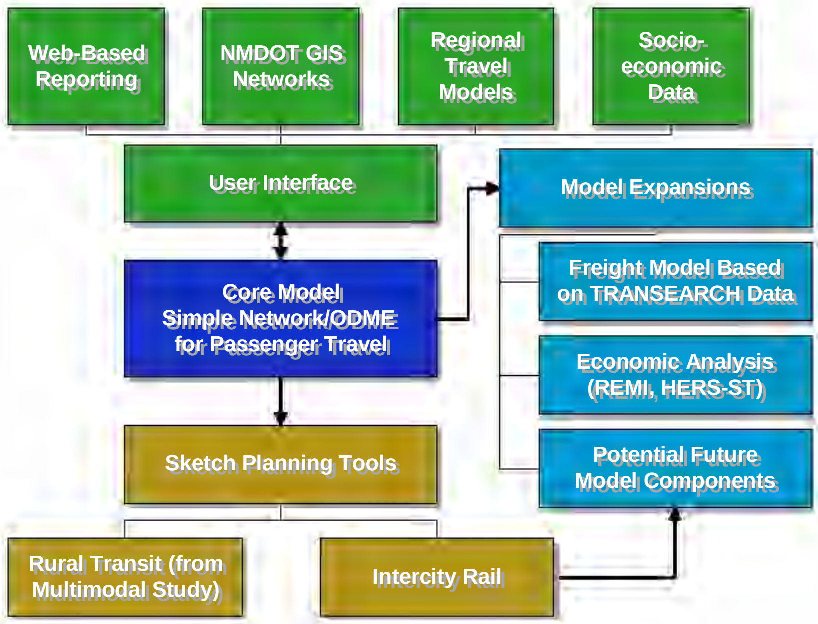
1. **Core Model**. The recommendation is that the New Mexico DOT begin with a Simple Network Model at the core for passenger modeling. This model would use ODME based on existing network data and traffic counts to estimate current and future roadway passenger volumes. The focus of this component is on intercity travel. This core model would include the development of commodity-flow-based freight models using TRANSEARCH data. This freight modeling element of the core model would provide New Mexico DOT with a detailed set of freight commodity flow models for rail and truck. This is the basic core system for several statewide models including Montana.

2. **User Interface.** A simple user interface will be developed to help the sharing of data with other models and importing and exporting data for other purposes.

3. **Model Expansions.** The model development process would allow for easy expansion.

4. **Microsimulation and Sketch Planning Tools.** The model would link to existing and proposed microsimulation and sketch planning tools. Microsimulation linkages would provide a means to assess the detailed transportation operations of corridors in the State. Sketch planning tools for intercity rail and rural transit are being developed as part of the Strategic Multimodal Study and would interface with the core model. Some sketch planning tools, such as for intercity rail, may eventually become full-blown model components.

5. **Development of Common Database and Analytical Tools to Support On-going Statewide Policy and Planning.** The model will provide the New Mexico DOT with a common set of data, analytical procedures, and linkages with various tools to perform a wide variety of planning and policy functions at the statewide and corridor levels. This approach provides the agency with a set of core tools that can be used to support these needs over time rather than continuing to create (in some cases, re-create) a set of both costly and disparate analytical tools.



Source: New Mexico Multimodal Study: Travel Modeling Approach – Task E Report prepared by New Mexico Department of Transportation

Figure 3-3 Schematic of New Mexico DOT Statewide Travel Model

The recommended modeling option will consider the following features:

- Link with New Mexico DOT's current GIS system to create transportation networks, zone systems, and supporting statewide data;
- Link with the regional travel models and socioeconomic datasets (Las Cruces, Santa Fe, Farmington, and Albuquerque) to allow for data sharing;
- Include an automated operating interface for applying the model to reduce human error, promote ease of use, support successful staff training, and aid in developing a consistent planning environment;
- Provide a web-based reporting platform that allows policy-makers and analysts within and outside of the New Mexico DOT to see and use outputs of the model;
- Link with economic and benefit/cost tools (HERS-ST, others) to prioritize corridor infrastructure improvements across the state;
- Link with Freight Tools, a tool that can be used to support both statewide freight modeling and planning), to support detailed freight analysis by economic sector for a Statewide Freight Plan;
- Integrate with toll diversion and revenue tools to assess the potential viability of both traditional and non-traditional (HOT or managed Lanes) passenger and freight (Truck

only Lanes) strategies and policy assessments (toll conversion of existing facilities or development of new toll facilities);

- Link with microsimulation (VISSIM in this case) to perform corridor evaluations for detailed engineering, environmental, and planning purposes to conduct;
- Link with the ITS Deployment Analysis System (IDAS) to assess the impacts of operational and other informational strategies on the transportation network; and
- Provide integrated passenger and freight forecasts and associated performance measures by mode and system.

Developing the model in this way will allow New Mexico DOT to use aspects of the model more quickly and spread out the costs of development over several years.

The cost to develop the model system is $450,000. The contract includes base and future transportation networks; calibrated base year travel demand for cars and trucks; future forecasts of cars and trucks; base and future year socioeconomic databases of population, employment, and economic sector information; base and future year commodity flows by type; linkages to available New Mexico datasets such as REMI, HPMS, and GIS; and linkages to sketch planning tools for microsimulation (VISSIM), freight (Freight Tools), tolling, and operations (IDAS).

Like the Montana DOT model, the New Mexico DOT core model (Simple Network/ODME Passenger Travel model) could be a potential model system for SDDOT. The idea of starting out from a simple network and develop enhancements later seems a good direction for SDDOT. The User Interface would allow better exchange of data and help build a better dataset that can be used in more advance modeling system in the future.

This modeling system could be a potential model for South Dakota DOT as a next better approach than a sketch planning type tool (demand and link factoring). The simple network model could provide the capabilities required for long-range and policy planning, performance-based corridor evaluations, statewide systems planning, and other analytical tools.

Like the MTD model system, the development cost of the NMDOT modeling system of nearly half a million, included several linkages to sub models such as economic model and regional travel models. It would cost less to develop such a system for South Dakota without the linkages to other sub models.

Iowa Statewide Travel Model

In January 2007, the Iowa Department of Transportation (IADOT) completed its needs assessment for developing a statewide travel model. The Needs Assessment determined the following: types of analysis that will be incorporated into the STM, the model components required to support the IADOT functions, an inventory of available data sources necessary for the model components, and data not available and the cost of obtaining such data.

Based on extensive consultations, the needs assessment study recommended a statewide travel model that will be developed in two tiers, Tier I and Tier II.

The model structure for **Tier I** will be designed to perform the following analyses:

1. Traffic Forecasting (Automobile and truck)
2. Corridor Analysis
3. Policy Evaluations (Finance, Funding, and Project Prioritization)
4. Rural Freeway Interchange Evaluations
5. MPO External and through Trip Analysis
6. Major Stateline Crossing Analysis (Bridge and Highways)
7. Special Generators
8. Safety Analysis (investigate the use of PLANSAF)

The model structure for **Tier II** will be designed to perform the following analyses:

9. Statewide Rail Freight Analysis
10. Commodity/Freight Flow Analysis (non-modal)

Tier I is the first priority for model development, which is currently being developed by consultants. Tier II would be developed as funding becomes available.

The recommended model components to support the analyses identified for Tier I include:

1. Passenger Car Model
   A. Highway Network
   B. Zonal System
   C. Trip Generation Model
   D. Trip Distribution Model
   E. Assignment Model
   F. Accessibility Model (reporting function)
   G. Model Report Component
2. Truck Model
   A. Truck Network
   B. Zonal System (same as the Highway Model)
   C. Truck Trip Generation Model
   D. Truck Trip Distribution Model
   E. Truck Trip Assignment Model

Basic data requirements for the Tier I model components include:

1. Network Information – GIS Based
   A. Number of Lanes
   B. Posted Speed
   C. Capacities (estimates based on the Highway Capacity Manual)
   D. Area Type (Urban vs. Rural – by Census definitions)
   E. Functional Class
   F. Posted Bridges and Truck Restrictions (optional)

2. Traffic Counts
   A. Vehicle Counts (24 Hour and Peak Period)
   B. Vehicle Classification Counts (Trucks)
   C. Stateline Boundary Traffic Counts

3. Zonal Information (may vary based upon model architecture)
   A. Population or Households by Geographic Area (current and forecasted)
   B. Employment by Category (Retail, Non-retail, etc for current and forecasted)
   C. Car ownership (0, 1, 2, 3+)

The above list of basic data is considered minimum informational needs for implementing a statewide model. Additional information such as trip generation rates and trip length frequencies will be necessary to develop model algorithms.

For data availability, most of the data needed for the model components is available from the IADOT, other state agencies, or the MPOs and RPAs within the state and from national data sources. Most of the MPOs and RPAs use Iowa Workforce Development data for their employment totals and the Census for their population totals. The study evaluated few if any data deficiencies that would stand in the way of developing the Tier I STM. IADOT has leased REMI (Regional Economic Models, Inc) data—a commercially available database for socioeconomic data and forecasts. The consultants also plan to supplement the REMI data using another commercial database of Woods & Poole Economics, Inc.

Other relevant information:

- The cost for Tier I model development is $375,000.
- The Iowa STM is developed in TransCAD, which is the same planning software used in all Iowa MPOs.
- The Iowa DOT has purchased an add-on sample for the 2010 National Household Survey (NHTS) for 2,000 samples. The cost for this add-on sample is $350,000.
- The Iowa DOT has a well established Forecasting and Modeling Team under the Office of Systems Planning.

The Passenger Car Model system for Iowa DOT could be another potential model system for a statewide South Dakota model if a need exists and justifiable under current limited funding. This model system would provide better analysis than a simple network model, but would require more resources. The Iowa DOT has a well-established forecasting and modeling team to oversee the successful development and maintenance of the STM. This model system would require, at the very least, a half time of an experienced modeler/planner that would be dedicated for model maintenance and upgrade.

Nebraska Statewide Travel Model[2]

The Nebraska statewide travel demand model is a base year model. It is not used to produce forecast. The origin and destination data that the STM is based on dates from the 1960s and 1970s. In certain areas of the state where there is not much change in population and travel characteristics, for example in certain areas of western or even in central Nebraska, the STM may still work. However, in Eastern Nebraska where more changes have occurred, the STM has its problems. According to Nebraska Department of Roads (NDOR) staff, generally, the results from the model have not been that reliable. Nevertheless, the STM can be used as a starting point for a subarea analysis. The STM will probably be phased out in the near future.

NDOR adopts different approaches to traffic forecasting in rural and urban areas. For forecasts on the rural highways (outside of the urban areas), NDOR relies on a program that looks at a 20-year history of traffic counts. Linear regression technique is used to estimate future growth.

In the urban areas, each MPO has their own model for future forecasting and in the cities over 5,000 population, but less than 50,000 (non-MPO's), NDOR developed the Comprehensive Plan Assist Program. This program assists these cities (that are not in an MPO area) with financial aid (up to $75,000) to hire a consultant to update their Comprehensive Plan and along with it, develop a future traffic model for the city. According to NDOR staff, the program has been working great and has helped both the cities and NDOR to come up with forecasts in the urban non-MPO areas.

Wisconsin DOT Statewide Travel Model

The Wisconsin Department of Transportation (WisDOT) has developed a multimodal statewide travel demand model and eleven new Metropolitan Planning Organization (MPO) urban travel models. One important feature of the STM is its integration with urban models, which presented benefits as well as challenges. The statewide and MPO model development was completed over a two-year period culminating in June 2005. The primary application of the models is to provide a tool for updating Long Range Transportation Plans and developing project level forecasts for highway design purposes. Elements of this statewide model included the following:

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2 Personal communication with Ron Schlautman, MPO & Urban Liaison Engineer/ State Bike & Ped Coordinator, Nebraska Department of Roads.

- The model consists of two distinct components: a passenger forecasting model and a freight and commodities movement model. The statewide passenger model utilizes elements of the MPO planning models as inputs to the statewide forecasting process. In return, the statewide model provides valuable information on interregional travel for use by MPOs in their metropolitan planning and forecasting activities.

- Various levels of MPO model/statewide model integration were considered. While each level presented its own set of challenges, it was acknowledged that a viable multimodal statewide model would have to feature at least a minimal degree of integration with the urbanized area model networks, zonal structures, and processes.

- The integration of the state's MPO urbanized areas presented numerous challenges. An ultimate level of MPO integration could allow for focused analysis of the roadways within the urbanized areas in a seamless automated approach as part of each statewide model run. This level of integration, though possible, was not feasible given the constraints and limited resources available to complete the project.

- The integration of statewide travel model forecasts with local urban travel models was proposed as a means of providing benefits for long-range transportation planning in Wisconsin. The statewide and urban models were developed and integrated electronically with WisDOT's historical forecast system called TAFIS (Traffic Analysis Forecasting Information System). This application allowed direct comparison of historical and statewide model forecasts at external cordon line locations within Metropolitan Planning Organizations in Wisconsin. The comparison showed improved travel demand forecasting in MPO areas and facilitated consensus building on travel forecasts for major highway improvement projects.

The WisDOT approach demonstrates a more comprehensive modeling system on a statewide basis. However, this approach may not be practical for South Dakota considering the geographical locations of urban areas with significant trip interchanges unlike the case in Wisconsin.

North Dakota Freight Study

The North Dakota DOT has commissioned research studies on freight. In April 2007, the Upper Great Plains Transportation Institute (UGPTI) presented a report on the "Impacts of Transportation Infrastructure on the Economy of North Dakota" to the North Dakota Legislative Council. Currently, a research study on freight undertaken by UGPTI is underway.

UGPTI has developed a base year model that encompasses the entire North Dakota state. The statewide model is a simple network type that uses traffic counts to estimate the origin and destination matrix. Both passenger cars and trucks are included in the model. The coverage of the network includes the state highway system. There is a plan to include county roadways when data is available. GIS is heavily used for developing data inputs, which are then loaded onto the travel demand model using the transportation planning software "CUBE." Cube was used to model commodity movements over highways and to analyze the effects of seasonal highway load limits. Key input data utilized the Regional Economic Models, Inc. (REMI). Outputs from the CUBE model are used as inputs to the Highway Economic Requirements System–State Version (HERS-ST) economic model.

Minnesota Statewide Travel Model Feasibility

Like South Dakota DOT, the Minnesota Department of Transportation (Mn/DOT) is currently undertaking the feasibility of a statewide travel demand model. One of the study tasks involves a survey with other state DOT's, Mn/DOT professionals, Minnesota MPOs, Minnesota RDCs (Regional Development Commissions), and NARC (National Association of Regional Councils) Memberships.

The feasibility study has completed the surveys and preliminary results were available for this review, which provided some useful information such as the ITD and WYDOT experiences described below. SDDOT could gain more insights for future consideration from the outcome of Mn/DOT feasibility study.

Experiences from Idaho Transportation Department and Wyoming DOT

From the MnDOT Feasibility of a Statewide Travel Demand Model survey, previous attempts by Idaho Transportation Department (ITD) and Wyoming Department of Transportation (WYDOT) to build a statewide travel model is included in this review to provide insights into the pitfalls of building an STM (MnDOT, 2007).

<u>Idaho Transportation Department</u>

The ITD attempted to build a statewide travel model during 1996 to 1999 with a consultant. ITD spent millions of dollars for Origin-Destination studies, consultant payments, and surveys. The results from these surveys were found to be unusable, and the model results were found to be not accurate even after calibration. The STM was not used, and ITD defaulted back to using projections from MPOs and using the traditional straight line projection to generate future traffic volumes.

ITD staff acknowledged there was lack of commitment to the manpower resources needed to maintain a STM. They still doubt that a STM is technically possible.

<u>Wyoming Department of Transportation</u>

The WYDOT did some work in the past to develop a statewide travel model to a mostly negative conclusion, although some work is contemplated for the future. Wyoming State has urban models for all communities in excess of 5,000 populations. Although WYDOT staffs are investigating combined models for some closer communities, they are inclined to think that this finer detail would not directly affect the statewide model process, primarily due to the generally great distances between communities in Wyoming and the preponderance of tourist and pass-through travel in Wyoming.

The ITD and WYDOT experiences in developing a STM provide good insights for SDDOT. The issue of manpower resources by ITD is one that SDDOT needs to bear in mind. WYDOT's assessment of combined models for some closer communities and the impact on a statewide model process relates very well to SDDOT's situation.

3.3.4 Review Findings

The review of other State DOTs experiences with developing a statewide travel model provides a wealth of information on which to base a model framework for a South Dakota DOT statewide travel model. All three types of model systems—demand and link factoring for ADOT, simple network models for MTD, NMDOT, CDOT, and NDDOT, and basic four-step model for IADOT—are potential model systems for a South Dakota STM. Cost to develop the statewide models varies greatly according to model type and sophistication, including linkages to other functions like the economic models. A suitable model option for South Dakota would largely depend on the needs of SDDOT for a STM, what benefits a particular model system would produce, what the associated costs would be, and most importantly, whether funding would be available.

The lessons to be gleaned from the ITD and WYDOT experiences would need to be borne in mind as well.

Table 3-2 Summary of Statewide Travel Demand Model Attributes

ATTRIBUTE	ARIZONA	MONTANA	NEW MEXICO	IOWA	WISCONSIN	NORTH DAKOTA
APPROACH	Link factoring	Simple network model	Simple network model	Basic 4-step model	Basic 4-step model	Simple network model
SOFTWARE	Spreadsheet	TransCAD	VISUM	TransCAD	TP+/VIPER	CUBE
MODEL USES	Support the MoveAZ long-range transportation plan Support regional and system studies	Assess statewide plans and policies Assess system and corridor impacts	Model link to various analytical tools to perform a wide variety of planning and policy functions at the statewide and corridor levels	Forecasting auto & truck, corridor analysis, policy evaluations, rural freeway interchange evaluations, MPO external and through trips, major stateline crossings, special generators, and safety analysis	A tool for updating long range transportation plans and developing project level forecasts for highway design purposes	Freight and economic studies
NETWORK VARIABLES	VMT forecasts mapped to statewide network using GIS and HPMS	Statewide transportation network developed from MTD GIS	Link to NMDOT's GIS system to create transportation networks	Statewide transportation networks	Integrates MPO urban models with statewide model	State highway system from GIS
MODEL COMPONENTS INCORPORATED	Not a network-based	O-D matrix for passenger cars and freight integrated to generate trip assignments; linked to economic model	Link with regional travel models and socioeconomic datasets; link with economic and benefit/cost tools (HERS-ST & others); link with freight tools	Passenger car model and truck model	Passenger forecasting model and freight and commodities movement model	OD matrix for passenger car and trucks
PROP. DATA		TRANSEARCH, REMI	TRANSEARCH, REMI	REMI, Woods & Poole	TRANSEARCH	TRANSEARCH
COSTS	Approximately $75,000 as part of the overall Arizona LRTP	$500,000; includes cost to develop the Highway Economic Analysis Tool.	$450,000;includes base and future transportation networks, socioeconomic databases, and future commodity flows	$375,000	No information available	No information available

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4.0 Needs and Benefits of Travel Demand Forecasting at SDDOT

Task 3. Interview managers, traffic engineers, designers, planning staff, and other stakeholders within SDDOT to determine policies, requirements, uses, and benefits of travel demand forecasting.

Task 4. Identify processes and systems in SDDOT and other state agencies that have needs for travel demand forecasting.

4.1 INTRODUCTION

The first step in identifying the travel demand forecasting requirements for SDDOT is to undertake an evaluation of the needs for travel demand forecasting by different departments and regions within SDDOT, including South Dakota's Metropolitan Planning Organizations of Rapid City, Sioux Falls, and SIMPCO. The evaluation is designed to examine policies, resources, requirements, and uses of current and projected demand for travel in the state highway system, as well as the potential benefits to be gained from an improved travel demand forecasting capability within the SDDOT.

This task was largely accomplished through interviews with managers, traffic engineers, designers, planning staff, other stakeholders within SDDOT, and MPO planning staff. Subsequent sections present the outcomes of those interviews and a synthesis of the review of policies, processes, and resources.

4.1.1 SDDOT Organizational Arrangement

The South Dakota DOT is organized into four divisions as shown in Figure 4-1. Department functions with traffic data needs or that uses traffic data are largely concentrated within the Division of Planning & Engineering and within the Division of Operations. Some functions under the Division of Finance & Management also have some use of traffic data.

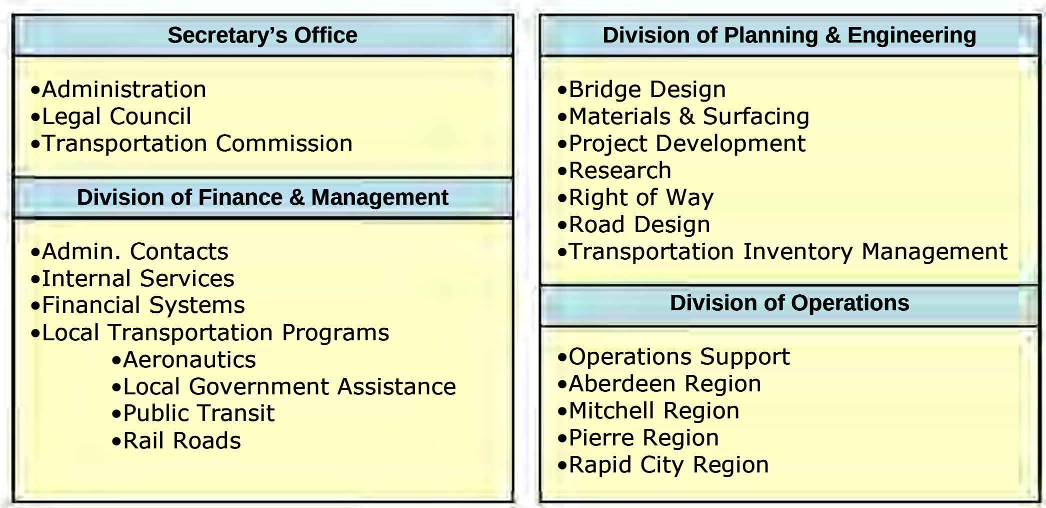


Figure 4-1 South Dakota DOT Organization Chart

4.1.2 Interviewed SDDOT and MPO Staffs

Table 4-1 provides the list of 29 SDDOT staff that includes a mix of managers, traffic engineers, designers, and planners from different divisions and programs who participated in the stakeholder interviews. The list also includes the three MPO staff.

Table 4-1 Interviewed SDDOT and MPO Staff

NAME	TITLE/ POSITION
Office of Secretary	
Ben Orsbon	Federal Funding Specialist
Local Transportation Programs	
Wade Dahl	Urban Systems Engineer
Jacquelyn Mattheis	Transportation Specialist I
Office of Research	
Hal Rumpca	Research Engineer
Dennis Johnson	Research Engineer
Division of Planning & Engineering - Transportation Inventory Management	
Rocky Hook	Program Manager
Ken Marks	Engineering Supervisor
Jeff Brosz	Transportation Specialist
Roger Brees	Transportation Specialist I (GIS)
Division of Planning & Engineering - Road Design	
Mark Leiferman	Chief Road Design Engineer
Dan Martell	Traffic Design Engineer Specialist
Pete Longman	Engineering Supervisor
Division of Planning & Engineering - Bridge Design	
Kevin Goeden	Program Manager
Division of Planning & Engineering - Project Development	
Tim Bjorneberg	Program Manager
Terry Keller	Environmental & Safety Supervisor
Jerry Ortbahn	Engineering Supervisor
Cliff Reuer	Engineering Specialist (Safety)
Steve Gramm	Data Analysis Engineer
Brad Remmich	MPO Coordinator
Mark Malone	Transportation Planning Engineer
Division of Planning & Engineering - Materials & Surfacing	
Joe Feller	Program Manager
Gill Hedman	Pavement Design Engineer
Division of Operations	
John Adler	Traffic Operations Engineer
Rick Laughlin	Corridor Preservation Specialist
Ed Rogers	Operations Maintenance Engineer
Alan Petrich	Aberdeen Region Engineering Specialist
Scott Jansen	Mitchell Region Engineering Specialist
Darren Griese	Pierre Region Traffic Engineer
Dan Staton	Rapid City Region Engineering Specialist
MPO	
Kip Harrington	Rapid City MPO
Sam Trebilcock	Sioux Falls MPO
Sheldon Harrison	Transportation Planner/Modeler - SIMPCO MPO

4.1.3 Questionnaire

To facilitate the interviews, questionnaires were prepared separately for SDDOT staff and for MPO staff. Appendices A and B include the interview questionnaires.

4.2 RESULTS OF SDDOT STAFF INTERVIEWS

4.2.1 Present Use and Sources of Traffic Forecasting Factors or Other Data

Questions 1 through 3 relate to SDDOTs present use and sources of traffic forecasting factors or traffic data. Identifying which DOT programs/divisions use traffic data for what purpose will aid in designing the most appropriate and cost effective traffic forecasting tool.

Q_1 Does your program/division use traffic forecasting factors or other traffic data?

The table below presents a summary of traffic data elements used by different programs/ divisions throughout SDDOT. Table 4-2 categorizes the traffic data into five major groups.

Division / Program	Traffic Forecasting or Other Traffic Data Used
Office of Secretary	• AADT, DHV, PHTV, TMV, VMT, #Crashes, Freight-TM
Div. F&M - Local Trans. Programs	
Local Government Assistance	• AADT, DHV
Public Transit	• Bus ridership provided by agencies (River City Transit, etc); do not use traffic data for identifying/determining bus routes.
Div. P&E - Office of Research	• AADT, Crash Rate, PHTV, TMV
Div. P&E – Trans. Inventory Mgt.	• AADT, DHV, PHTV, VMT, Truck Volumes, Truck Percentage, Speeds
Div. P&E – Road Design	• AADT, PHTV, TMV, 12-HR Turning Movements, VMT, #Crashes, Crash Rate
Div. P&E – Bridge Design	• ADT, AADT, ADTT, #Crashes, Truck Percentage
Div. P&E – Project Development	• AADT, ADTT, ESAL, PHTV, TMV, VMT, #Crashes, Crash Rate, O-D data
Div. P&E – Materials & Surfacing	• AADT, ADTT
Div. Operations – Support	• AADT, PHTV, VMT, #Crashes, Crash Rate, Freight-TM
Div. Operations – Regions	
Aberdeen	• AADT, PHTV, TMV, #Crashes
Mitchell	• AADT, PHTV, TMV, VMT, #Crashes, Crash Rate, Travel Times, Speeds
Pierre	• AADT, PHTV, TMV, #Crashes
Rapid City	• AADT, PHTV, TMV, VMT, #Crashes, Crash Rate

ADT – Average Daily Traffic
AADT - Annual Average Daily Traffic
ADTT – Average Daily Truck Traffic
DHV – Directional Hourly Volumes
ESAL – Equivalent Single Axle Load
#Crashes – Number of Crashes
PHTV - Peak Hour Traffic Volumes
TMV - Turning Movement Volumes
VMT – Vehicle Miles of Travel
Freight-TM – Freight Ton-Miles
O-D – Origin-Destination

Table 4-2 Traffic Data Used at SDDOT

1. Volume	• Average Daily Traffic (ADT) • Average Annual Daily Traffic (AADT) • Vehicle Miles of Travel (VMT) • Design Hourly Volume (DHV) • Peak-hour Traffic Percentage (K) • Directional Split (D) • Peak-hour Volume Turning Movement • 12-Hour Volume Turning Movement • Hourly Approach Volumes
2. Vehicle Classification	• Average Daily Truck Traffic (ADTT) • Percentage Trucks in Peak • Percentage of Vehicle Class
3. Truck Weight	• Truck Weights • Equivalent Single Axle Loads (ESAL)
4. Speed Data	• Travel Times
5. Accident Data	• Number of Crashes • Crash Rate

Key to the roadway design is fundamental traffic characteristics that include daily and peak-hour traffic projections, turning movements, and truck volumes. These traffic characteristics are the main input into design and operations analyses, which influence the geometric design requirements for a roadway including number of lanes, ramps, interchanges, intersections, and signalization.

Pavement design also depends on traffic forecasts – especially forecasts of truck traffic for correct selection of pavement thickness and type. As geometric design and pavement design have great effects on the final cost of a project, virtually all road and bridge improvements in the Transportation Improvement Plan (TIP) rely on the project-level traffic forecasts.

Q_2 What are the sources of your current traffic forecasting factors or other traffic data?

Current and forecast traffic data used by different programs/divisions largely come from Transportation Inventory Management. Other sources are MPO models, consultant and site-specific studies, and some traffic counts and occasional joint studies from bordering states.

Division / Program	Sources of Traffic Forecasting Factors / Traffic Data
Office of Secretary	• Historical Counts, Raw Traffic Counts, 20-Year FF, Census, ITE Procedures, Land Use, Wyoming (traffic counts across the border)
Div. F&M - Local Trans. Programs Local Government Assistance Public Transit	 • Raw Traffic Counts, 20-Year FF • FTA 530; funding is not tied to traffic projections
Div. P&E - Office of Research	• Historical Counts, Raw Traffic Counts, 20-Year FF, MPO Models, Classification Counts, Directional Counts, Consultant Studies
Div. P&E – Trans. Inventory Mgt.	• Historical Counts, Raw Traffic Counts, 20-Year FF, MPO Models
Div. P&E – Road Design	• Historical Counts, Raw Traffic Counts, 20-Year FF, MPO Models, Directional Counts, Classification Counts, Truck Percentage, Consultant Trip Generation
Div. P&E – Bridge Design	• Historical Counts, 20-Year FF, Number of Trucks
Div. P&E – Project Development	• Historical Counts, Raw Traffic Counts, 20-Year FF, MPO Models, Consultant Studies, Site Specific Studies
Div. P&E – Materials & Surfacing	• Raw Traffic Counts, 20-Year FF
Div. Operations – Support	• Historical Counts, Raw Traffic Counts, 20-Year FF, MPO Models, Accident Records
Div. Operations – Regions Aberdeen Mitchell Pierre Rapid City	 • Historical Counts, Raw Traffic Counts, 20-Year FF • Historical Counts, Raw Traffic Counts, 20-Year FF, MPO Models, Consultant Studies done for developments, • Raw Traffic Counts • Historical Counts, Raw Traffic Counts, 20-Year FF

20-Year FF -> SDDOT 20-Year Traffic Forecasting Factors

Q_3 What have been the major uses of traffic forecasting factors or other traffic data in your program/ division? Please rank the Top 5 uses.

As can be expected, different programs/divisions assigned somewhat different rankings as to their major use of traffic data. Some respondents place equal importance as to their use of traffic data and thus did not provide ranking. It is important to note that there were minor variations in individual ranking by each interviewed staff reflecting differences in individual function/ responsibility. A representative sort of ranking reflecting the program/division function is reflected in the aggregated response presented in the table below. Where individual rankings in the same division differ significantly, it is noted in the table.

Additional uses cited includes noise studies, interchange justification studies, public meeting, safety issues, and traffic intersection safety.

Use of Traffic Data	Office of Secretary	Div. F&M LTP -Local Govt Assistance	Div. F&M LTP -Public Transit	Div. P&E Office of Research	Div. P&E Trans. Inventory Mgt	Div. P&E Road Design	Div. P&E Bridge Design	Div. P&E Project Development	Div. P&E Materials & Surfacing	Div. Operations Support	Div. Operations Aberdeen	Div. Operations Mitchell	Div. Operations Pierre	Div. Operations Rapid City
Statewide System Planning or System EIS	Y				1		4	2		Y				
Regional Planning	Y					6		4		Y		Y		
Corridor Planning/Preservation	Y			3	5	3		3		Y		Y		
Bypass Studies	Y			4	5	5		Y		Y				
Project Prioritization							3	1				Y		
Project Level Traffic Forecasts/Project EIS		2			4	1		5		4		Y		
Operational Level Studies	Y							Y		Y		Y		1
Economic Development Studies										Y		Y		
Freight/Intermodal Planning	Y							Y		(4)				
Rail Planning														
Airport Planning														
Air Quality Conformity Analysis														
Intercity Bus Planning														
Bridge Design		3			3		1							
Pavement Design, ESALS	Y	1			2				1	(3)				
Safety Analysis, Crash "Hot Spot" Analysis		4		5						3	1	Y	Y	2
Traffic Impact Studies	Y			1	5	2		Y		Y	2	Y		3
Land Use Planning				2		4		Y		Y				
Inputs to Economic Modeling														
Long-Term Investment Studies														
Detour Analysis							2	Y		2	3	Y	Y	4
Work Zone Planning								Y		1	4	Y	Y	5
Truck Weight Studies										(1)				
Weigh Station Location										(2)		Y		

Y – means not ranked; (#) Indicates very different ranking by another staff in the same division.

4.2.2 Existing Policies, Documentation, Staffing and Training Requirements

Questions 4 through 8 were designed to identify existing SDDOT policies and documentation related to traffic data collection, use and forecasting, as well as staffing level and training requirements needed to enhance traffic forecasting skills at the SDDOT. The following describes the responses to each of the four questions.

Q_4 Does your program/division have policies for the use of traffic forecasting factors or other traffic data? If so, can we get a copy?

The general response to this question was a "NO." The Transportation Inventory Management Traffic Monitoring Section has published a Traffic Monitoring Documentation that provides insight into the SDDOT's current traffic monitoring activities. Other procedures and documentation for traffic use that respondents refer to include:

- 1998 Road Design
- 3R Policy
- SDDOT 20-Year Traffic Forecasting Procedural Manual
- ADT clear zone policy

Q_5 Do you have documented or undocumented procedures for collecting and forecasting traffic data? If so, please provide an example.

The general response to this question was a "NO" as reflected in the table below. Program/division staffs are relying heavily on Jeff Brosz for forecast data and on Dan Martell for post-processing of turning movement data to derive future turning movements. Jeff uses the 20-Year Traffic Forecasting Factors as the main documentation for deriving forecasts while Dan relies on NCHRP 255 method for post-processing of turning movements (TRB, 1982).

Some comments were made that there is little documentation of the forecasting process. This perception perhaps stemmed from the lack of awareness of the 20-Year Traffic Forecasting Factors document; besides, staffs rely simply on Jeff for the forecasts.

Division / Program	Yes / No	Comments
Office of Secretary	N	• Obtain data from Jeff Brosz and from MPOs who do some of their own traffic counts
Div. F&M - Local Trans. Programs	N	• Obtain data from Jeff Brosz • Record in either electronic or paper form in a database called "transit reporting." Each transit agency conducts survey to find out what riders need.
Div. P&E - Office of Research	N/A	• FHWA maintains guide; pavement management system calculates factors (by year, truck ADT, VMT, AADT and forecast factors)
Div. P&E – Trans. Inventory Mgt.	Y	• Operating documents, Traffic Monitoring Document, 1999 Resource Project on Traffic Forecasts, and HPMS
Div. P&E – Road Design	N	• Jeff Brosz provides traffic forecasts; area engineers collect turning movements, which Dan Martell post processed to derive forecast turning movements; site impact studies are based on the Institute of Transportation Studies (ITE) Manual
Div. P&E – Bridge Design	N	• Obtain data from Jeff Brosz
Div. P&E – Project Development	N	• Rely on Jeff Brosz for traffic data
Div. P&E – Materials & Surfacing	N	• RD 1998-3 and policies for rumble strips and shoulder strips
Div. Operations – Support	N	• FHWA, TRB, trucking industry, and consultants
Div. Operations - Regions	N	

Q_6 How many staff in your program/division have experience in forecasting traffic data?

As the table below indicates, there is only a handful of staff experienced in forecasting traffic data. SDDOT would need to enhance the number of staff in this area.

Division / Program	No. of Staff	Comments
Office of Secretary	0	• Do a bit of STIP programming; other states are developing journey to work survey
Div. F&M - Local Trans. Programs	0	
Div. P&E - Office of Research	N/A	
Div. P&E – Trans. Inventory Mgt.	1	• Jeff is the only staff performing traffic forecasting
Div. P&E – Road Design	1	• Dan Martell, Stacy Bartlett, and region traffic specialists • Could use more traffic engineers in the Central Office for scoping and detail design
Div. P&E – Bridge Design	0	
Div. P&E – Project Development	0	• Rely on Jeff Brosz; could use some experienced staff for analysis
Div. P&E – Materials & Surfacing	0	• Obtain information from Jeff Brosz
Div. Operations – Support	2	• Couple of staff with relatively minor forecasting experience
Div. Operations - Regions		• Region traffic engineers • In Mitchell Region, they depend on forecasting done by cities for short term coordination; they would like to have sound forecasts to address development that occur on highways including those stretches of highway warranting traffic signals; need forecast for spot traffic impact studies; and short to medium term factors from data inventory studies on trip generation.

Q_7 What type of training would be needed to develop skills in forecasting traffic data in your program/division?

The interviews highlighted the need to have more staff trained in the following areas: forecasting traffic data; theory and application of travel demand forecasting and modeling, particularly in the understanding of model calibration/validation and reasonableness checking; travel demand surveys and use of travel data for modeling and forecasting; manipulating Census data and mapping in GIS; and use of ITE procedures and traffic impact analyses.

Division / Program	Type of Training Required
Office of Secretary	• Training in processing and manipulating Census data, ITE procedures, and travel demand survey.
Div. F&M - Local Trans. Programs	• Program relies on staff from another office.
Div. P&E - Office of Research	• Depends on what kinds of forecasts are needed.
Div. P&E – Trans. Inventory Mgt.	• No training needed at this time, unless there are changes to the forecasting procedures.

Div. P&E – Road Design	• Training is needed for those dealing with traffic data on basic traffic forecasting and quick response method of analysis.
Div. P&E – Bridge Design	
Div. P&E – Project Development	• Need to familiarize the process of travel forecasting and modeling (how it is done without necessarily performing it themselves) for Quality Assurance • At current operation, there is a need for backup to Jeff Brosz. • Staff would need training if more sophisticated forecasting procedure will be needed.
Div. P&E – Materials & Surfacing	
Div. Operations – Central office	• General traffic forecasting theory, specific model use/operation, application of forecast data.
Div. Operations - Regions	• The Rapid City region awaits the outcome of this research study that will identify new forecasting methodology. It is interested to train staff to be able to do independent analysis. • Mitchell region has staff available for training on long range modeling.

Q₈ Does your program/division get any traffic data or forecasts from other states? If so, what type of data (e.g., VMT, AADT, peak hour traffic, ton-miles, etc.)?

Traffic data obtained from other states were for those locations at the borders, and mainly AADT.

Division / Program	Types of Traffic Data Obtained from Other States
Office of Secretary	• ADT, AADT--Wyoming sends a book of their traffic counts.
Div. F&M - Local Trans. Programs	
Div. P&E - Office of Research	• Examine ADT at the state border, e.g., in Iowa for corridor studies on the interstates at Sioux City.
Div. P&E – Trans. Inventory Mgt.	• AADT at border locations; coordinate with states for border crossings with existing traffic counts, but not traffic forecasts.
Div. P&E – Road Design	
Div. P&E – Bridge Design	
Div. P&E – Project Development	• For specific border locations; some joint studies like the Heartland Expressway, which is not done on a regular basis; some regional freight like the Northern Great Plain studies.
Div. P&E – Materials & Surfacing	
Div. Operations – Support	• AADT for corridor studies; mostly obtain information shared at conferences, by request, or volunteered from TRB, FHWA, or trucking industry studies, and consultants.
Div. Operations - Regions	• Rapid City region obtains interstate traffic data with Wyoming around the motorcycle rally (not done routinely, one time a year big event).

4.2.3 Role of Traffic Forecasting Factors in Programming/ Budgeting

Questions 9 through 12 were designed to gain insights into the role of travel forecasts in programming and budgeting of SDDOT resources.

Q$_9$ Which programming and budgeting process does your program/division contribute to? Please provide an example (e.g., STIP, pavement management, bridge design, etc.).

The table below summarizes the programming and budgeting process by program.

Division / Program	Programming and Budgeting Process Program / Division Contributes
Office of Secretary	• Traffic data are used as trigger mechanism to programming. • Freight forecasting/modeling around facilities being built having ethanol plant (many being built now). • Looking at more facility-based programming or forecasting of traffic, which affects how traffic will be collected.
Div. F&M - Local Trans. Programs	• Funding request is put in to FTA, which is estimated based on the age of vehicles/buses. • Request is also put in with Sioux Falls or Rapid City and when awarded, the request will be split by percentage rate. Award is given on a ranking process. • FTA 5309 funds bus services
Div. P&E - Office of Research	• Passenger and truck traffic for STIP - each division for its own needs
Div. P&E – Trans. Inventory Mgt.	• Provide support data
Div. P&E – Road Design	• Construction plan which impacts the STIP
Div. P&E – Bridge Design	• Bridge design and bridge management
Div. P&E – Project Development	• STIP, long range plan, MPO coordination, scoping, cost estimating, environmental assessment, corridor studies, pavement management
Div. P&E – Materials & Surfacing	• Pavement design
Div. Operations – Support	• Roadway characteristics, profile information video login, traffic forecasts, VMT & funding formula
Div. Operations - Regions	• Region engineers were not asked on this question.

Q10 10 How are current measures of travel forecasts and traffic data (e.g., VMT, AADT, etc.) used to allocate budget resources to various uses such as capital expansion, operations, and maintenance/ preservation?

Measures of travel forecasts are not directly used as basis for capital expansion, operations, and maintenance/preservation.

Division / Program	Measures of Travel Forecasts Used to Allocate Budget Resources
Office of Secretary	• Programming based on traffic
Div. F&M - Local Trans. Programs	• Utilized by Class 1 cities and their consultants • For transit, an application is used where SDDOT personnel go through and rank each request. The highest scoring agency receives award of their request.
Div. P&E - Office of Research	
Div. P&E – Trans. Inventory Mgt.	
Div. P&E – Road Design	
Div. P&E – Bridge Design	• Traffic count is part of bridge management (sufficiency rating for structures uses traffic data).
Div. P&E – Project Development	• Capital expansion comes first if a new road is needed. Funding for different classification of roads uses traffic data. VMT, road condition, and length of system are used in budget allocation. • Suggested current process need better communication between agencies for ethanol plant locations. • Traffic signals come from safety or operational budgets.
Div. P&E – Materials & Surfacing	
Div. Operations – Support	
Div. Operations - Regions	Region engineers were not asked on this question.

Q11 Are current travel demands or projected future travel growth used to determine staffing or skills requirements within your program/division? Please provide examples, such as how many design engineers or traffic engineers are needed due to projected traffic in SDDOT, areas, and regions.

Response to this question was "NO." The number of projects, size, and complexity dictate staffing levels not the current or projected future travel demand. STIP uses traffic forecasts to help prioritize where and when projects are needed. Likewise, sufficiency rating for structures involves ADT, and thus indirectly affects budgeting.

Q12 How are current or projected future travel forecasts or traffic data used to plan the locations or distribution of SDDOT programs, services, or field locations? Please give examples, such as new interchanges, traffic impact studies, bypass studies, etc.

Planning for locations or distribution of SDDOT programs or services is not directly tied to current or projected traffic rather allocation of resources are keyed to political demand and construction activity.

Division / Program	Use of Current and Projected Traffic Data in Program Distribution
Office of Secretary	• Programmed based somewhat on traffic
Div. F&M - Local Trans. Programs	
Div. P&E - Office of Research	• Site impact studies, ITE Manual, engineer experience
Div. P&E – Trans. Inventory Mgt.	• Accident rates based on AADT; some special studies, which are usually done by consultants.
Div. P&E – Road Design	•
Div. P&E – Bridge Design	• Helps determine design standards for roadway width, clear zone, detour responsibility, etc.
Div. P&E – Project Development	• Only on project specific application, interchange justification studies (mainly being done by MPOs and MPO forecasts were used), traffic impact studies, bypass studies
Div. P&E – Materials & Surfacing	• Industry or developer provide the traffic numbers, ethanol plant field locations, etc.
Div. Operations – Support	• Current allocation of resources keyed to political demand and construction activity.
Div. Operations - Regions	• Region engineers were not asked on this question.

4.2.4 Use of Geographic Information System (GIS)

Questions 13 and 14 relate to the use of geographic information system at the SDDOT.

Q_{13} Does your program/division use GIS for storing data and networks? If so, what type of data do you store?

The table below indicates some programs are using GIS for storing data and networks. The GIS section maintains the GIS-based dynamically segmented state highway network, which can be readily used for a statewide or region wide travel forecasting model. None of the programs or regions, however, indicates storing socioeconomic data in GIS.

Division / Program	Use of GIS and Types of Data Stored
Office of Secretary	• Data users
Div. F&M - Local Trans. Programs	• Buses are equipped with GIS (Automatic Vehicle Locator). A program was being built for bus locator in an area for emergency disaster. Buses are GIS compatible.
Div. P&E - Office of Research	• Mainframe has the main traffic database that GIS can access.
Div. P&E – Trans. Inventory Mgt.	• Public road inventories, routing networks/applications, traffic count locations, and traffic flow maps.
Div. P&E – Road Design	• Only accessing data, e.g., accident records
Div. P&E – Bridge Design	• Drainage maps, drainage application with existing WMS software (hydraulics group mostly using), use existing layers for drainage, and USGS stream stats • Bridge inventory, bridges are all mapped out including automated routing and permitting system
Div. P&E – Project Development	• Use of GIS for storing data is still limited. • Use for storing functional classification and STIP projects • Desire to use GIS map showing growth and decline in roadways and counties
Div. P&E – Materials & Surfacing	• Would like to store foundations, structures, light poles, land slide locations with possibly one person will be devoted in.
Div. Operations – Support	• Road Geometrics, Accidents, AADT • Load segments by maintenance unit, area, and region
Div. Operations - Regions	• Aberdeen region use GIS for accident data locations. • Sioux Falls region use GIS for some other applications other than traffic. • Storing data in GIS is not done at the Rapid City region, although some staffs are accessing GIS data.

Q14 How many staff with GIS skills are in your program/division?

As the table below indicates, beyond the GIS section, the level of GIS skills is minimal and largely involves use/access of data rather than produce GIS data.

Division/ Program	Number of Staff with GIS Skills and Level of GIS Knowledge
Office of Secretary	None
Div. F&M - Local Trans. Programs	None
Div. P&E - Office of Research	• Environmental group does some GIS independent from the GIS section.
Div. P&E – Trans. Inventory Mgt.	• 4-10 that use GIS; currently 5 staff in the GIS section that creates and maintains the Department GIS system
Div. P&E – Road Design	• Mostly novice users – turn layers on/off; do not create GIS layers
Div. P&E – Bridge Design	• About 6 novice users
Div. P&E – Project Development	• About 8-9 use some GIS data, but do not produce GIS layers • Produces functional class
Div. P&E – Materials & Surfacing	• One user
Div. Operations – Support	• About 4-6 users
Div. Operations - Regions	• Minimal skills; designers and land surveyors access GIS

4.2.5 Additional Traffic Data Needs

Questions 15 and 16 were designed to identify additional needs for traffic data that were not covered in Questions 1 to 3.

Q15 Does the existing SDDOT traffic forecasting process meet your program/division traffic data needs?

As the table below indicates, the existing SDDOT traffic forecasting process is short of meeting traffic data needs to many DOT programs/divisions. The current reliance on a couple of very experienced staff for traffic data analysis and forecasting is highlighted as a potential area that SDDOT needs to address.

Division/ Program	Yes/No	Comments
Office of Secretary	N	• Would like to have more confidence in the accuracy of forecasts because of the large amount of investment involved; • Freight issue and confidence in the accuracy of freight information; would like to have sound information on potential shipping trends and its implications on farm constraints.
Div. F&M - Local Trans. Programs	Y	
Div. P&E - Office of Research	N/A	• Sometimes corridor studies have more needs. In 2005, the City of Watertown built a travel model for use in Watertown corridor studies.

Div. P&E – Trans. Inventory Mgt.	Y	
Div. P&E – Road Design	N	• Forecasting data from Jeff Brosz is fine for rural. • Need more hands on experience (internally within road design) rather than getting the information from outside sources. • Currently relying on one staff for traffic analysis (Dan Martell), need more in-house capability.
Div. P&E – Bridge Design	Y	
Div. P&E – Project Development	Y/N	• Project development currently relies on MPOs and consultants. • Need self-sufficiency to be able to carry out analysis, such as capacity of rail.
Div. P&E – Materials & Surfacing	Y	
Div. Operations – Support	N	
Div. Operations - Regions	N	• Aberdeen region engineer wants an expanded (better) forecasting tool. • Rapid City region partially made use of the current forecasting procedure, but would want to have in-house capability.

Q$_{16}$ If the existing SDDOT traffic forecasting process does not meet your traffic data needs, in which areas are additional traffic data needed?

Traffic data needs that are not met in the existing traffic forecasting process are summarized below.

Additional Traffic Data Needed	P&E Road Design	P&E Project Development	Operations Support	Operations - Regions
Identification of corridors that should be targeted for preservation	Y	Y	Y	Y
Identification of corridors that should be targeted for capacity expansion, multi modal development,	Y	Y	Y	Y
Identification of bottlenecks that should be targeted for capacity expansion, multi modal development	Y		Y	Y
Identification of highway segments with safety improvement needs	Y	Y		Y
Identification of existing and forecast freight movement needs,		Y		Y
Identification of which corridors are crucial to the state's long term economic growth		Y	Y	Y

Division / Program	Additional Comments
Office of Secretary	• Freight forecasting, ethanol plants, potential power plant; need better communication with ethanol industry and other industries • Through traffic can become an issue (how much is there?)
Div. F&M - Local Trans. Programs	
Div. P&E - Office of Research	• Traffic diversion from other routes to the expressway; no-way to calculate under current forecasting process • What data is needed? - Future year AADT for specific roadways • Number of studies needed? Specific corridor • Highway capacity studies of all state routes • Detour traffic diversion
Div. P&E – Trans. Inventory Mgt.	
Div. P&E – Road Design	• Jeff forecasts are good for rural 2-lane roads but have to rely on MPOs for data if the project is near that city • Would want to have more staff to analyze traffic data
Div. P&E – Bridge Design	• Would like to have truck traffic data
Div. P&E – Project Development	• Detour analysis • Growth factors for corridors • Effect of a corridor improvement on parallel corridors • Historical growth factors for different areas of the state - possibly with GIS • Planning group - determine need for projects including traffic impacts, costs, environmental, and railroads
Div. P&E – Materials & Surfacing	• Current forecast meets all program needs
Div. Operations – Support	• Detour analysis; most are done by areas and regions
Div. Operations - Regions	• Freight - only concern could be when there is the expansion of ethanol plant • Forecasting Factors – not quite satisfied with the current forecasting procedure. Prefer a procedure that takes account of land use developments—assess the impacts of a mini-mart or a mall, assess anticipated impacts of land use on existing infrastructure (at interchanges, on bridges, etc), evaluate the depth of future land use impacts. • Desire for a robust/ good regional factor that can be used to predict the impacts of proposed developments, such as a mini-mart • The question is not really on "identification;" already aware of what some of the needs are (e.g., whether need to expand capacity or to preserve ROW). The main issue is the lack of better data to be able to make a more precise/accurate analysis of the following: - impact on the vicinities - improve capability in the future to say how big is the problem (believable results, being able to assess how big is the problem) - better prediction of either existing facility and estimate "X" more amount is required - accurately identify need for signal, corner of interchange, add turn lanes • Forecast LOS in the urban fringe area (like Sioux Falls) on roadways with 500 to 6000 vpd; identify the growth in those highways to determine if growth has caused a drop in the LOS. Such a capability would provide a better way of assessing, for example, applications for an approach driveway in those urban fringe roadways.

4.2.6 Summary

The stakeholders' interviews provided valuable information on traffic data that is key input to roadway geometric design, requirements for a roadway including number of lanes, ramps, interchanges, intersections, and signalization, pavement design, pavement management system, safety analysis, corridor studies, corridor preservation, regional and statewide planning, and other system level analysis.

Stakeholders expressed their desire for better, more robust and credible traffic forecasts. The existing SDDOT traffic forecasting process falls short of meeting traffic data needs to many DOT programs/divisions. The current reliance on a couple of very experienced staff for traffic data analysis and forecasting is highlighted as a potential area that SDDOT needs to address.

Stakeholders prefer a procedure that takes account of land use developments. They want a tool that can assess the impacts of developments such as a mini-mart or a mall. They want to be able to assess anticipated impacts of land use on existing infrastructure including interchanges, bridges, etc. Moreover, they desire a tool that can produce a robust/ good regional factor that can be used to predict the impacts of proposed developments.

Stakeholders highlighted the need for a traffic forecasting procedure that can guide in decision-making of whether there is a need to expand capacity or to preserve the right-of-way. One major shortcoming of the current practice is the lack of better traffic data to be able to make a more precise/accurate analysis of the following:

- impact of developments and roadway improvements on the vicinities,
- improve capability to assess the extent of the problem,
- better prediction to estimate "X" more amount is required, and
- accurately identify need for improvements such as a need for traffic signal, improve corner of interchange, or add turn lanes.

Perceived Needs for a Better Traffic Forecasting and Analysis Tool

Perceived needs that are not met in the current traffic forecasting process include:

- Identify corridors that should be targeted for preservation, capacity expansion, multi modal development, and corridors that are crucial to the state's long term economic growth;
- Identify bottlenecks that should be targeted for capacity expansion, multi modal development;
- Identify highway segments with safety improvement needs;
- Identify existing and forecast freight movement needs and data on truck traffic;
- Analyze traffic diversion from other routes to the expressway;

- Analyze the effect of a corridor improvement on parallel corridors;
- Obtain future year AADT for specific roadways;
- Obtain growth factors for corridors and for different areas of the state;
- Evaluate highway capacity of all state routes;
- Determine need for projects including traffic impacts, costs, environmental, and railroads; and
- Forecast LOS in the urban fringe area (like Sioux Falls) on roadways with 500 to 6000 vpd; identify the growth in those highways to determine if growth has caused a drop in the LOS. Such a capability would provide a better way of assessing, for example, applications for an approach driveway in those urban fringe roadways.

Staff Skills and Training Needs

Stakeholders emphasize the need to increase the number of staff involved in traffic forecasting, as well as enhance SDDOT staff's skills and knowledge in the following:

- Use and application of the Institute of Transportation Engineers (ITE) trip generation procedures
- Process and manipulate Census data for use in transportation analysis
- Basic understanding of travel demand surveys and the application of survey data
- Understand general traffic forecasting theory and the process of traffic forecasting and modeling, including quick response method of analysis
- Understand the application of forecast data

Chapter 6, Section 6.4 outlines potential approaches for a better traffic forecasting capability at SDDOT that could meet many of the identified perceived needs.

4.3 RESULTS OF MPO INTERVIEWS

4.3.1 Present Use and Sources of Traffic Forecasting Factors or Other Data

There were four questions posed concerning use and sources of MPO traffic forecasting. Questions 2 and 3, which asked for MPOs use of traffic forecasting factors or other traffic data together with the sources of those forecasting factors or traffic data, were not relevant since all three MPOs each have a travel demand model. Responses to Questions 1 and 4 are presented below.

Q_1 Does the MPO have a regional travel demand model?

All three MPOs have developed and maintained a travel demand model. The table below provides an overview of model attributes.

Travel Demand Model Attributes	Rapid City MPO	Sioux Falls MPO	SIMPCO MPO
Software platform	TransCAD	TP+/VIPER*	TransCAD
Model type	Passenger only	Passenger and freight to a certain degree	Passenger only
Modes modeled	Passenger auto	Passenger auto	Passenger auto
Time period modeled	24-Hours (weekday)	AM Peak Hour PM Peak Hour Off-Peak (weekday)	24-Hours (weekday)
Number of traffic analysis zones (TAZ)	210 internals 16 externals	570 internals 12-15 externals	180 internals 21 externals
Model structure	3-step	3-step basically with some amount of mode choice	3-step

* There is a plan to update the current TP+/VIPER to the Cube Voyager software platform in 2008.

Q_4 What have been the major uses of the regional travel demand model? Please rank the Top 5 uses.

The table below summarizes the top 5 uses of MPO travel demand models. The Sioux Falls MPO also indicated traffic impact studies as the top 6 use of its travel demand model.

Rapid City MPO	Sioux Falls MPO	SIMPCO MPO
• Regional planning • Land use planning (testing land use scenarios) • Long-term investment • Corridor planning/ preservation • Project prioritization	• Regional planning • Land use planning (testing land use scenarios) • Corridor planning/ preservation • Project prioritization • Project level traffic forecasts/project EIS (project level	• Regional planning • Land use planning (testing land use scenarios) • Corridor planning/ preservation • Project level traffic forecasts/project EIS (project level modeling) • Economic development studies

4.3.2 Data for Passenger Travel Demand Model Development

Questions 5 to 11 asked MPOs details of sources of data that are used in their travel demand models, including data collection efforts. The following describes the responses to each of the seven questions.

Q5 What were the primary sources of travel behavior data?

The SIMPCO MPO has the advantage of using travel behavior data from a household survey through the Des Moines add-on sample.

Rapid City MPO	Sioux Falls MPO	SIMPCO MPO
• Census journey-to-work data • Census Transportation Planning Package • ITE Trip Generation	• Census journey-to-work data • Census Transportation Planning Package • NCHRP Report 365 • NCHRP Report 187	• Census journey-to-work data • Census Transportation Planning Package • National House Travel Survey (Des Moines add-on sample) • ITE Trip Generation • NCHRP Report 365

Q6 What were the primary sources of household socioeconomic data?

None of the MPOs purchased commercially available socioeconomic data.

Rapid City MPO	Sioux Falls MPO	SIMPCO MPO
• Census Transportation Planning Package • Other US Census • MPO databases • School enrollment data	• Census Transportation Planning Package • Employment data from Department of Labor • Land use data used to identify major employment	• Other US Census • MPO databases • GIS maintained by MPO • School enrollment data

Q7 What were the primary sources of traffic data?

Rapid City MPO	Sioux Falls MPO	SIMPCO MPO
• MPO counts • SDDOT counts (mainly on externals) • Counts, speeds, or travel times from another agency	• MPO counts (City of Sioux Falls) • SDDOT counts (in county) • Speed limits	• SDDOT counts • Counts, speeds, or travel times from another agency

Q8 What were the primary sources of network data?

Rapid City MPO	Sioux Falls MPO	SIMPCO MPO
• MPO GIS database county road system	• MPO GIS system (primary source of data)	• TIGER (enhanced and accurate)

Q₉ Please list any data collection effort the MPO conducted to complete the model. Also, please indicate the cost involved in the data collection effort.

Rapid City MPO	Sioux Falls MPO	SIMPCO MPO
• Fair amount of data parcel for commercial/ non-commercial, verification of parcel employment done by an intern	• Data collection of land use report each year, employment update (yearly)	• Employment information

Q_{10} What passenger data couldn't you get that you wish you could?

Rapid City MPO	Sioux Falls MPO	SIMPCO MPO
• Travel survey to help develop a peak hour model	• Number of employees • Origin-Destination surveys • Travel time surveys	• Detailed trip behavior

Q_{11} Were there serious problems with completeness of any passenger data set?

Rapid City MPO	Sioux Falls MPO	SIMPCO MPO
• Happy with calibration	• Wanted better employment data and Origin-Destination data	• Wanted data on trip making behavior

4.3.3 Model Development, Cost, Staffing and Training Requirements

Questions 12 to 16 asked details pertaining to sources of MPO data used in modeling, including data collection efforts. The table below summarizes the responses to each of the five questions.

Travel Demand Model Attributes	Rapid City MPO	Sioux Falls MPO	SIMPCO MPO
Q_{12} How long did it take to develop the model (months)?	12-14	12-18	15 (part-time)
Q_{13} How much did it cost to develop the model?	$100,000[a]	$20,000[b]	Staff time
Q_{14} Who was primarily involved for the model development (percentage involvement)?	20% MPO staff (2 FTE and 1 intern) 80% Consultant	75% MPO staff (1 FTE)	100% MPO staff (1 FTE)
Q_{15} How many MPO staff are dedicated to maintaining/using the model (include estimates of partial time for multitasked staff)?	1 FTE	1 FTE 0.5 FTE	1 FTE
Q_{16} What training programs does MPO staff attend to obtain skills/ expertise in the use of the model or its results?	Federal Highway Forecasting TransCAD	VIPER Consultant	MTMUG[c] in AMES Caliper Corp. training workshops Conferences

a Consultant contract; MPO staff involved in data collection and review of model
b Cost only involved consultant supervision in model development. MPO staff developed the model.
c Midwest Travel Modeler Users Group

4.3.4 Validation

Questions 17 through 21 relate to travel model validation. The following describes the responses to each of the five questions.

Q_{17} Has the regional model been validated?

All three MPOs responded affirmatively.

Q_{18} What data were used to validate the model?

The common data used to validate the travel model were observed counts of passenger vehicles. The Sioux Falls model is validated using more data since it has a more complex model structure than that of Rapid City and SIMPCO.

Rapid City MPO	Sioux Falls MPO	SIMPCO MPO
• Passenger vehicle counts	• Passenger vehicle counts • Truck counts • Comparisons to average values from similar MPOs or cities • Known trip length frequency distribution(s)	• Passenger vehicle counts • FHWA trip length frequency

Q_{19} What were the validation criteria?

Link root mean square error (RSME) and correlation coefficient were validation criteria common to all three MPO models. Other validation criteria were applied based on model structure and data availability.

Rapid City MPO	Sioux Falls MPO	SIMPCO MPO
• Link root mean square error (RSME) by volume strata • Correlation coefficient between link volume forecasts and counts • Screenline count absolute deviation	• Link root mean square error (RSME) by volume strata • Correlation coefficient between link volume forecasts and counts • VMT by functional classification absolute deviation • Total assigned volumes versus counts • FWHA error criteria	• Link root mean square error (RSME) by volume strata • Correlation coefficient between link volume forecasts and counts • VMT by functional classification absolute deviation • Screenline count absolute deviation • Link absolute deviation

Q_{20} Did you use the "Model Validation and Reasonableness Checking Manual"?

All three MPOs utilized the "Model Validation and Reasonableness Checking Manual."

Q_{21} How well did the model validate?

All three MPOs responded that their models were validating reasonably well, with the exception of SIMPCO MPO that noted some validation issues in certain areas.

4.3.5 Use of Geographic Information Systems

Questions 22 through 24 relate to MPOs use of geographic information systems for travel demand modeling. The following describes the responses to each of the three questions.

Q₂₂ Does the MPO use GIS for storing data and networks? If so, what type of data do you store?

All three MPOs use GIS. Rapid City MPO uses GIS to store networks, parcel data, employment data by TAZ, and household and demographic data. The Sioux Falls MPO has a good number of roadways, including outside of the City Limits, which is stored in GIS. The City of Sioux Falls has extensive database for roadways, right-of-way, speed limits, and sidewalks. The County also has a GIS. SIMPCO MPO has its roadway network in TransCAD. It uses ArcGIS to store road, trail, rail, and park shape files data.

Q₂₃ Were network data obtained from a GIS database?

All three MPOs obtained their network data from a GIS database.

Q₂₄ How many MPO staff have advance GIS skills (i.e., skills in creating GIS layers, etc.)?

The numbers of staff in each MPO with advance GIS skills are: Rapid City MPO has two staff, Sioux Falls MPO has five staff in different entities, and SIMPCO MPO has three staff.

4.3.6 Freight/Commercial Vehicle Model

Q₂₅ If the MPO regional model includes freight, please describe the scale/level of detail.

All three MPOs do not currently model freight/commercial vehicles. However, the Sioux Falls MPO model has the capability to approximate truck traffic where the number of trucks are projected and can be assigned in the highway network. The model can estimate 24-hour truck traffic volumes.

4.3.7 Benefits of a Statewide Travel Model to MPOs

The current practice for estimating external trips – traffic that passes through the MPO study area, as well as those traffic outside of the MPO study area whose destinations are inside the study area and vice versa – relies heavily on available traffic counts at the external locations, i.e., in those roadway segments that provide connections to the MPO study area. MPOs do their own growth projections for externals based on traffic counts. Moreover, MPOs do not use the SDDOT 20-year traffic forecasting factors in their growth projections of external trips.

MPO respondents cited that ***data on external trips*** would be the main benefit from a South Dakota statewide travel model (STM). Determining trip interchanges between the MPO study area and the surrounding counties with no land use data is fraught with uncertainty and "educated" guess estimate of origins and destinations of those trips. Hence, a STM may provide a better estimate of such external trip interchanges.

A statewide travel model would enable MPOs to see a ***"big picture"*** look of the state, providing insight of the effect of developments in other parts of the state on the MPO area. This is another benefit cited of a South Dakota STM.

Outside of the MPO planning areas, MPO respondents felt that a STM would be helpful in ***planning for major highways in towns and smaller communities***.

Besides the STM, SDDOT could help coordinate communities to make use of available resources.

4.4 RELEVANT DATA AND MANAGEMENT SYSTEMS AT SDDOT

This section of the report provides an overview of relevant data needed for travel demand modeling that is readily available at SDDOT. Moreover, database management systems at SDDOT that can be readily used for modeling purposes are also identified in this section.

4.4.1 Traffic Data Collection and Reporting Overview

The Traffic Monitoring section of the Office of Transportation Inventory Management provides the collection, retention, and analysis of traffic data, which indicates the volumes, classification, weights, speeds and other characteristics of motor vehicles that traverse South Dakota highways and streets.

Traffic at over 6,600 locations are monitored throughout the state. Sampling techniques and automatic recording equipment are utilized whenever possible to maximize efficiency. The Traffic Monitoring Section contains the following sections of data:

- Vehicle Mileage
- Automatic Traffic Recorders
- Speed Monitoring
- Sturgis Rally Data
- Vehicle Classification Monitoring
- Traffic Maps

The South Dakota Traffic Monitoring Documentation (Revised June 2005) prepared by the Office of Transportation Inventory Management provides a summary of traffic monitoring activities.

The above traffic data provides valuable input in developing a travel demand model. Traffic counts can be used to produce synthetic origin-destination trips, and to calibrate and validate models.

4.4.2 Traffic Data Management System

Traffic Data Management System (TDMS) is a software system for collection, inspection, summarization, and reporting of a wide range of traffic data. It was being developed in-house by Bureau of Information and Telecommunications (BIT). The TDMS is designed to handle data polling, collection, and routing tasks for traffic monitoring devices, as well as the inspection, analysis and reporting of traffic data being collected.

Graphing of historical traffic counts by individual count locations and the ability to perform statistical analysis and projection by regression analysis, for example, can be easily programmed as an additional functionality of TDMS. The historical VMT determined from the HPMS process can be stored in the TDMS and statistical analysis and 20-year forecasts can be performed.

4.4.3 Geographic Information System

The GIS Section of Transportation Inventory Management maintains GIS-based highway network and local roads system. The GIS-based dynamically segmented state highway network for SDDOT is managed using ESRI GIS software. The network is calibrated using U.S. miles as the measures. The network is spatially defined in the Stateplane projection with units in feet, Datum NAD83, and the zone is FIPSZONE 4001.

The local roads system dataset contain all publicly accessible roads for South Dakota. This dataset has been approved by the U.S. Census Bureau for spatial accuracy, which will replace the current TIGER roads layer in the 2010 Census dataset. The local roads system is spatially defined in the Stateplane projection; the units are feet, Datum NAD83, and the zone is FIPSZONE 4001. The local roads system is nearly a full magnitude greater in total U.S. miles than the network. The local roads system dataset contain over 150,000 individual road segments with 37 attributes fields.

The GIS-based highway network and local roads system provides a backbone in developing a travel demand model for South Dakota whether on a regional or statewide geographical coverage. The GIS system also provides a powerful tool for any future travel demand modeling efforts at SDDOT.

4.4.4 SDDOT 20-Year Growth Factors

The Traffic Monitoring Section produces 20-year growth factors. The procedure for deriving the 20-year growth factors follows the process described in the research project "20-Year Traffic Forecasting Factors: Study SD1999-04 Final Report, October 2000". The report is on file at the Department, which is also accessible on line at http://www.state.sd.us/Applications/HR19ResearchProjects/Projects/SD1999_04_final_report.pdf.

The procedure uses 20-year historical VMT by county and county business pattern data from the Census Bureau. The county business data is broken down into two traffic generating groups (passenger and commercial) and by number of employees. A regression analysis is performed to calculate growth factors 20 years into the future. Similarly, a regression analysis is performed with the VMT data. The business data factors are used only indirectly in arriving at the final 20-year traffic forecasting factors by comparing the trends in the growth of county business activity to the VMT growth by county. The final factors are calculated for both passenger vehicles and trucks.

Chapter 5 of this report provides a review of the 20-Year Traffic Forecasting Factors to evaluate its adequacy of meeting the needs of traffic forecasts expressed in the stakeholder interviews.

5.0 REVIEW AND VALIDATION OF EXISTING 20-YEAR TRAFFIC FORECASTING FACTORS

Task 5. Review and analyze SDDOT's existing travel demand forecasting process and identify and test a procedure to validate the forecasting factors.

5.1 INTRODUCTION

One of the research tasks involves reviewing and analyzing the current 20-year traffic forecasting factors with the objective of validating its applicability. The review needs to determine if the forecasted factors accurately reflect traffic volumes for the various functionally classified roadways.

The 20-year traffic forecasting procedure was originally developed in 1999 under South Dakota Department of Transportation (SDDOT) research study SD1999-04-F "*20-Year Traffic Forecasting Factors*." The traffic forecasting factors were based on a county level analysis of vehicle miles traveled (VMT) and indirectly with business growth. Since they were originally developed, the SDDOT has not validated the traffic forecasting factors.

This technical memorandum summarizes the results of the review, analysis, and validation of the current SDDOT 20-year traffic forecasting factors. It also includes discussions and recommendations to enhance the current traffic forecasting procedure.

5.2 OVERVIEW OF 20-YEAR TRAFFIC FORECASTING PROCESS

5.2.1 Background

The SDDOT 20-year traffic forecasting factors are determined separately for rural and urban areas, and by functional class and user/ vehicle types as outlined in Figure 5-1. Grouping of VMT into functional highway classification and into two commercial vehicle types involved aggregation of VMTs from the standard annual report of vehicle miles of travel by county as follows:

- *Arterials* is the sum of Federal Aid Principal Arterial and Minor Arterial designations
- *Other* is the sum of State Trunk System/Federal Aid Major Collectors, State Trunk/Non-Federal Aid Other, Non-State Trunk/Federal Aid Major Collectors, Non-State Trunk/ Non-Federal Aid Minor Collectors, and Non-State Trunk/Non-Federal Aid Local Roads
- *Class 5-9 Commercial* vehicle data includes all single unit and/or single trailer trucks
- *Class 10-13 Commercial* vehicle data includes all multi-trailer trucks

The forecasting factors categories have a maximum of 14 in counties with interstate highways spanning in both rural and urban areas. The number of categories reflects the level of effort involved in deriving 20-year forecasts for each county.

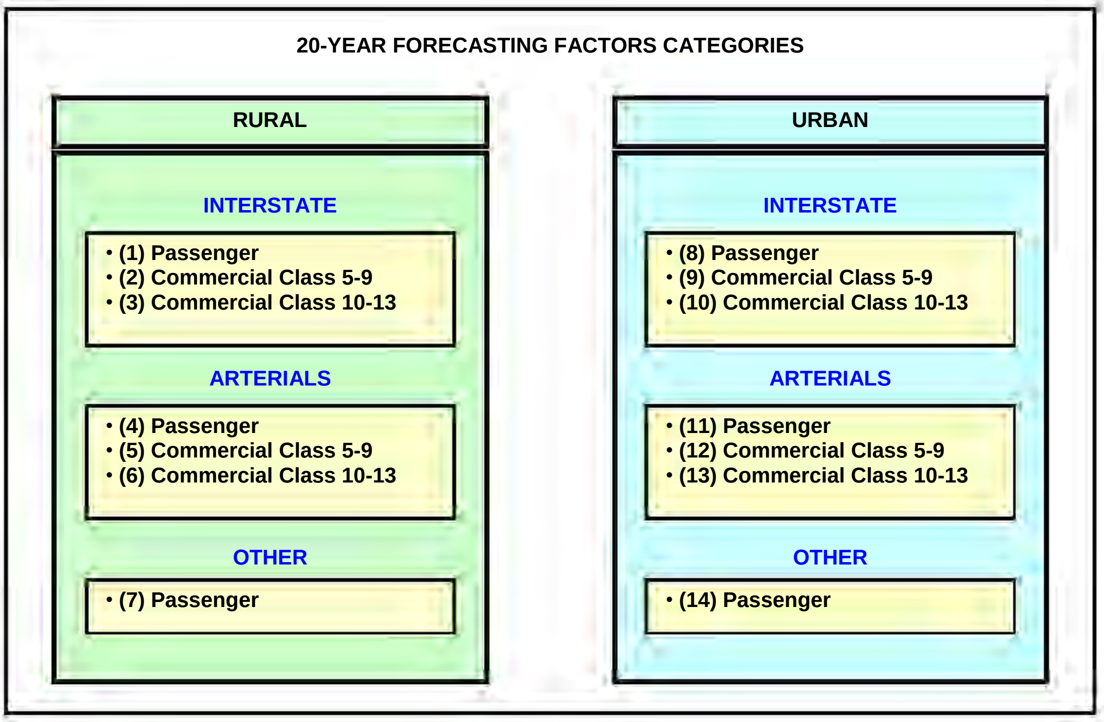


Figure 5-1 Categories of Current 20-Year Traffic Forecasting Factors

5.2.2 Data

The county level 20-year traffic forecasting factors use the following data set:

- Historical traffic data in vehicle miles traveled (VMT)
- Business growth trends by county

An overview of each data set and its use in deriving the forecasting factors is described below.

<u>Historical Traffic Data</u>

Countywide VMTs dating from 1981 to 1998 were used in the initial forecasting model formulation. Currently, VMT to 2004 were already updated in the forecasting model. Subsequent discussions refer mainly to the most recent historical VMT (1981-2004). The VMTs were stratified according to the categories in Figure 5-1. Table 5-1 shows an example of rural and urban VMTs for Lawrence County. The VMTs are stratified into Interstate, Arterials, and Other, and by passenger and commercial types. Commercial VMTs were available only starting in 1986. Moreover, commercial VMTs have no data for the year 1993 due to a computer system crash.

Table 5-1 Historical Rural and Urban VMTs for Lawrence County

	RURAL							URBAN						
	INTERSTATE			ARTERIALS			OTHER	INTERSTATE			ARTERIALS			OTHER
Year	Passenger (1)	Class 5-9 Commercial (2)	Class 10-13 Commercial (3)	Passenger (4)	Class 5-9 Commercial (5)	Class 10-13 Commercial (6)	Passenger (7)	Passenger (8)	Class 5-9 Commercial (9)	Class 10-13 Commercial (10)	Passenger (11)	Class 5-9 Commercial (12)	Class 10-13 Commercial (13)	Passenger (14)
1981	42,843,892													
1982	41,355,563			82,705,527			48,886,950	7,350,835			1,802,970			1,577,072
1983	46,938,822			88,697,628			48,982,773	5,176,345			2,062,358			2,169,348
1984	42,851,423			94,379,972			48,955,723	6,201,714			3,537,493			2,671,235
1985	44,621,433			74,942,496			48,422,569	7,880,019			3,754,373			2,709,477
1986	45,107,733	8,534,559	126,126	75,386,346	10,161,009	92,975	48,555,696	7,943,663	492,507		3,847,204	134,278	2,799	2,742,035
1987	47,039,293	8,736,396	295,148	63,784,431	8,715,331	50,874	49,670,170	6,775,685	410,090	10,002	4,622,267	176,132	1,583	2,931,614
1988	45,162,602	8,491,815	179,405	66,674,716	9,035,185	156,178	49,845,570	7,742,125	463,460	16,552	5,086,674	202,615	6,140	3,026,372
1989	47,713,933	8,891,632	269,443	74,096,712	9,915,876	240,792	50,675,675	8,102,772	494,643	7,729	5,055,633	196,875	5,707	3,007,538
1990	54,462,960	10,136,125	320,763	96,245,054	12,733,853	289,765	23,549,827	8,957,246	531,203	24,146	15,215,350	778,110	14,681	5,476,000
1991	50,342,178	9,387,548	278,150	96,945,474	12,744,588	277,045	24,137,959	8,279,560	513,333	8,114	13,940,369	656,190	16,825	4,934,000
1992	54,984,180	10,241,830	315,133	104,366,120	13,909,231	416,135	21,156,728	10,054,509	599,404	23,976	14,936,736	796,130	25,807	5,246,561
1993	47,545,250			107,274,790			22,260,693	7,815,070			14,057,521			5,245,540
1994	71,028,803	13,065,326	572,204	96,193,902	11,577,980	551,228	22,533,916	8,768,256	522,313	21,319	18,726,519	1,071,439	32,843	5,396,025
1995	71,297,056	12,540,922	1,148,113	99,656,704	11,806,099	687,128	25,460,628	8,845,895	516,184	32,261	19,299,532	1,106,161	60,807	5,413,045
1996	76,439,687	13,256,121	1,420,299	99,051,653	11,267,120	1,233,379	25,308,414	9,271,215	532,549	42,266	20,403,011	1,071,735	171,584	5,414,855
1997	78,688,116	13,140,915	1,967,203	98,650,317	10,713,584	1,782,447	25,383,723	9,036,702	535,916	35,017	19,921,873	956,632	254,920	5,401,365
1998	84,429,774	14,268,632	1,941,885	97,960,866	10,721,930	1,745,298	25,206,075	9,804,889	528,364	79,539	19,139,466	932,696	227,566	5,418,885
1999	84,590,225	13,385,557	2,179,044	101,155,270	10,148,933	2,862,519	25,023,836	9,859,636	1,631,079	666,216	20,313,266	1,227,146	409,049	5,518,690
2000	82,005,327	12,905,999	2,100,977	99,293,601	9,918,164	2,797,431	24,961,024	9,702,302	1,363,950	557,106	20,618,198	1,199,747	399,916	5,518,690
2001	81,526,009	12,830,564	2,088,696	93,769,349	8,896,615	3,125,838	24,926,511	9,994,155	1,563,286	415,557	20,544,523	1,146,930	446,029	5,518,690
2002	84,023,080	12,916,028	2,460,196	94,466,804	9,188,720	2,901,701	24,892,364	12,906,738	2,069,983	485,551	20,602,240	1,280,947	320,237	5,527,100
2003	86,014,258	12,592,487	3,148,122	94,221,648	8,429,416	3,612,607	24,889,788	13,262,340	2,116,510	509,433	13,262,339	1,305,718	306,280	5,526,749
2004	64,734,364	9,595,575	2,250,814	95,179,652	8,867,198	3,279,648	25,054,457	37,574,795	5,207,866	2,231,943	22,101,489	830,530	864,429	5,487,680

(1) Categories or forecasting factors

The Lawrence County example has 14 categories or forecasting factors, which is the maximum number of categories. Some counties have fewer categories, which include those counties that do not have Interstate VMTs or those that do not have urban VMTs. For example, Brown County has both rural and urban VMTs, but no Interstate VMTs. Buffalo County has only rural VMTs with no Interstate VMTs. Brown County has eight forecasting factors while Buffalo County has four. As mentioned earlier, the number of categories reflects the level of effort involved in deriving 20-year traffic forecasts for each county.

Business Growth Trends

The county business data obtained from the U.S. Census Bureau came under the general categories of Agricultural Services/Forestry/Fishing, Construction, Finance/Insurance/Real Estate, Manufacturing, Mining, Services, Transportation/Public Utilities, Wholesale Trade, Retail Trade, and Unclassified Establishments. These categories were apportioned into two categorical groups for direct correlation with the vehicle-type traffic data categories of passenger vehicles and commercial vehicles outlined in Figure 5-1. The following assumptions were established to apportion the business data into the corresponding vehicle types and to correlate with the VMTs:

(a) Two business groupings

Group I include the business categories of Agricultural Services/Forestry/ Fishing, Retail Trade, Finance/Insurance/Real Estate, Services, and Unclassified Establishments.

Group II include Construction, Manufacturing, Mining, Transportation/Public Utilities, and Wholesale Trade.

(b) Grouping of businesses by the number of employees

"County Business Pattern" data groups businesses "size-wise" by the number of employees per establishment. Based on the number of employees per business, the groupings are 1–19 employees, 20–99 employees, 100–499 employees, and >499 employees.

In developing the 20-year traffic forecasting procedure, business size groupings of the U.S. Census Bureau were adopted directly, with the exception that the category >499 was combined with the 100–499 category to give a >100 categorical grouping. The rationale for combining the categories was based on the exceedingly small number of businesses in South Dakota that have greater than 499 employees.

Groupings of South Dakota businesses according to the number of employees per business was made for the purpose of establishing "traffic" multipliers that were then applied to each group (i.e., a business with 8 employees will generate traffic that is less than a similar, but larger business with 28 employees by some given multiple). The 1999 Study assumed the following multipliers based on their review of data from the South Dakota Retailers Association:

Traffic Multiplier	Employee Grouping
1	1-19
5	20-99
10	>100

Accordingly, the multipliers were meant to develop trends only and were not an effort to establish actual relative numbers. The multipliers were applied to the total number of businesses by size and type to give a means to correlate business data directly with the projected traffic trends for each county.

Table 5-2 shows an example of business data for Lawrence County. Historical data for the two business groupings by business size from 1984 to 2004 is used in the regression analysis to derive factors for passengers and trucks categories. The column "Weighted Total" is obtained by applying the traffic multiplier described earlier. For example, Group I weighted total is obtained as the sum of 430 +(5*22) + (10*3) = 570. The weighted total for Group I is regressed with column 1 (i.e., calendar year) to obtain the factor for passengers, and Group II weighted total is also regressed with column 1 to obtain the factor for trucks. A subsequent section on methodology provides an example of calculated factors and the application of those factors in adjusting some of the 20-year VMT factors.

Table 5-2 Historical Business Data for Lawrence County

	GROUP I					GROUP II				
	Agricultural Services, Retail Trade, Finance, Services, Other					Construction, Manufacturing, Mining Transportation, Wholesale Trade, Utilities				
	# Employees					# Employees				
Year	1-19	20-99	>100	Total	**Weighted Total**	1-19	20-99	>100	Total	**Weighted Total**
1984	430	22	3	455	**570**	107	14	2	123	**197**
1985	438	16	4	458	**558**	108	15	1	124	**193**
1986	430	23	2	455	**565**	121	12	2	135	**201**
1987	453	24	3	480	**603**	140	12	3	155	**230**
1988	432	26	3	461	**592**	136	13	3	152	**231**
1989	466	30	3	499	**646**	132	17	3	152	**247**
1990	493	43	5	541	**758**	131	22	3	156	**271**
1991	451	53	5	509	**766**	162	23	2	187	**297**
1992	492	44	1	537	**722**	180	21	3	204	**315**
1993	508	55	7	570	**853**	174	20	3	197	**304**
1994	532	59	8	599	**907**	178	21	3	202	**313**
1995	541	63	7	611	**926**	181	19	4	204	**316**
1996	541	59	8	608	**916**	185	16	4	205	**305**
1997	554	61	7	622	**929**	199	14	3	216	**299**
1998	560	65	6	631	**945**	170	12	3	185	**260**
1999	571	65	6	642	**956**	174	11	3	188	**259**
2000	559	62	9	630	**959**	175	12	3	190	**265**
2001	579	60	10	649	**979**	175	13	3	191	**270**
2002	583	68	11	662	**1033**	187	11	3	201	**272**
2003	600	61	11	672	**1015**	186	15	2	203	**281**
2004	612	64	12	688	**1052**	196	13	2	211	**281**

5.2.3 20-Year Traffic Forecasting Methodology

This section outlines the approach adopted in the current 20-year traffic forecasting procedure. Interpretation and analysis of the resulting forecasting factors are described in subsequent sections. Figure 5-2 provides a schematic representation of the traffic forecasting process. Discussion of the forecasting technique used and steps in deriving the forecasting factors follow.

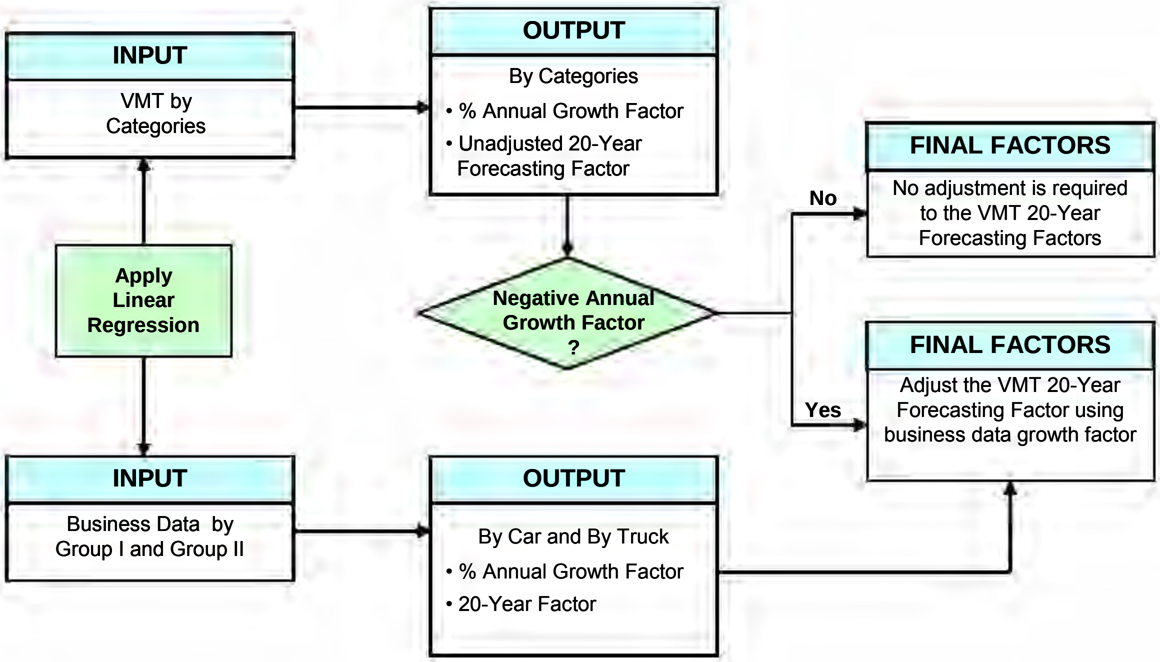


Figure 5-2 Schematic Diagram of the 20-Year Traffic Forecasting Process

(1) Unadjusted 20-year VMT traffic forecasting factors

- **Linear regression** of historical VMT at the county level for each category in Figure 5-1 is applied as depicted in Figure 5-2. The coefficients from the linear regression are then used to determine the VMT for the 2004 base year and for the 20-year forecast (year 2024). Table 5-3 shows an example for the rural portion in Lawrence County. Highlighted in yellow are base year and 20-year forecast VMTs by functional class and by passenger and commercial vehicles.

- **Annual percent growth factor** for each category is determined as a compound percentage annual growth using base year VMT and the projected 20-year VMT. The calculated annual percent growth factor is shown in Table 5-3. This annual growth factor is used in adjusting the 20-year forecasting factor. Adjustment is usually carried out when the annual growth factor is negative. A more elaborate discussion on the use of the annual growth factor in the adjustment process is found later in this section.

- **Unadjusted 20-year forecasting factor** for each category in Table 5-3 is derived simply by dividing the 20-year VMT projections by the base year VMT projections. As mentioned above, adjustment is usually performed to the 20-year forecasting factor when the percentage annual growth is negative.

- For some categories with negative annual growth rate, such as the case for Arterials Class 5-9 Commercial for Lawrence highlighted in red in column 6 of Table 5-3, adjustment to the 20-year forecasting factor was applied using the growth factor for trucks derived from the business data. The adjustment process is outlined below.

Table 5-3 Example Linear Regression of Rural VMT Categories for Lawrence County

LAWRENCE	RURAL						
	INTERSTATE			ARTERIALS			OTHER
Year	Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Arterials	Class 5-9 Commercial	Class 10-13 Commercial)	Passenger
1981	42,843,892						
1982	41,355,563			82,705,527			48,886,950
1983	46,938,822			88,697,628			48,982,773
1984	42,851,423			94,379,972			48,955,723
1985	44,621,433			74,942,496			48,422,569
1986	45,107,733	8,534,559	126,126	75,386,346	10,161,009	92,975	48,555,696
1987	47,039,293	8,736,396	295,148	63,784,431	8,715,331	50,874	49,670,170
1988	45,162,602	8,491,815	179,405	66,674,716	9,035,185	156,178	49,845,570
1989	47,713,933	8,891,632	269,443	74,096,712	9,915,876	240,792	50,675,675
1990	54,462,960	10,136,125	320,763	96,245,054	12,733,853	289,765	*23,549,827*
1991	50,342,178	9,387,548	278,150	96,945,474	12,744,588	277,045	*24,137,959*
1992	54,984,180	10,241,830	315,133	104,366,120	13,909,231	416,135	*21,156,728*
1993	47,545,250			107,274,790			*22,260,693*
1994	71,028,803	13,065,326	572,204	96,193,902	11,577,980	551,228	*22,533,916*
1995	71,297,056	12,540,922	1,148,113	99,656,704	11,806,099	687,128	*25,460,628*
1996	76,439,687	13,256,121	1,420,299	99,051,653	11,267,120	1,233,379	*25,308,414*
1997	78,688,116	13,140,915	1,967,203	98,650,317	10,713,584	1,782,447	*25,383,723*
1998	84,429,774	14,268,632	1,941,885	97,960,866	10,721,930	1,745,298	*25,206,075*
1999	84,590,225	13,385,557	2,179,044	101,155,270	10,148,933	2,862,519	*25,023,836*
2000	82,005,327	12,905,999	2,100,977	99,293,601	9,918,164	2,797,431	*24,961,024*
2001	81,526,009	12,830,564	2,088,696	93,769,349	8,896,615	3,125,838	*24,926,511*
2002	84,023,080	12,916,028	2,460,196	94,466,804	9,188,720	2,901,701	*24,892,364*
2003	86,014,258	12,592,487	3,148,122	94,221,648	8,429,416	3,612,607	*24,889,788*
2004	64,734,364	9,595,575	2,250,814	95,179,652	8,867,198	3,279,648	*25,054,457*
Forecasts:							
Base Year (2004)	86,140,964	13,620,449	2,750,974	101,914,555	9,645,764	3,388,780	25,583,652
2006	90,428,190	14,117,363	3,077,589	103,882,426	9,459,010	3,819,583	25,945,725
2010	99,002,641	15,111,192	3,730,818	107,818,169	9,085,501	4,681,190	26,669,871
2015	109,720,706	16,353,477	4,547,356	112,737,847	8,618,616	5,758,197	27,575,054
2020	120,438,771	17,595,763	5,363,893	117,657,526	8,151,731	6,835,205	28,480,237
2024	**129,013,222**	**18,589,591**	**6,017,123**	**121,593,269**	**7,778,222**	**7,696,812**	**29,204,383**
Annual % Growth Factor=	**2.0402%**	**1.5673%**	**3.9908%**	**0.8866%**	**-1.0702%**	**4.1870%**	**0.2081%**
20-Year Forecasting Factor=	**1.4977**	**1.3648**	**2.1873**	**1.1931**	**1.0291**	**2.2713**	**1.1415**

(2) Car and truck factors from business data

- **Linear regressions** were performed to the business data (Group I weighted total and Group II weighted total) to determine the base year and the 20-year business growth factors. Table 5-4 shows the calculated annual percent growth factor and calculated 20-year factors for passenger cars and trucks for Lawrence County.

- **Assumption on traffic split into passenger/commercial vehicle by business grouping**. The two categories of business types need to have the 'Annual Growth Factor' adjusted to reflect the appropriate passenger/commercial traffic split that the categorical types of businesses are expected to generate. The purpose of the adjustment is to relate the business data directly in comparative analyses with the commercial and/or passenger VMT projections.

  Group I (for car factor**)** is assumed to have attraction rates of 80 percent cars and 20 percent trucks. **Group II (**for truck factor) is assumed to have attraction rates of 80 percent trucks and 20 percent cars. Table 5-4 provides an example of the car/commercial traffic split for Lawrence County.

  The adjusted percentages of **1.80%** for cars and **1.23%** for trucks are the values used for adjusting the 20-year VMT forecasting factors. The adjusted percentage for cars is applied to adjust VMT factor for passengers while the adjusted percentage for trucks is applied to the commercial vehicles (Class 5-9 and Class 10-13).

Table 5-4 Example Linear Regression of Business Data for Lawrence County

	GROUP I					GROUP II				
	Agricultural Services, Retail Trade, Finance, Services, Other					Construction, Manufacturing, Mining Transportation, Wholesale Trade, Utilities				
	# Employees					# Employees				
Year	1-19	20-99	>100	Total	**Weighted Total**	1-19	20-99	>100	Total	**Weighted Total**
1984	430	22	3	455	**570**	107	14	2	123	**197**
1985	438	16	4	458	**558**	108	15	1	124	**193**
1986	430	23	2	455	**565**	121	12	2	135	**201**
1987	453	24	3	480	**603**	140	12	3	155	**230**
1988	432	26	3	461	**592**	136	13	3	152	**231**
1989	466	30	3	499	**646**	132	17	3	152	**247**
1990	493	43	5	541	**758**	131	22	3	156	**271**
1991	451	53	5	509	**766**	162	23	2	187	**297**
1992	492	44	1	537	**722**	180	21	3	204	**315**
1993	508	55	7	570	**853**	174	20	3	197	**304**
1994	532	59	8	599	**907**	178	21	3	202	**313**
1995	541	63	7	611	**926**	181	19	4	204	**316**
1996	541	59	8	608	**916**	185	16	4	205	**305**
1997	554	61	7	622	**929**	199	14	3	216	**299**
1998	560	65	6	631	**945**	170	12	3	185	**260**
1999	571	65	6	642	**956**	174	11	3	188	**259**
2000	559	62	9	630	**959**	175	12	3	190	**265**
2001	579	60	10	649	**979**	175	13	3	191	**270**
2002	583	68	11	662	**1033**	187	11	3	201	**272**
2003	600	61	11	672	**1015**	186	15	2	203	**281**
2004	612	64	12	688	**1052**	196	13	2	211	**281**
2005 (Projected):					*1118.0*					*305.5*
2025 (Projected):					*1657.2*					*375.6*
				Factor for Cars	***1.482***				***Factor for Trucks***	***1.229***
Annual % Growth Factor:					**1.99%**					**1.04%**
Car/Commercial 20%-80% Traffic Split					***1.80%***				***80%-20% Traffic Split***	***1.23%***

(3) Adjustment to the 20-Year VMT Factors

The current approach to adjust the 20-year VMT factors involves two different procedures as depicted in the schematic diagram of Figure 5-3.

As mentioned earlier on page 81 (first bullet), annual percentage growth adjustment was derived using business data. Linear regressions to the two categories of business types (Group I and Group II) were performed to determine the 20-year growth projections. Table 5-4 shows the calculated annual percent growth factor for Lawrence County (1.80% for cars and 1.23% for trucks).

Figure 5-3 outlines how the 20-year VMT factors for passenger and commercial categories are adjusted. As mentioned on page 80 (second bullet), adjustment is only applied to those categories showing negative annual growth. It is important to note, however, that adjustment is not always applied to all categories indicating negative annual growth. Some categories with negative annual growths are considered valid estimates reflective of an expected decline in future VMT as judged by the traffic engineer/analyst's experience and knowledge of socioeconomic or demographic growth trends and of other factors that may have influence on VMT growth.

In all of the 66 counties in South Dakota, adjustments are largely applied to Class 5-9 commercial using adjustment procedure 1.

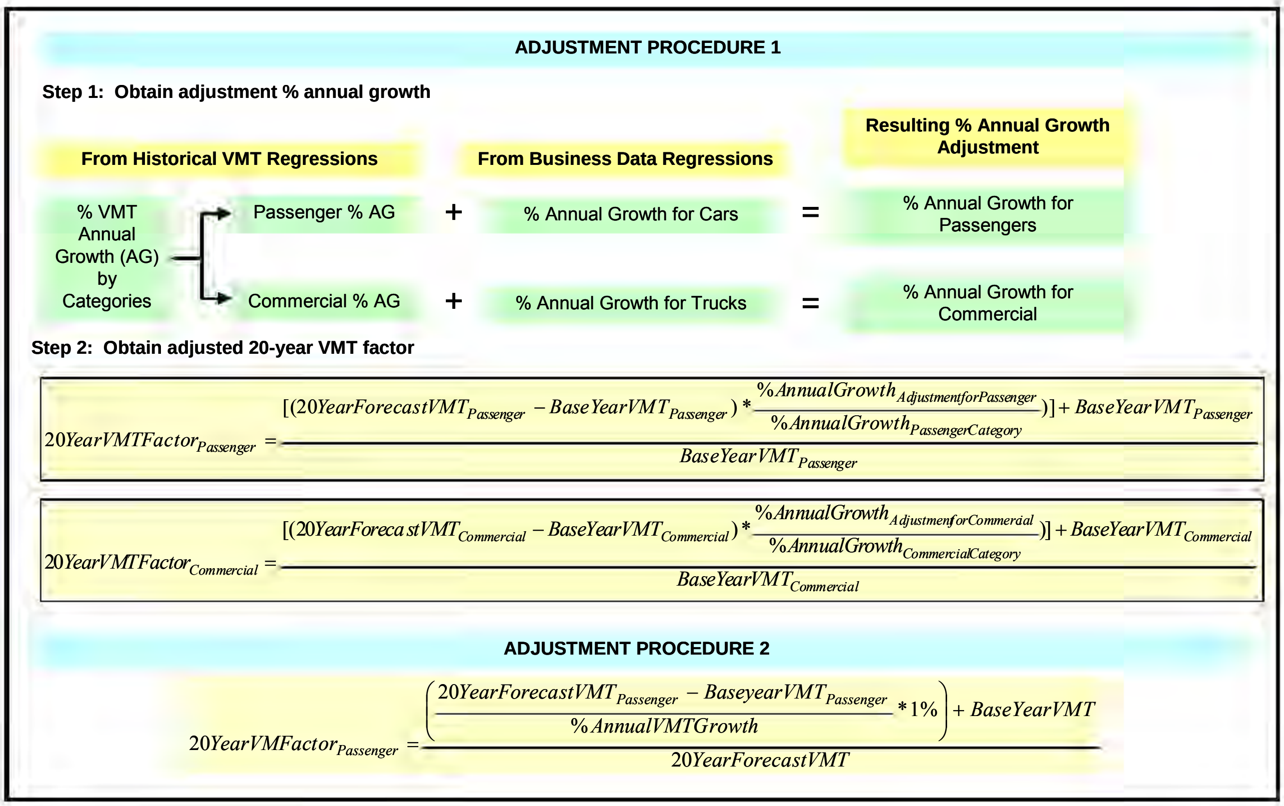


Figure 5-3 Schematic Diagram of the 20-Year Forecasting Factor Adjustment Calculation

(4) Adjusted 20-year traffic forecasting factors

- **Adjusted 20-Year forecasting factor** is calculated by multiplying the unadjusted forecasting factor by the ratio of the adjusted growth percentage and dividing by the initial unadjusted growth percentage, as demonstrated in Adjustment Procedure 1 above. Table 5-5 summarizes the 20-year traffic forecasting factors for selected counties.
- Factors with asterisk (*) were adjusted using business data, with the exception of Brown County where Adjustment Procedure 2 was applied. Only three counties, including Brown, were adjusted using Procedure 2. Adjustments were applied to *Other Passenger* category.
- Overall, adjustments were applied to about 30 counties, mainly for category *Class 5-9 Commercial*.

Table 5-5 Year 2024 Traffic Forecasting Factors for Selected Counties

YEAR 2024 TRAFFIC FORECASTING FACTORS: RURAL							
County	INTERSTATE			ARTERIALS			OTHER
	Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger
Brown				1.221	0.919	2.283	1.193
Buffalo				1.159	1.000	2.307	1.054
Clay				1.391	1.129	2.308	1.169
Lawrence	1.498	1.365	2.187	1.193	1.029*	2.271	1.142
Meade	1.484	1.349	2.206	1.199	0.745*	2.282	1.290
Pennington	1.241	1.068	2.187	1.158	1.013*	2.284	1.115
Roberts	1.696	1.510	2.208	1.354	1.055	2.305	1.309
Todd				1.247	1.204	2.270	1.280

YEAR 2024 TRAFFIC FORECASTING FACTORS: URBAN							
County	INTERSTATE			ARTERIALS			OTHER
	Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger
Brown				1.305	1.333	2.382	1.213**
Clay				1.290	1.066	2.307	1.015
Lawrence	1.654	2.191	2.534	1.820	1.866	2.353	1.562
Meade	1.759	2.210	2.535	1.415	1.200	2.338	1.311
Pennington	1.725	2.127	2.481	1.321	1.106	2.363	1.305

* Adjusted factor using business data (Adjustment Procedure I in Section 5.2.3)

** Adjusted factor using Adjustment Procedure 2 (Refer Section 5.2.3)

5.3 REVIEW AND ANALYSIS OF THE 20-YEAR TRAFFIC FORECASTING PROCEDURE

To provide a basis for validating the 20-year traffic forecasting procedure, it is important to examine the patterns in the historical VMT and business data, the assumptions in using the data, and the suitability of the forecasting technique. Specifically, this section analyzed the following:

- Trends in historical VMT – check for data outliers, influential points, and linear pattern;
- Trends in business data – check for data outliers, influential points, and linear pattern;
- Evaluate the assumptions employed for business groupings (Group I and Group II), passenger/commercial vehicle traffic attraction splits by business group, and grouping of businesses by the number of employees;
- Assess the strength of the relationship of county business data to explain the variability in county VMT;
- Assess the applicability of a linear regression technique to forecast county level VMT. Specifically, evaluate important statistical quality tests such as R^2, residuals, and standard error.
- Examine the appropriateness of other techniques if a linear regression exhibits poor prediction.

5.3.1 Counties Included for Review and Validation

During the project kickoff meeting, the Technical Panel selected the eight counties listed in Table 5-6 for the purpose of reviewing and validating the 20-year traffic forecasting factors. The selected counties represent areas of the state that have been experiencing different levels of growth as Table 5-6 and Figure 5-4 depict. With the exception of Roberts County, all counties experience increase in population relative to the 1990 Census. However, starting around the mid 1990s, most counties have experienced population decline, which they later regained. Clay County and Brown County, however, continued to lose population. On the other hand, Pennington and Todd counties represent counties of large and small populations that have been experiencing upward population growth.

The effect of countywide population growth or decline on the accuracy of the 20-year traffic forecasting factors is the rationale for selecting these counties in the forecasting validation exercise in Section 5-4. Specifically, the validation analyzed the effect of population on the linear regression technique used in the forecasting procedure.

Table 5-6 Population Trend of Selected Counties

	Year	Brown County	Buffalo County	Clay County	Lawrence County	Meade County	Pennington County	Roberts County	Todd County	South Dakota	
	1990	35,528	1,779	13,193	20,707	21,964	81,695	9,906	8,385	*696,004*	Statewide % Growth
	2005	34,706	2,100	12,995	22,395	24,623	93,580	10,044	9,882	*703,669*	
Growth/Decline Relative to 1990 Census Population	1991	86	39	41	477	826	1,838	-122	19	*7,665*	1.1%
	1992	227	70	204	838	1,888	2,820	-188	130	*16,797*	2.4%
	1993	445	57	439	1,301	1,931	4,107	-6	239	*26,155*	3.8%
	1994	557	107	589	1,674	2,096	4,566	-18	307	*34,786*	5.0%
	1995	576	182	695	1,981	2,334	5,220	38	446	*41,921*	6.0%
	1996	645	194	465	1,985	2,388	4,947	129	472	*46,209*	6.6%
	1997	559	170	404	1,883	1,906	5,250	259	438	*48,219*	6.9%
	1998	298	198	436	1,671	1,986	5,585	177	424	*50,054*	7.2%
	1999	177	263	452	1,132	2,030	6,352	121	561	*54,408*	7.8%
	2000	-151	225	288	1,057	2,264	7,069	96	706	*58,840*	8.5%
	2001	-450	240	271	965	2,284	8,289	154	896	*62,064*	8.9%
	2002	-647	227	61	940	2,532	9,151	-12	1,017	*64,364*	9.2%
	2003	-734	271	23	1,243	2,494	9,758	167	1,092	*68,595*	9.9%
	2004	-795	298	-174	1,605	2,693	11,201	210	1,343	*74,617*	10.7%
	2005	-822	321	-198	1,688	2,659	11,885	138	1,497	*79,929*	11.5%

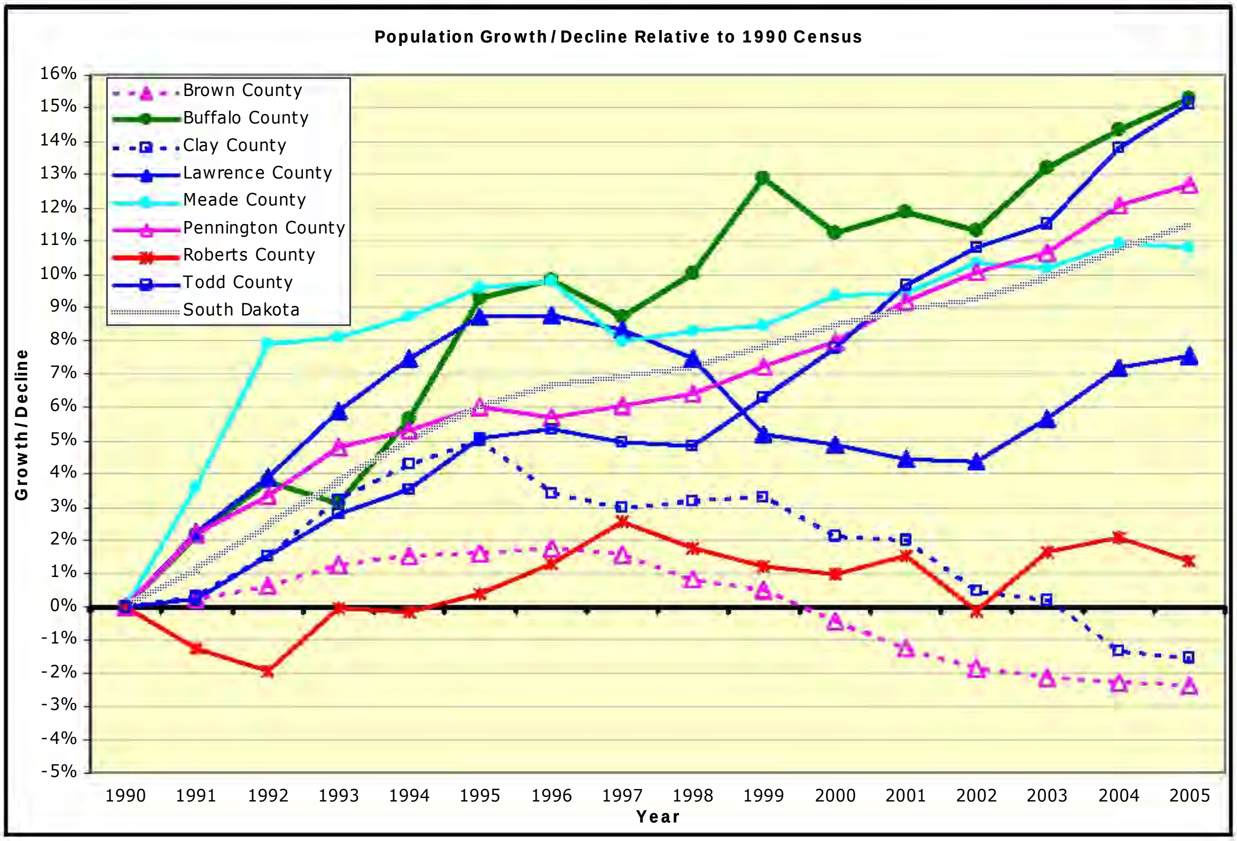


Figure 5-4 Selected Counties Population Growth/ Decline

5.3.2 Simple Linear Regression

An overview of the simple linear regression forecasting technique is briefly described in this section to aid in interpreting the results of the linear regression VMT and business county models.

In a cause and effect relationship, the **independent variable** is the cause, and the **dependent variable** is the effect. **Least squares linear regression** is a method for predicting the value of a dependent variable *Y*, based on the value of an independent variable *X*. Least squares regression involving one dependent and one independent variable is called a simple linear regression. Regression analysis provides a tool for developing an equation that defines the line that “best fits” the data.

Simple linear regression is appropriate when the following conditions are satisfied.

- The dependent variable *Y* has a linear relationship to the independent variable *X*. This is easily checked by examining if the XY **scatterplot** is linear and that the **residual plot** shows a random pattern.
- For each value of *X*, the probability distribution of *Y* has the same **standard deviation σ**. When this condition is satisfied, the variability of the residuals will be relatively constant across all values of *X*, which is easily checked in a residual plot.

The **coefficient of determination** (denoted by $\mathbf{R^2}$) is a key output of regression analysis. It is interpreted as the proportion of the variance in the dependent variable that is predictable from the independent variable. It is an estimate of the accuracy of the fit.

- The coefficient of determination ranges from 0 to 1.
- An R^2 of 0 means that the dependent variable cannot be predicted from the independent variable.
- An R^2 of 1 means the dependent variable can be predicted without error from the independent variable. Therefore, the closer the R^2 value to 1, the stronger the relationship between the dependent variable and the independent variable.

An R^2 between 0 and 1 indicates the extent to which the dependent variable is predictable; an R^2 of 0.10 means that 10 percent of the variance in *Y* is predictable from *X*; an R^2 of 0.20 means that 20 percent is predictable; and so on.

Recommended and desirable R^2 values adopted in other state departments of transportation and the Institute of Transportation Engineers are discussed in Section 5.3.3. Suggested desirable R^2 for the 20-year traffic forecasting factors is also discussed.

The **standard error** about the regression line is a measure of the average amount that the regression equation over- or under-predicts. The higher the coefficient of determination, the lower the standard error and the more accurate predictions are likely to be.

Residuals, Outliers, and Influential Points

A linear regression model is not always appropriate for the data. The appropriateness of the model can be assessed by examining residuals, outliers, and influential points.

Residuals

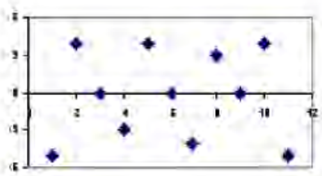
The difference between the observed value of the dependent variable (y) and the predicted value ($\hat{y}$) is called the **residual** (e). Each data point has one residual.

$$\text{Residual} = \text{Observed value} - \text{Predicted value};\ e = y - \hat{y}$$

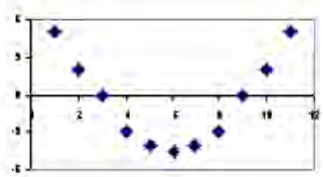
Both the sum and the mean of the residuals are equal to zero; that is, $\Sigma\ e = 0$ and $e = 0$.

Residual Plots

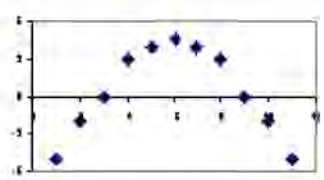
A **residual plot** is a graph that shows the residuals on the vertical axis and the independent variable on the horizontal axis. If the points in a residual plot are randomly dispersed around the horizontal axis, a linear regression model is appropriate for the data; otherwise, a non-linear model is more appropriate.



Random pattern



Non-random: U-shaped curve



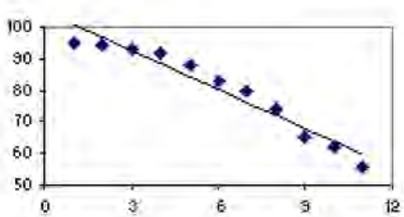
Non-random: Inverted U

Data Outliers

Data points that diverge from the overall pattern and have large residuals are called outliers.

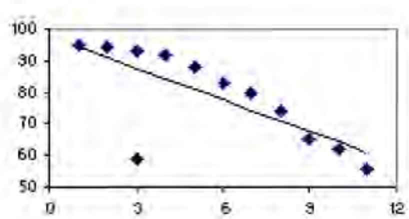
Outliers limit the fit of the regression equation to the data. This is illustrated in the scatterplots below. The coefficient of determination is bigger when the outlier is not present.

Without Outlier



Regression equation: $\hat{y}$ = 104.78 - 4.10x
Coefficient of determination: R^2 = 0.94

With Outlier



Regression equation: $\hat{y}$ = 97.51 - 3.32x
Coefficient of determination: R^2 = 0.55

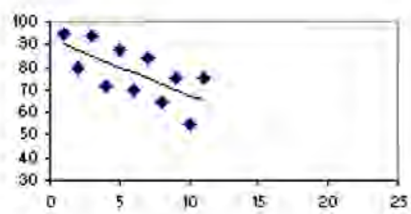
Influential Points

Influential points are data points with extreme values that greatly affect the slope of the regression line.

The charts below compare regression statistics for a data set with and without an influential point. The chart on the right has a single influential point, located at the high end of the X axis (where x = 24). Because of that single influential point, the slope of the regression line increases dramatically, from -2.5 to -1.6.

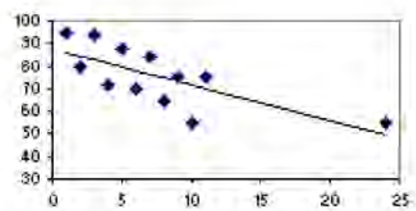
Note that this influential point, unlike the outliers discussed above, did not reduce the coefficient of determination. In fact, the coefficient of determination was bigger when the influential point was present.

Without Influential Point



Regression equation: $\hat{y}$ = 92.54 - 2.5x
Slope: b_0 = -2.5
Coefficient of determination: R^2 = 0.46

With Influential Point



Regression equation: $\hat{y}$ = 87.59 - 1.6x
Slope: b_0 = -1.6
Coefficient of determination: R^2 = 0.52

5.3.3 Plots of Historical VMTs and Trend Line for the Selected Counties

To validate the linearity assumption adopted in the SDDOT 20-year traffic forecasting procedure, plots of historical VMT for each category were prepared for each county in Figure 5-4. Providing a graph for each category gives a visual representation of the relationship that exists in the historical VMT data. It is important to note here that the Y-axis is not always drawn to start from zero to show the data pattern better. The next 20 pages present the historical VMT plots that also show the trend line or linear regression line. The coefficient of determination, R^2, is also shown on the plots. Table 5-7 provides a summary of R^2 values for all categories.

Acceptable and Desirable Values for the Coefficient of Determination, R^2

While linear regression technique is a widely used method for traffic forecasting, there is no published standard value for the goodness of fit measure. It is highly desired to achieve a value close to 1.0; however, a single acceptable or desirable value is not specified. Several state DOTs use linear regression technique, but most do not publish the R^2 value deemed desirable. The "Minnesota DOT Procedure Manual for Forecasting Traffic on Minnesota's Highway Systems" indicates on page 52 for at least an R^2 value of 0.70 (Mn/DOT, 2006). The Arizona DOT regression equations for population groups and functional classification types do not specifically indicate the desirable R^2 values; however, the table summary shows a range of R^2 starting from as low as 0.67 for rural freeway under Population Group C (150,000-250,000) category. Analysis of Traffic Growth Rates for the Kentucky Transportation Center (KYTC) conducted in 2001 suggests a much higher desirable R^2 (above 0.90 range) for prediction of VMT based on socioeconomic data. KYTC has an additional requirement that VMT prediction models should have a reasonable level of accuracy, which is a goal of a (+-) 10% error. In 2005, a study commissioned by the Pennsylvania DOT completed a "Statistical Evaluation of Projected Traffic Growth," which estimated various models of VMT with socioeconomic variables. Based on PennDOT's needs, the study establishes criteria for evaluating the statistical models. One of the criteria was that the models should explain more than fifty percent of the variation (i.e., R^2 >0.50).

The Institute of Transportation Engineers (ITE) Trip Generation Manual indicates a preferred R^2 of at least 0.75 as the desirable level of correlation between the trips generated by a site and the value measured for an independent variable. The value of the independent variable for the study site must fall within the range of data included.

For travel demand models, the system wide R^2 desired value is 0.88.

For the South Dakota 20-year traffic forecasting factors, an R^2 of at least 0.70 is recommended as desirable measure of goodness of fit. A lower R^2 of at least 0.60 is recommended as acceptable measure of goodness of fit with additional consideration of land use growth in the county or at the site where forecast data is needed for specific projects. Consideration of land use growth and other factors affecting traffic growth needs to be accounted for also for those factors with desirable goodness of fit when traffic forecasts are required for specific projects.

Table 5-7 R-Squared Values of VMT Linear Regressions by Categories

	Categories	Brown County	Buffalo County	Clay County	Lawrence County	Meade County	Pennington County	Roberts County	Todd County
RURAL	Interstate-Passenger	-	-	-	**0.7947***	**0.9062**	0.4625	**0.9290**	-
	Interstate-Class 5-9	-	-	-	0.4919*	**0.7620**	0.0258	**0.7789**	-
	Interstate-Class 10-13	-	-	-	**0.8989**	**0.9084**	**0.7582**	**0.9151**	-
	Arterials Passenger	**0.8345**	0.1188	**0.8179**	0.3057	0.4155	0.3607	**0.7755**	0.2162
	Arterials-Class 5-9	0.1197	0.0099	0.2706	0.1156	0.4821	0.2315	0.0349	0.1365
	Arterials-Class 10-13	**0.8908**	**0.8848**	**0.8688**	**0.9024**	**0.8745**	**0.8704**	**0.9151**	**0.8669**
	Other-Passenger	0.1137	0.0502	0.1542	0.3712	0.1655	0.2049	0.4437	0.2137
URBAN	Interstate-Passenger	-	-	-	0.3284*	0.4058*	**0.7803***	-	-
	Interstate-Class 5-9	-	-	-	0.4919*	0.4724*	**0.7377***	-	-
	Interstate-Class 10-13	-	-	-	0.4429*	0.4165*	0.5851*	-	-
	Arterials Passenger	**0.7446**	-	0.5929	**0.7935**	**0.7704***	**0.8274**	-	-
	Arterials-Class 5-9	0.2665	-	0.1593	**0.7166**	0.2847	0.0436	-	-
	Arterials-Class 10-13	**0.7851**	-	**0.8293**	**0.7258***	**0.6473***	**0.7422**	-	-
	Other-Passenger	0.0063	-	0.3774	**0.7638**	0.5445	0.3845	-	-

Route re-classification
Data outlier
** Sharp increase/significant decrease in 2004 VMT due to re-classification from rural to urban*

General Observations of the Historical VMT Plots

- The plots show yearly VMT variation with some categories showing wide variation between successive years.
- Data outliers are present, which has significant influence on the estimated trend line. The VMT plot for *Rural Other Passenger* in Brown County and *Urban Other Passenger* in Pennington County are good examples.
- Sharp increases/decreases in annual VMT are present largely due to reclassification from one functional class to another or from rural classification to urban. The following are good examples:
  - ⇨ *Rural Other Passenger* to *Rural Arterials Passenger* in Buffalo County that occurred in 1990. It is noted here that the current procedure already takes into account the effect of reclassification by changing the starting point of the regression to year 1990. This change, however, still yields a poor R^2 of 0.0502 as reflected in Table 5-8.
  - ⇨ Reclassification from rural to urban in 2003 for *Interstate Passenger and Commercial* in Lawrence, Meade, and Pennington counties.
- The annual growth for *Other Passenger* category is marginal and tends to fluctuate about every other year. The somewhat sinusoidal pattern could be attributed to the 6-year cycle of traffic data collection for *Other* functional class. The results suggest that a linear regression technique may need to be combined with a data smoothing technique to estimate long term VMTs for *Other Passenger* class. Application of data smoothing is discussed in Section 5.4.1.
- Other categories also reflect no significant growth in some successive years, for example from 1994 to 1998 for *Urban Interstate Class 5-9 Commercial* in Lawrence County and Urban *Interstate Passenger* in Pennington County. "No significant growth" in this context refers to the VMT trend that is characterized by an alternating growth/decline within (+-) 2 percent and with an average annual growth of less than 1 percent.
- Towards the late 1990s, the trend for category *Class 10-13 Commercial* shows a sharp increase for all counties, which is in contrast to the population trend around this time where most counties experienced a decline in population as discussed earlier in Section 5.3.1. One major factor for this sharp increase is the use of HPMS data after 1994. In addition, VMT data by county was not broken down by functional class until 1994. These changes in VMT calculation and aggregation have created some shifts, as exhibited by Class 10-13. It is, therefore, logical to start the regression for commercial vehicles from 1994 onwards.

- The presence of some data outliers and reclassifications in rural miles to urban significantly influenced the goodness of fit of the linear regressions.
- Consequently, more than half of the categories reflect low coefficient of determination, R^2. As outlined in earlier in this section, an R^2 of at least 0.70 is desired for traffic forecasting.
- Table 5-7 provides a summary of R^2 values. Of the 44 "rural" categories, only 20 have the desired R^2. Similarly, of the 29 "urban" categories, only 12 have the desired R^2.
- *Class 10-13* commercial category shows high R^2 in all counties. The lower values in urban areas of Lawrence, Meade, and Pennington counties are attributed to a shift in VMT in 2003 from rural to urban.
- In contrast, *Class 5-9* commercial category generally reflects poor linear fit.
- Table 5-8 presents a summary of R^2 values after correcting some data outliers and adjusting the VMTs to account for reclassification from rural to urban. Other changes performed include:
  - ⇨ Some adjustments in the starting year of the regression analysis were also applied to better capture the trend in the data,
  - ⇨ Some data smoothing were applied where applicable, and
  - ⇨ Some aggregation in categories, such as combining *Class 5-9* and *Class 10-13*, were carried out and linear regression was performed on the total commercial VMTs. This is applied to the categories for urban commercial in Lawrence, Meade, and Pennington counties. The "Changed" column in Table 5-8 are the corrected R^2 values, which shows the same R^2 values for urban categories *Class 5-9* and *Class 10-13*.
- About 74 percent (54 out of 73) of the categories have the desirable R^2 values (0.70 and above) after implementing the above adjustments compared to 44 percent (32 out of 73 categories) before adjustments. Likewise, 73 percent (32 out of 44) of rural categories have desirable R^2 after adjustments compared to 46 percent (20 out of 44) before adjustments. The percent change for urban categories is 76 percent (22 out of 29) from 41 percent (12 out of 29). Section 5.4.5 provides some discussion on the factors and annual percent growth by county.
- The results in Table 5-8 demonstrates that a linear regression technique has sufficient predictive ability to estimate long term VMTs for most functional classes in either rural or urban areas of the state. It is important that data outliers and shifts in VMT due to reclassifications be corrected before using the data.

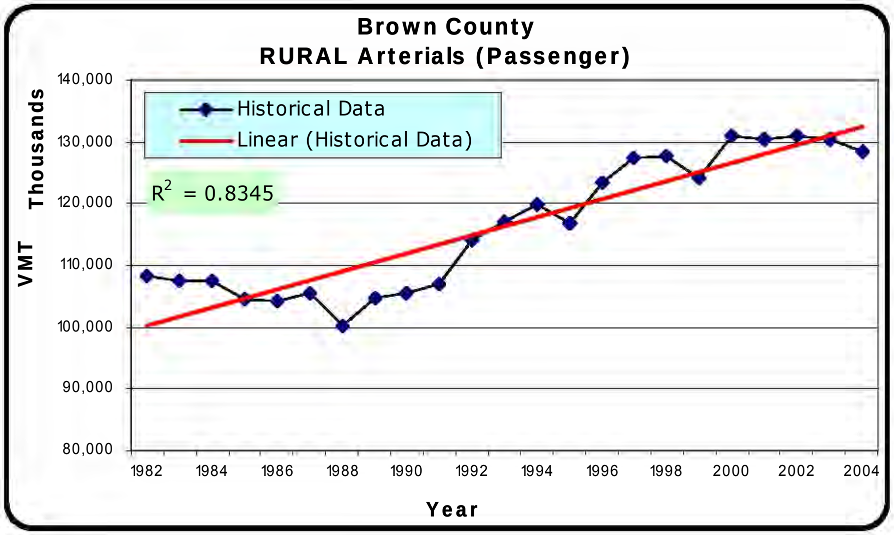
- Section 5.4.5 describes some possible approach to deal with those categories where a linear regression method is not a suitable technique for estimating future VMTs.
- The results in Table 5-8 also indicate no apparent effect discernible from the historical trend line with respect to growth or decline in county population, i.e., the linear regression technique applies to all counties. Section 5.4.3 examines further the relationship between population and VMT.

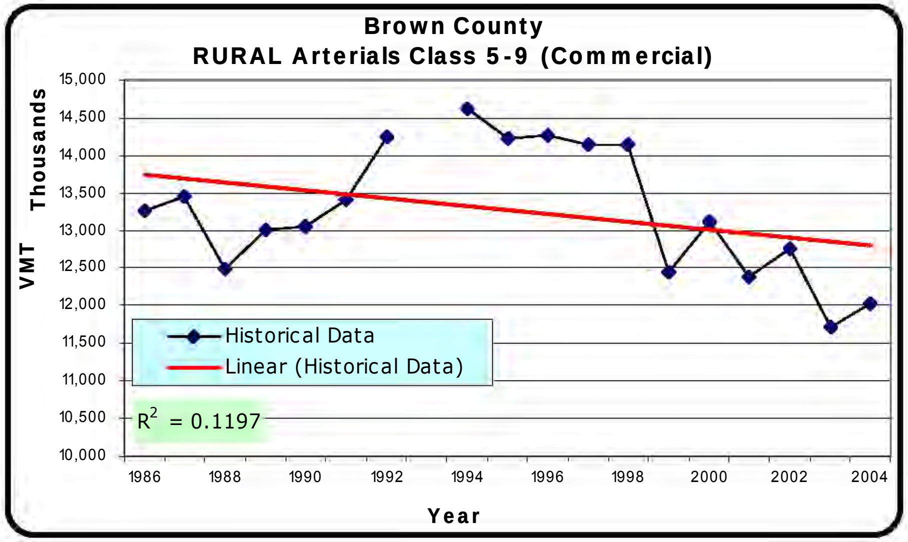
Table 5-8 R-Squared Values of VMT Linear Regressions by Categories After Adjustments

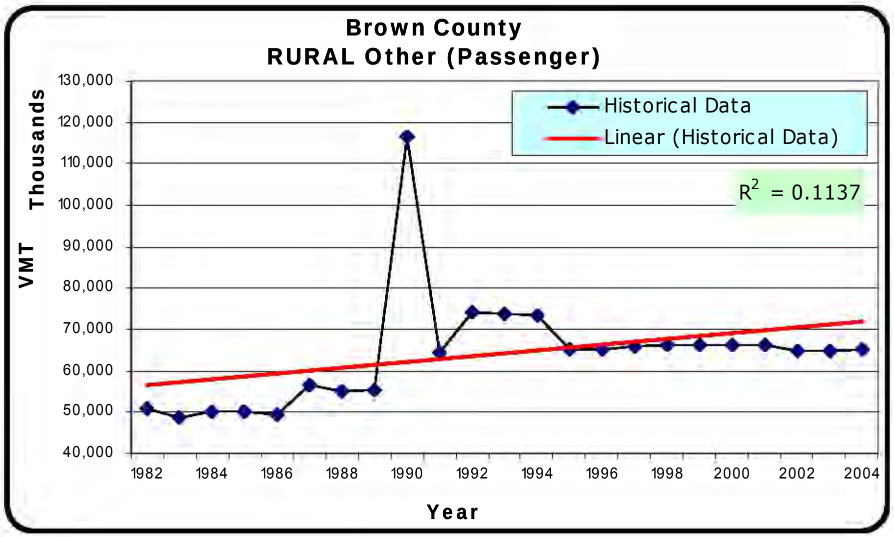
		Brown County		Buffalo County		Clay County		Lawrence County		Meade County		Pennington County		Roberts County		Todd County	
		Original	Changed	Original	Changed	Original	Changed	Original	Changed	Original	Changed	Original	Changed	Original	Changed	Original	Changed
RURAL	Interstate-Passenger	-	-	-	-	-	-	0.7947*	0.8884	0.9062	0.9327	0.4625	0.7931	0.9290	0.9379	-	-
RURAL	Interstate-Class 5-9	-	-	-	-	-	-	0.4919*	0.7383	0.7620	0.9014	0.0258	0.7931	0.7789	0.7789	-	-
RURAL	Interstate-Class 10-13	-	-	-	-	-	-	0.8989	0.9132	0.9084	0.9055	0.7582	0.8116	0.9151	0.8410	-	-
RURAL	Arterials Passenger	0.8345	0.8345	0.1188	0.1477	0.8179	0.8179	0.3057	0.3339	0.4155	0.4155	0.3607	0.3607	0.7755	0.7853	0.2162	0.7852
RURAL	Arterials-Class 5-9	0.1197	0.8523	0.0099	0.7612	0.2706	0.2706	0.1156	0.9361	0.4821	0.8499	0.2315	0.2315	0.0349	0.8413	0.1365	0.6162
RURAL	Arterials-Class 10-13	0.8908	0.9307	0.8848	0.9001	0.8688	0.9087	0.9024	0.8419	0.8745	0.8585	0.8704	0.7865	0.9151	0.9064	0.8669	0.8335
RURAL	Other-Passenger	0.1137	0.5324	0.0502	0.8760	0.1542	0.8395	0.3712	0.7332	0.1655	0.4595	0.2049	0.2049	0.4437	0.5386	0.2137	0.4616
URBAN	Interstate-Passenger	-	-	-	-	-	-	0.3284*	0.7707	0.4058*	0.8231	0.7803*	0.8530	-	-	-	-
URBAN	Interstate-Class 5-9	-	-	-	-	-	-	0.4919*	0.7006	0.4724*	0.7238	0.7377*	0.7867	-	-	-	-
URBAN	Interstate-Class 10-13	-	-	-	-	-	-	0.4429*	0.7006	0.4165*	0.7137	0.5851*	0.7637	-	-	-	-
URBAN	Arterials Passenger	0.7446	0.7446	-	-	0.5929	0.5929	0.7935	0.7728	0.7704*	0.8328	0.8274	0.8274	-	-	-	-
URBAN	Arterials-Class 5-9	0.2665	0.2665	-	-	0.1593	0.1593	0.7166	0.9281	0.2847	0.8942	0.0436	0.8638	-	-	-	-
URBAN	Arterials-Class 10-13	0.7851	0.8481	-	-	0.8293	0.8722	0.7258*	0.9281	0.6473*	0.8942	0.7422	0.8638	-	-	-	-
URBAN	Other-Passenger	0.0063	0.4085	-	-	0.3774	0.1272	0.7638	0.7660	0.5445	0.5445	0.3845	0.3845	-	-	-	-

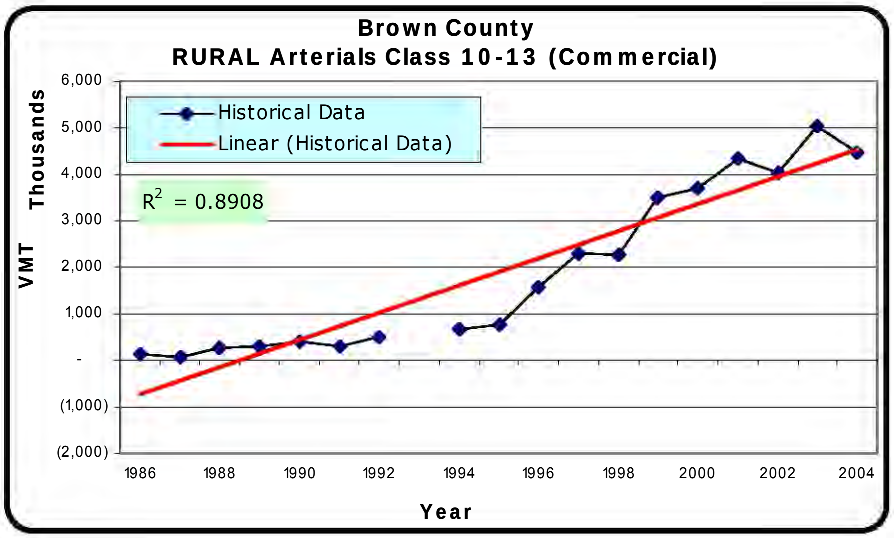
Route reclassification
Data outlier
** Sharp increase/significant decrease in 2004 VMT*

BROWN COUNTY

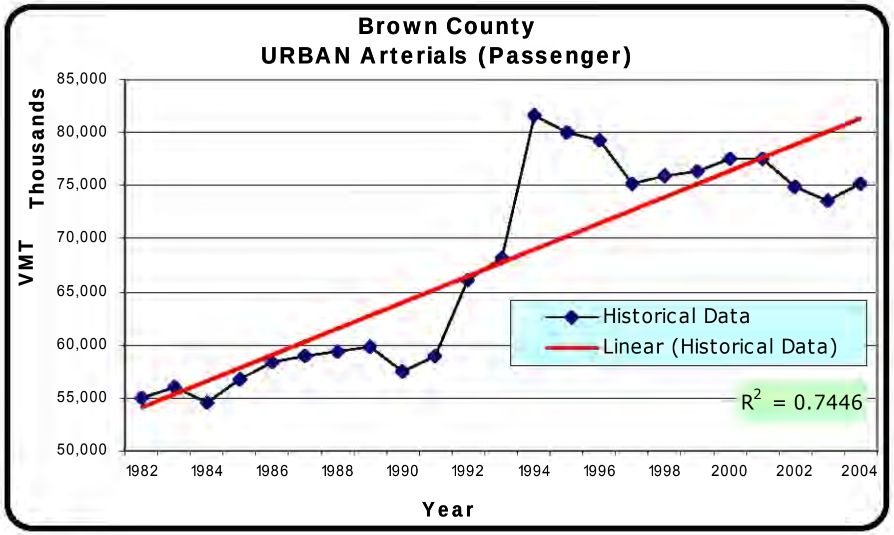


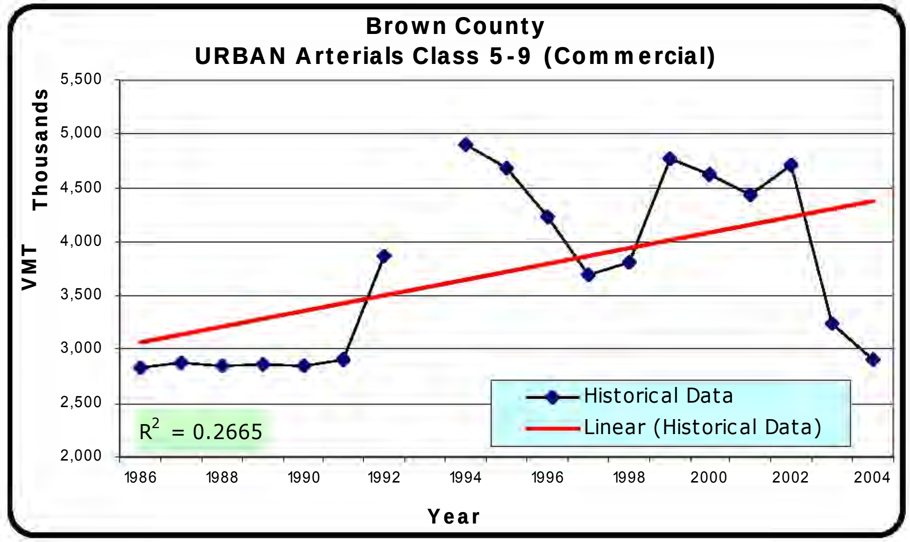


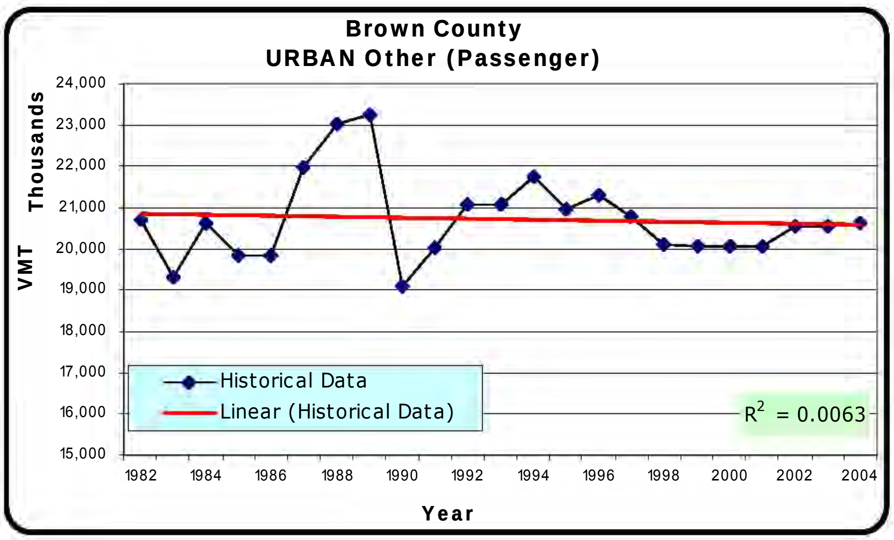


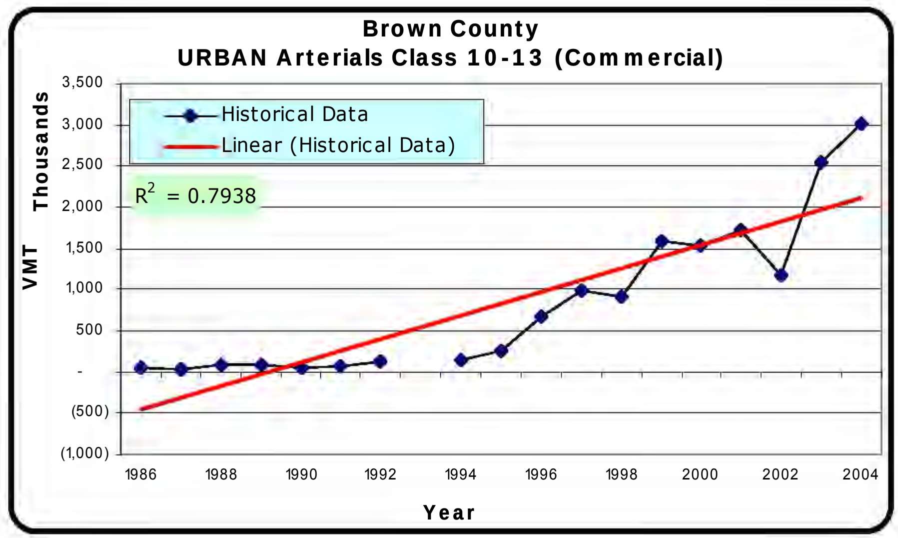


BROWN COUNTY

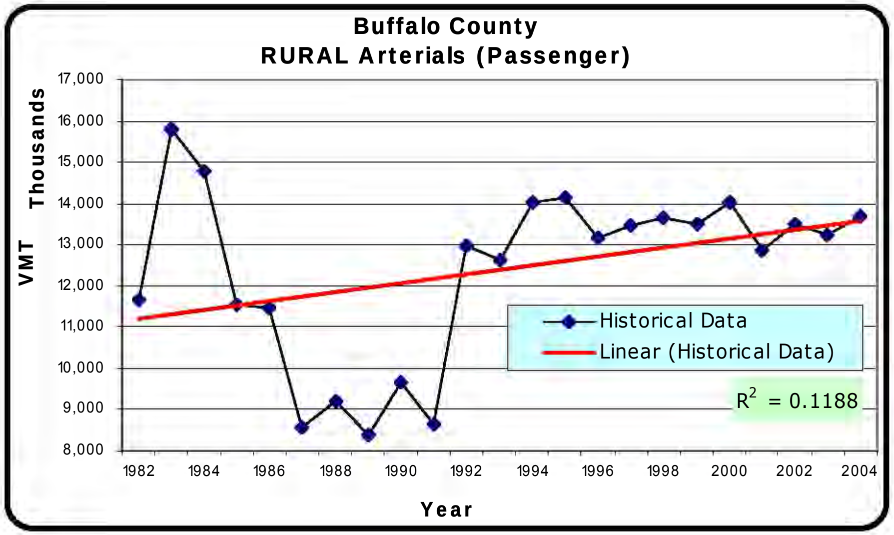


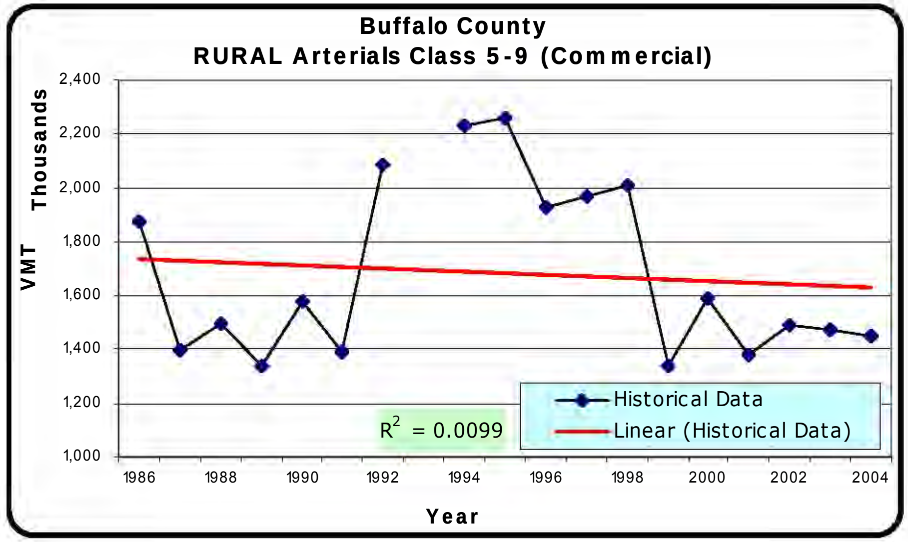


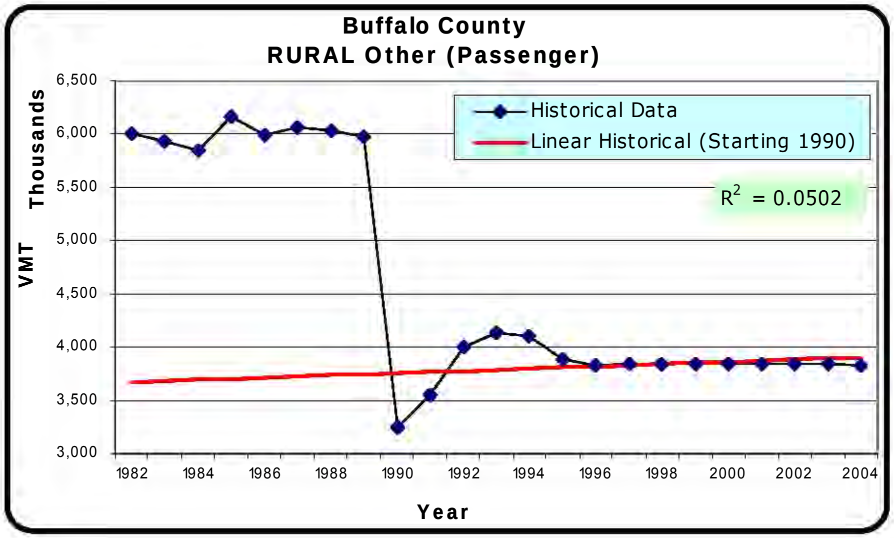


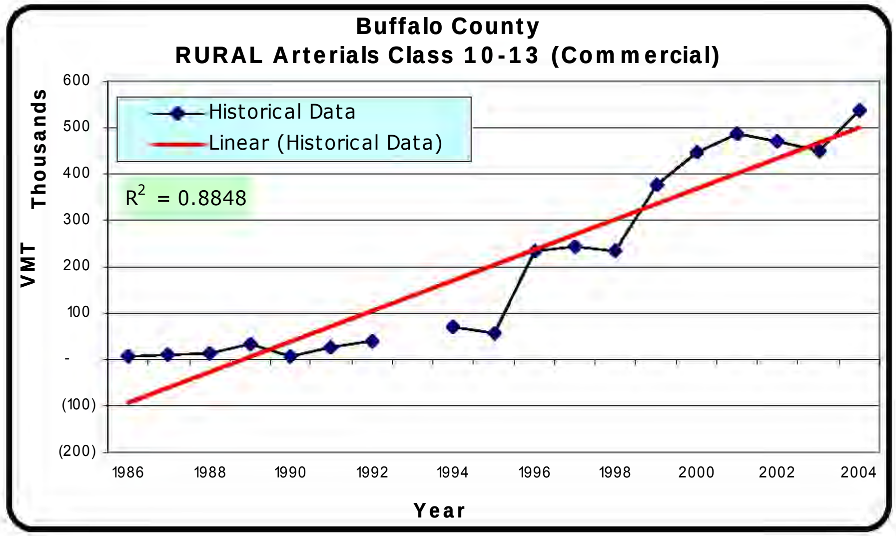


BUFFALO COUNTY

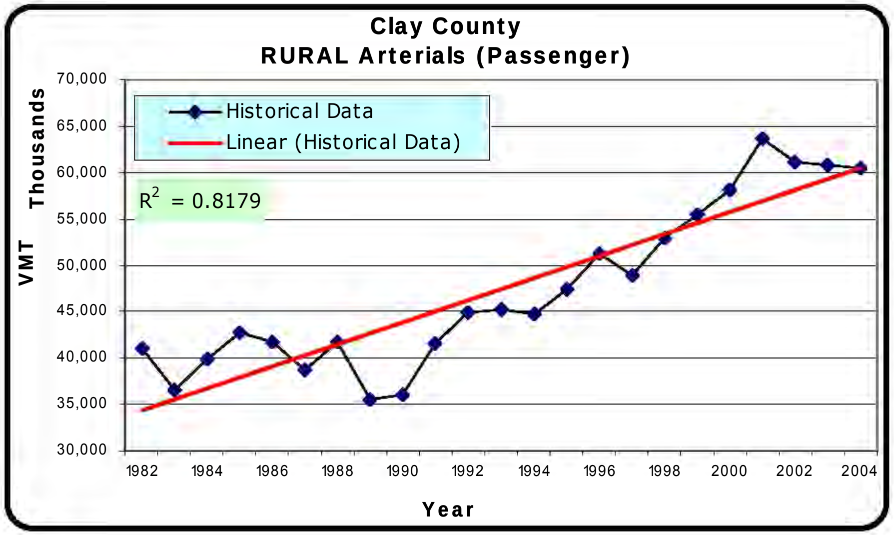








CLAY COUNTY


Clay County
RURAL Arterials (Passenger)
Historical Data
Linear (Historical Data)
R² = 0.8179
VMT Thousands
70,000
65,000
60,000
55,000
50,000
45,000
40,000
35,000
30,000
1982
1984
1986
1988
1990
1992
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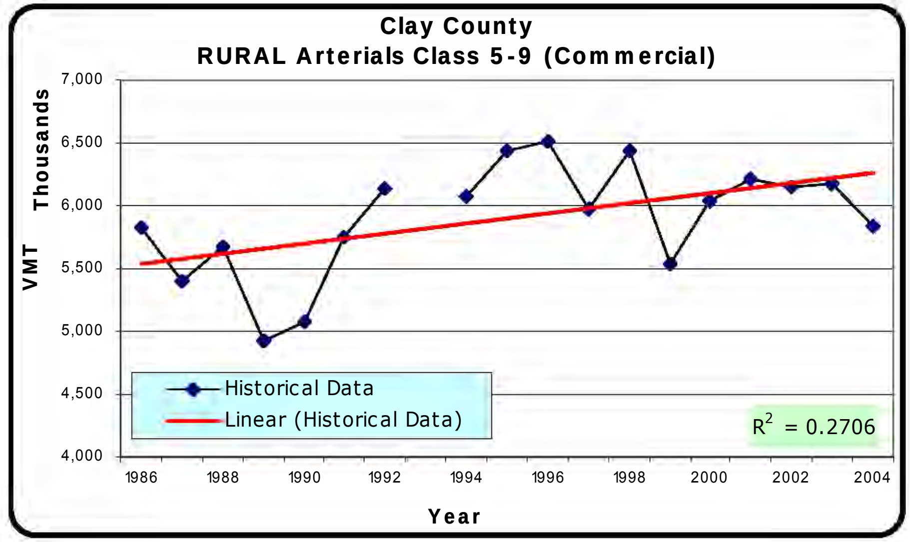
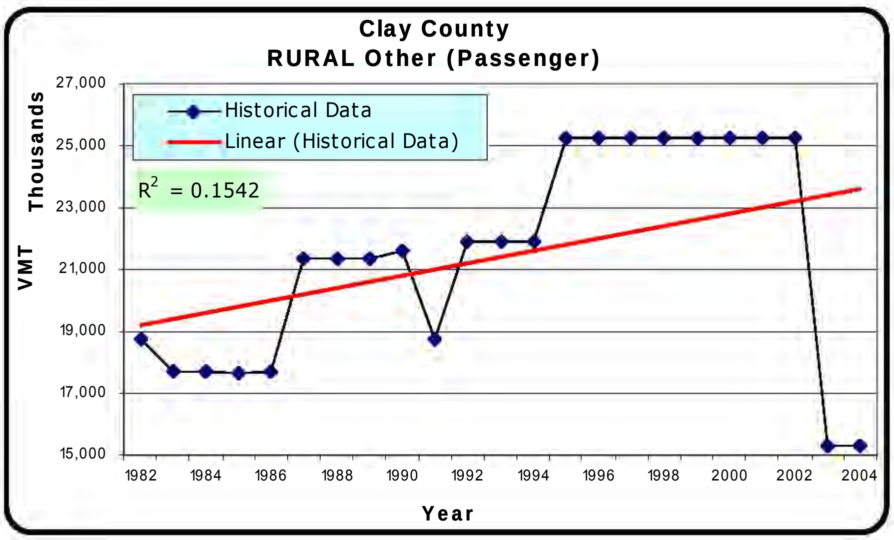
1996
1998
2000
2002
2004
Year


Clay County
RURAL Arterials Class 5-9 (Commercial)
Historical Data
Linear (Historical Data)
R² = 0.2706
VMT Thousands
7,000
6,500
6,000
5,500
5,000
4,500
4,000
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Year


Clay County
RURAL Other (Passenger)
Historical Data
Linear (Historical Data)
R² = 0.1542
VMT Thousands
27,000
25,000
23,000
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17,000
15,000
1982
1984
1986
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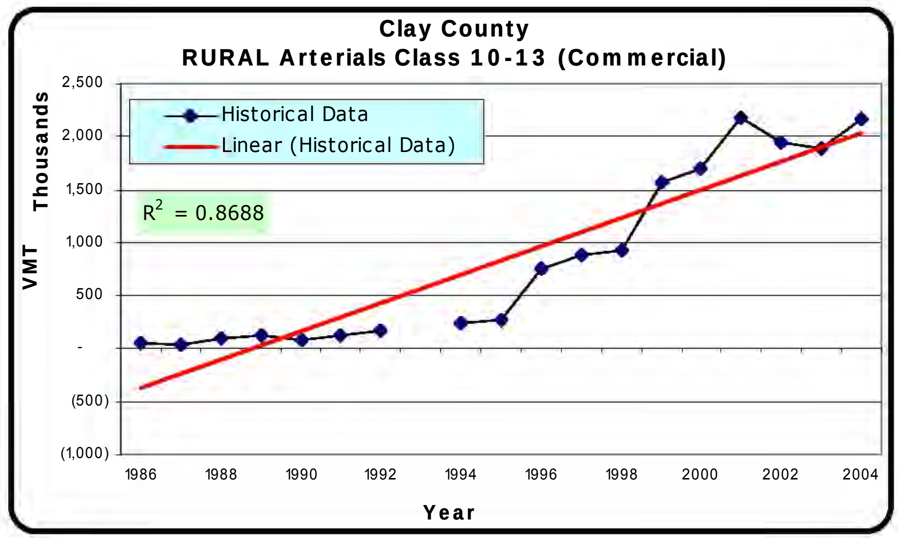
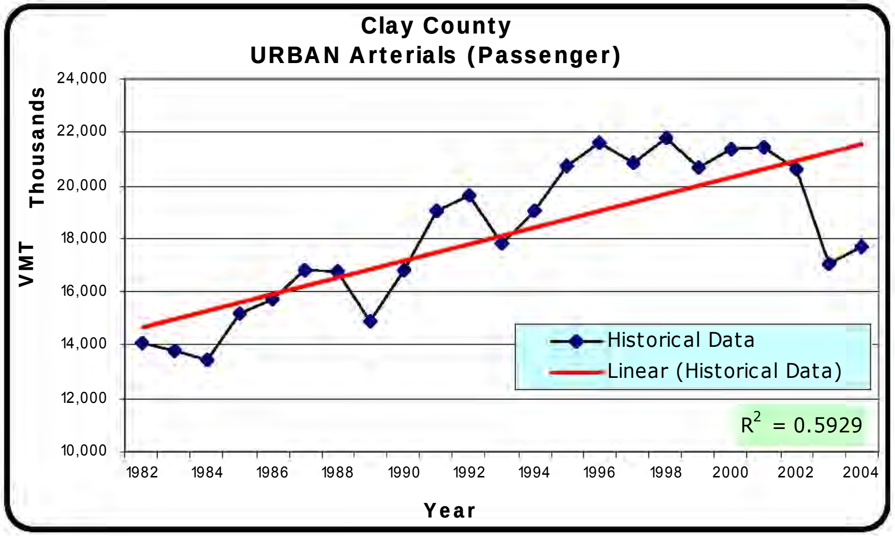
1998
2000
2002
2004
Year


Clay County
RURAL Arterials Class 10-13 (Commercial)
Historical Data
Linear (Historical Data)
R² = 0.8688
VMT Thousands
2,500
2,000
1,500
1,000
500
-
(500)
(1,000)
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Year

CLAY COUNTY


Clay County
URBAN Arterials (Passenger)
VMT Thousands
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
1982
1984
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1992
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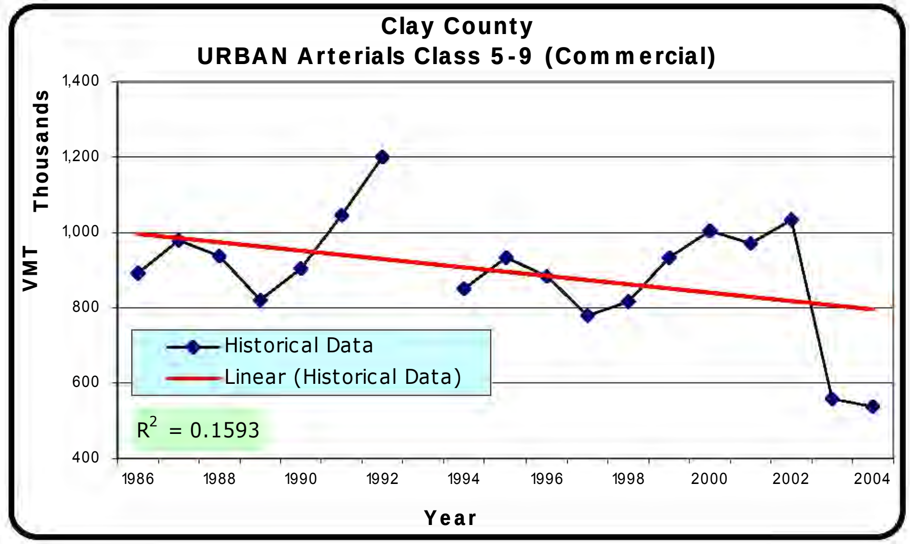
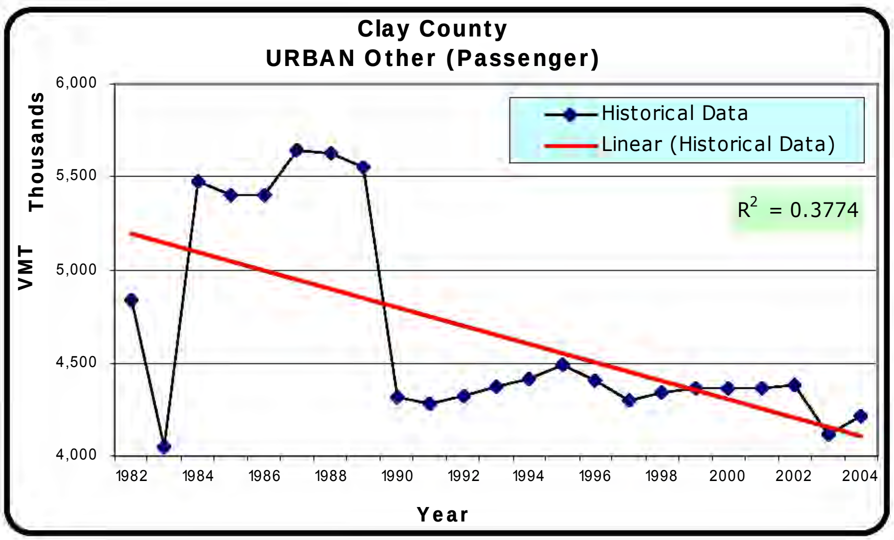
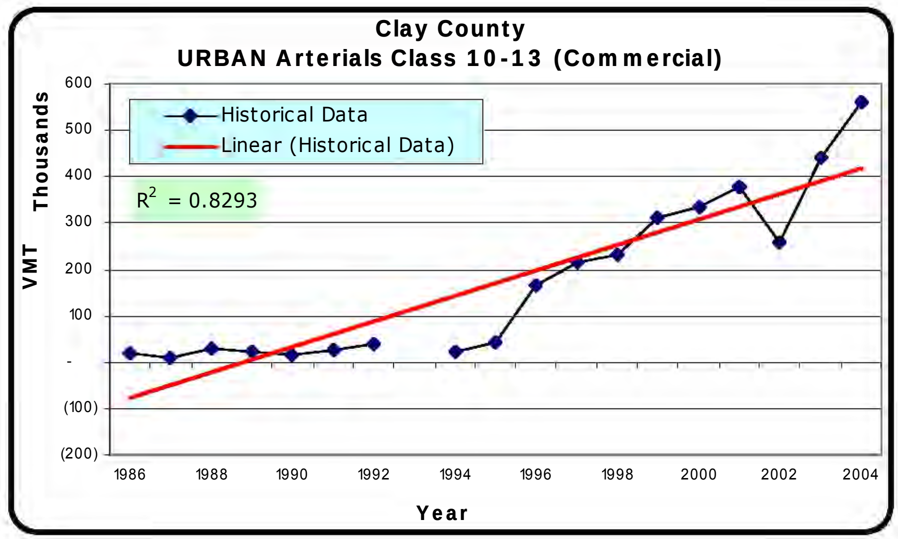
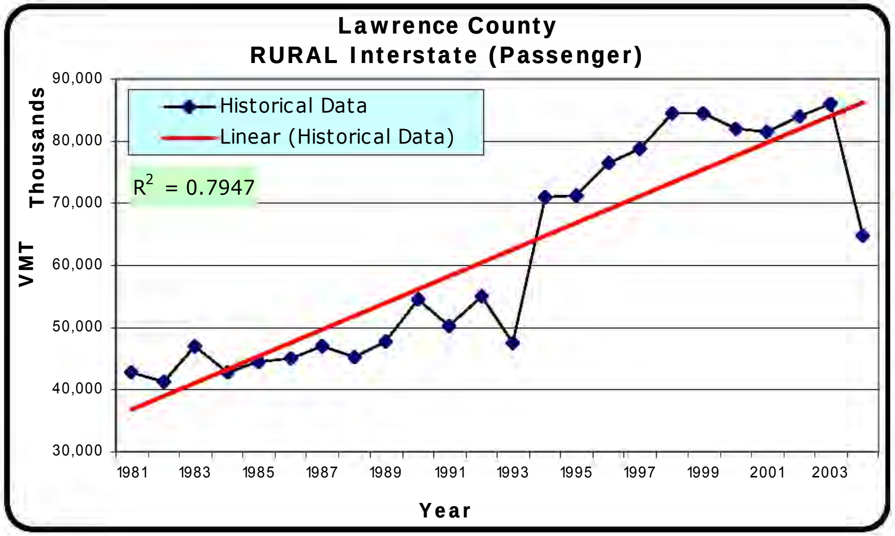
1996
1998
2000
2002
2004
Year
Historical Data
Linear (Historical Data)
R2 = 0.5929

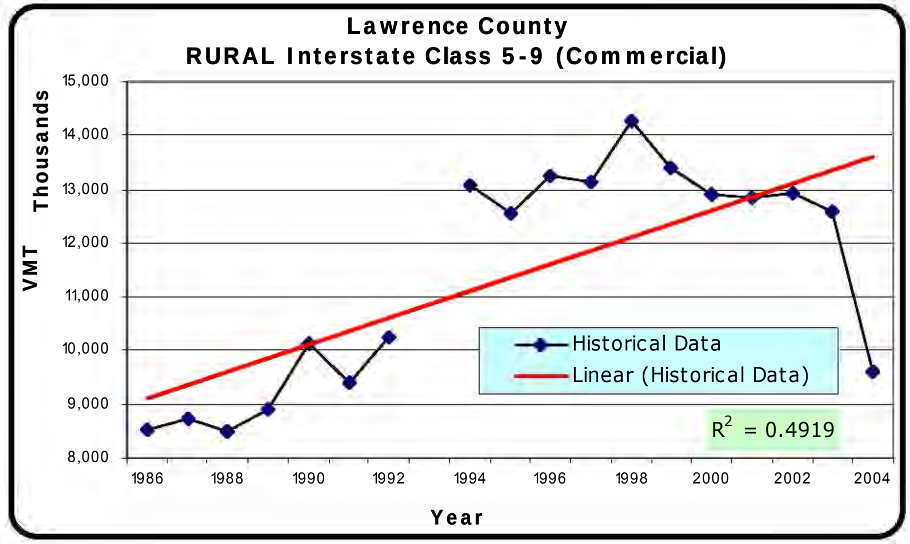

Clay County
URBAN Arterials Class 5-9 (Commercial)
VMT Thousands
1,400
1,200
1,000
800
600
400
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Year
Historical Data
Linear (Historical Data)
R2 = 0.1593

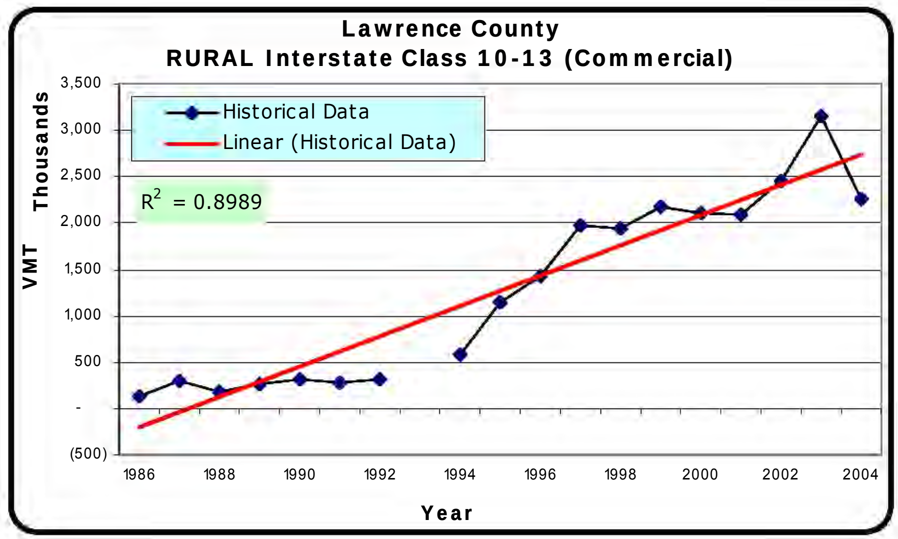

Clay County
URBAN Other (Passenger)
VMT Thousands
6,000
5,500
5,000
4,500
4,000
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Year
Historical Data
Linear (Historical Data)
R2 = 0.3774


Clay County
URBAN Arterials Class 10-13 (Commercial)
VMT Thousands
600
500
400
300
200
100
-
(100)
(200)
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Year
Historical Data
Linear (Historical Data)
R2 = 0.8293

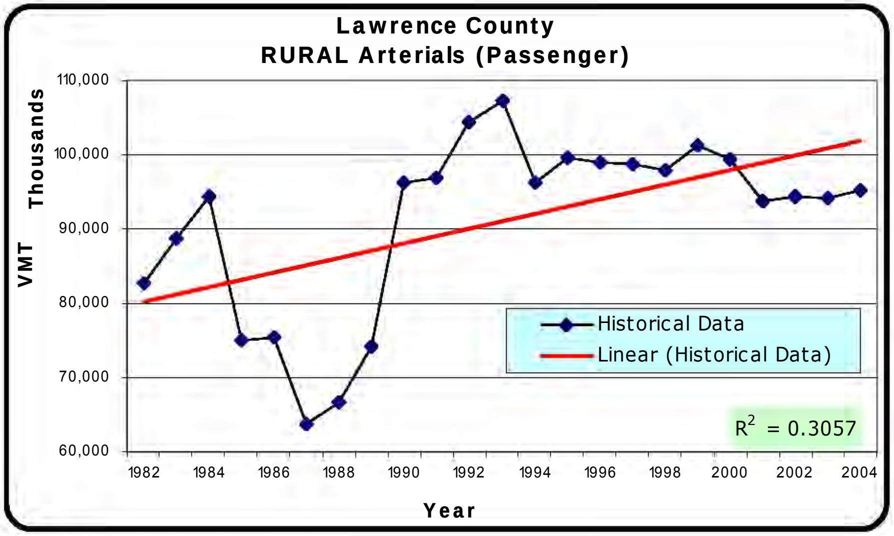
LAWRENCE COUNTY

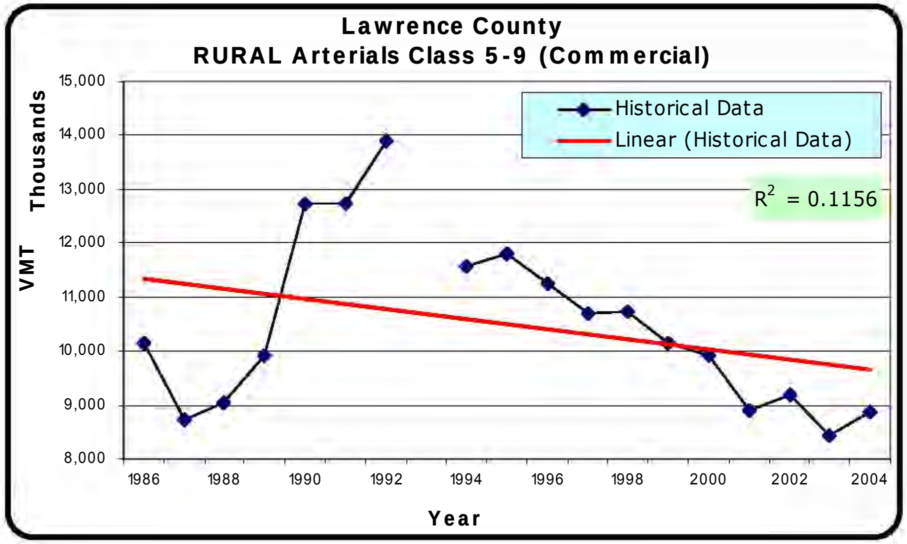


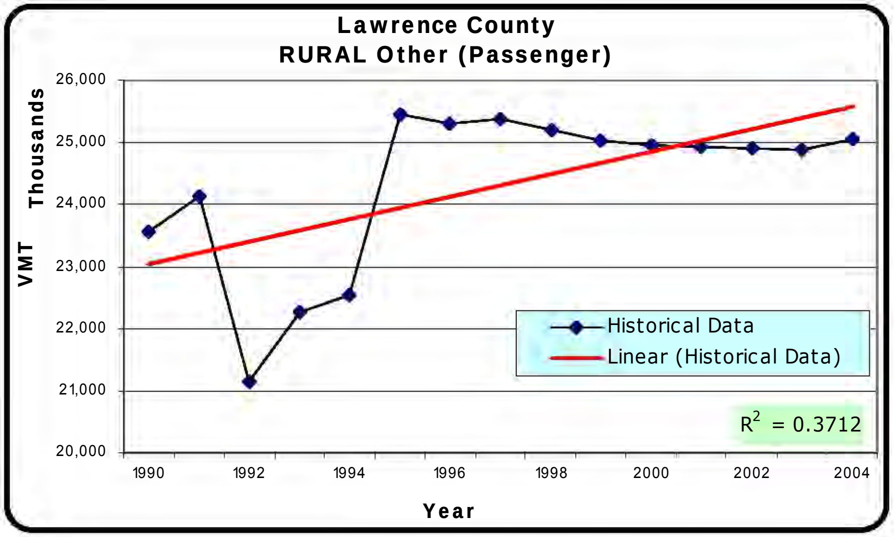


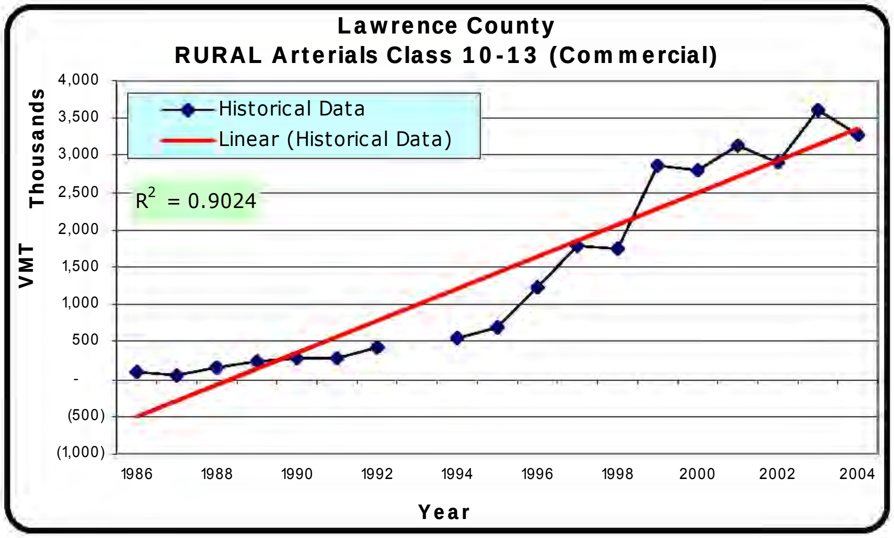


LAWRENCE COUNTY

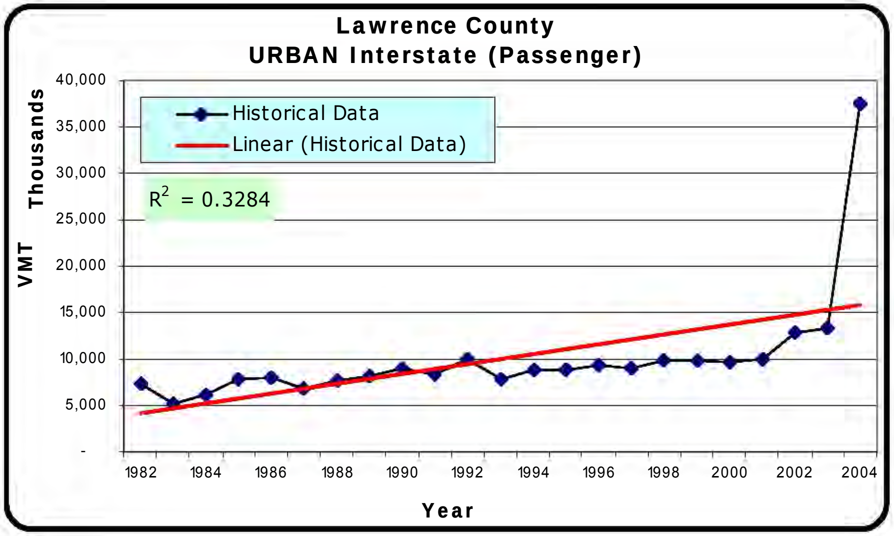


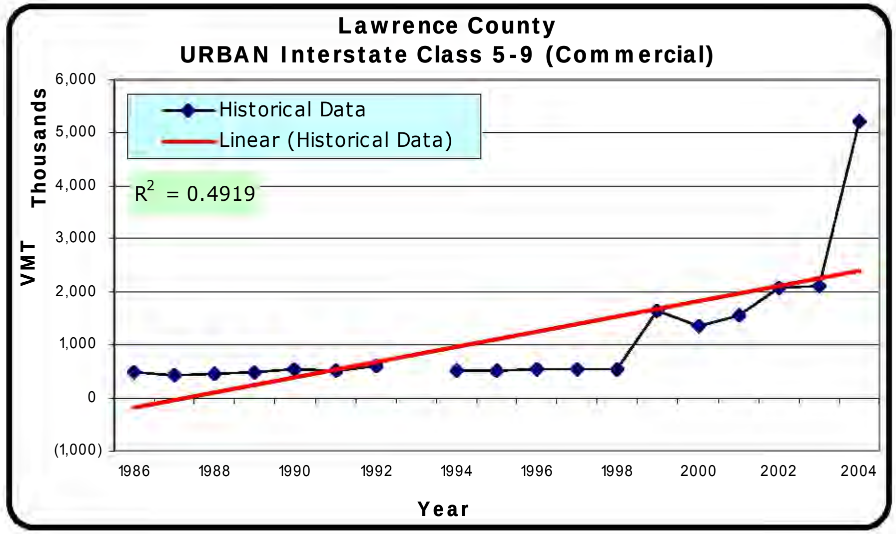


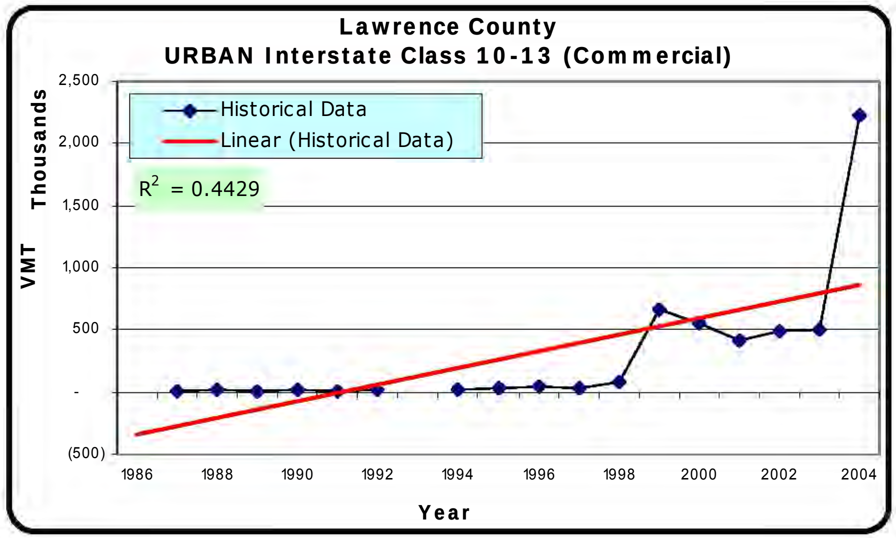




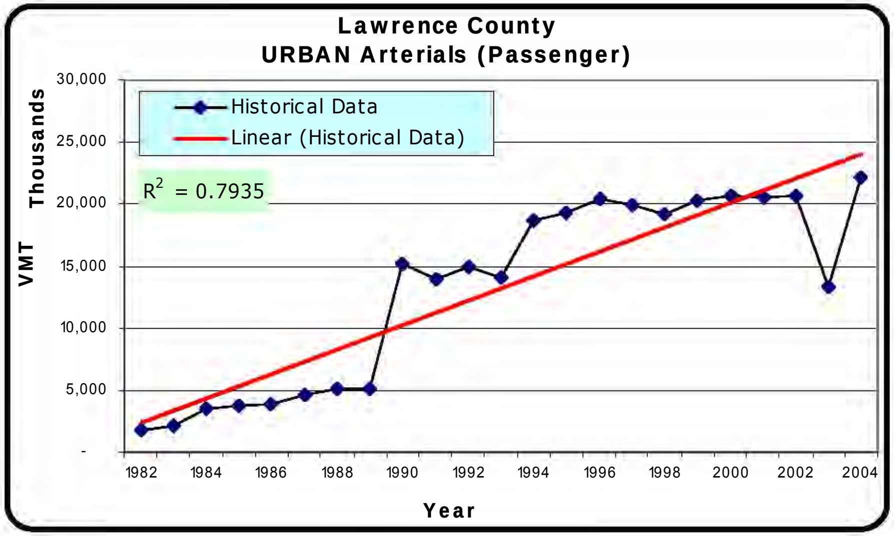
LAWRENCE COUNTY

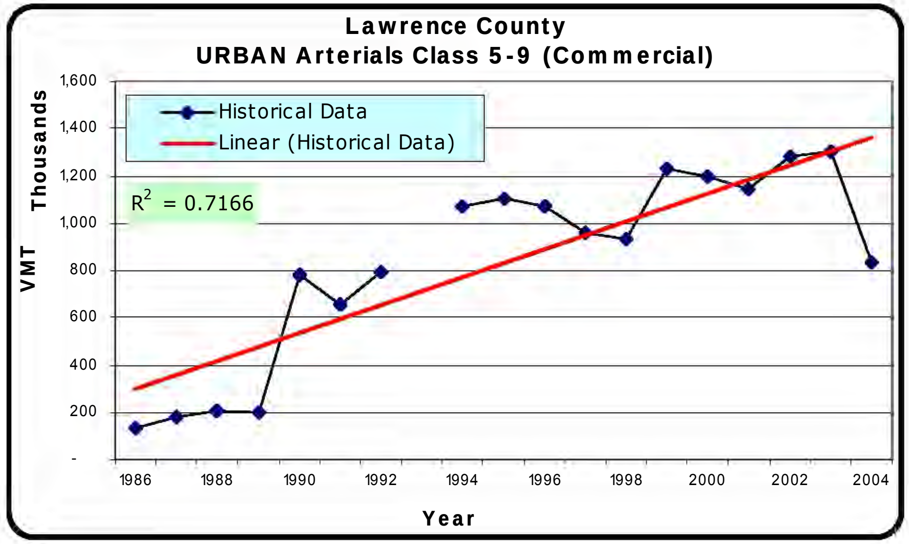


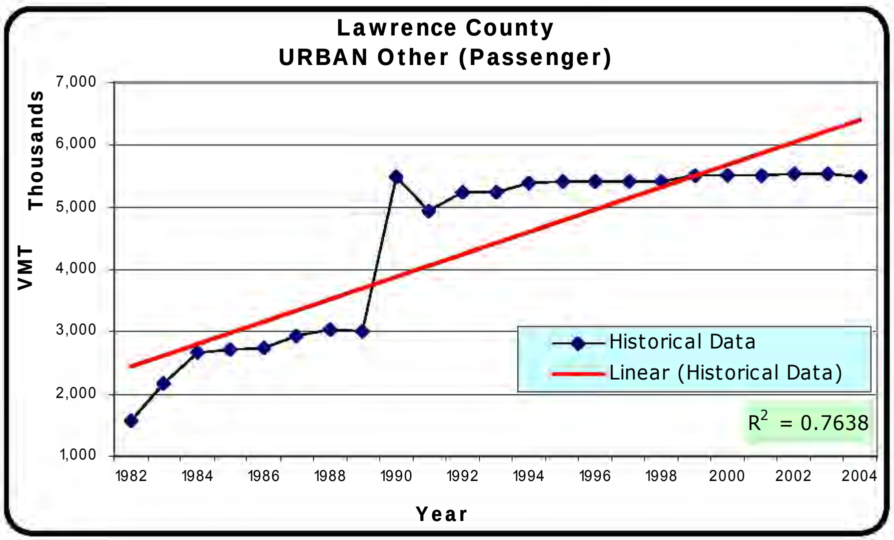


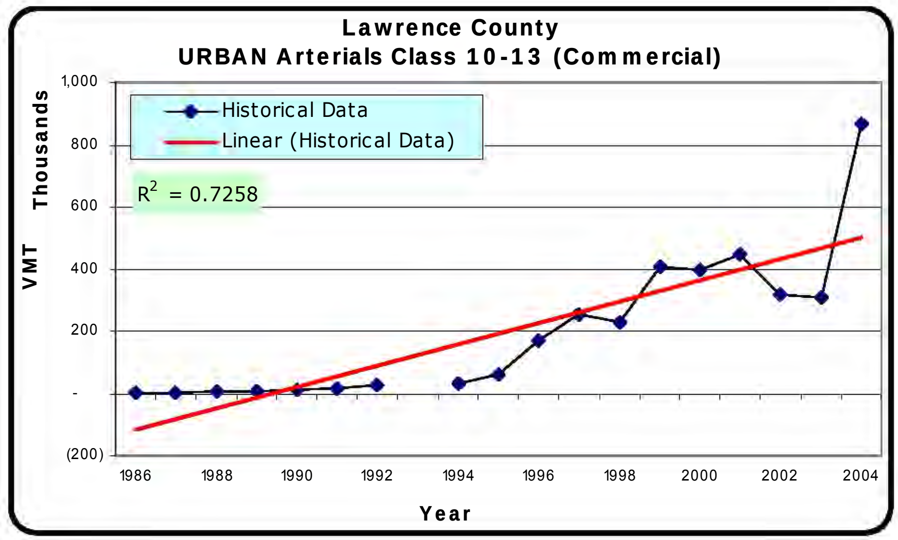


LAWRENCE COUNTY

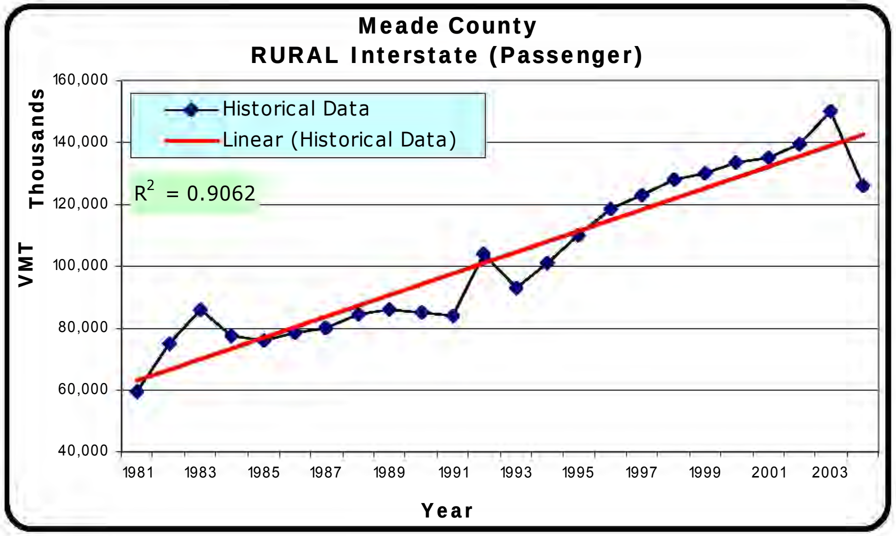


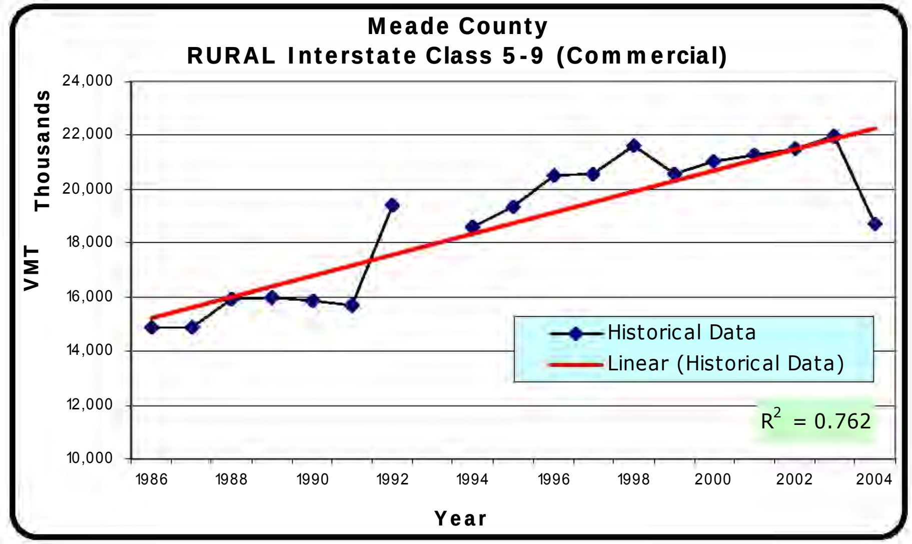


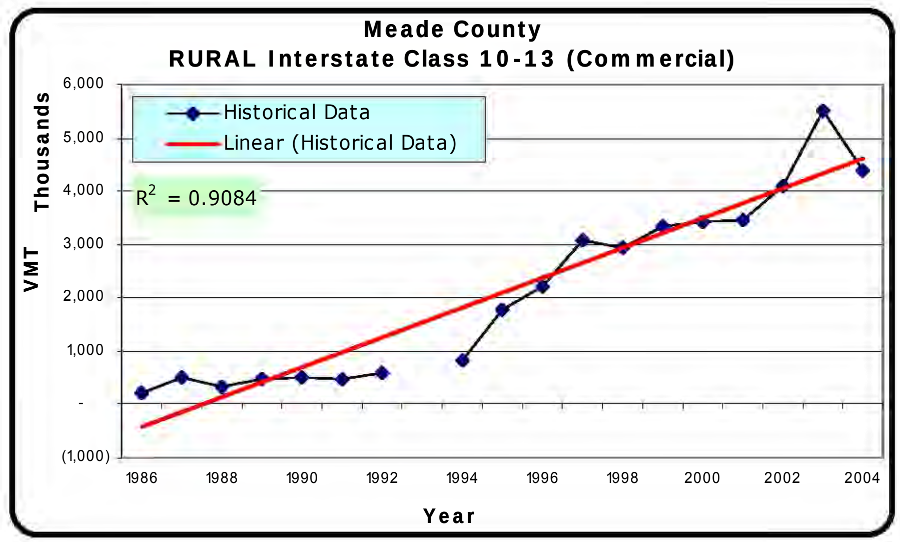




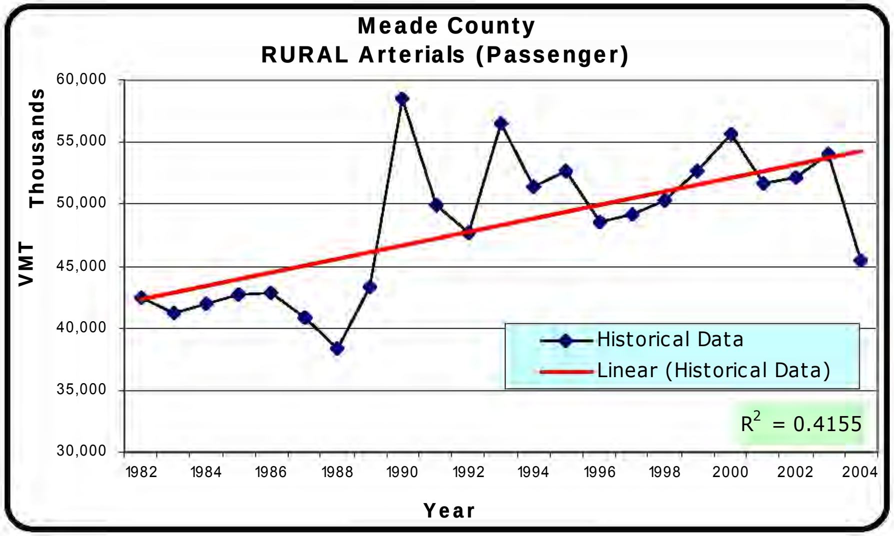
MEADE COUNTY

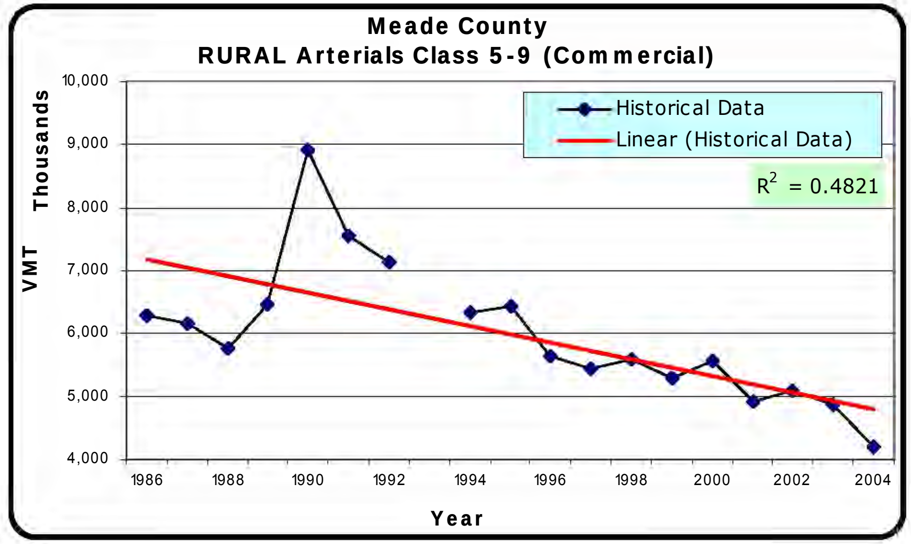


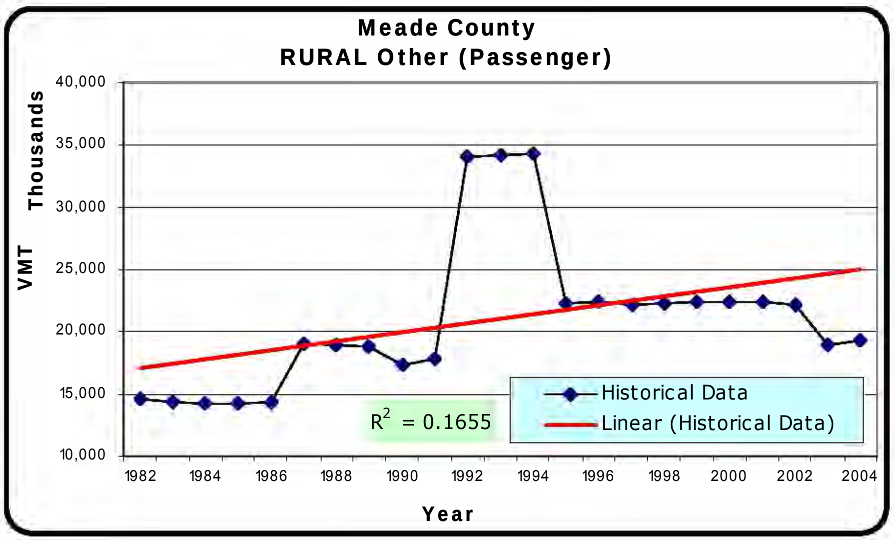


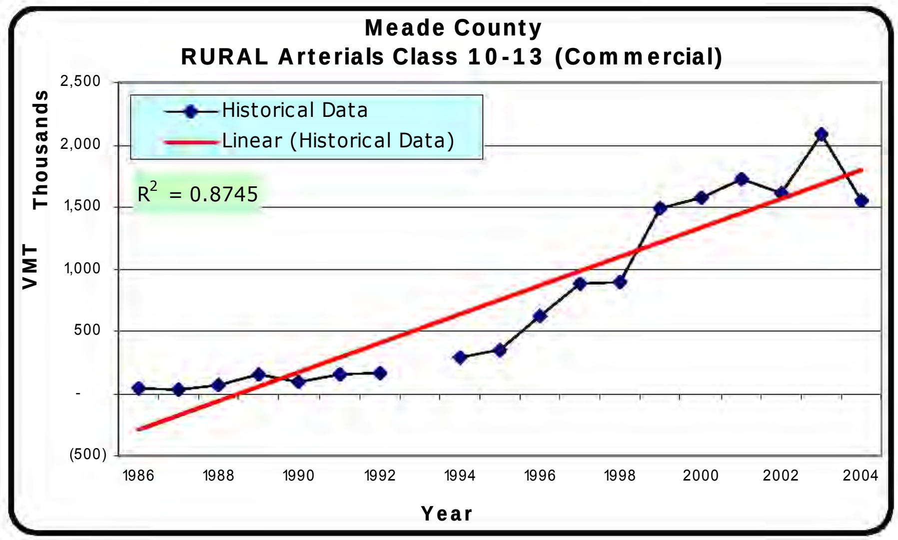


MEADE COUNTY

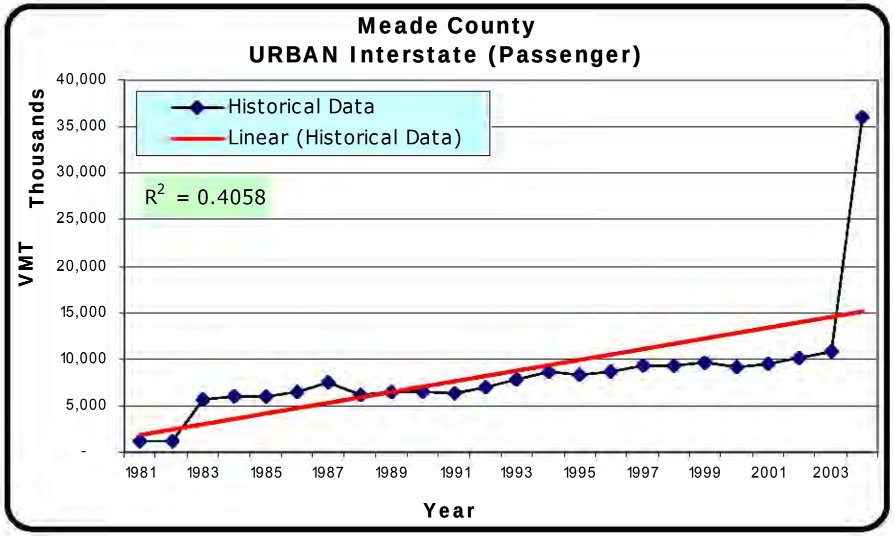


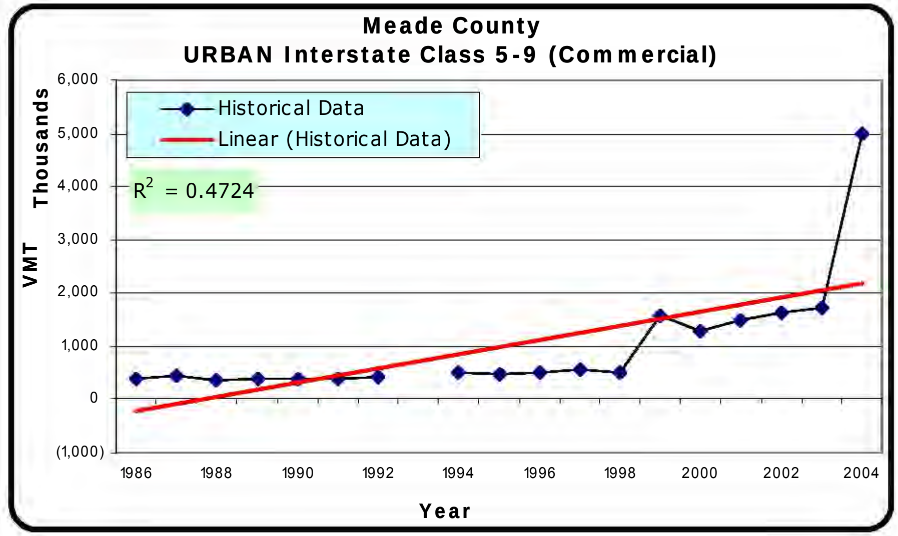


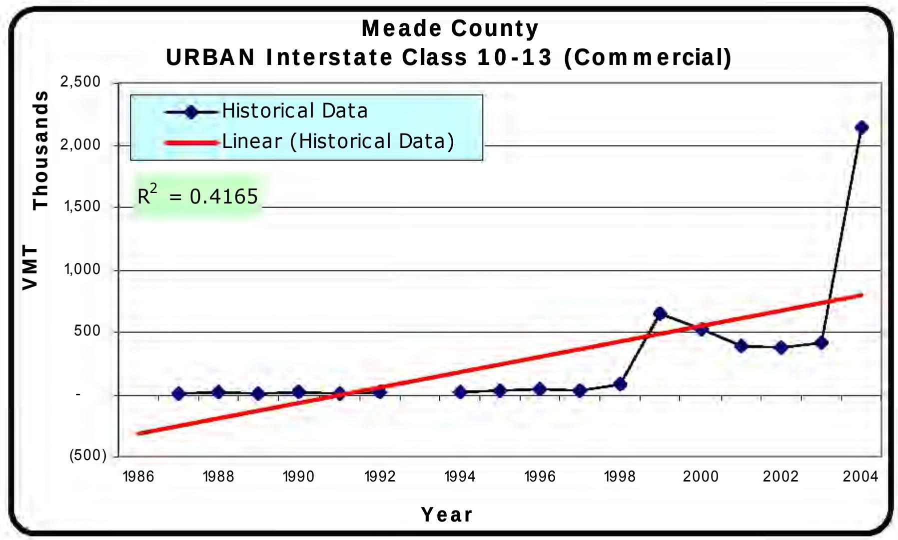




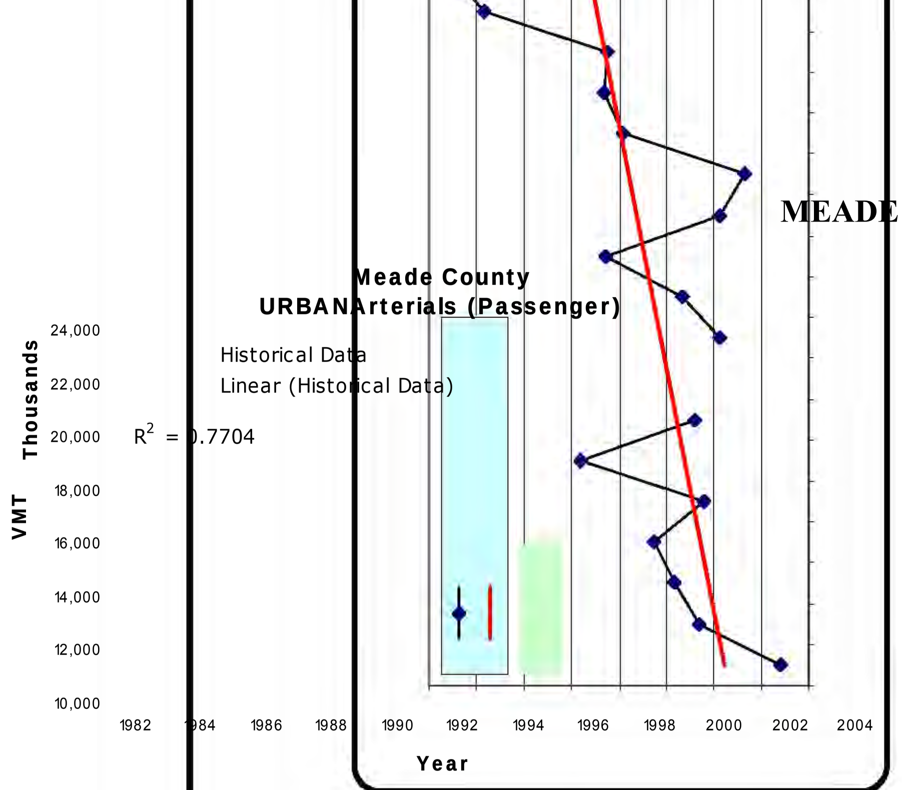
MEADE COUNTY

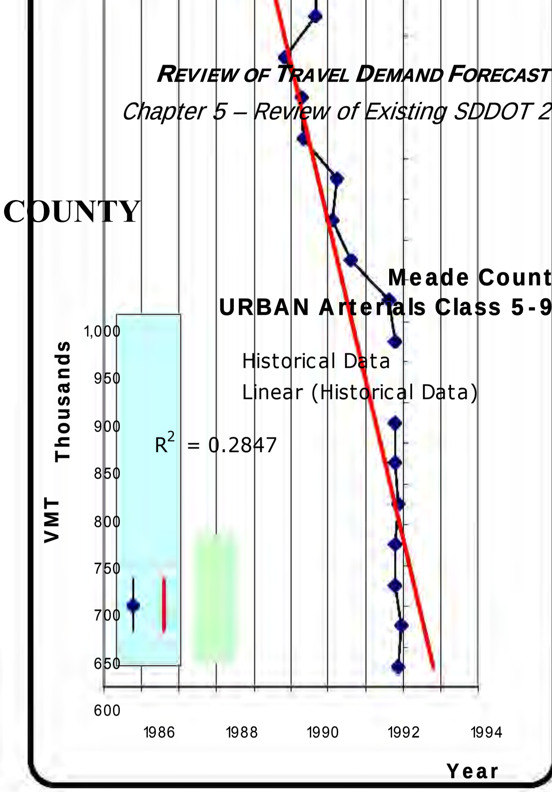


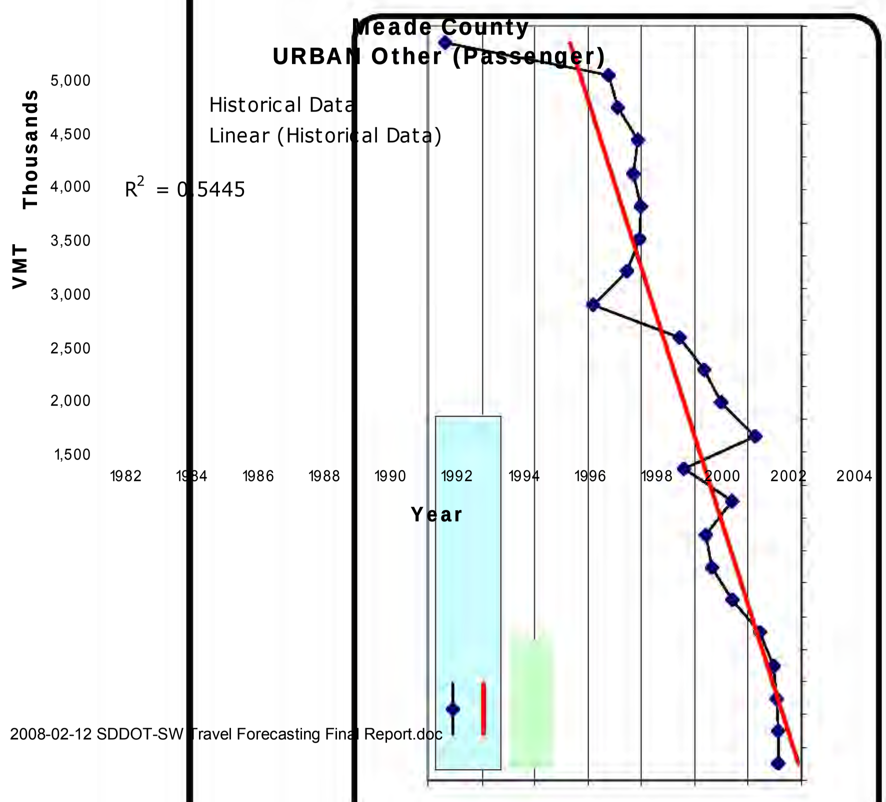


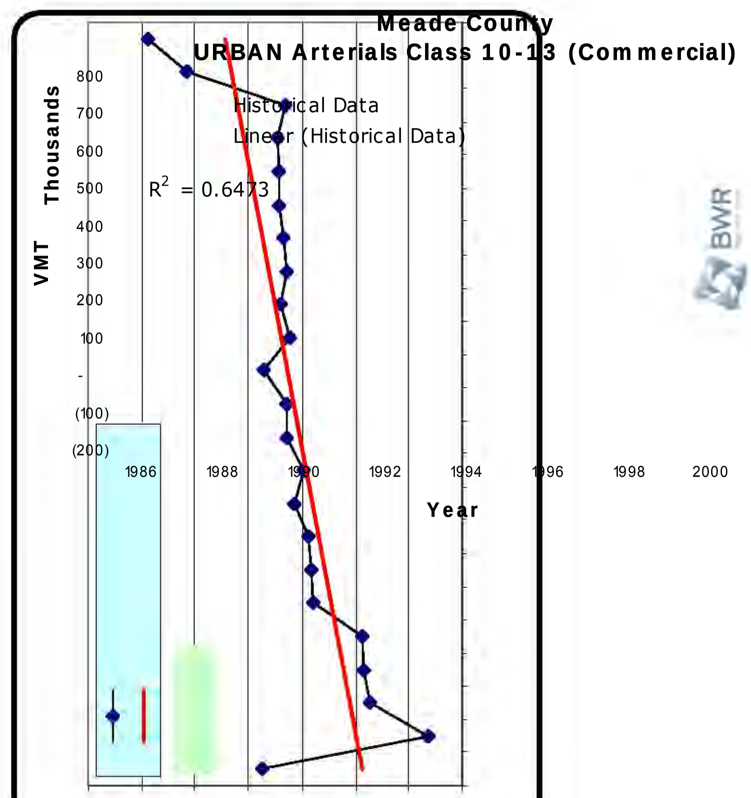


MEADE COUNTY

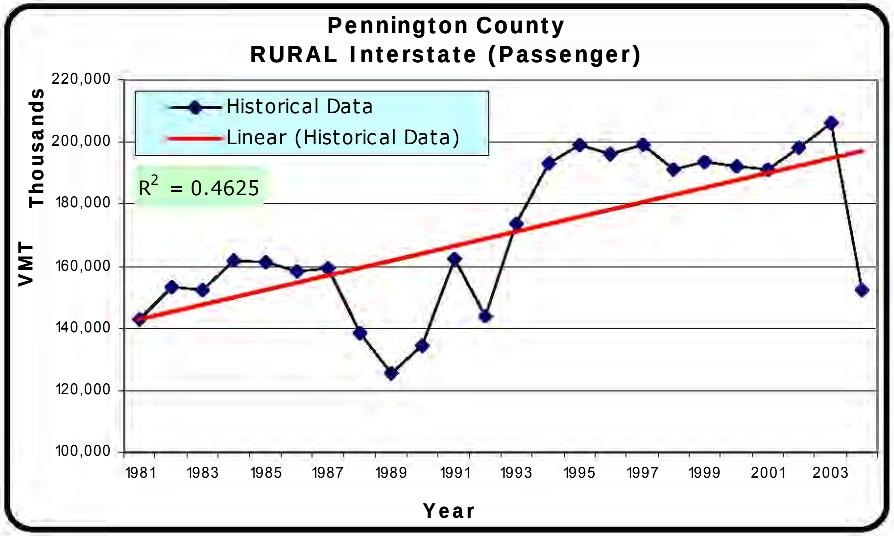


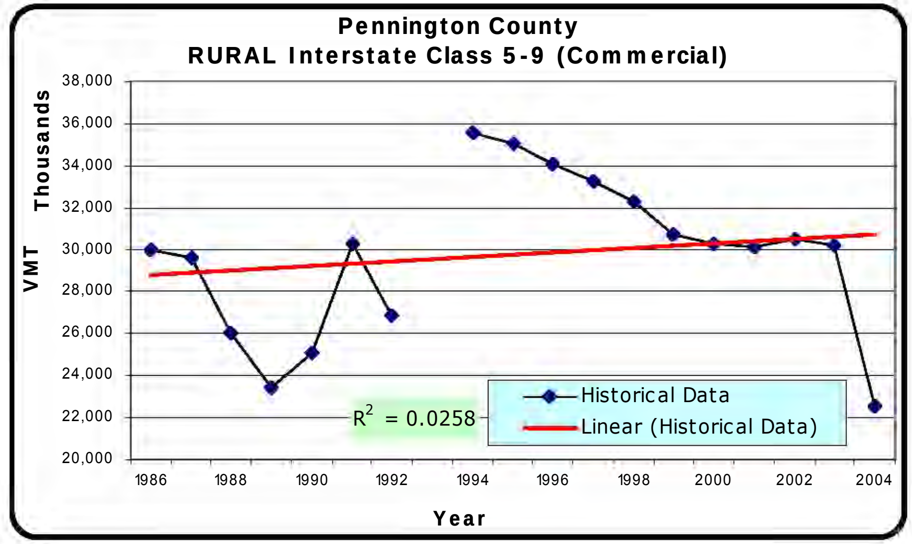


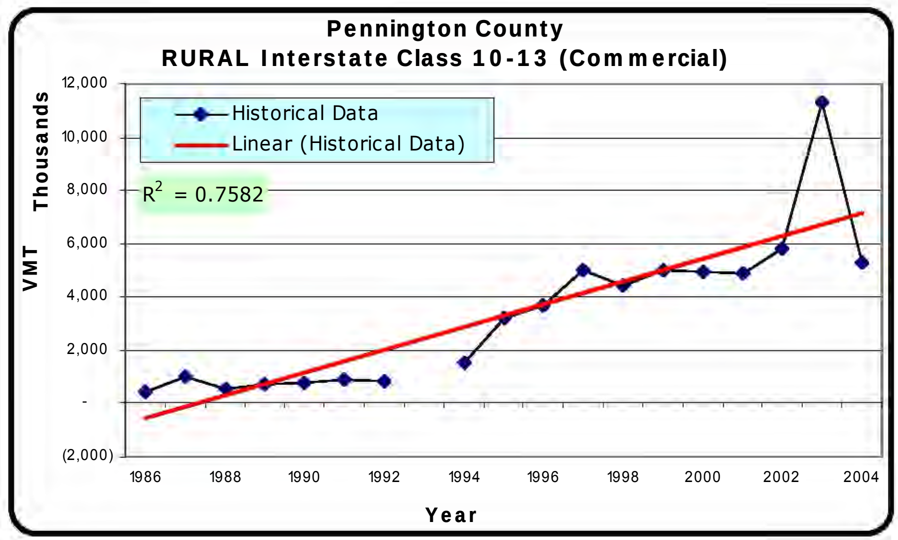




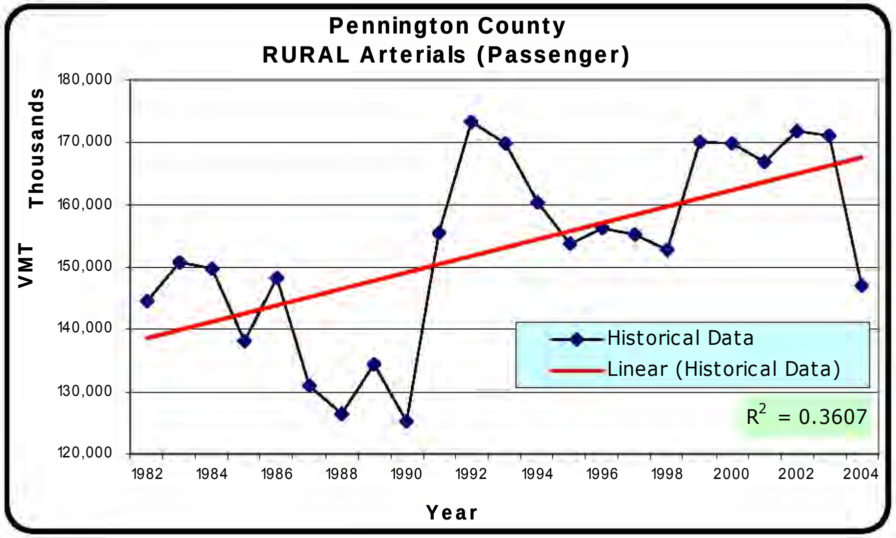
PENNINGTON COUNTY

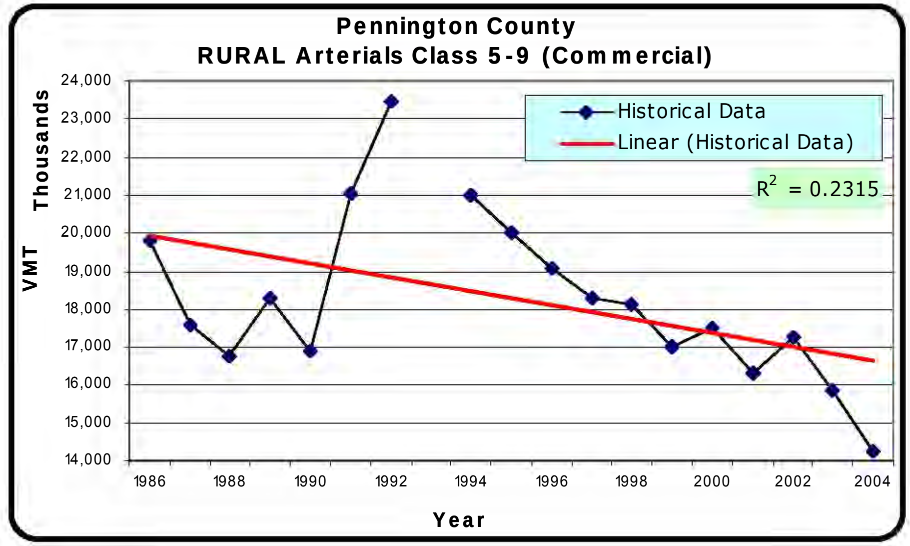


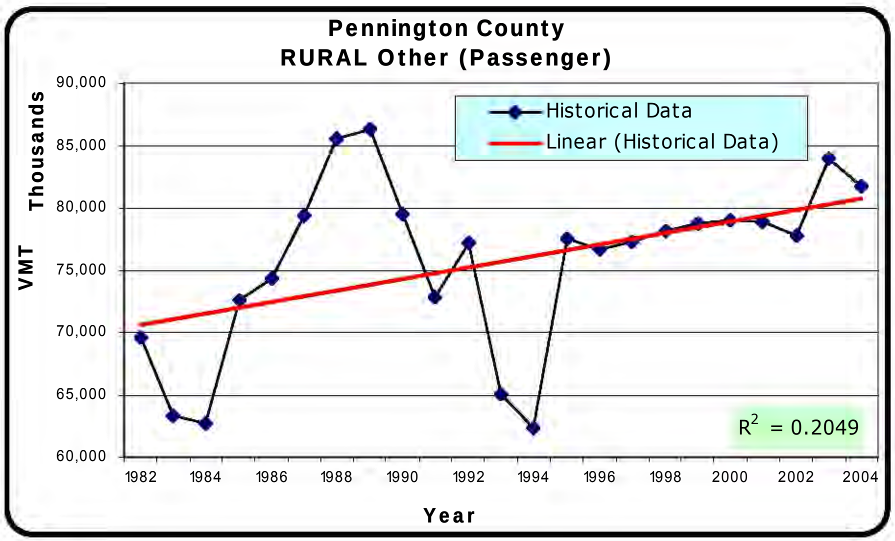


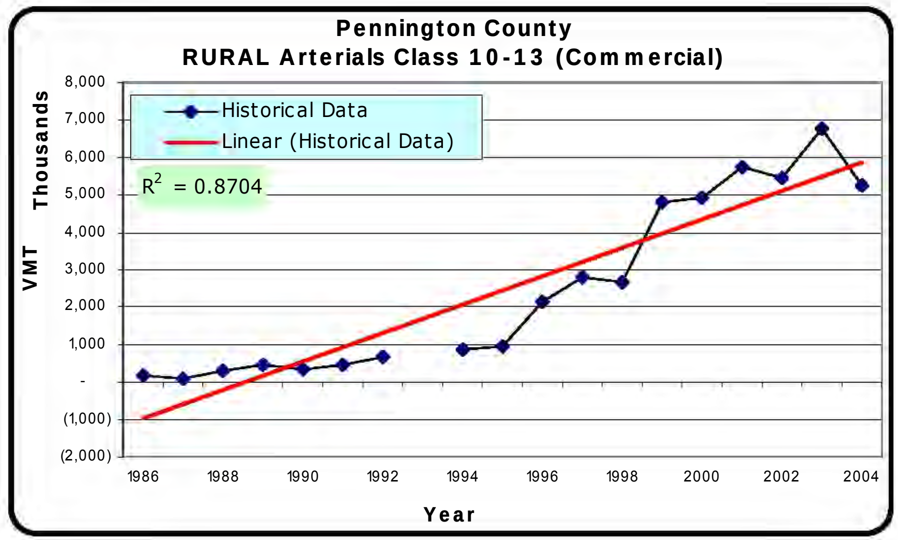


PENNINGTON COUNTY

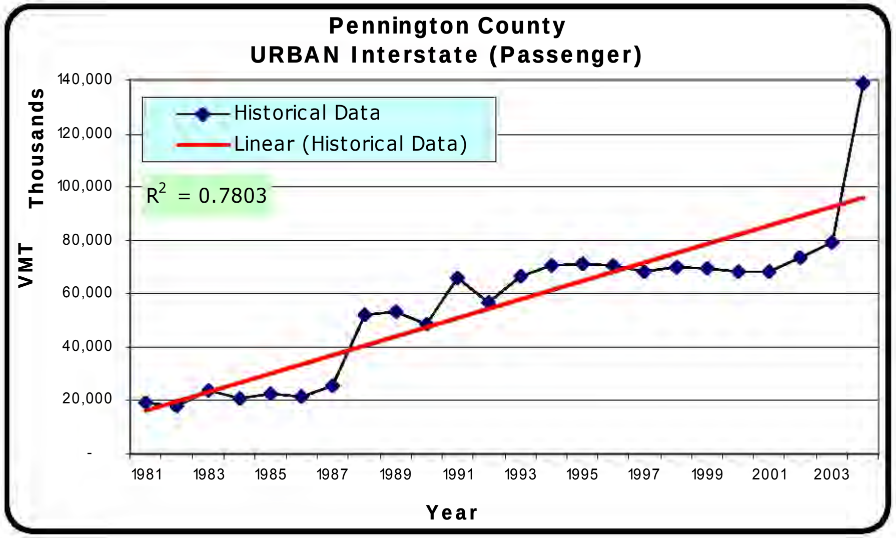


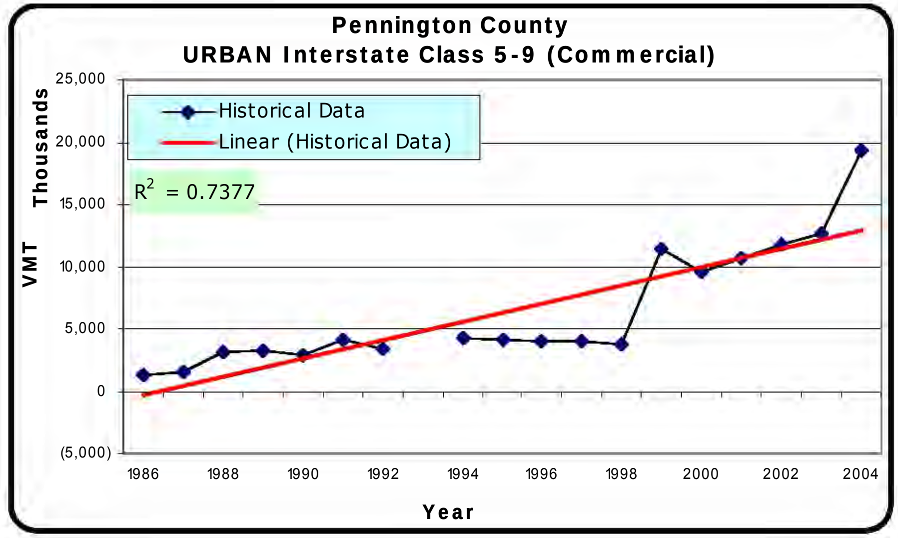


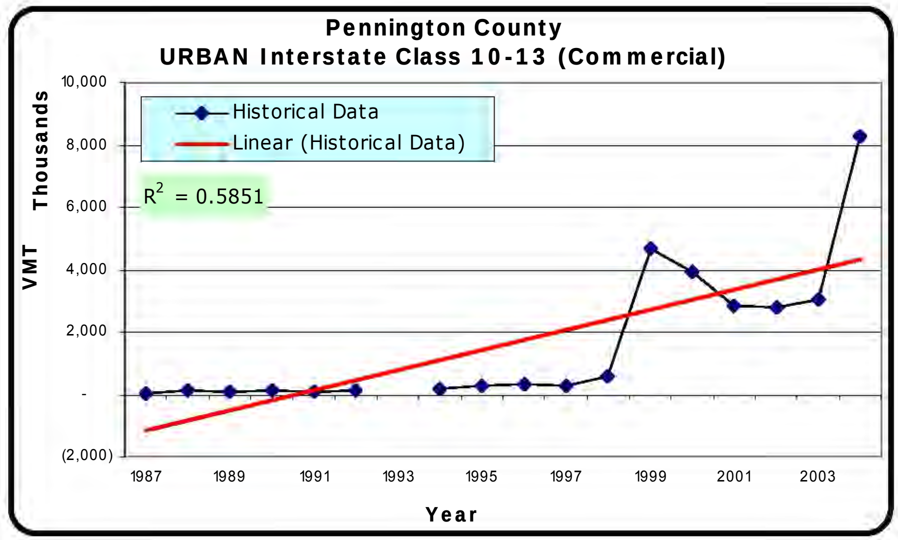




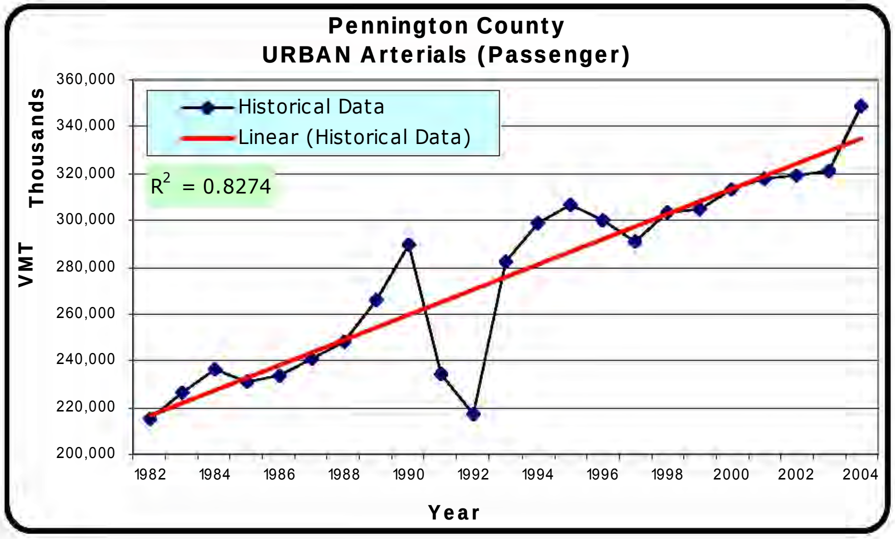
PENNINGTON COUNTY

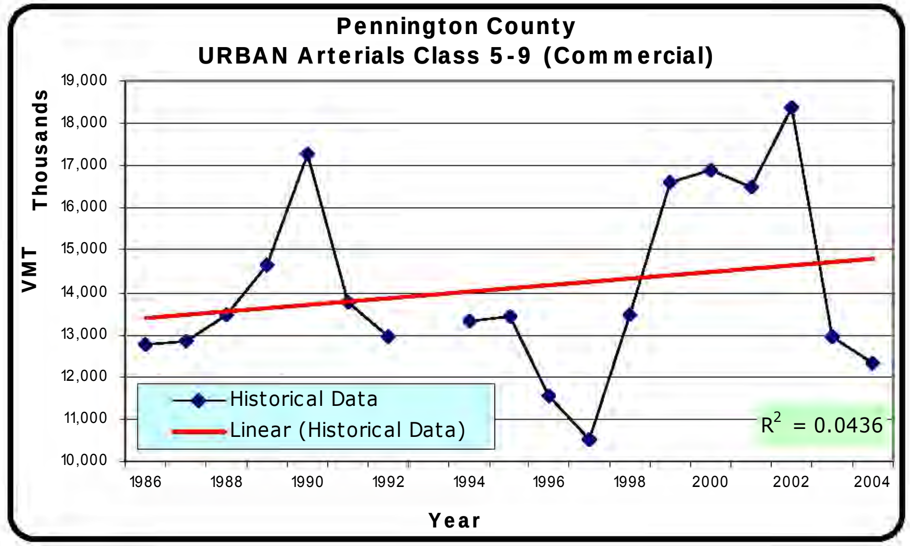


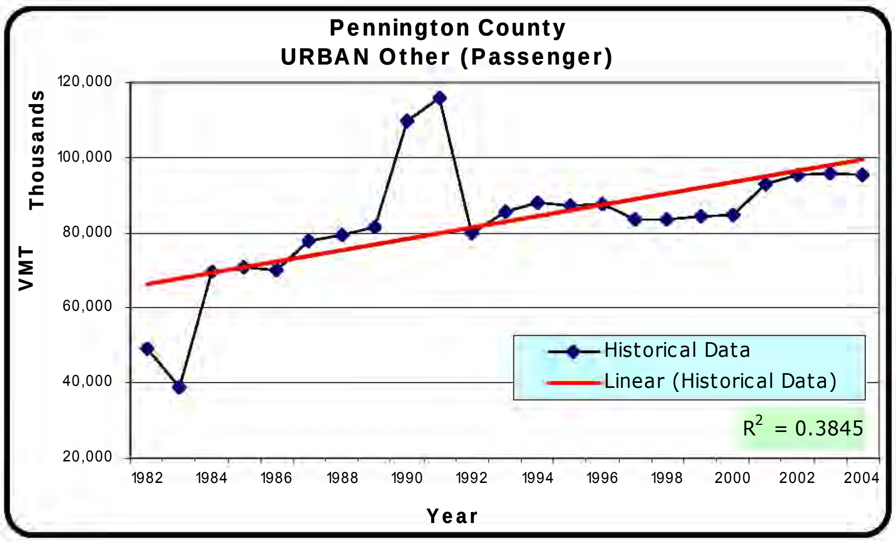


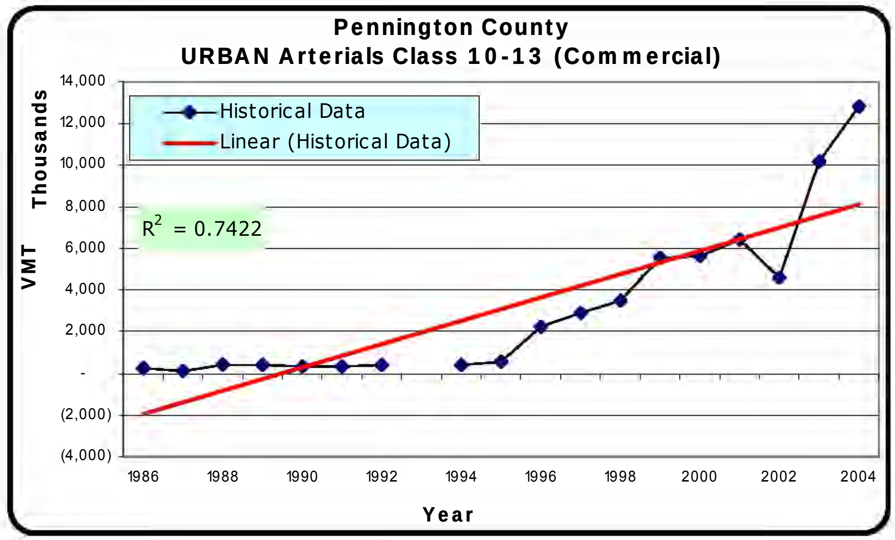


PENNINGTON COUNTY

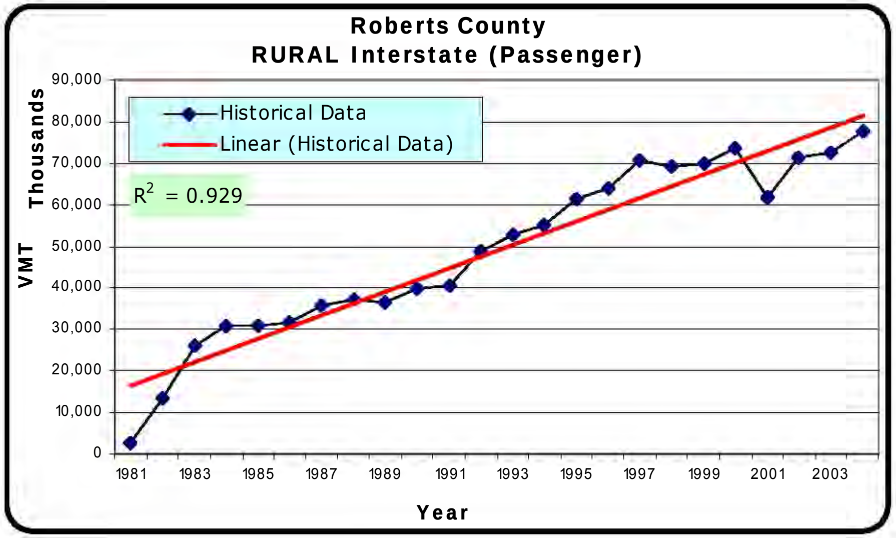


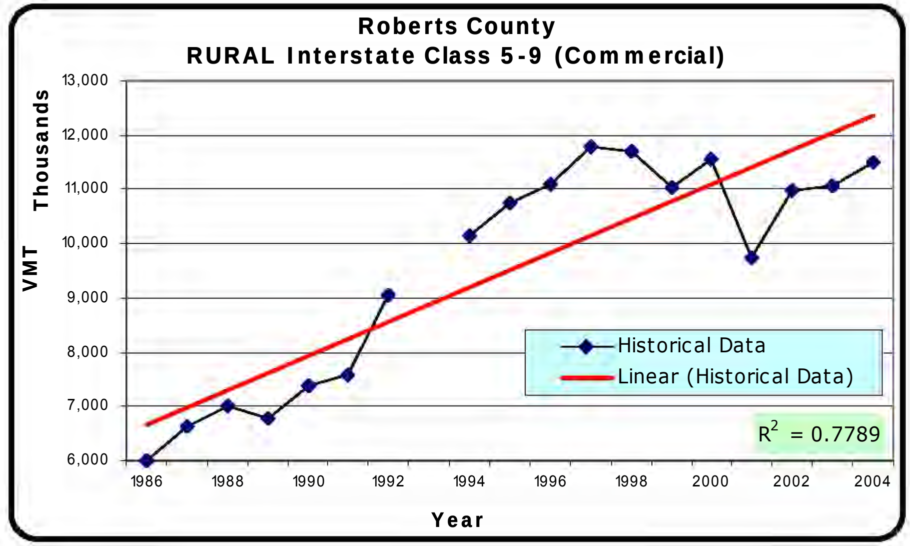


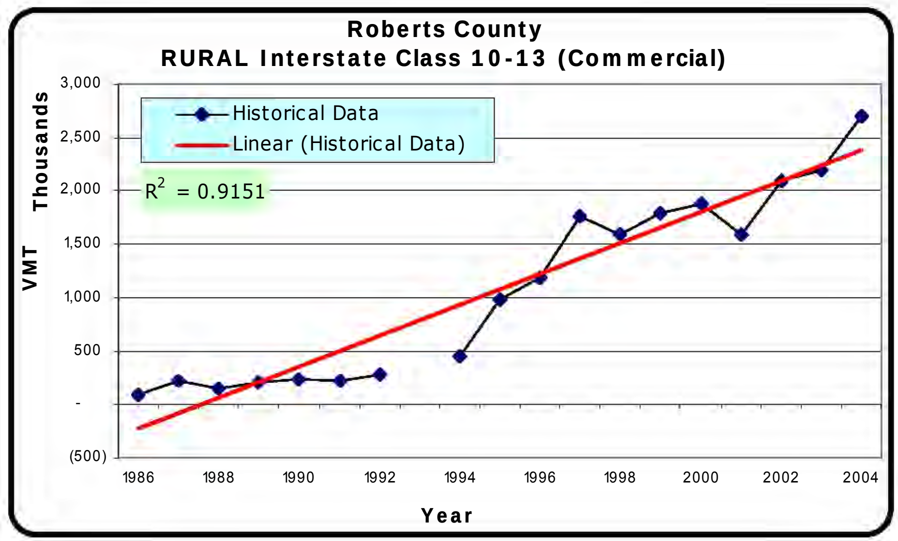




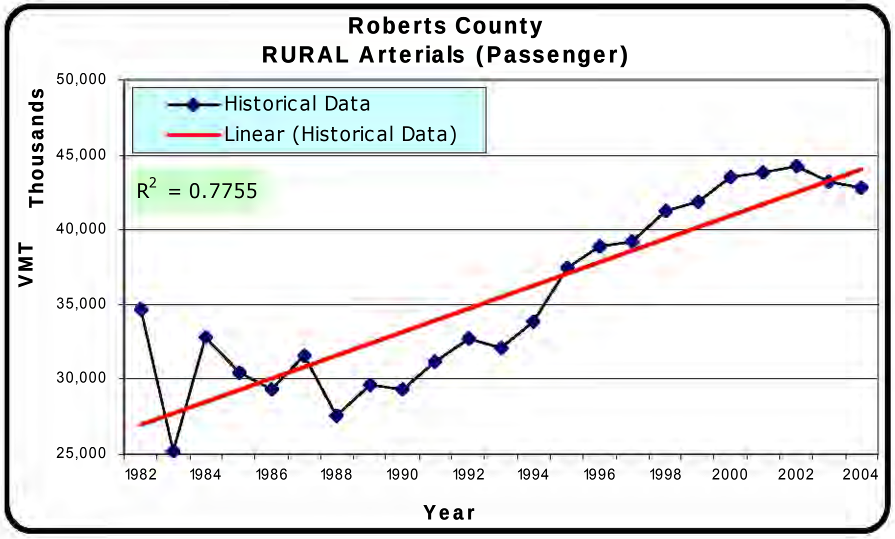
ROBERTS COUNTY

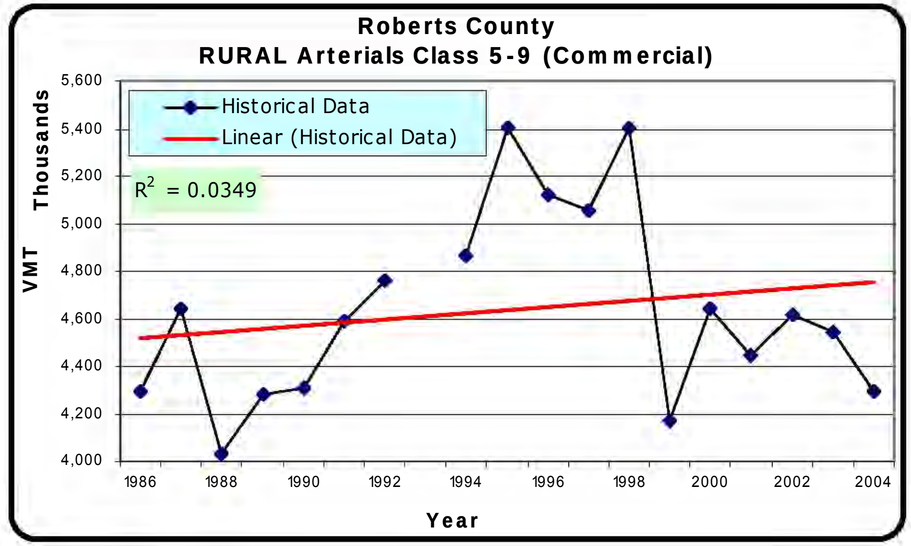


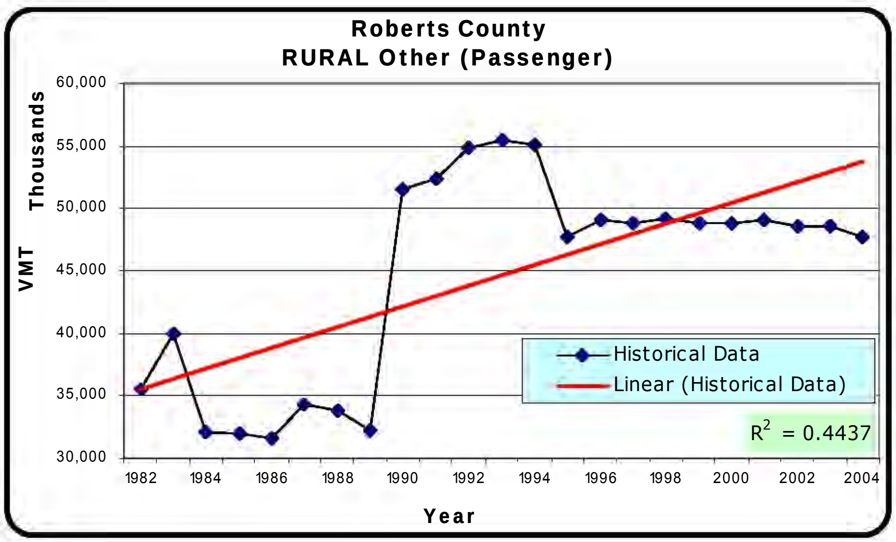


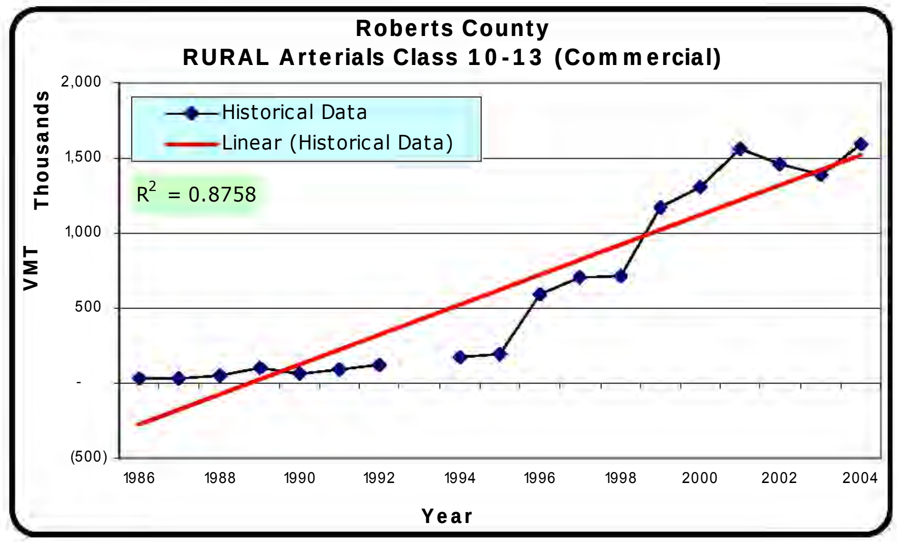


ROBERTS COUNTY

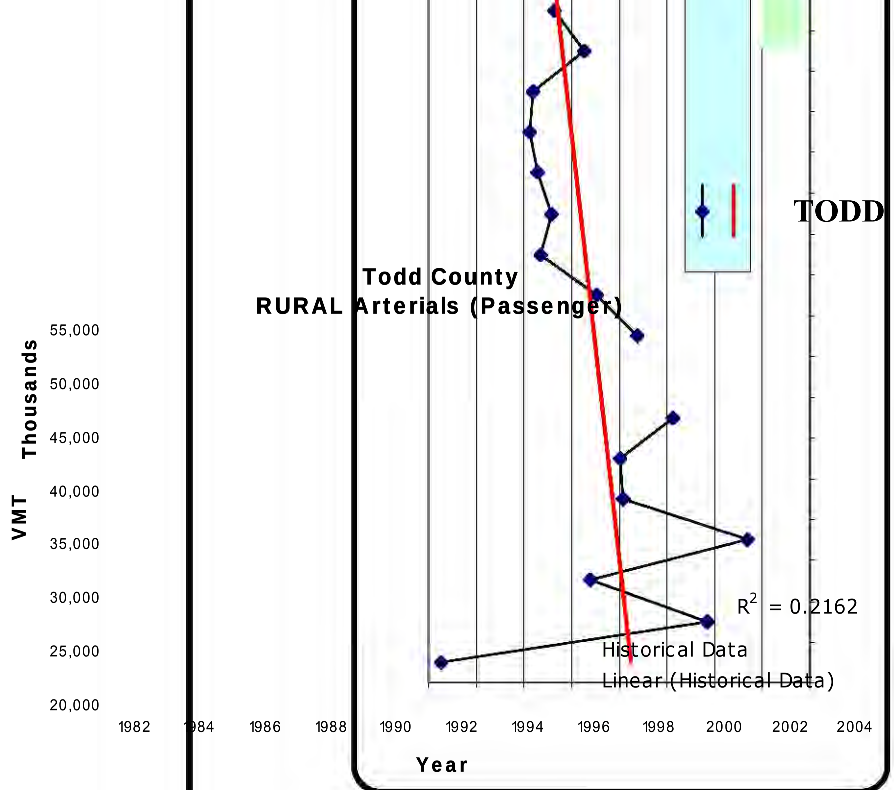


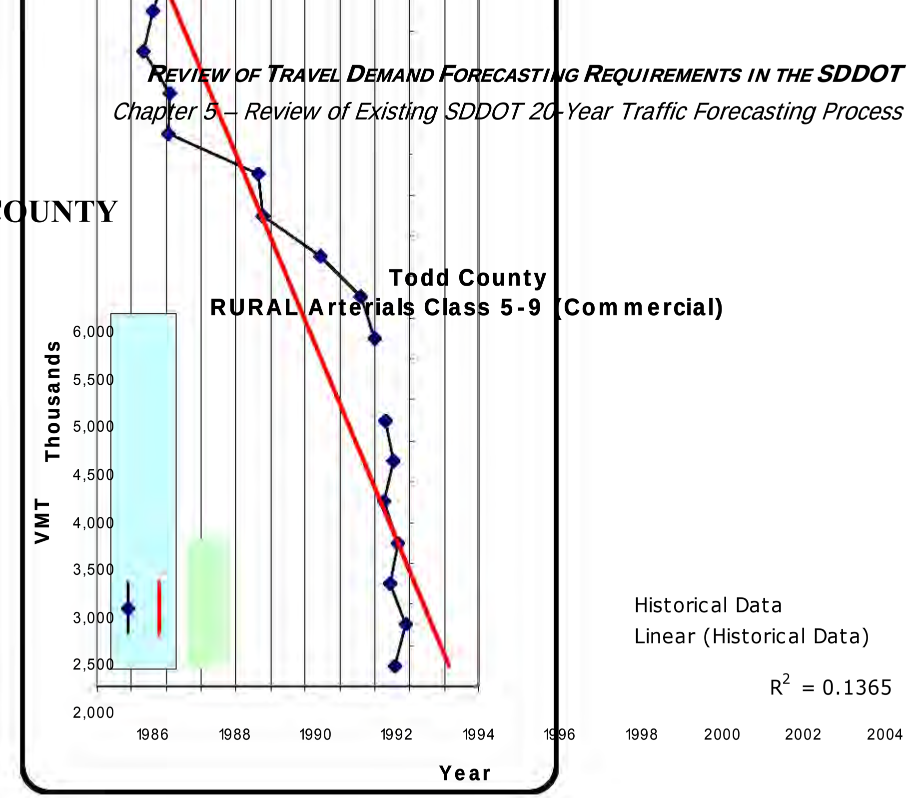


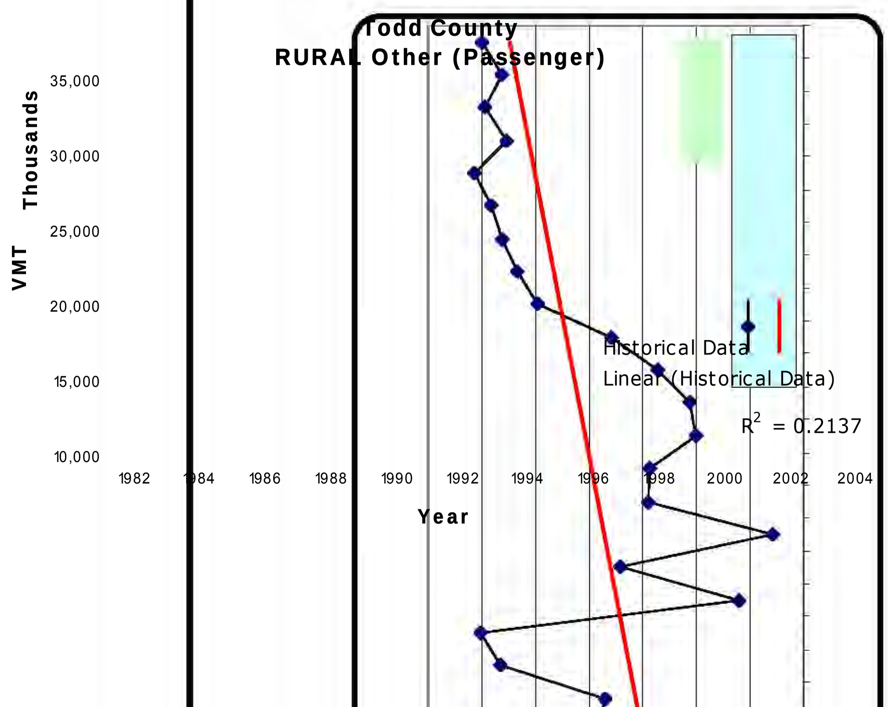


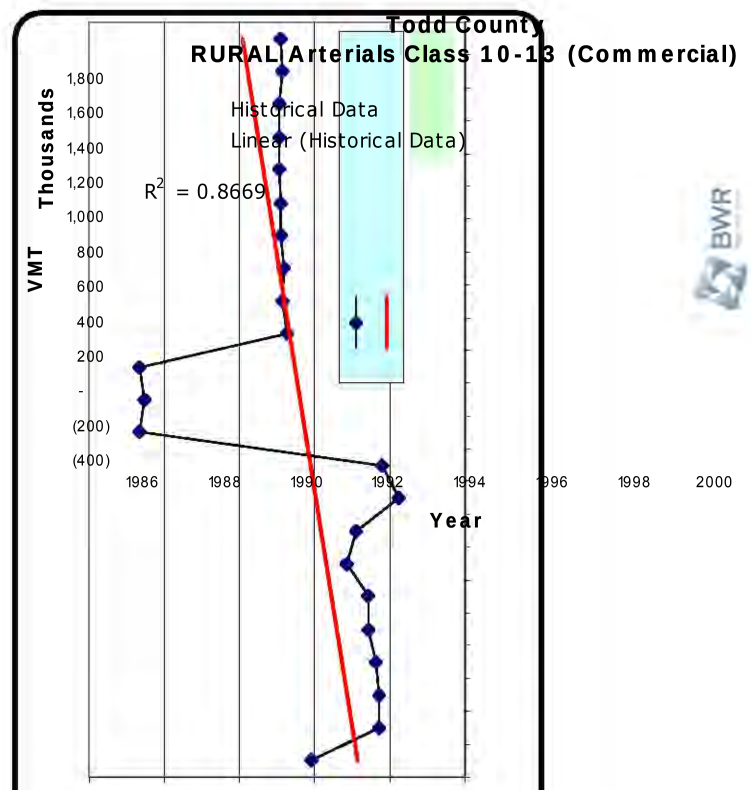


TODD COUNTY


Todd County
RURAL Arterials (Passenger)
VMT Thousands
55,000
50,000
45,000
40,000
35,000
30,000
25,000
20,000
1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004
Year
Historical Data
Linear (Historical Data)
R^2 = 0.2162


Todd County
RURAL Arterials Class 5-9 (Commercial)
VMT Thousands
6,000
5,500
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1986 1988 1990 1992 1994 1996 1998 2000 2002 2004
Year
Historical Data
Linear (Historical Data)
R^2 = 0.1365


Todd County
RURAL Other (Passenger)
VMT Thousands
35,000
30,000
25,000
20,000
15,000
10,000
1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004
Year
Historical Data
Linear (Historical Data)
R^2 = 0.2137


Todd County
RURAL Arterials Class 10-13 (Commercial)
VMT Thousands
1,800
1,600
1,400
1,200
1,000
800
600
400
200
-
(200)
(400)
1986 1988 1990 1992 1994 1996 1998 2000 2002 2004
Year
Historical Data
Linear (Historical Data)
R^2 = 0.8669

5.3.4 Plots of Historical Business Data and Trend Line

As outlined in Section 5.2.2, county business data from 1984 to 2004 were used as variable in the SDDOT 20-year traffic forecasting procedure. The 1999 study indicated a direct relationship between county VMT and business county pattern was found to exist. Linear regression technique was applied to the historical county business data to obtain annual growth factor as outlined in Section 5.2.3.

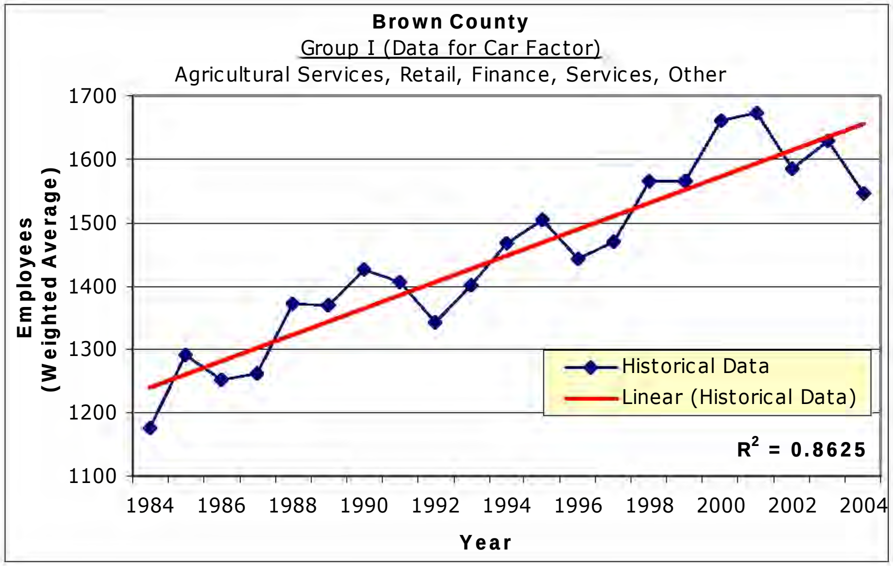
Plots of business county pattern depicting trend lines were prepared for the eight selected counties. The next four pages present the plots of business data for the two business groupings (Group I and Group II) described in Section 5.2.2. Table 5-9 provides a summary of the regression R^2 values.

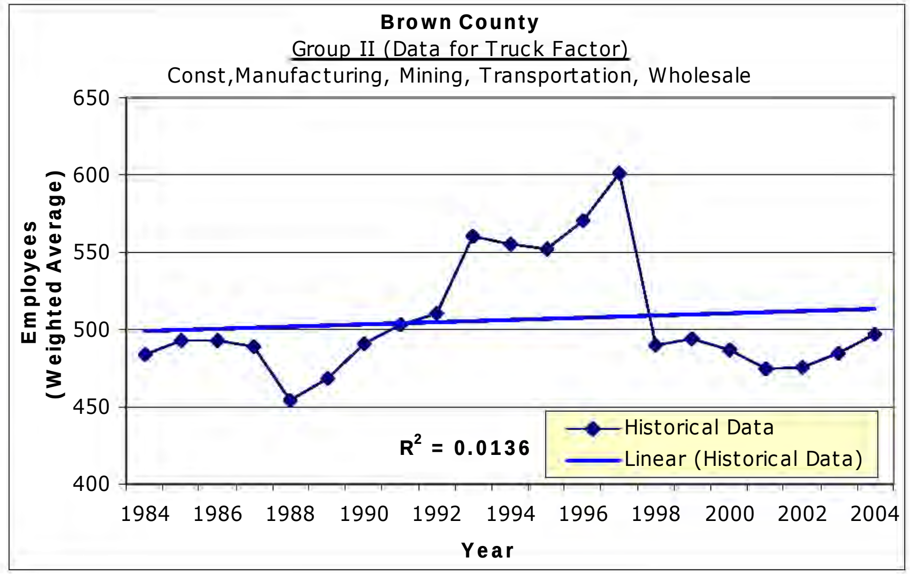
General Observations of the Historical Business Pattern

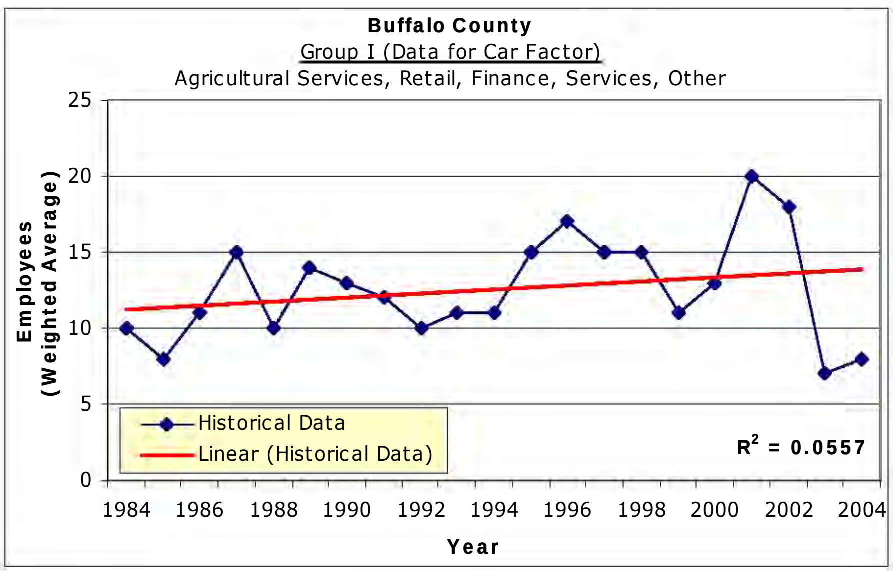
- Wide variation in county business pattern between successive years for less populated counties, such as Buffalo County and Todd County, exist. Such a wide variation is typical for small sample size to be sensitive to changes.
- Except for Buffalo and Roberts counties, a linear pattern generally exists for Group I, which is reflected in high R^2 values in Table 5-9. Moreover, the business pattern for group I generally indicates an increasing trend.
- In contrast, Group II business pattern indicates a non-linear pattern, with the exception of Pennington County.
- Although R^2 for Group II in Buffalo County is high, it does not represent a meaningful linear relationship as the graph in the following page depicts. Since 1997, employment under Group II business category in Buffalo County is zero. Consequently, the linear equation yields a negative employment from 2001, which is not a valid outcome for traffic forecasting. While zero employment forecast can be assumed to replace negative values, this would not be useful for adjusting commercial VMT factors.
- The next section discusses the relationship of county business pattern with the historical countywide VMT.

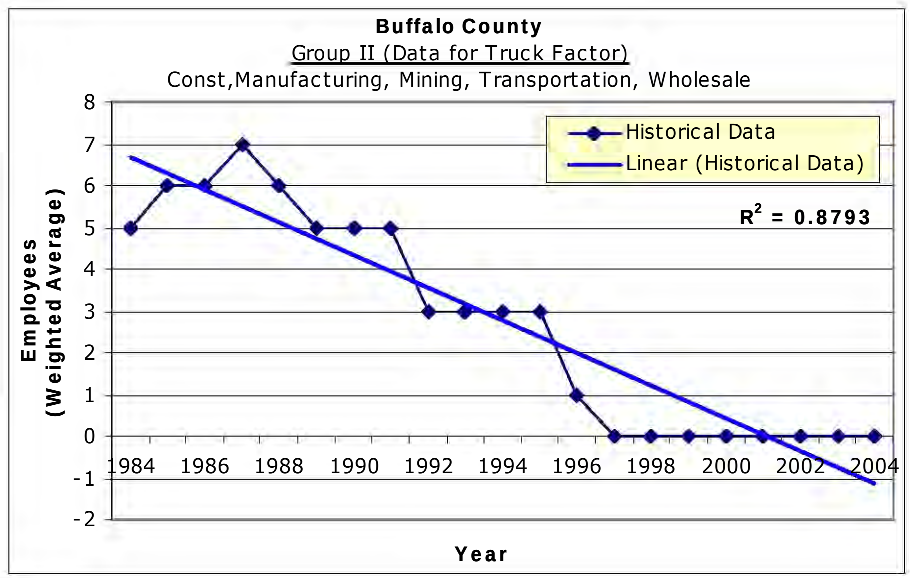
Table 5-9 Results of Linear Regressions by Business Group I and II

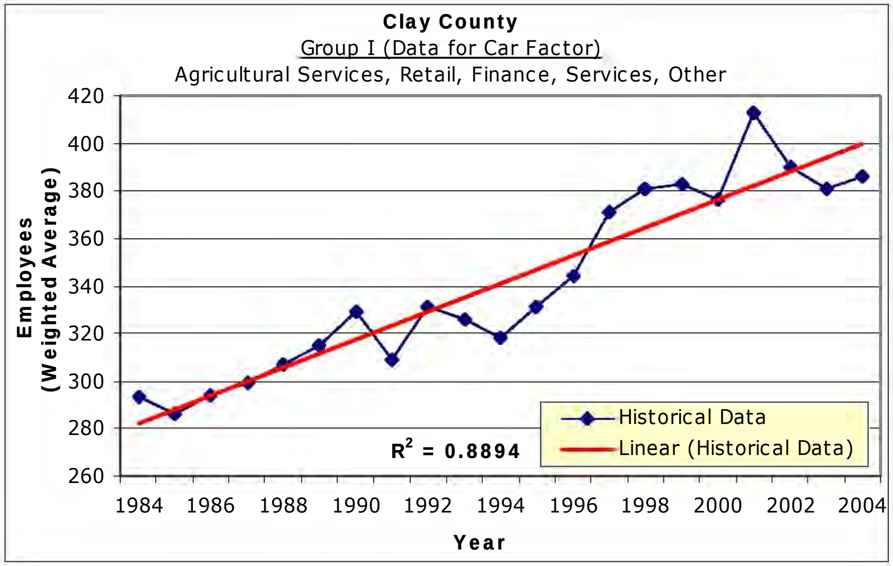
County	Group I (R^2 Values)	Group II (R^2 Values)
Brown	0.8625	0.0136
Buffalo	0.0557	0.8793
Clay	0.8894	0.3987
Lawrence	0.9347	0.3160
Meade	0.9336	0.9012
Pennington	0.9699	0.6088
Roberts	0.5693	0.0033
Todd	0.7649	0.2225

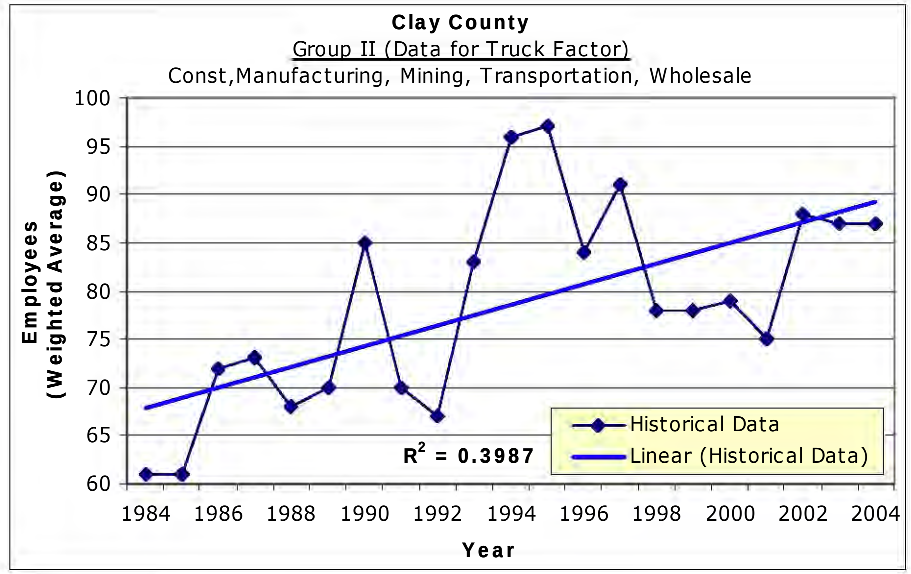

Brown County
Group I (Data for Car Factor)
Agricultural Services, Retail, Finance, Services, Other
Employees (Weighted Average)
Year
Historical Data
Linear (Historical Data)
R² = 0.8625

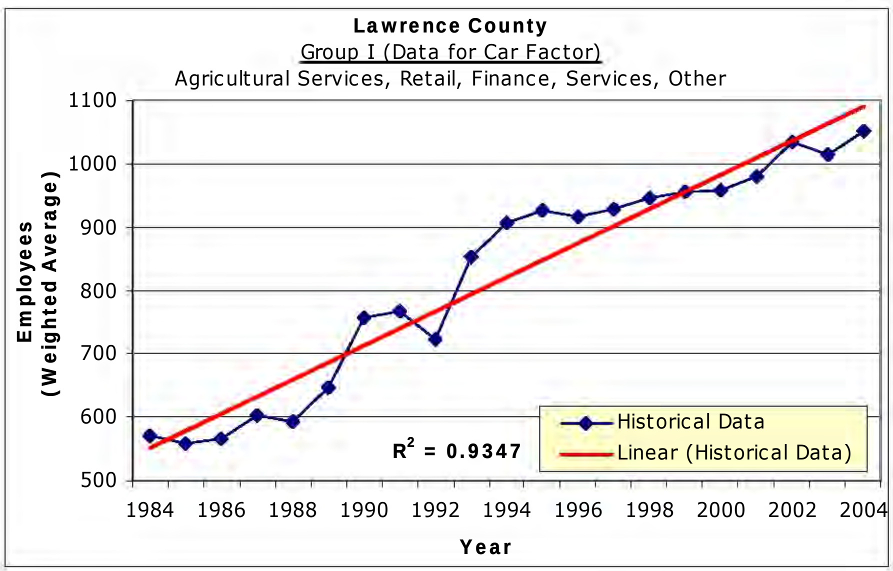

Brown County
Group II (Data for Truck Factor)
Const,Manufacturing, Mining, Transportation, Wholesale
Employees (Weighted Average)
Year
Historical Data
Linear (Historical Data)
R² = 0.0136

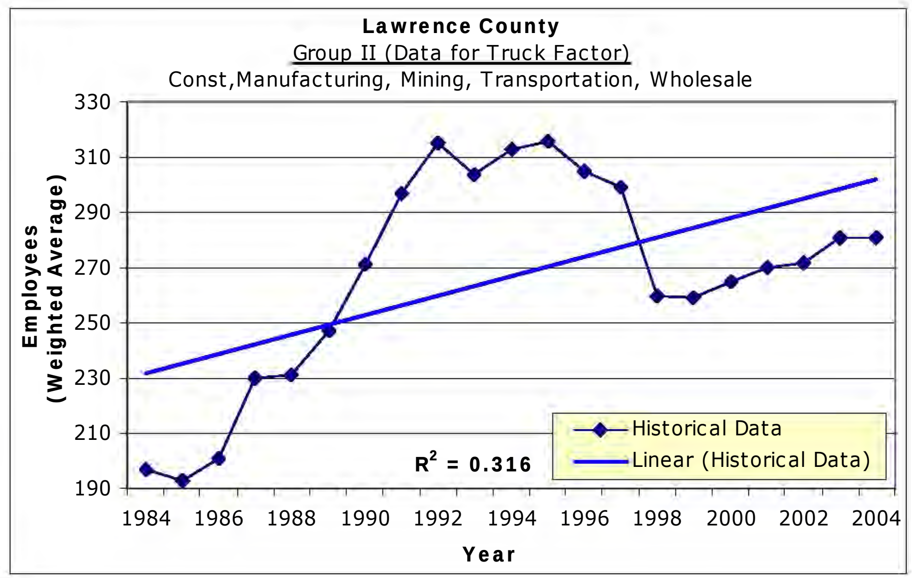

Buffalo County
Group I (Data for Car Factor)
Agricultural Services, Retail, Finance, Services, Other
Employees (Weighted Average)
Year
Historical Data
Linear (Historical Data)
R² = 0.0557

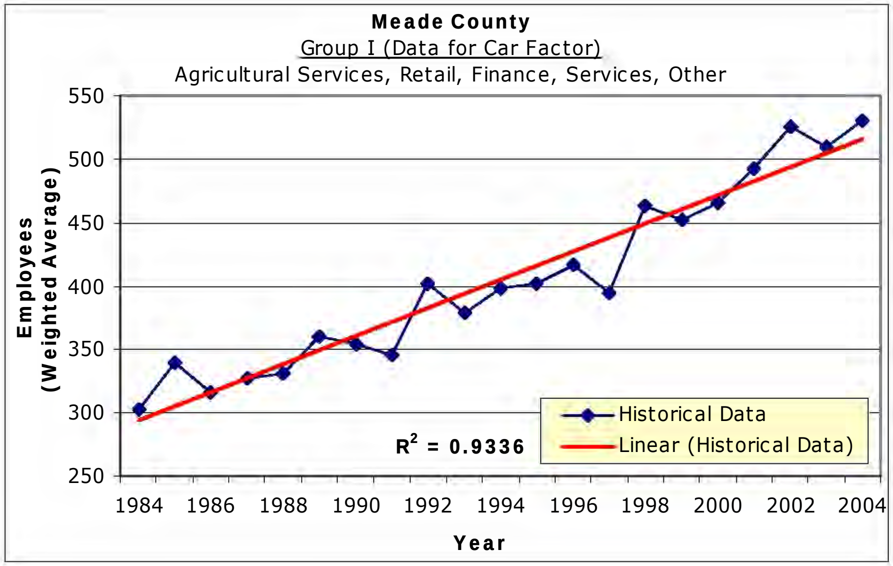

Buffalo County
Group II (Data for Truck Factor)
Const,Manufacturing, Mining, Transportation, Wholesale
Employees (Weighted Average)
Year
Historical Data
Linear (Historical Data)
R² = 0.8793

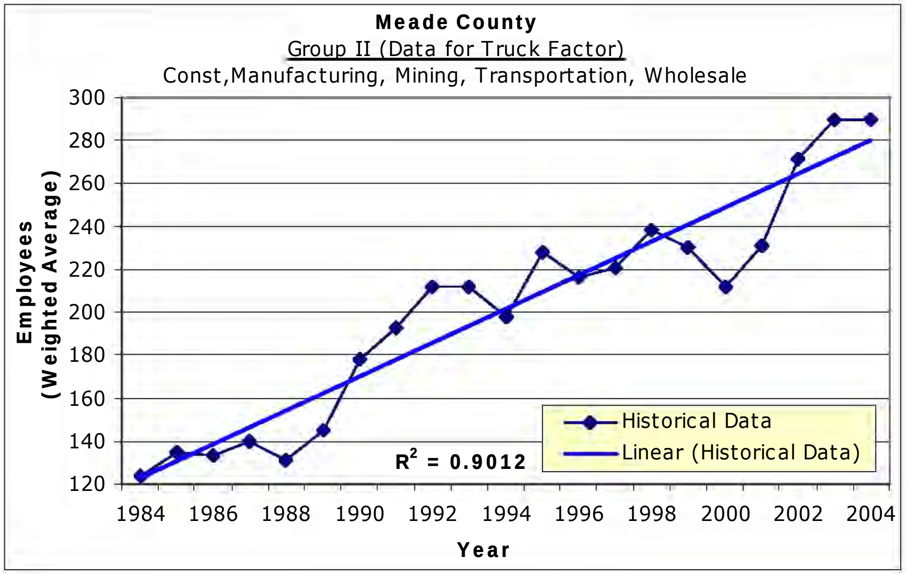

Clay County
Group I (Data for Car Factor)
Agricultural Services, Retail, Finance, Services, Other
Employees (Weighted Average)
420
400
380
360
340
320
300
280
260
1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004
Year
R^2 = 0.8894
Historical Data
Linear (Historical Data)

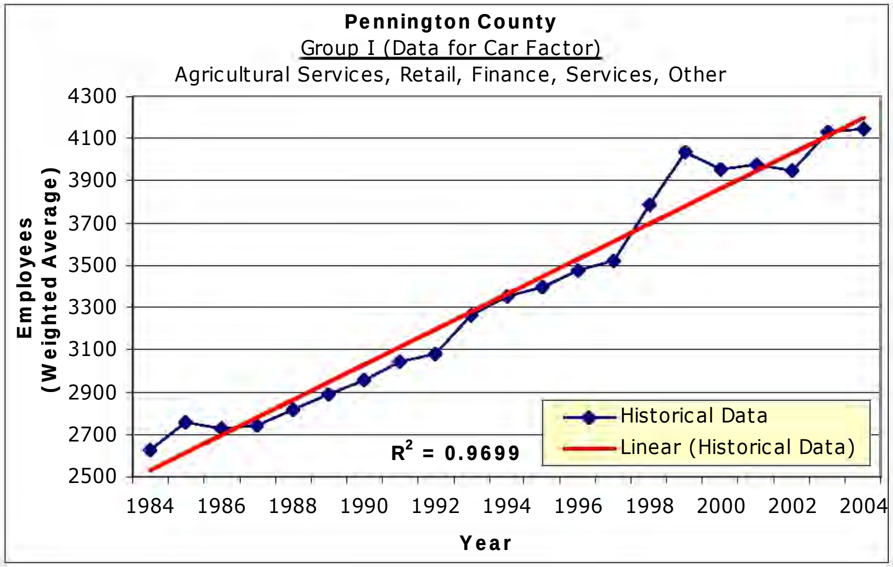

Clay County
Group II (Data for Truck Factor)
Const,Manufacturing, Mining, Transportation, Wholesale
Employees (Weighted Average)
100
95
90
85
80
75
70
65
60
1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004
Year
R^2 = 0.3987
Historical Data
Linear (Historical Data)

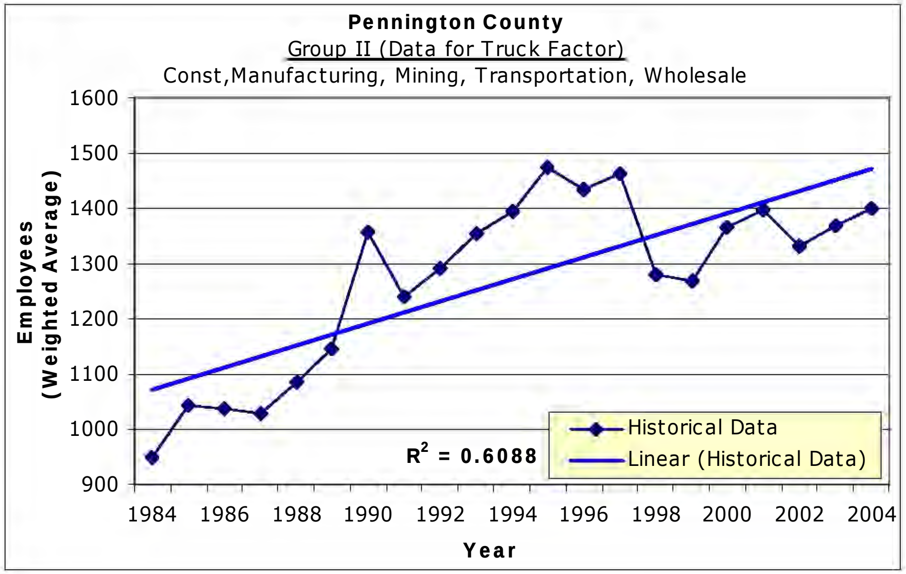

Lawrence County
Group I (Data for Car Factor)
Agricultural Services, Retail, Finance, Services, Other
Employees (Weighted Average)
1100
1000
900
800
700
600
500
1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004
Year
R^2 = 0.9347
Historical Data
Linear (Historical Data)

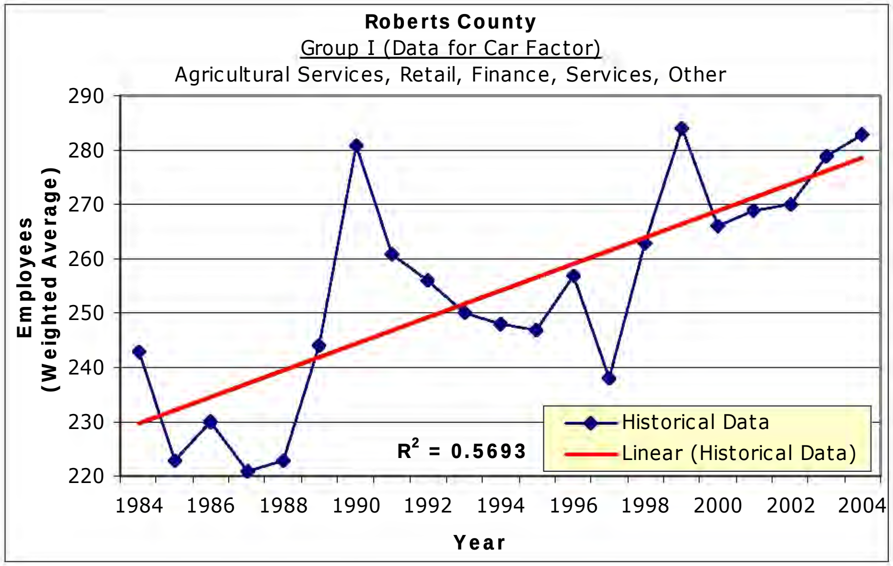

Lawrence County
Group II (Data for Truck Factor)
Const,Manufacturing, Mining, Transportation, Wholesale
Employees (Weighted Average)
330
310
290
270
250
230
210
190
1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004
Year
R^2 = 0.316
Historical Data
Linear (Historical Data)

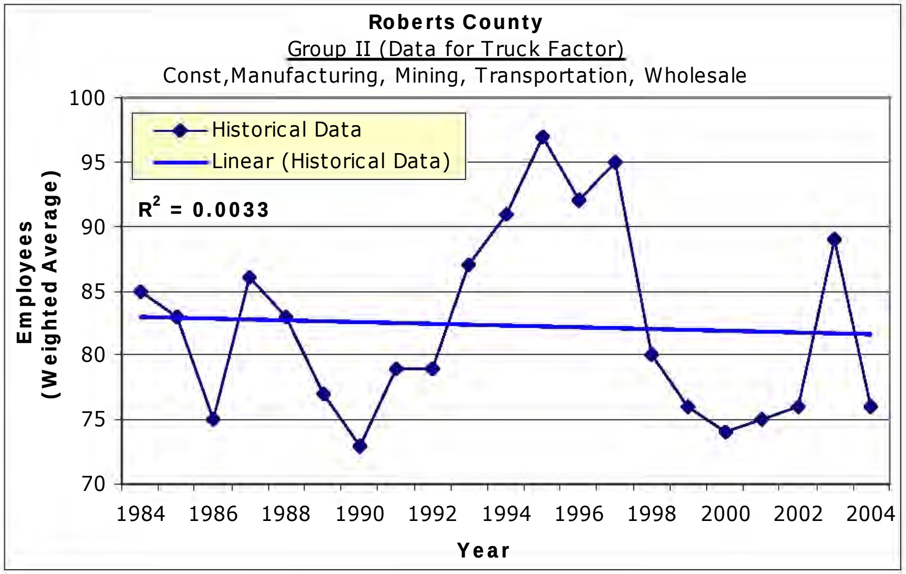

Meade County
Group I (Data for Car Factor)
Agricultural Services, Retail, Finance, Services, Other
Employees (Weighted Average)
Year
Historical Data
Linear (Historical Data)
R² = 0.9336

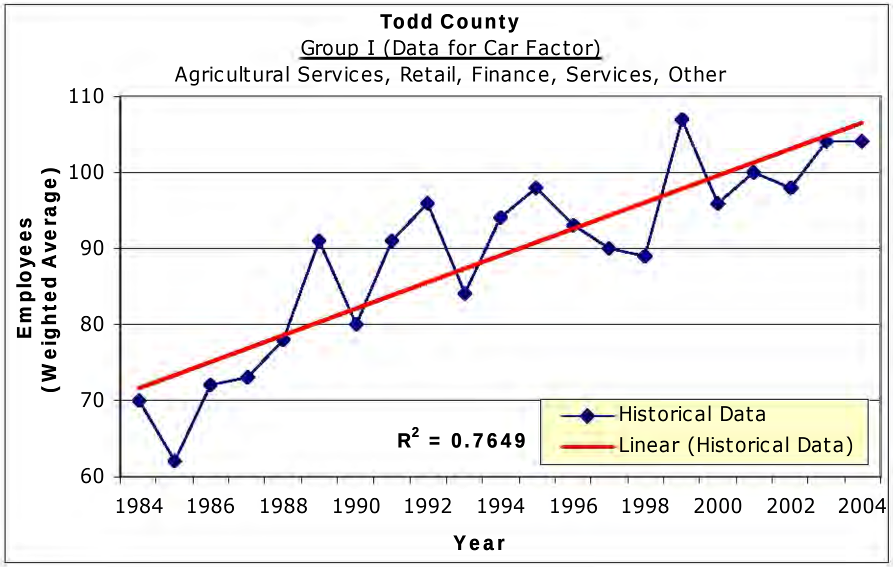

Meade County
Group II (Data for Truck Factor)
Const,Manufacturing, Mining, Transportation, Wholesale
Employees (Weighted Average)
Year
Historical Data
Linear (Historical Data)
R² = 0.9012

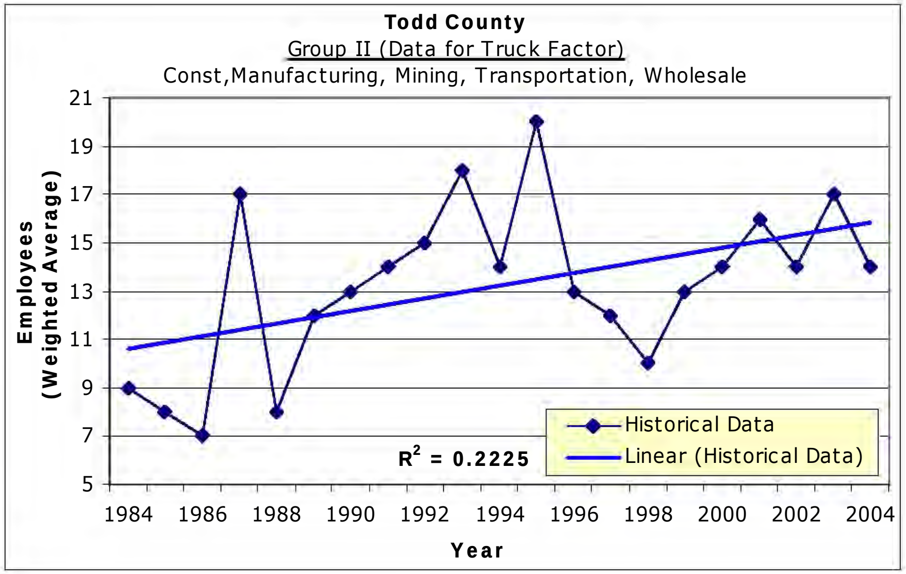

Pennington County
Group I (Data for Car Factor)
Agricultural Services, Retail, Finance, Services, Other
Employees (Weighted Average)
Year
Historical Data
Linear (Historical Data)
R² = 0.9699


Pennington County
Group II (Data for Truck Factor)
Const,Manufacturing, Mining, Transportation, Wholesale
Employees (Weighted Average)
Year
Historical Data
Linear (Historical Data)
R² = 0.6088


Roberts County
Group I (Data for Car Factor)
Agricultural Services, Retail, Finance, Services, Other
Employees (Weighted Average)
Year
Historical Data
Linear (Historical Data)
R2 = 0.5693


Roberts County
Group II (Data for Truck Factor)
Const,Manufacturing, Mining, Transportation, Wholesale
Employees (Weighted Average)
Year
Historical Data
Linear (Historical Data)
R2 = 0.0033


Todd County
Group I (Data for Car Factor)
Agricultural Services, Retail, Finance, Services, Other
Employees (Weighted Average)
Year
Historical Data
Linear (Historical Data)
R2 = 0.7649


Todd County
Group II (Data for Truck Factor)
Const,Manufacturing, Mining, Transportation, Wholesale
Employees (Weighted Average)
Year
Historical Data
Linear (Historical Data)
R2 = 0.2225

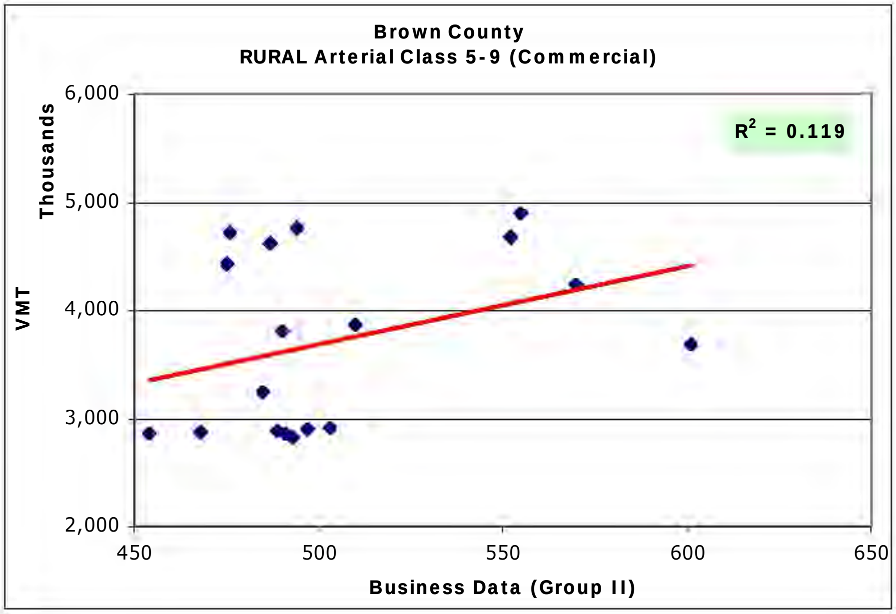
5.3.5 Analysis of the Relationship of Historical VMT & County Business Data

In the current forecasting procedure, factors for cars and trucks derived from county business data are largely used as a check for patterns in the VMT factors. As outlined in Section 5.2.3, adjustment to the 20-year traffic forecasting factor is usually performed when forecast annual growth rate is negative. Growth factor for trucks derived from the business data is used to adjust for commercial VMT factors while growth factor for cars derived from the business data is used to adjust for passenger VMT factors. This adjustment process assumes that there is a direct linear relationship between VMT and business pattern.

This section explores if such a linear relationship does exist between VMT and business pattern. A linear regression analysis was performed using VMT as the dependent variable and business county data as the independent variable. The 21 years of business data from 1984 to 2004 was used to correspond with the annual VMT for the same period. Results of the regression analysis in Table 5-10 indicate how much the variability in VMT is explained by the business county pattern. In another way of expressing, how much of the VMT can be predicted from the county business pattern?

The column "Grp. I" shows the R^2 values of linear regressions of "passenger" VMT and Group I business data. Similarly, the column "Grp. II" shows the R^2 values of linear regressions of "commercial" VMT and Group II business data. The column "Total" shows the R^2 values of linear regressions of both passenger and commercial VMT with the total of Group I and Group II business data. In other words, the "Total" reflects the relationship with VMT and business data without categorizing between passenger and commercial vehicles.

Linear regressions of business data by group and total were performed for each category and aggregations of categories as reflected in Table 5-10. The figure below is an example for Brown County.



General Observations of the Historical VMT and Business Pattern Relationship

- With the exception of Rural Interstate for Meade County, there is no apparent relationship of commercial VMT and Group II business pattern. This has direct implication to the final 20-year forecasting factors since annual percent growth for trucks derived from business data is directly used in adjusting Class 5-9 commercial category that exhibits a negative future annual growth.

- The county business pattern (by Group and Total) does not seem to explain variations in VMT for counties with relatively low population, as reflected in poor R^2 for Buffalo, Todd, and Roberts counties.

- On the other hand, total business pattern indicates some predictive ability for counties with relatively large population, as reflected by Clay and Brown.

- It can be concluded from the regression results in Table 5-10 that county business trend is not a good predictor for commercial VMTs, particularly in low population counties such as exhibited by Buffalo, Todd, and Roberts counties; 2004 population for these three counties range between 2,000 and 10,200. Definition of low population counties, however, should not be limited to this range because the eight-county sample used in the current analysis cannot be considered a representative sample of the sixty-six counties for the entire South Dakota state. It suffices to mention here that continued use of county business data should be carefully examined for applicability in counties with low population.

- Total county business pattern could be used for some categories or aggregation of categories as indicated in Table 5-10.

Table 5-10 R-Square Values: 1984-2000 Business County Data and VMT Regression Results

	Area Type and Functional Class	Brown County			Buffalo County			Clay County			Lawrence County			Meade County			Pennington County			Roberts County			Todd County		
		Grp. I	Grp. II	Total	Grp. I	Grp. II	Total	Grp. I	Grp. II	Total	Grp. I	Grp. II	Total	Grp. I	Grp. II	Total	Grp. I	Grp. II	Total	Grp. I	Grp. II	Total	Grp. I	Grp. II	Total
RURAL	Interstate (Passenger)	-	-	-	-	-	-	-	-	-	0.877	-	0.805	0.934	-	0.931	0.667	-	0.667	0.444	-	0.575	-	-	-
RURAL	Interstate Class 5-9 (Commercial)	-	-	-	-	-	-	-	-	-	-	0.269	0.855	-	0.820	0.875	-	0.283	0.202	-	0.083	0.506	-	-	-
RURAL	Interstate Class 10-13 (Commerc	-	-	-	-	-	-	-	-	-	-	0.043	0.677	-	0.797	0.867	-	0.288	0.754	-	0.000	0.465	-	-	-
RURAL	Interstate Total (Commercial)	-	-	-	-	-	-	-	-	-	-	0.186	0.881	-	0.862	0.927	-	0.435	0.643	-	0.043	0.526	-	-	-
RURAL	Interstate Total	-	-	-	-	-	-	-	-	-	0.845	-	0.785	0.899	-	0.896	0.719	-	0.736	0.443	-	0.561	-	-	-
RURAL	Arterials (Passenger)	0.733	-	0.792	0.000	-	0.239	0.810	-	0.763	0.464	-	0.522	0.246	-	0.309	0.417	-	0.417	0.431	-	0.489	0.056	-	0.019
RURAL	Arterials Class 5-9 (Commercial)	-	0.484	0.019	-	0.003	0.000	-	0.144	0.217	-	0.312	0.003	-	0.298	0.416	-	0.004	0.188	-	0.411	0.029	-	0.147	0.001
RURAL	Arterials Class 10-13 (Commercia	-	0.019	0.651	-	0.771	0.247	-	0.077	0.819	-	0.019	0.615	-	0.667	0.801	-	0.235	0.811	-	0.052	0.403	-	0.041	0.429
RURAL	Arterials Total (Commercial)	-	0.060	0.813	-	0.373	0.103	-	0.139	0.798	-	0.555	0.427	-	0.000	0.009	-	0.247	0.339	-	0.027	0.418	-	0.020	0.106
RURAL	Arterials Total	0.786	-	0.813	0.013	-	0.194	0.845	-	0.816	0.579	-	0.651	0.283	-	0.343	0.530	-	0.547	0.438	-	0.485	0.117	-	0.058
RURAL	Other (Passenger)	0.083	-	0.105	0.063	-	0.076	0.171	-	0.190	0.690	-	0.773	0.060	-	0.086	0.083	-	0.068	0.436	-	0.562	0.255	-	0.289
RURAL	Rural Total	0.602	-	0.654	0.000	-	0.142	0.863	-	0.849	0.049	-	0.057	0.230	-	0.294	0.606	-	0.609	0.587	-	0.708	0.295	-	0.217
URBAN	Interstate (Passenger)	-	-	-	-	-	-	-	-	-	0.610	-	0.563	0.851	-	0.868	0.699	-	0.793	-	-	-	-	-	-
URBAN	Interstate Class 5-9 (Commercial)	-	-	-	-	-	-	-	-	-	-	0.001	0.394	-	0.560	0.699	-	0.191	0.725	-	-	-	-	-	-
URBAN	Interstate Class 10-13 (Commerc	-	-	-	-	-	-	-	-	-	-	0.000	0.370	-	0.451	0.581	-	0.099	0.591	-	-	-	-	-	-
URBAN	Interstate Total (Commercial)	-	-	-	-	-	-	-	-	-	-	0.000	0.402	-	0.540	0.680	-	0.164	0.706	-	-	-	-	-	-
URBAN	Interstate Total	-	-	-	-	-	-	-	-	-	0.616	-	0.550	0.883	-	0.872	0.818	-	0.876	-	-	-	-	-	-
URBAN	Arterials (Passenger)	0.641	-	0.790	-	-	-	0.534	-	0.647	0.860	-	0.890	0.666	-	0.683	0.780	-	0.811	-	-	-	-	-	-
URBAN	Arterials Class 5-9 (Commercial)	-	0.119	0.449	-	-	-	-	0.009	0.082	-	0.405	0.868	-	0.263	0.291	-	0.000	0.046	-	-	-	-	-	-
URBAN	Arterials Class 10-13 (Commercia	-	0.014	0.492	-	-	-	-	0.014	0.543	-	0.010	0.476	-	0.517	0.610	-	0.169	0.661	-	-	-	-	-	-
URBAN	Arterials Total (Commercial)	-	0.017	0.803	-	-	-	-	0.049	0.267	-	0.251	0.917	-	0.652	0.756	-	0.122	0.614	-	-	-	-	-	-
URBAN	Arterials Total	0.691	-	0.813	-	-	-	0.558	-	0.648	0.874	-	0.898	0.682	-	0.695	0.813	-	0.835	-	-	-	-	-	-
URBAN	Other (Passenger)	0.064	-	0.059	-	-	-	0.549	-	0.673	0.820	-	0.883	0.616	-	0.679	0.142	-	0.196	-	-	-	-	-	-
URBAN	Urban Total Total	0.656	-	0.776	-	-	-	0.475	-	0.544	0.878	-	0.907	0.698	-	0.718	0.766	-	0.812	-	-	-	-	-	-
	County Total			0.813			0.142			0.817			0.843			0.913			0.942			0.650			0.106

0.XXX -> categories with R^2 values of at least 0.60 and below 0.70
0.XXX -> categories with R^2 values of 0.70 and above

Comments on the 20-Year Traffic Forecasting Factor Adjustment Using Business Data

For Lawrence, Meade, and Pennington counties, adjustments were performed to the 20-year forecasting factors for *Arterial Class 5-9 Commercial* using the annual growth for trucks derived from the business data. Regression analysis and scatter plots of business data (Group II) and VMT for *Class 5-9 Commercial* for Lawrence and Pennington are shown on page 129.

As the graphs on page 129 suggest, there is no linear relationship between the two sets of data. The regression estimates indicate opposite slopes, with VMT decreasing while business pattern is increasing. This result is contrary to the assumption of a direct relationship, which implies that adjustment to the 20-year traffic forecasting factor using business data does not appear to be meaningful.

It is important to note that of the 66 counties in the state, nearly half have adjustments performed mainly for *Class 5-9 Commercial* with a few for *Other Passenger*. At least 90 percent of those adjusted factors are in rural areas.

The regression analysis of business county data by groupings in Table 5-9 indicates a generally linear pattern for Group I. It is important to note that Group I business data is used to derive the growth factor for cars to relate to the passenger VMT factor. An example adjustment using the growth factor for cars to adjust the VMT passenger factor is included for Codington County. The graphics depicted on page 130, however, indicate no apparent relationship between Group I business data and VMT data.

Based on the analysis, it can be concluded that the use of county business pattern to relate directly or indirectly to the VMT 20-year forecast for commercial VMT is not statistically meaningful; and therefore, business data should not be used in adjusting the commercial VMT forecasting factors. For *Other Passenger* class, adjustment using business data should be applied only when a linear relationship exists.

VMT and Business Data Factors

Table 5-11 provides a summary of the calculated 20-year traffic forecasting factors and factors derived from business data. The VMT factors for cars is determined as the average of functional class factors for passengers while that for trucks represent the average for commercial vehicles for all functional classes.

Factors for cars appear to have some closeness while that for trucks are significantly different. The seemingly close factors for cars depicted in Table 5-11, however, can be misleading because the VMT factors by functional class for passengers vary significantly with *Interstate* VMT factor generally higher than *Other Passenger* functional class.

Table 5-11 Comparison of Business Data and VMT Factors

County	BUSINESS DATA		VMT DATA	
	Cars	Trucks	Cars	Trucks
Brown	1.249	1.028	1.233	1.729
Buffalo	1.233	6.276	1.107	1.653
Clay	1.290	1.237	1.216	1.702
Lawrence	1.482	1.229	1.478	1.974
Meade	1.421	1.546	1.410	1.858
Pennington	1.398	1.272	1.311	1.829
Roberts	1.175	0.983	1.453	1.770
Todd	1.328	1.329	1.264	1.737

YEAR 2024 TRAFFIC FORECASTING FACTORS: RURAL

County	INTERSTATE			ARTERIALS			OTHER
	Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger
Brown				1.221	0.919	2.283	1.193
Buffalo				1.159	1.000	2.307	1.054
Clay				1.391	1.129	2.308	1.169
Lawrence	1.498	1.365	2.187	1.193	1.029*	2.271	1.142
Meade	1.484	1.349	2.206	1.199	0.745*	2.282	1.290
Pennington	1.241	1.068	2.187	1.158	1.013*	2.284	1.115
Roberts	1.696	1.510	2.208	1.354	1.055	2.305	1.309
Todd				1.247	1.204	2.270	1.280

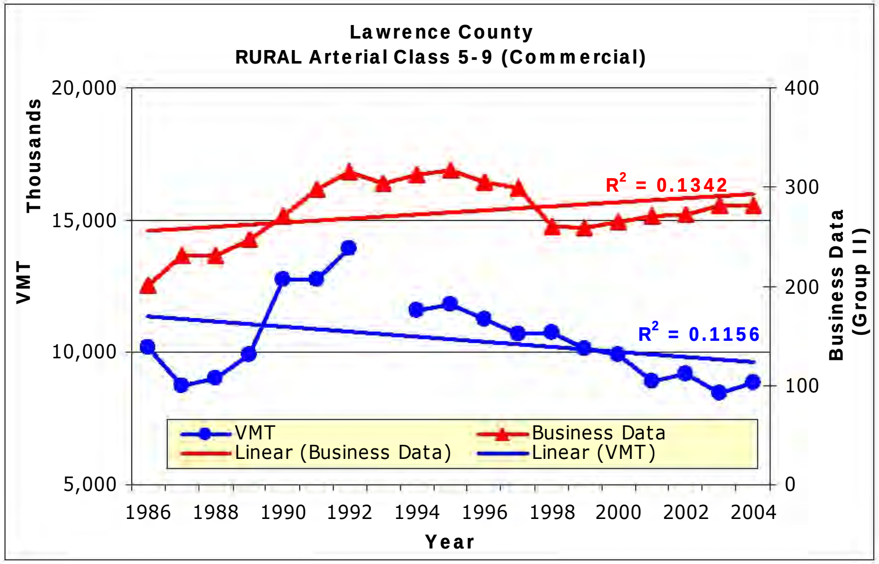
YEAR 2024 TRAFFIC FORECASTING FACTORS: URBAN

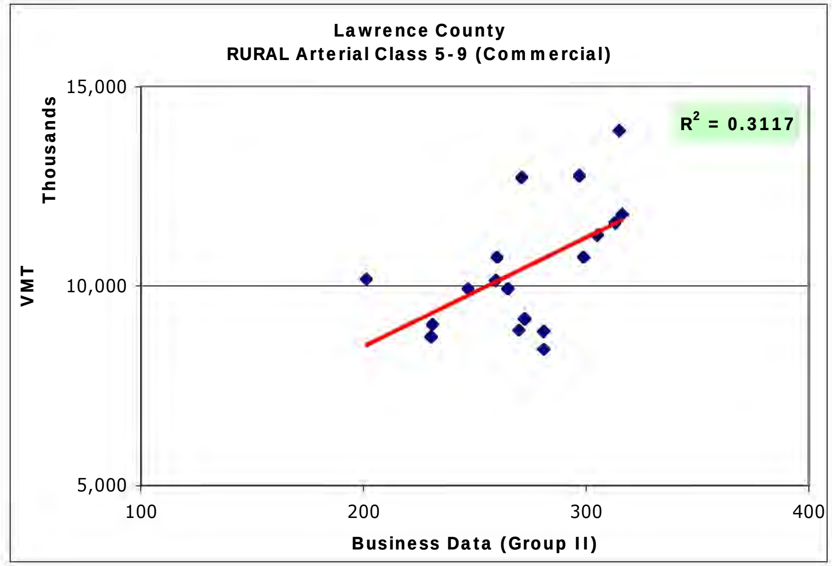
County	INTERSTATE			ARTERIALS			OTHER
	Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger
Brown				1.305	1.333	2.382	1.213**
Clay				1.290	1.066	2.307	1.015
Lawrence	1.654	2.191	2.534	1.820	1.866	2.353	1.562
Meade	1.759	2.210	2.535	1.415	1.200	2.338	1.311
Pennington	1.725	2.127	2.481	1.321	1.106	2.363	1.305

* Adjusted factor using business data (Adjustment Procedure I in Section 5.2.3)

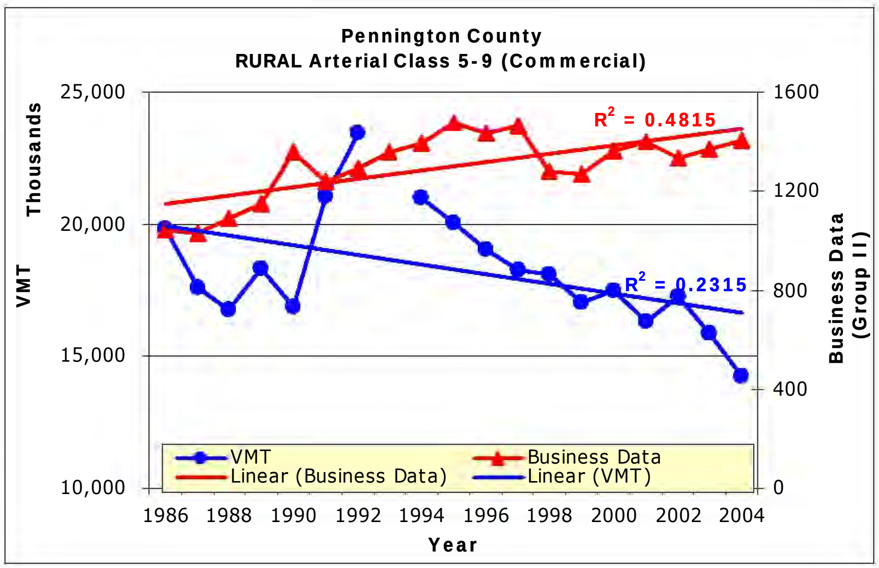
** Adjusted factor using Adjustment Procedure 2 (Refer Section 5.2.3)

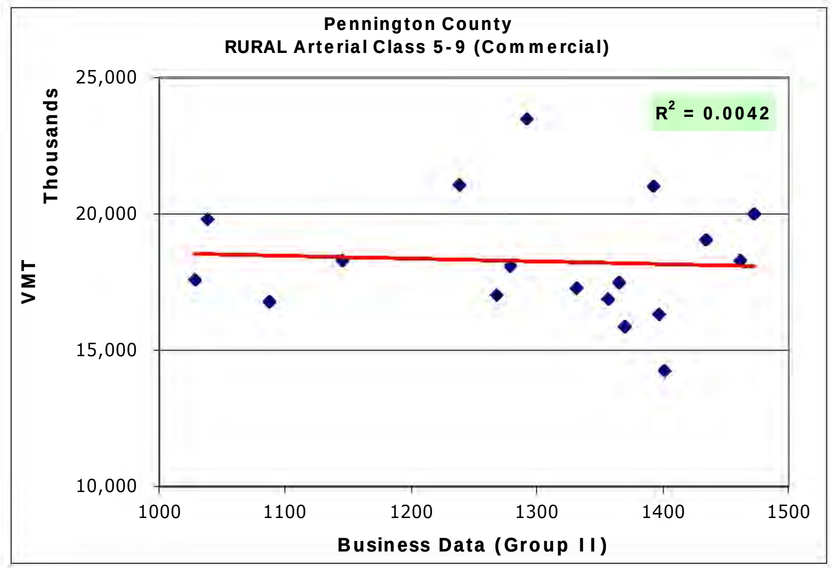
LAWRENCE COUNTY



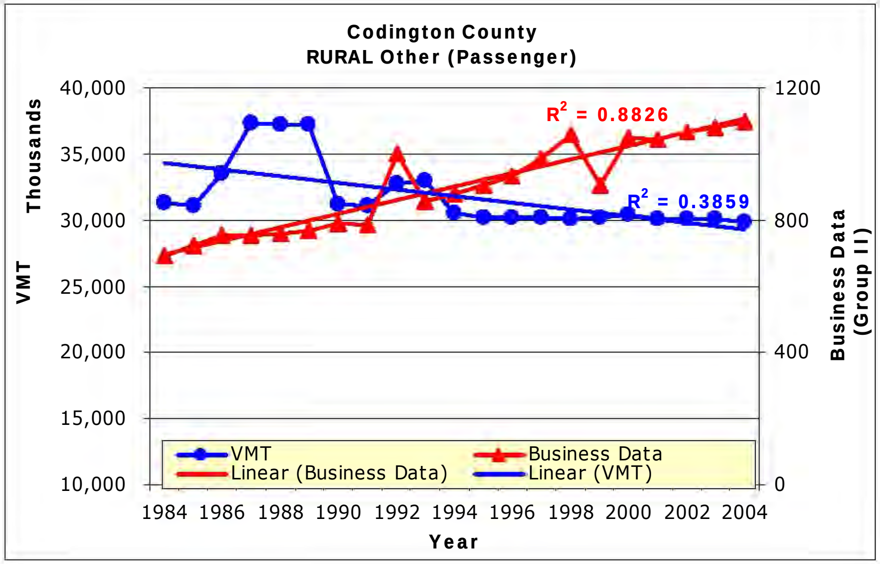


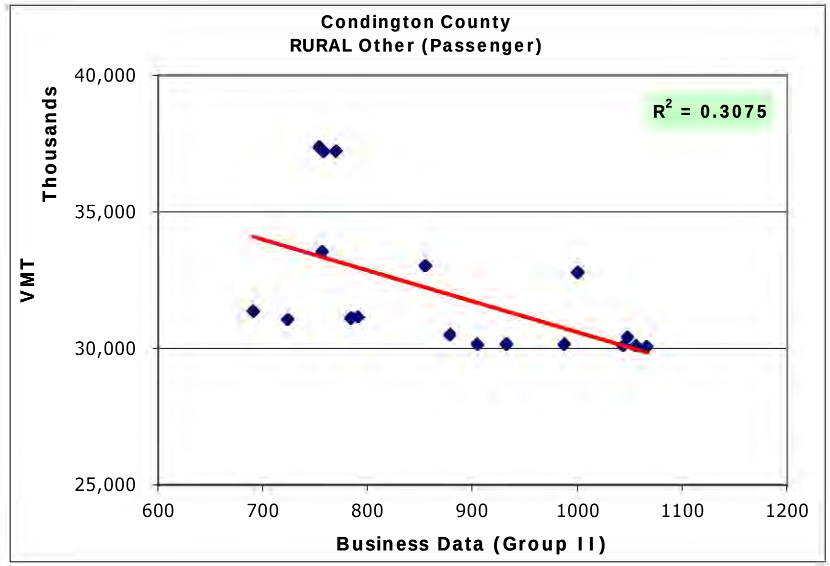
PENNINGTON COUNTY





CODINGTON COUNTY





5.3.6 Critique of the 20-Year Traffic Forecasting Procedure

The following summarizes the limitations and weaknesses of the current 20-year traffic forecasting procedure:

2. ***A single global approach***

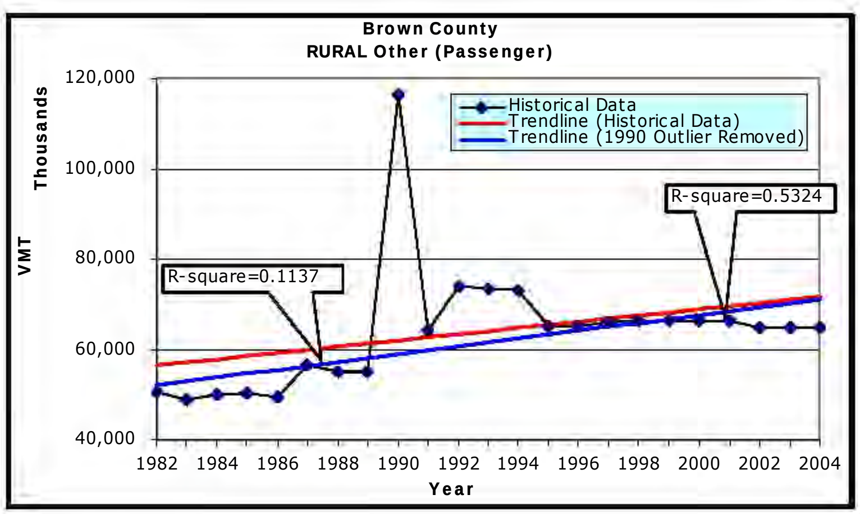
   Current implementation of the regression technique fails to distinguish differing growth patterns by category or functional class, and to some extent differing socioeconomic growth patterns in counties throughout the state. Lower class roads that include local highway system generally exhibit lower annual growth with extremely low traffic volumes that range between 25 and 125 average daily traffic. As indicated in the historical VMT plots, annual VMT variation fluctuates. One reason for this is the cycle over which traffic counts are carried out on those local roads. Traffic counts on rural roads are obtained once in 6 years for each county while for urban roads counts are conducted once in 4 years. Every year traffic counts are scheduled in some counties. In addition, over the last few years some counties have been experiencing population growth, others remain constant, while some have population decline. For categories in counties exhibiting nearly constant or marginal historical growth in annual VMT, a linear regression model would not be an appropriate technique.

3. ***Data outliers and adjustments required to correct for changes in functional class categories, data integrity issue***

   The plots of historical VMT indicate the presence of data outliers (abrupt change in annual VMT). Some could be attributed to reclassification of roadway sections, which is mainly from rural to urban. The presence of data outliers has significant effect on the linear regression model's statistical validity and prediction. Below are examples showing how data quality affects the linear regression results.

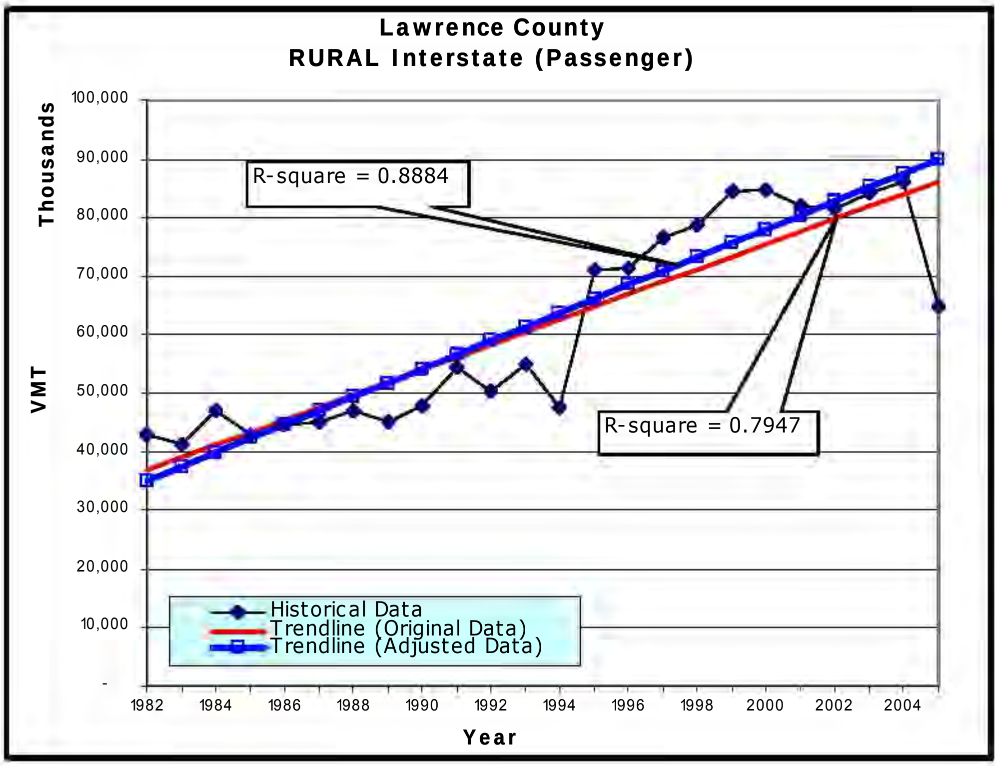
   Data Outliers

   It is obvious that the 1990 VMT is way out of trend. This outlier resulted in poor R^2 of 0.1137. If this outlier is removed from the data set, the R^2 improves to 0.5324.



Rural to Urban Reclassification

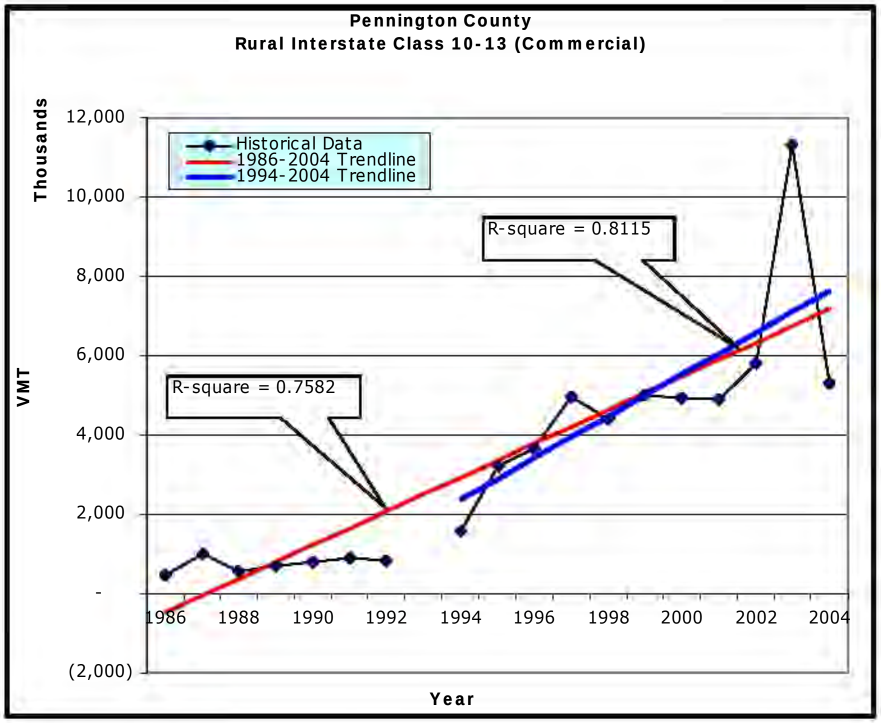
VMT for Lawrence County indicates that in 2003 Interstate routes were reclassified from rural to urban as seen in the sudden drop in rural VMT and a corresponding large increase in urban VMT. While not accounting for this abrupt change resulted in a good R^2 of 0.7947, this strong correlation is misleading. As depicted in the example graph for Lawrence County, the model would tend to underestimate. The logical approach would be to adjust the 2003 VMT using the approach outlined in Section 2.3.3 *(Method 3: Linear Projections of VMT by Functional Class, with Adjustments to Correct for Changes in Functional Class Categories)* and rerun the regression model. The adjusted VMT would result in a relatively higher $R^2$of 0.8884.



Change in VMT Pattern for Commercial Vehicles

After 1994, the VMT trend for category *Class 10-13 Commercial* shows a significant increase for all counties. As shown in the graphics on the next page, *Class 10-13 Commercial* VMT trend for Pennington County indicates the regression should be applied starting 1994 and onwards. The model fit improves slightly with different prediction outcome as the blue line indicates. Section 5.4.5 provides a comparison of calculated 20-year factors before and after adjustment to the starting point of the regression analysis.

It is important to note from the graph that the VMT in 2003 appears to be an outlier. The data needs to be adjusted for this, which would likely improve further the linear fit.



Use of linear regression in categories with no apparent growth (constant)

When VMT remains almost constant every year such as the pattern for *Other* class, a linear fit will only result in poor R^2 since there is no linear growth.

4. ***Lack of relationship between county business data and VMT***

Relationship of county business pattern by business size and VMT

The use of business pattern with employment data being grouped by business size to predict countywide VMT is not common. While there is logic to business size and the amount of trips generated that would significantly impact traffic at certain facilities, on a countywide level in a rural setting, employment growth by business size may not be a good predictor of growth in countywide VMT. Annual growth in the number of businesses in rural areas may not be significant for many years. The results of linear regressions of VMT and business pattern in Section 5.3.5 support this generalization as reflected in poor R^2 values for Buffalo, Todd, and Roberts counties (see Table 5-10).

Business groupings assumption

The business group assumption that correlates cars and trucks to VMT reveals to be a poor predictor of county VMT travel, particularly for commercial vehicles. Average annual growth derived from business data is used to adjust the 20-year forecasting factors for some categories, as described in Section 5.3.5. Business data should not be used to adjust the VMT factors when there is no meaningful relationship between the two data sets.

Assumption of 80/20 traffic split

There is little basis on this traffic split assumption especially that the business groupings do not correlate well with VMT.

5. ***Subjective adjustment process***

The current adjustment process has no sound basis since there is no meaningful direct relationship between county business data and VMT. Adjustment to the VMT factors is not necessary when there exists a good linear fit to use a linear regression technique. Use of an appropriate forecasting technique that best fits the data pattern would require no further adjustment to the calculated factors.

5.4 VALIDATION OF THE 20-YEAR TRAFFIC FORECASTING FACTORS

Validation involves testing the model's predictive capabilities. For traffic forecasting models, validation typically involves comparing model results with observed traffic data, as well as checks on reasonable expected growth trends in travel and socioeconomic activities. For this validation exercise, both countywide and statewide VMT, employment, and population growth are analyzed to evaluate the reasonableness of the linear regression technique for use in deriving 20-year traffic forecasts by functional class.

As mentioned in earlier sections, the 20-year traffic forecasting procedure originally developed in 1999 used historical county VMT from 1981 to 1998. Since then staff at SDDOT has been updating the forecasting procedure to include recent annual VMTs. The research team has received updated regressions to year 2004 with updated forecasting factors to 2024, which are used in the validation.

5.4.1 Statewide Historical Miles and VMT by Functional Class

Statewide historical VMT for passengers by functional class from 1993 to 2004 were analyzed to determine 20-year VMT factors and annual percentage growth. Results of the analysis are summarized in Table 5-11. It is important to note here that the results were obtained after adjusting the VMT data to account for the effect of reclassification from rural to urban that occurred in 2003.

Statewide historical data for trucks is only available as annual totals, i.e., no stratification into commercial class 5-9 and class 10-13 nor by functional no classifications and rural/urban areas. Results of linear regression for trucks are presented at the end of this section.

<u>General Observations of the Historical Statewide VMT Plots</u>

- In 2003, reclassification of rural miles to urban miles occurred requiring adjustment to the historical countywide VMTs. The reclassification largely affects VMTs on interstate highways and arterials.

- Besides reclassification, there has been a change in the Non-State Trunk Road Inventory (NSTRI) process. Over the last 5-6 years the collection of road data for the NSTRI has changed over to Geographic Positioning System (GPS) and the database of information is now stored in GIS resulting in a more accurate accounting of mileages in the lower functional class. This re-inventorying process resulted in decreased mileage in some counties and the opposite increased mileage in other countries.
- Table 5-12 provides a summary of linear fit for both original and adjusted (changed) 2004 VMT to account for the shift from rural to urban VMTs. Adjustment to the 2004 VMTs resulted in higher R^2 as depicted in the graphs and in Table 5-12, with the exception of *Other Passenger* class.
- The calculated 20-year VMT factors and annual percent growth indicates substantial differences with an improved linear fit.
- Interstate VMT trend shows nearly perfect linear fit for both rural and urban areas. The trend for Arterials and Other classes, however, are not as good as the linear trend for Interstates. Rural *Other* class exhibits a poor linear fit due to a sharp decline of VMT from 2003 which could be attributed to a drop in number of miles resulting from a reclassification from rural to urban and a change in the NSTRI process.
- Analysis of annual percent growth for *Other* class depicted in Figure 5-5 reveals marginal annual growth between 1995 and 2002, followed by a sharp decline in 2004 for rural. The somewhat sinusoidal pattern could be attributed to the 6-year cycle of traffic data collection for *Other* functional class. The results suggest that a linear regression technique may needed to be combined with data smoothing technique to estimate long term VMTs for *Other* class.
- One approach to smooth the data could be the *Moving Average* method that averages every 6 years of data. A test of this approach resulted in an improved R^2 for urban from 0.8752 to 0.9640. However, it did not substantially improve the R^2 for rural
- The Moving Average technique was performed in Brown, Clay, Todd, and Lawrence counties for *Other* class. While the results show improvement in R^2 with smoothed data, the results still fall short of the desirable R^2. It can be concluded that the Moving Average technique combined with linear regression technique is a less desirable technique to estimate long term VMT for *Other* class due largely to the marginal growth exhibited for this functional class.
- For *Other* class, Method 1 in Section 2.2.1 could be a suitable approach. Method 1 projects total VMT based on an estimated growth rate developed by planners. This growth rate may reflect historical growth, expectations for future growth using demographic or economic projections, or other factors as appropriate. Applying Method

1 for *Other* class, an average growth rate from 1997 could be used to estimate the 20-year VMT forecast.

- It is important to note that the roads classified in the *Other* category consist of lower functional classification of roads that the SDDOT has no jurisdiction over. While forecasting traffic on these roads may have some problems, however the importance of traffic forecasting factors of this road category to the SDDOT is very low.

Table 5-12 20-Year Statewide VMT (Passengers) Factors and Percent Annual Growth

		RURAL				URBAN				STATEWIDE
		Interstate	Arterials	Other	Total	Interstate	Arterials	Other	Total	Total
R-Square	Original	0.9075	0.7675	0.5832	0.6924	0.7726	0.7458	0.0070	0.8224	0.8788
	Changed	0.9677	0.8725	0.5816	0.8909	0.9777	0.7629	0.8752	0.9307	0.9349
% Annual Growth	Original	1.983%	0.969%	-1.327%	0.860%	2.914%	0.920%	0.119%	1.298%	0.965%
	Changed	2.109%	1.050%	-1.093%	0.986%	2.400%	0.712%	0.982%	1.163%	1.027%
20-Yr Factor	Original	1.481	1.213	0.766	1.187	1.776	1.201	1.024	1.294	1.212
	Changed	1.518	1.232	0.803	1.217	1.607	1.152	1.216	1.260	1.227

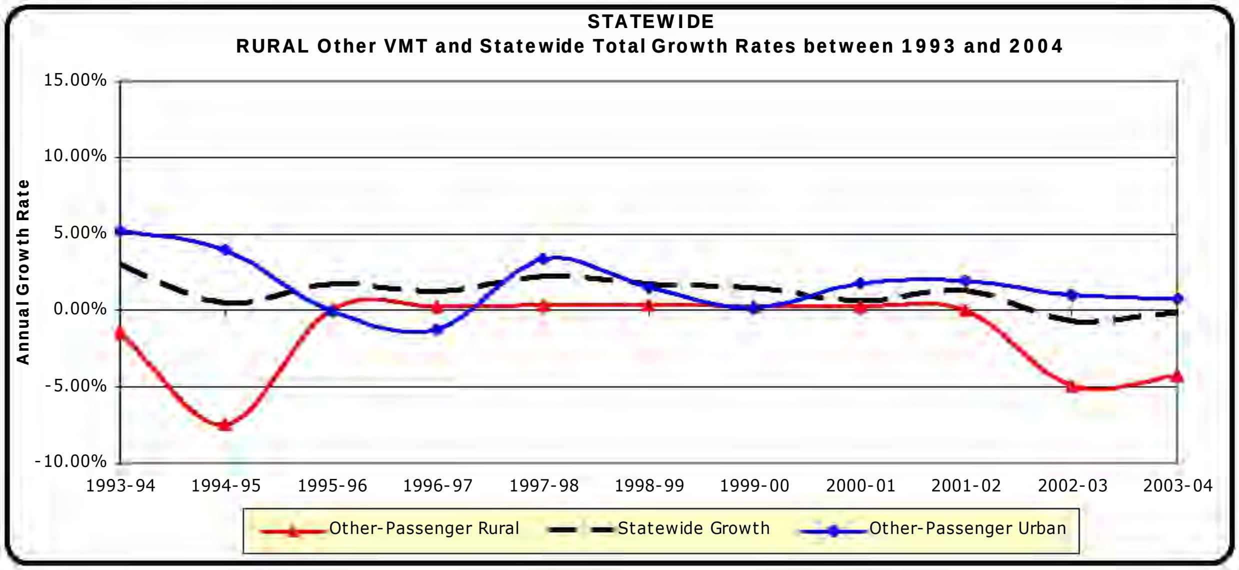
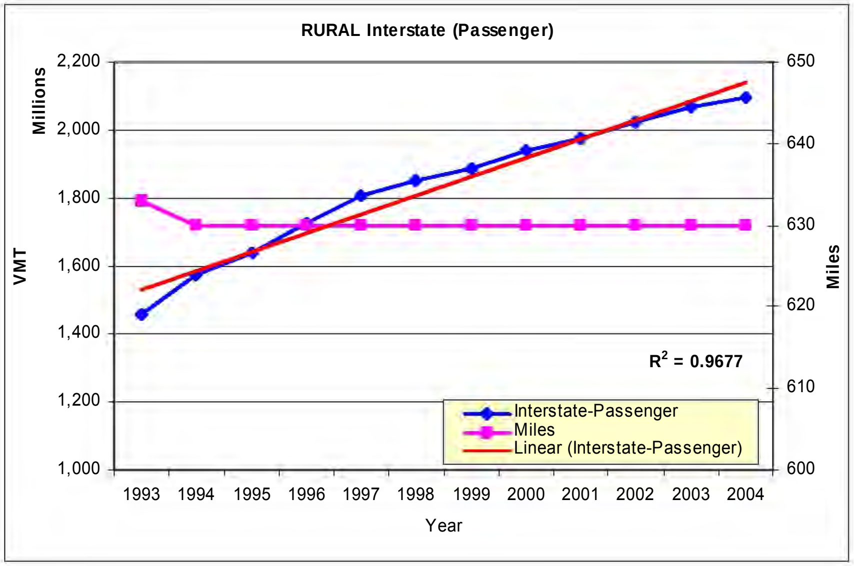
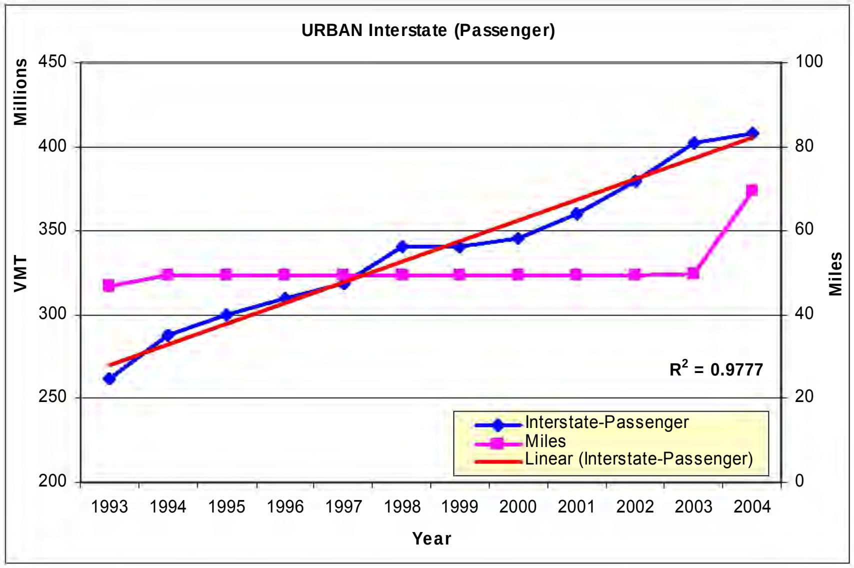
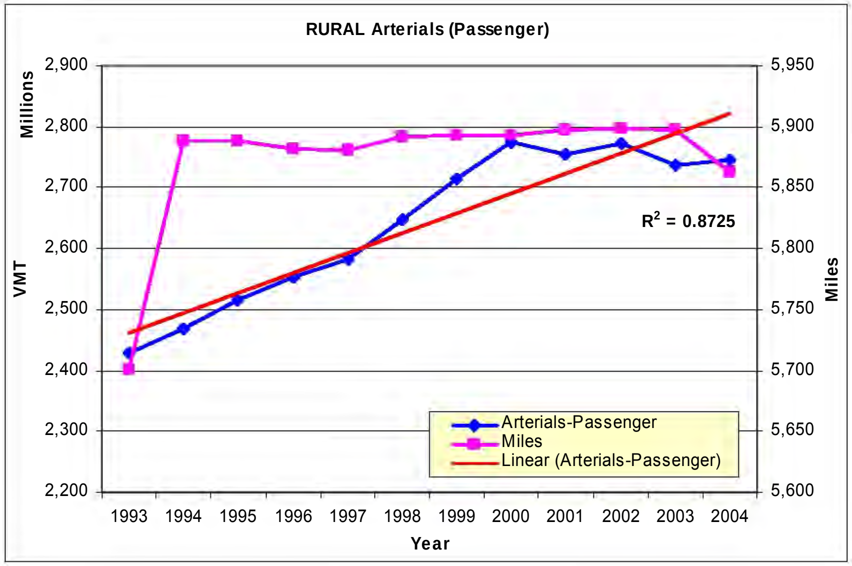


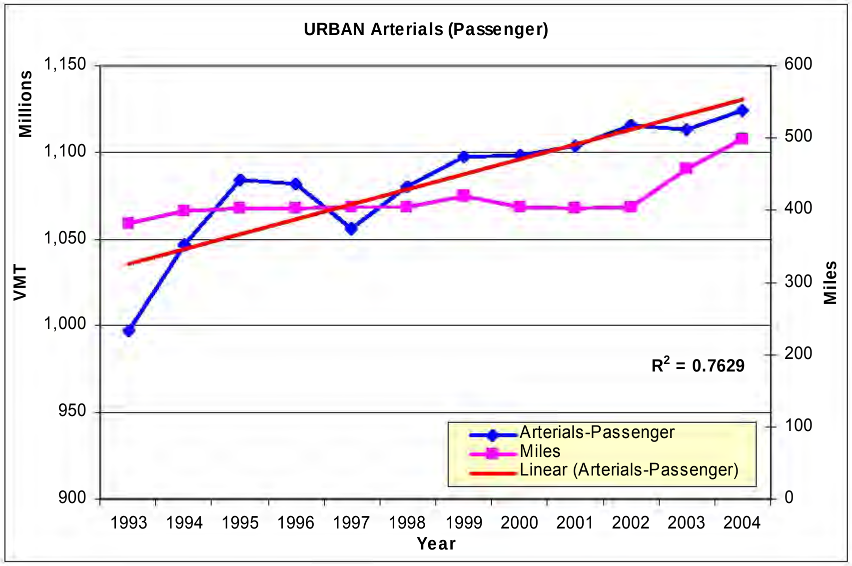
Figure 5-5 Statewide Other Passenger VMT and Statewide Total Passenger Growth Rates

STATEWIDE MILES AND VMT BY FUNCTIONAL CLASS

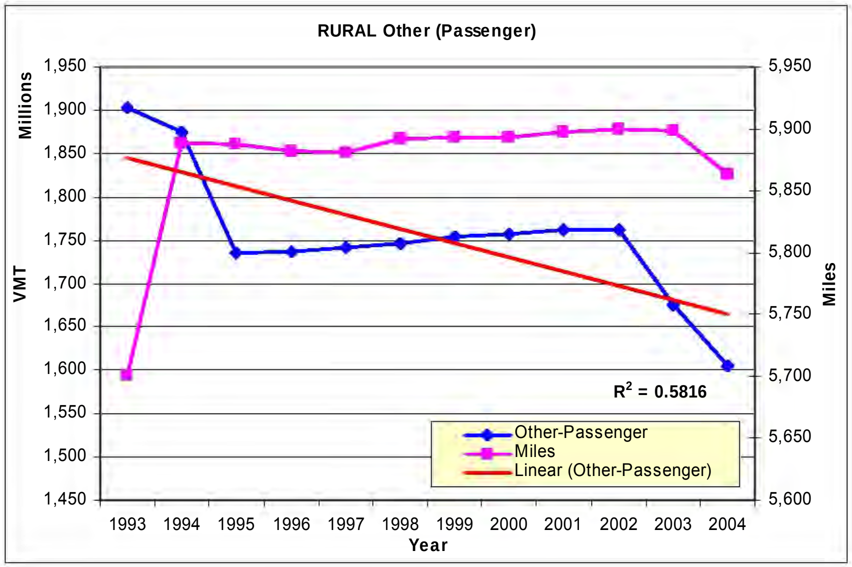


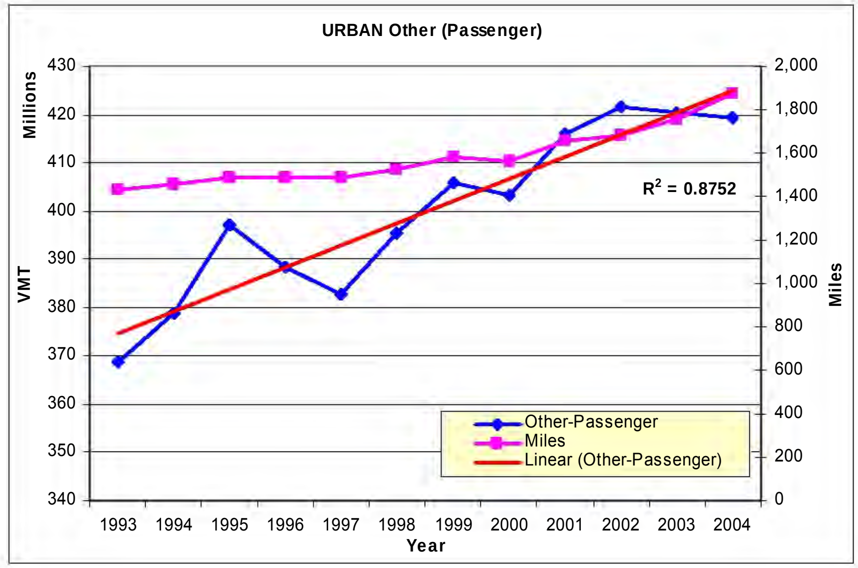




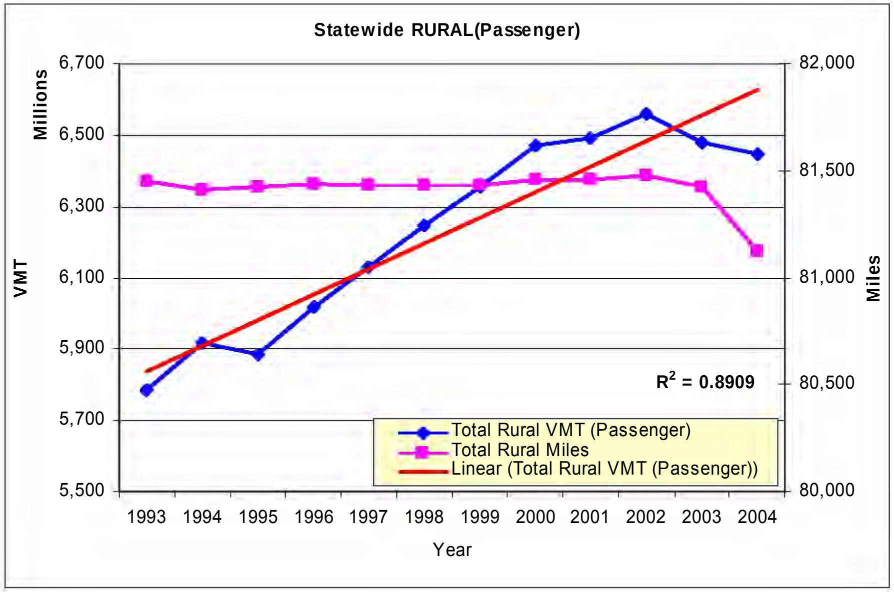


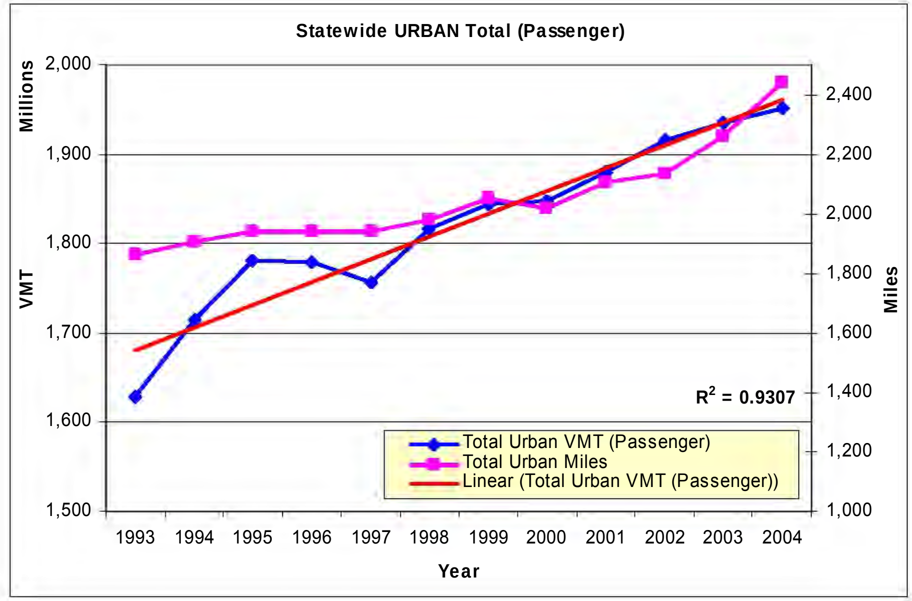
STATEWIDE MILES AND VMT BY FUNCTIONAL CLASS





STATEWIDE MILES AND VMT TOTAL BY RURAL AND URBAN AREAS



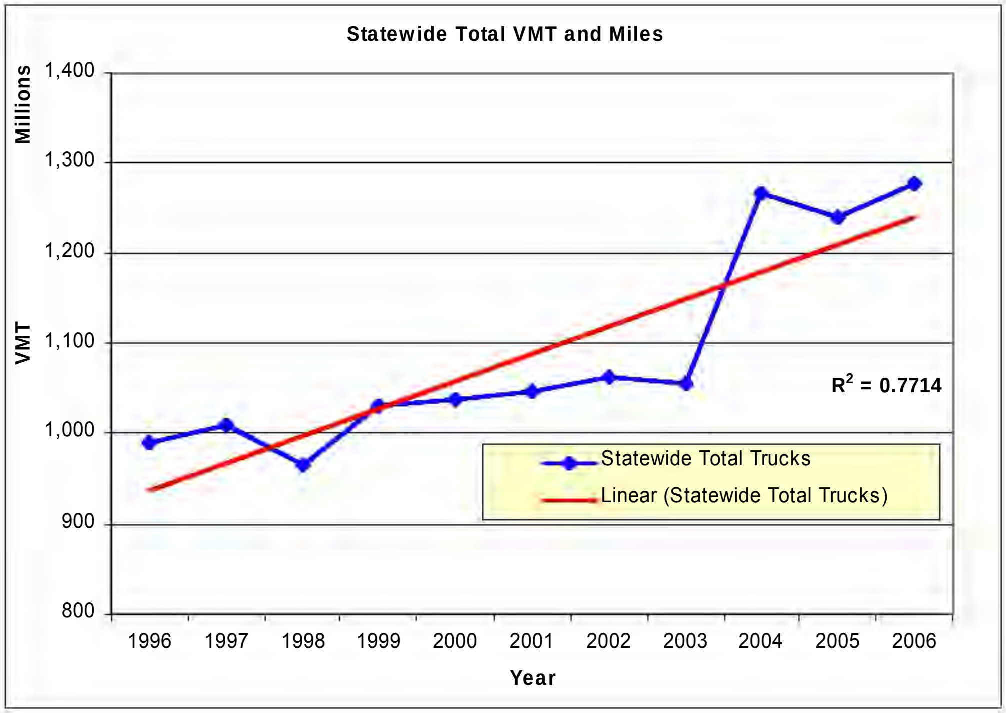


Statewide VMT (Trucks) Factors and Annual Growth

Linear regression of statewide historical VMT for trucks indicates a poor linear fit ($R^2 = 0.5483$) if using the data from 1996 to 2004. The linear fit improves ($R^2 = 0.7714$) if the data to 2006 is included. There is a sharp increase (about 20 percent) from 2003 to 2004, which affects the linear fit significantly, as the figure below indicates. The statewide pattern for trucks is not as smooth a trend as reflected for passenger car traffic. The calculated 20-year forecasting factors and annual percent growth are as follows:

20-year forecasting factor = 1.514
Annual percent growth = 2.097

These values provide a useful reference or control for the countywide factors and annual growth estimate.



5.4.2 Statewide VMT Growth Analysis by Functional Class

Analysis of annual percent growth in statewide VMT by functional class between 1993 and 2004 is summarized in Figures 5-6 and 5-7. These annual growth rates will be a useful indicator for the countywide VMT annual growth.

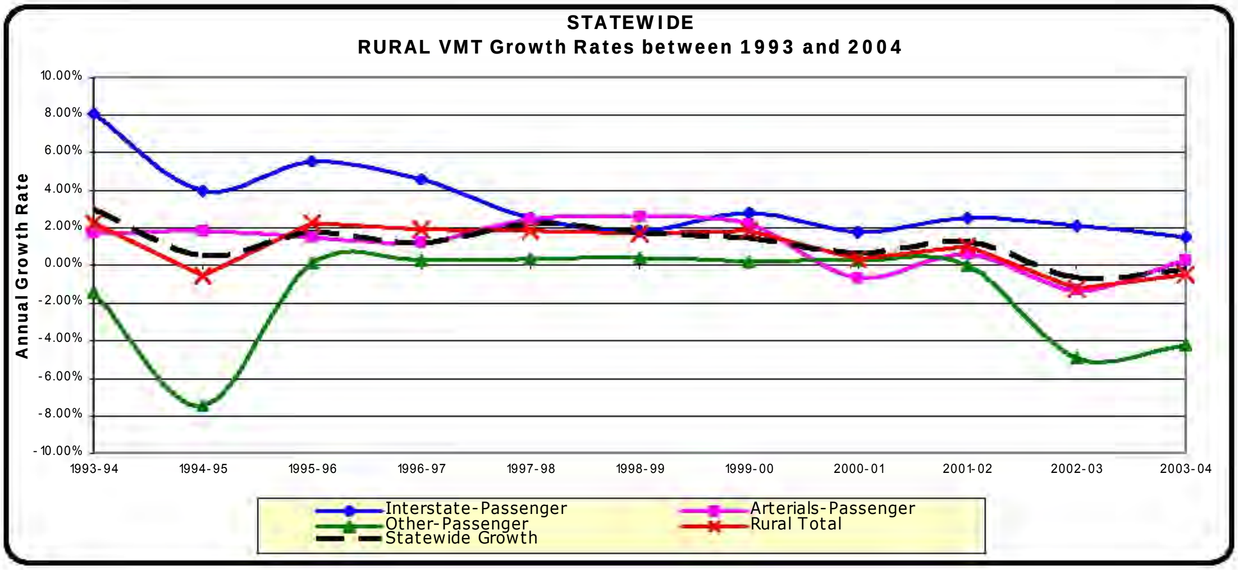


Figure 5-6 Statewide Rural VMT Growth Rates between 1993-2004

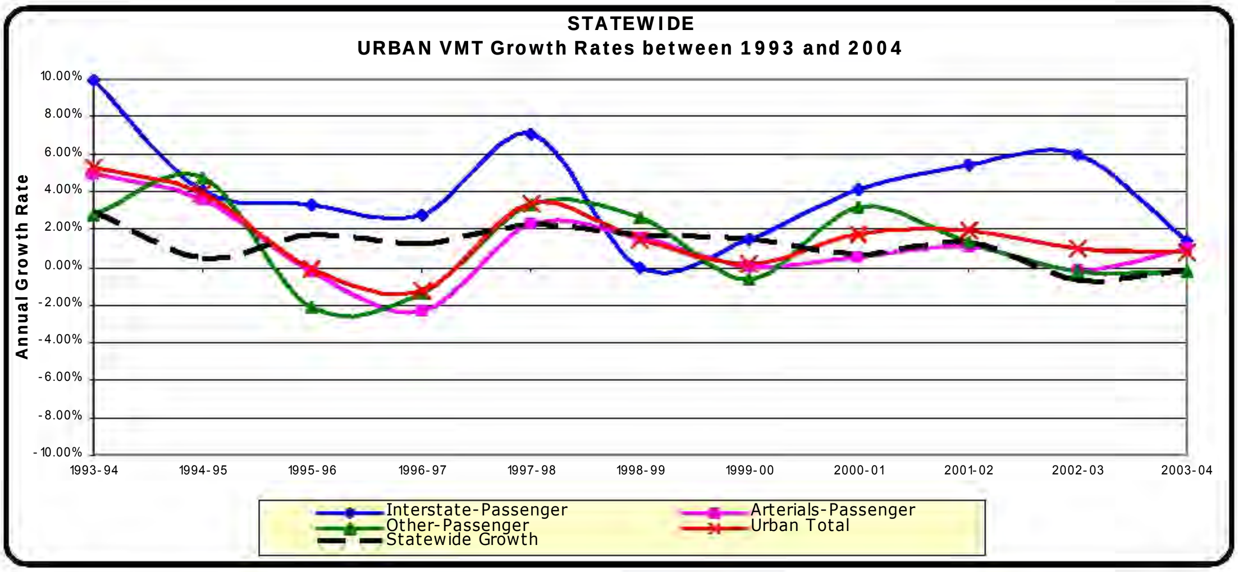


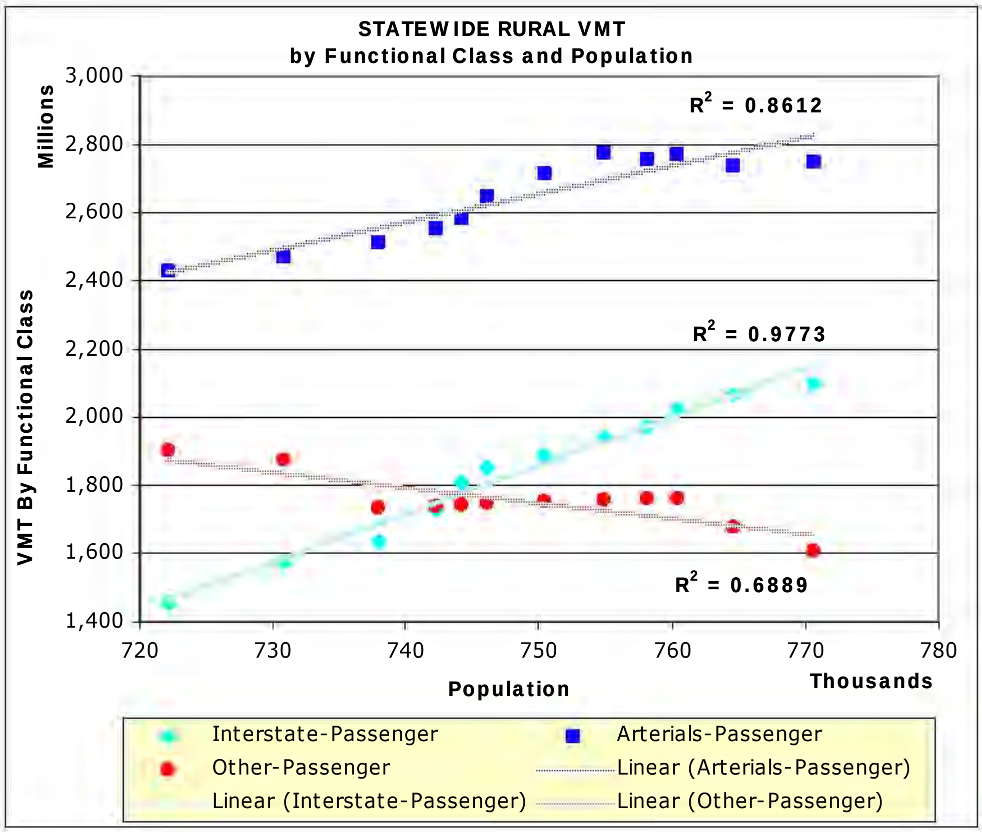
Figure 5-7 Statewide Rural VMT Growth Rates between 1993-2004

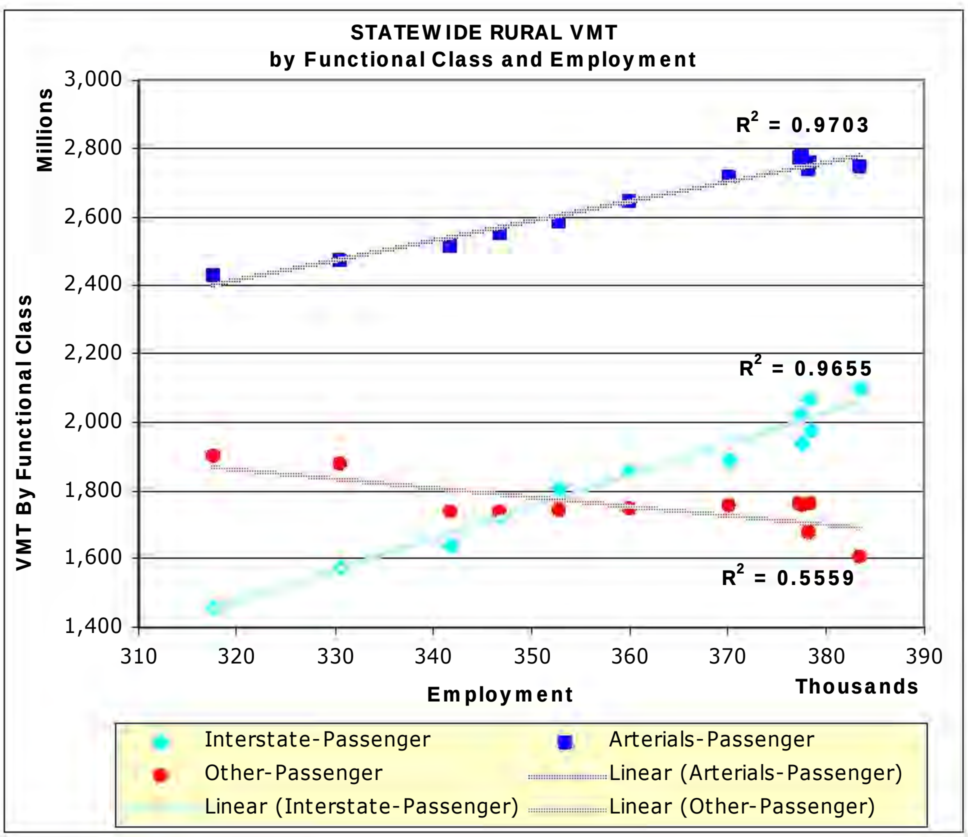
5.4.3 Statewide Employment, Population, and VMT Growth Trends

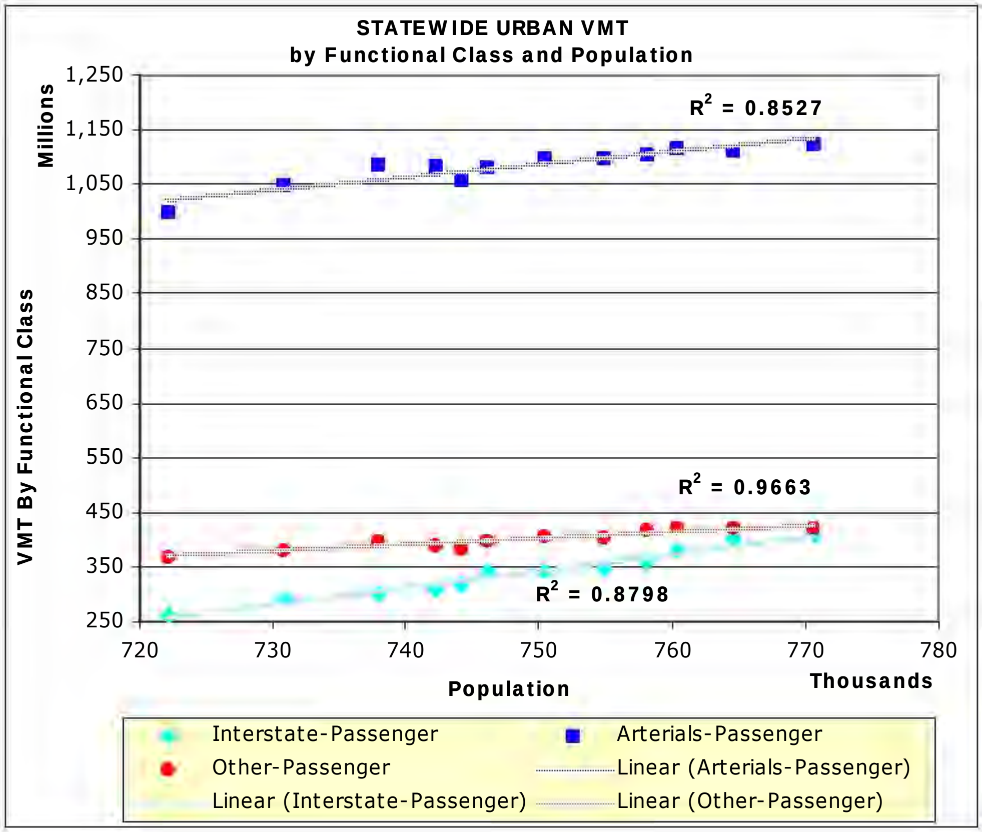
The relationship of statewide VMT with population and employment indicates a good linear fit, with the exception of *Rural Other* category and employment. The results are also shown graphically in the next two pages.

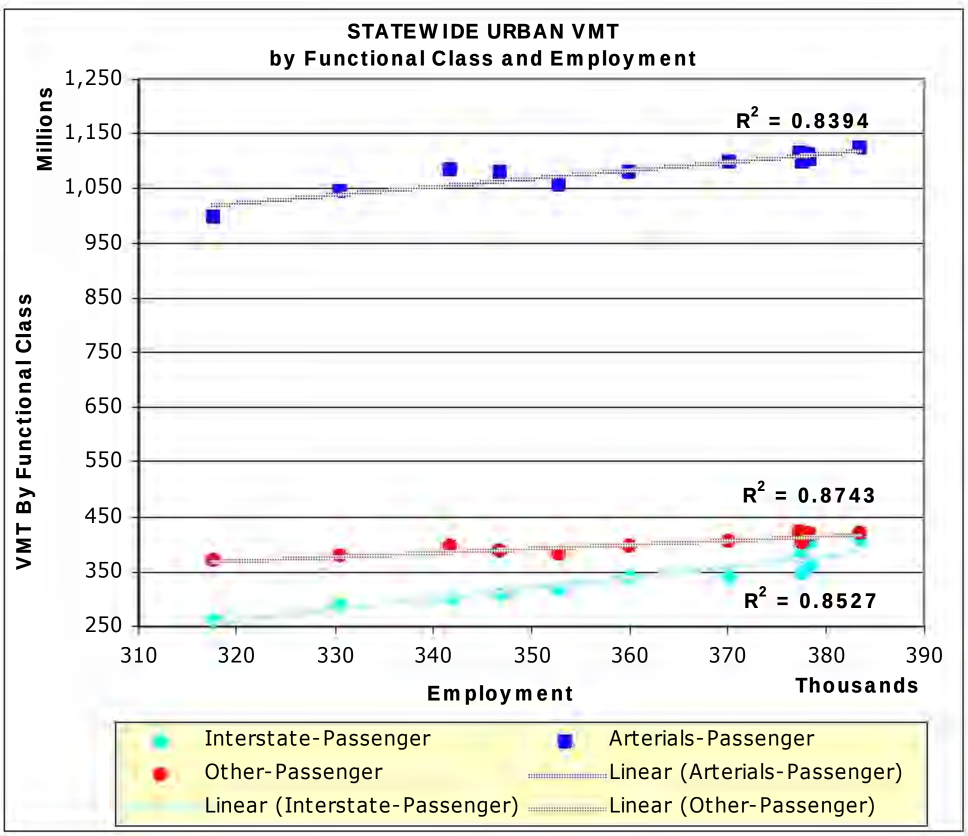
R-Square Values: Statewide VMT, Population, and Employment Regression

Categories	RURAL		URBAN	
	Population	Employment	Population	Employment
Interstate (Passenger)	0.9773	0.9655	0.9663	0.8743
Arterials (Passenger)	0.8612	0.9703	0.8527	0.8394
Other (Passenger)	0.6889	0.5559	0.8798	0.8527
Total	0.8567	0.9435	0.9625	0.9085


STATEWIDE RURAL VMT
by Functional Class and Population
VMT By Functional Class
Millions
3,000
2,800
2,600
2,400
2,200
2,000
1,800
1,600
1,400
R² = 0.8612
R² = 0.9773
R² = 0.6889
720
730
740
750
760
770
780
Population
Thousands
Interstate-Passenger
Arterials-Passenger
Other-Passenger
Linear (Arterials-Passenger)
Linear (Interstate-Passenger)
Linear (Other-Passenger)


STATEWIDE RURAL VMT
by Functional Class and Employment
VMT By Functional Class
Millions
3,000
2,800
2,600
2,400
2,200
2,000
1,800
1,600
1,400
R² = 0.9703
R² = 0.9655
R² = 0.5559
310
320
330
340
350
360
370
380
390
Employment
Thousands
Interstate-Passenger
Arterials-Passenger
Other-Passenger
Linear (Arterials-Passenger)
Linear (Interstate-Passenger)
Linear (Other-Passenger)


STATEWIDE URBAN VMT
by Functional Class and Population
Millions
VMT By Functional Class
1,250
1,150
1,050
950
850
750
650
550
450
350
250
R² = 0.8527
R² = 0.9663
R² = 0.8798
720
730
740
750
760
770
780
Population
Thousands
Interstate-Passenger
Arterials-Passenger
Other-Passenger
Linear (Arterials-Passenger)
Linear (Interstate-Passenger)
Linear (Other-Passenger)


STATEWIDE URBAN VMT
by Functional Class and Employment
Millions
VMT By Functional Class
1,250
1,150
1,050
950
850
750
650
550
450
350
250
R² = 0.8394
R² = 0.8743
R² = 0.8527
310
320
330
340
350
360
370
380
390
Employment
Thousands
Interstate-Passenger
Arterials-Passenger
Other-Passenger
Linear (Arterials-Passenger)
Linear (Interstate-Passenger)
Linear (Other-Passenger)

5.4.4 Countywide Employment, Population, and VMT Growth Trends

As mentioned in Section 5.4, model validation includes checking on annual growth in county level employment and population. County population from 1990 to 2005 was obtained from the U.S. Census Bureau while county employment was obtained from the Labor Market Information Center (LMIC) of the South Dakota Department of Labor. The employment data represents the total county nonfarm employment. LMIC defines "Nonfarm Wage & Salaried Workers" estimates to include all nonfarm full-time and part-time wage earners but exclude the self-employed and unpaid family workers. Persons holding more than one job are counted in each establishment in which they work. Statewide and MSA "Nonfarm Wage & Salaried Workers" estimates are developed by the South Dakota Department of Labor in cooperation with the US Bureau of Labor Statistics (LMIC, 2007).

The county nonfarm employment is not to be confused with the "county business pattern" data that has been indirectly used in deriving the 20-year traffic forecasting factors. As described in Section 5.2.2, the "county business pattern" data groups business "size-wise" by the number of employees per establishment.

Employment and Population Growth Trends

Table 5-13 presents county employment while Table 5-6 in Section 5.3.1 shows county population from 1990 to 2005. The notable absence of employment data for Meade and Pennington counties in Table 5-13 is due to the unavailability of county level data. Employment for these two counties are merged with the metropolitan area data.

Percent annual growth in employment is shown at the bottom of Table 5-13. Figure 5-8 provides a visual interpretation of employment growth for the selected counties. A similar visual representation of population growth is depicted in Figure 5-4 in Section 5.3.1. These growth patterns provide some controls for validating the results of the 20-year traffic forecasting factors in Section 5.4.5.

Table 5-13 Employment and Annual Growth for Selected Counties and Statewide

Year	Brown County	Buffalo County	Clay County	Lawrence County	Roberts County	Todd County	South Dakota
1990	17,255	320	5,345	10,255	2,750	1,865	288,651
1991	17,475	330	5,515	10,730	2,750	1,845	296,065
1992	17,715	330	5,655	10,960	2,599	1,995	307,820
1993	18,145	455	5,725	11,150	2,925	2,045	317,620
1994	18,800	450	5,820	11,100	2,905	2,085	330,535
1995	20,075	445	6,135	11,425	2,990	2,195	341,835
1996	20,145	400	6,090	11,370	3,060	2,180	346,880
1997	20,105	370	6,280	11,165	3,005	2,250	352,855
1998	20,255	425	6,725	10,595	3,000	2,290	360,025
1999	20,420	440	6,900	10,050	3,080	2,405	370,065
2000	20,900	515	7,000	10,300	3,305	2,595	377,600
2001	20,705	555	6,355	10,210	3,210	2,925	378,475
2002	20,165	555	6,330	11,010	3,140	2,870	377,310
2003	20,215	565	6,485	11,060	3,160	2,945	378,235
2004	20,510	570	6,730	11,095	3,325	2,955	383,530
2005	20,905	550	6,785	11,505	3,485	3,035	389,890
Annual Growth	**1.2%**	**3.4%**	**1.5%**	**0.7%**	**1.5%**	**3.1%**	**1.9%**

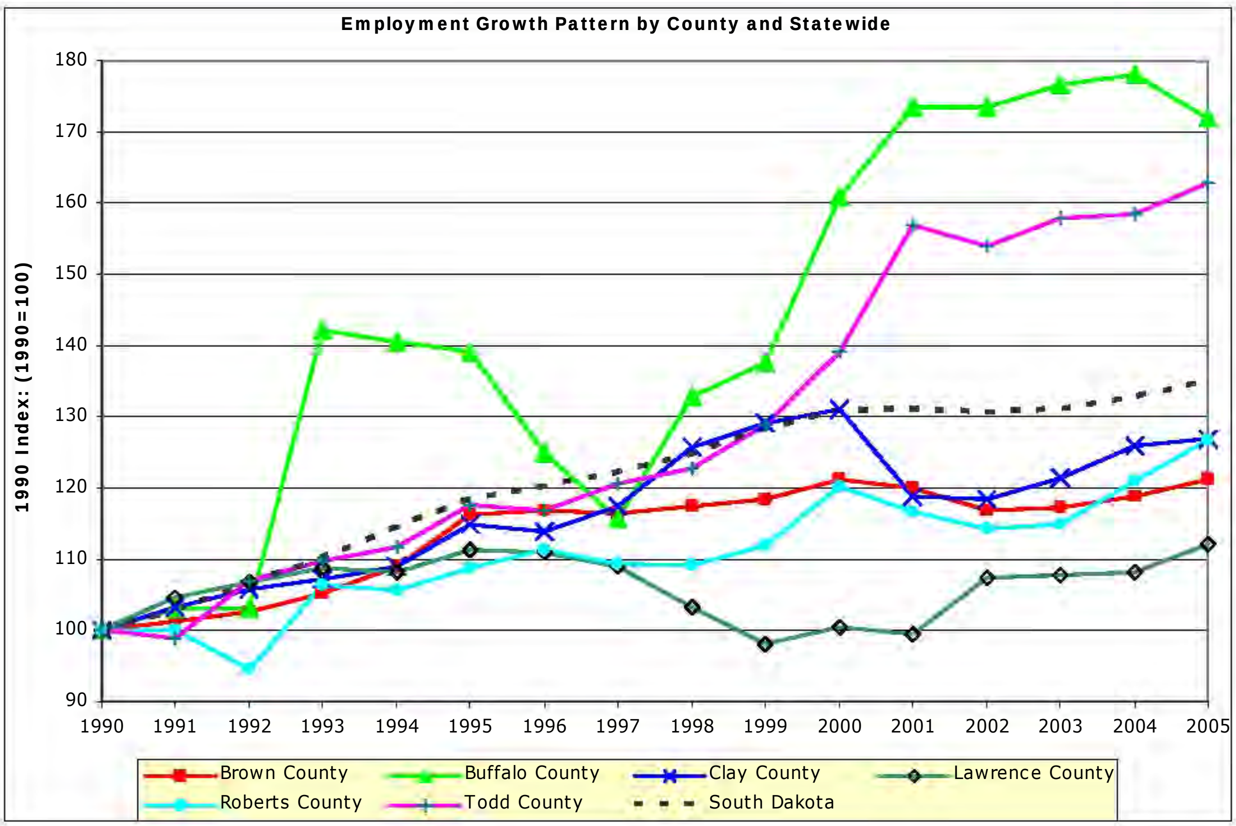


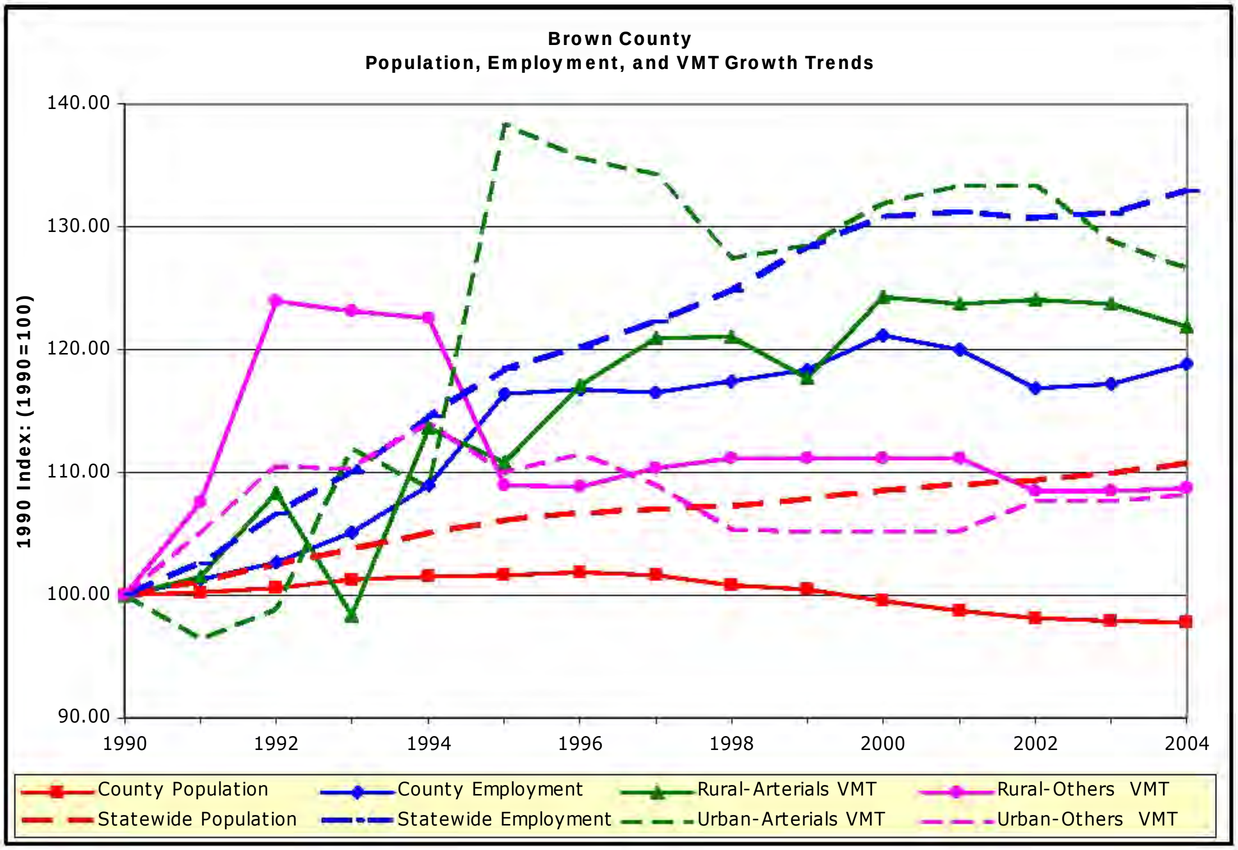
Figure 5-8 Employment Trend for Selected Counties and Statewide (1990-2005)

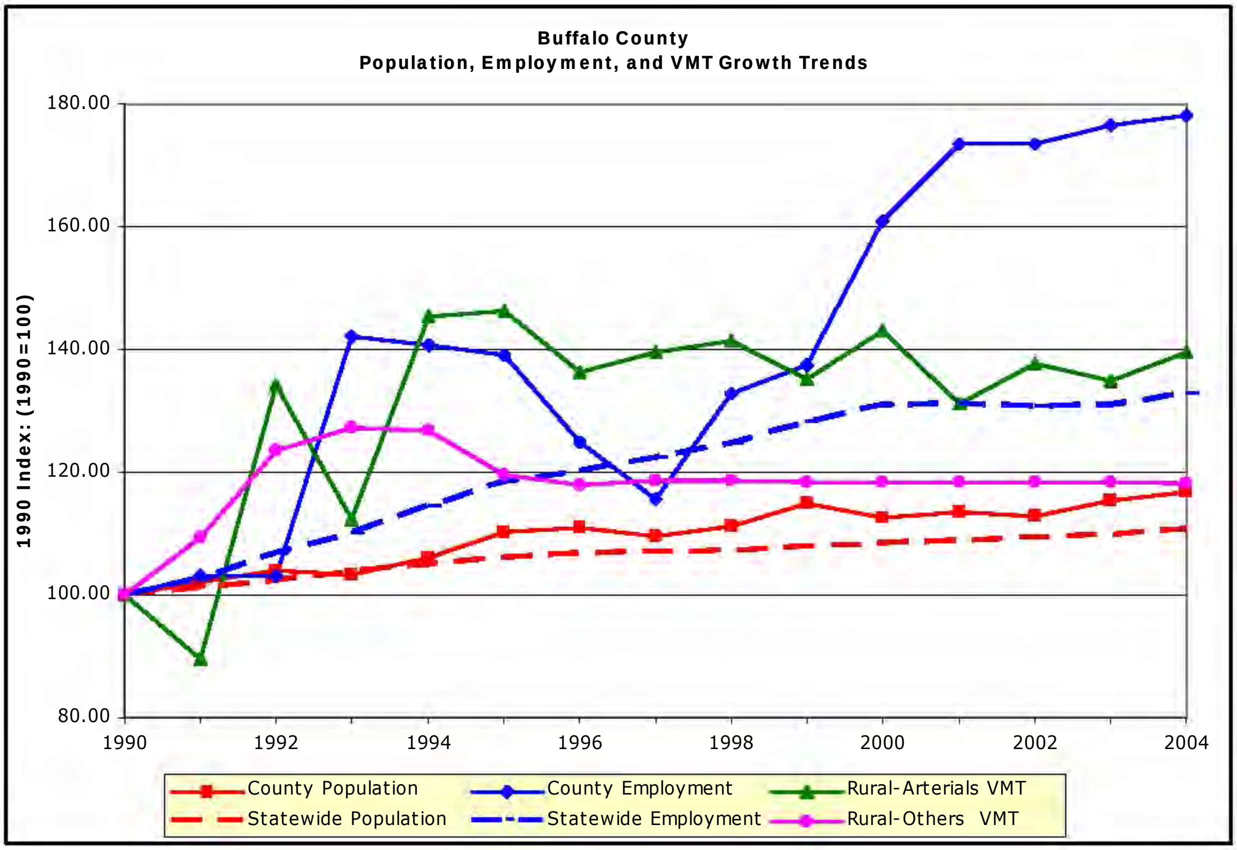
Employment, Population, and VMT Growth Trends

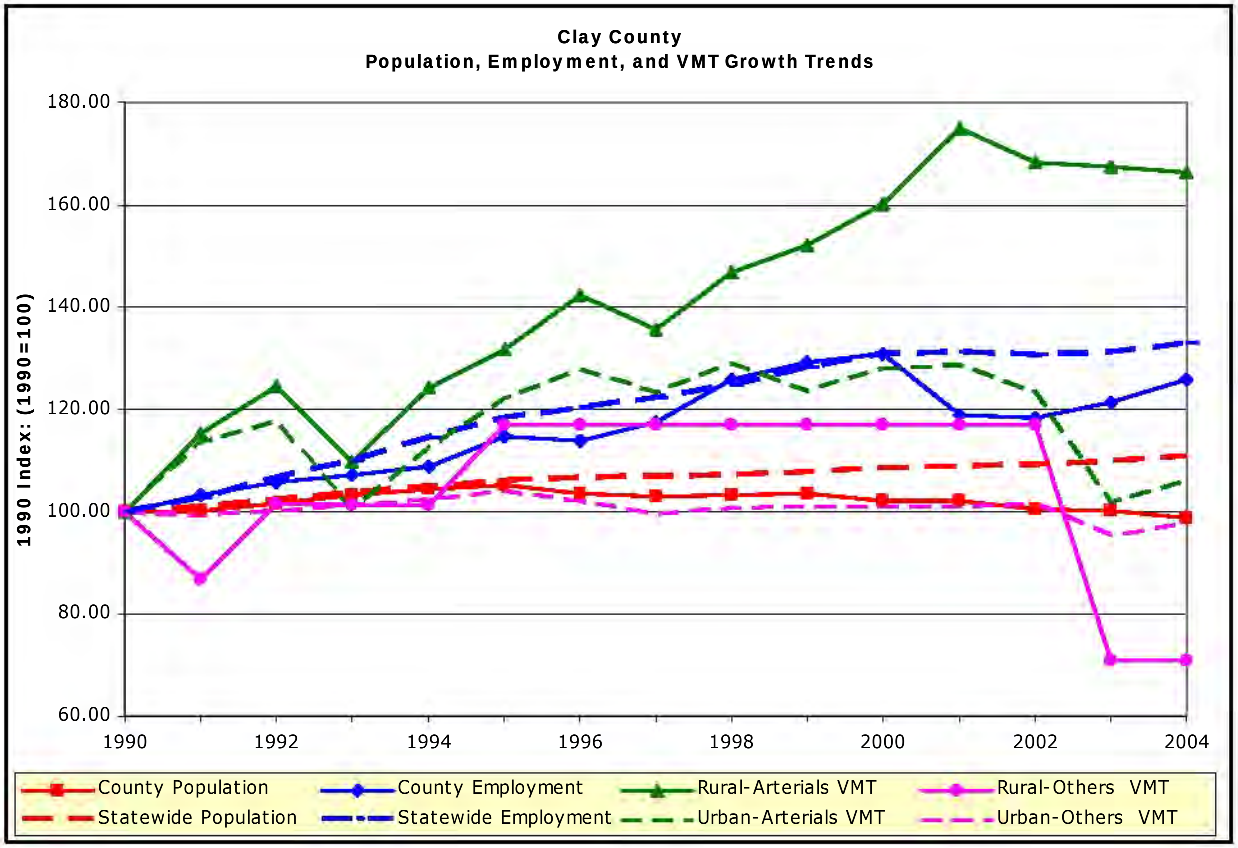
The next four pages provide a visual interpretation of growth trends in employment, population, and VMT by functional class and area type for the eight selected counties. The graphics also include growth trends in statewide employment and population.

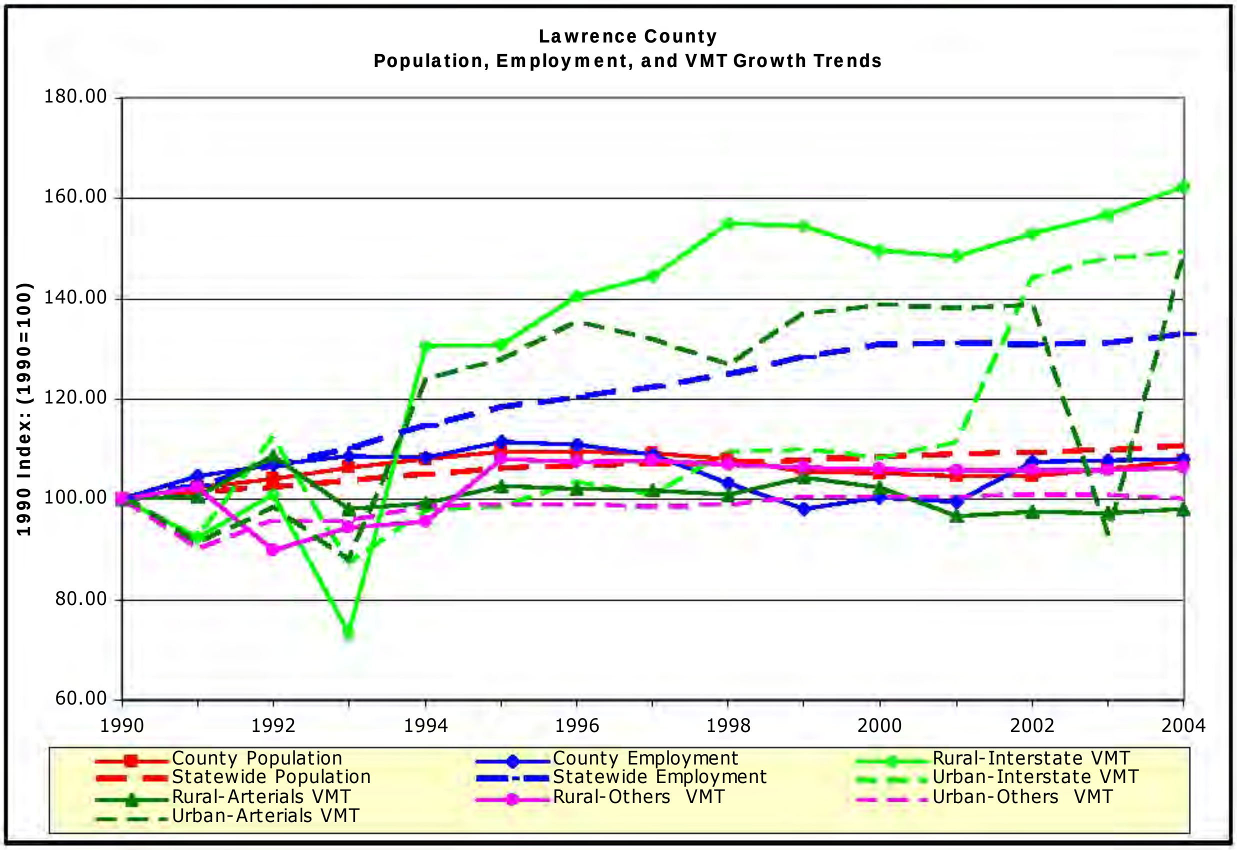
General Observations of Growth Trends in Employment, Population, and VMT

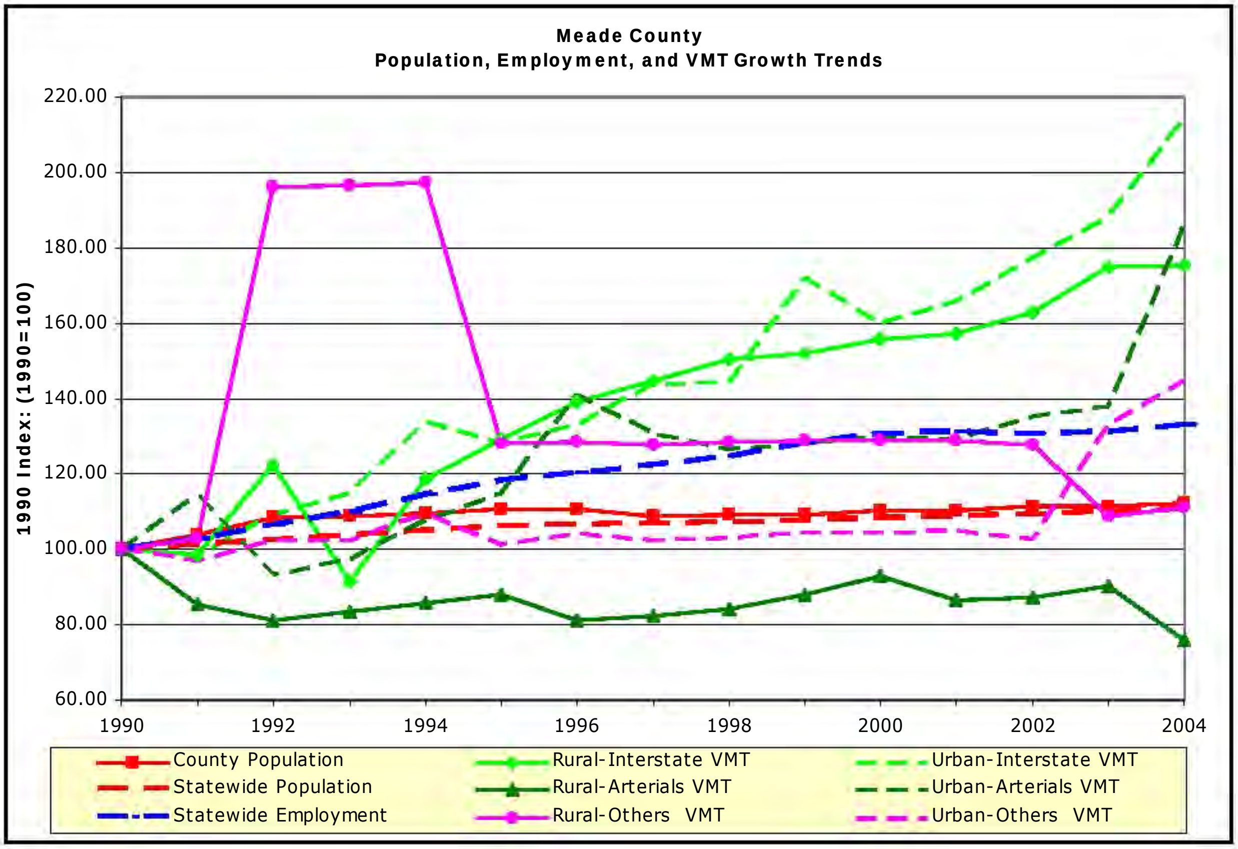
- While population in Brown County continues to decline, its employment shows an upward trend from 2002. From the same year, the VMTs suggest somewhat decreasing trend.
- Both population and employment show an upward trend for Buffalo County. VMTs on arterials appear to be fluctuating every other year from mid 1990s while VMTs on *Other* class appears constant from 1995.
- Like Brown County, Clay County's population continued to decline from mid 1990s. Employment appears somewhat on the upward trend after 2002. The downward trend in VMTs appear to be influenced by reclassification; otherwise, VMTs on *Other* class reflect no growth.
- Growth in employment, population and VMTs for arterials and *Other* class appear to be flat since 2000 for Lawrence County. Interstate VMTs, however, appear to be on an increasing trend since 2002.
- Similar to Lawrence County, growth in employment and population is also flat for Meade County. Interstate VMTs has significantly increased. The trend for arterials and other class appear to be affected by reclassification from rural to urban.
- Growth in population for Pennington County appears to be on a slight upward trend while employment growth remains flat. Interstate VMTs has significantly increased while VMT growth in arterials and other class remains modest since 2000. Sharp decline in VMTs in 2003 could be attributed to reclassification.
- Growth in population and employment for Roberts County appears to be on a slight the upward trend from 2002; however, the trend in VMTs for the same year appears to be on the downward side.
- Growth in population and employment for Todd County is slightly upward while VMT trend appears to be constant.

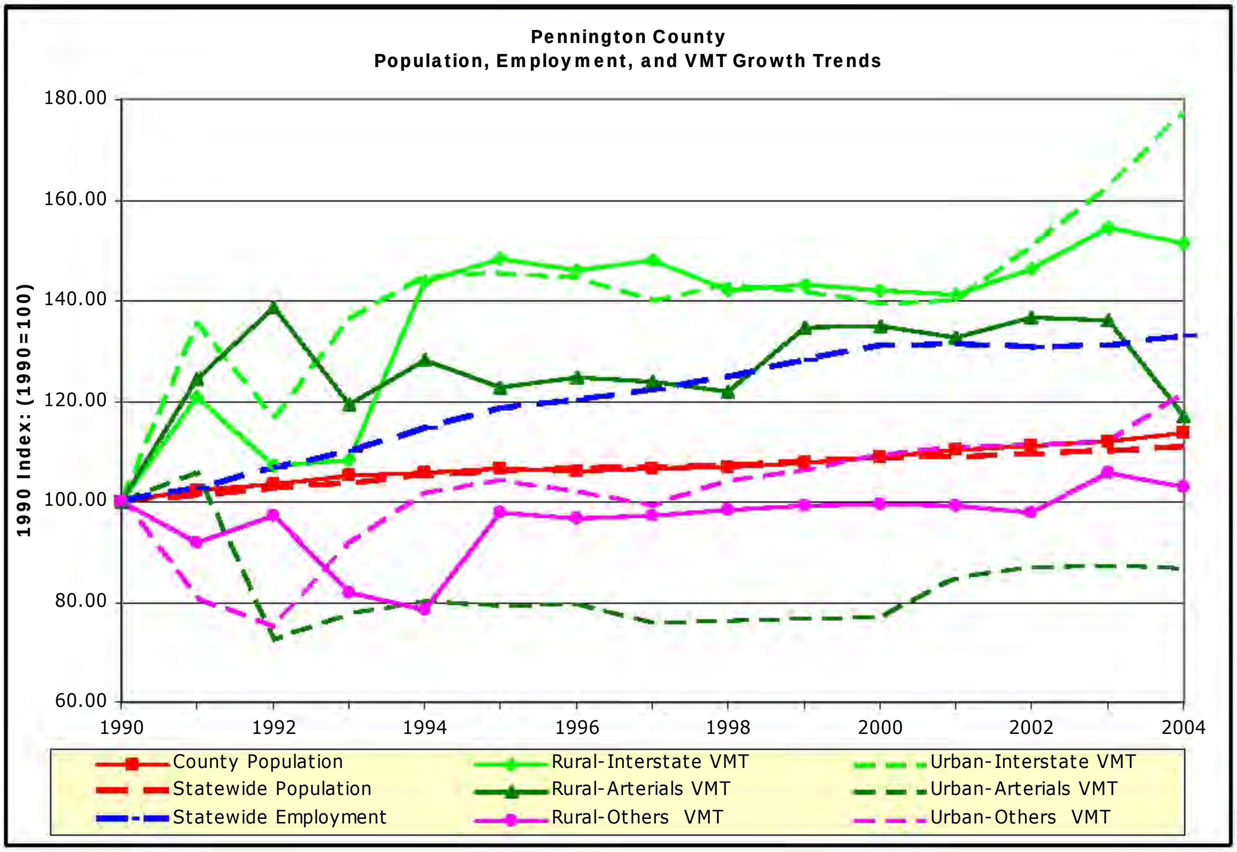

Brown County
Population, Employment, and VMT Growth Trends
1990 Index: (1990=100)
140.00
130.00
120.00
110.00
100.00
90.00
1990
1992
1994
1996
1998
2000
2002
2004
County Population
County Employment
Rural-Arterials VMT
Rural-Others VMT
Statewide Population
Statewide Employment
Urban-Arterials VMT
Urban-Others VMT

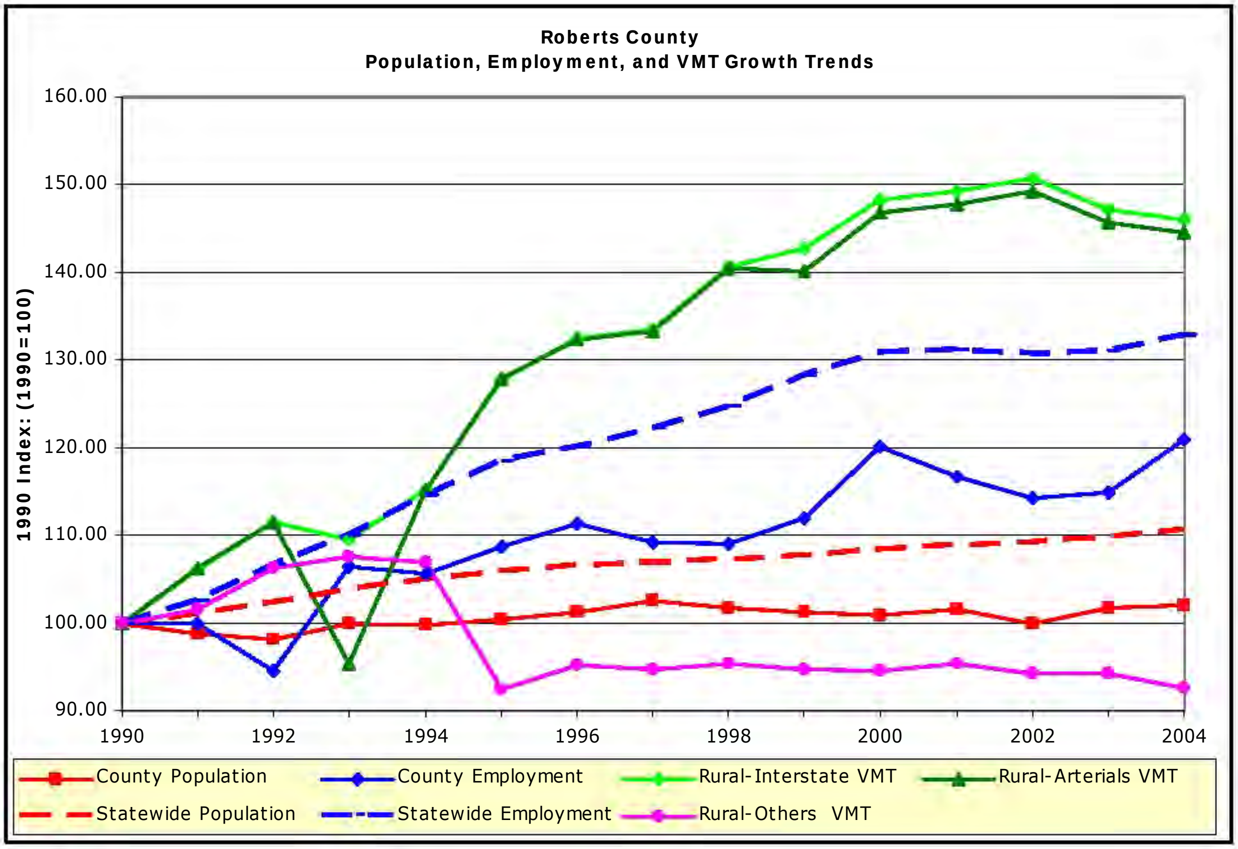

Buffalo County
Population, Employment, and VMT Growth Trends
1990 Index: (1990=100)
180.00
160.00
140.00
120.00
100.00
80.00
1990
1992
1994
1996
1998
2000
2002
2004
County Population
County Employment
Rural-Arterials VMT
Statewide Population
Statewide Employment
Rural-Others VMT

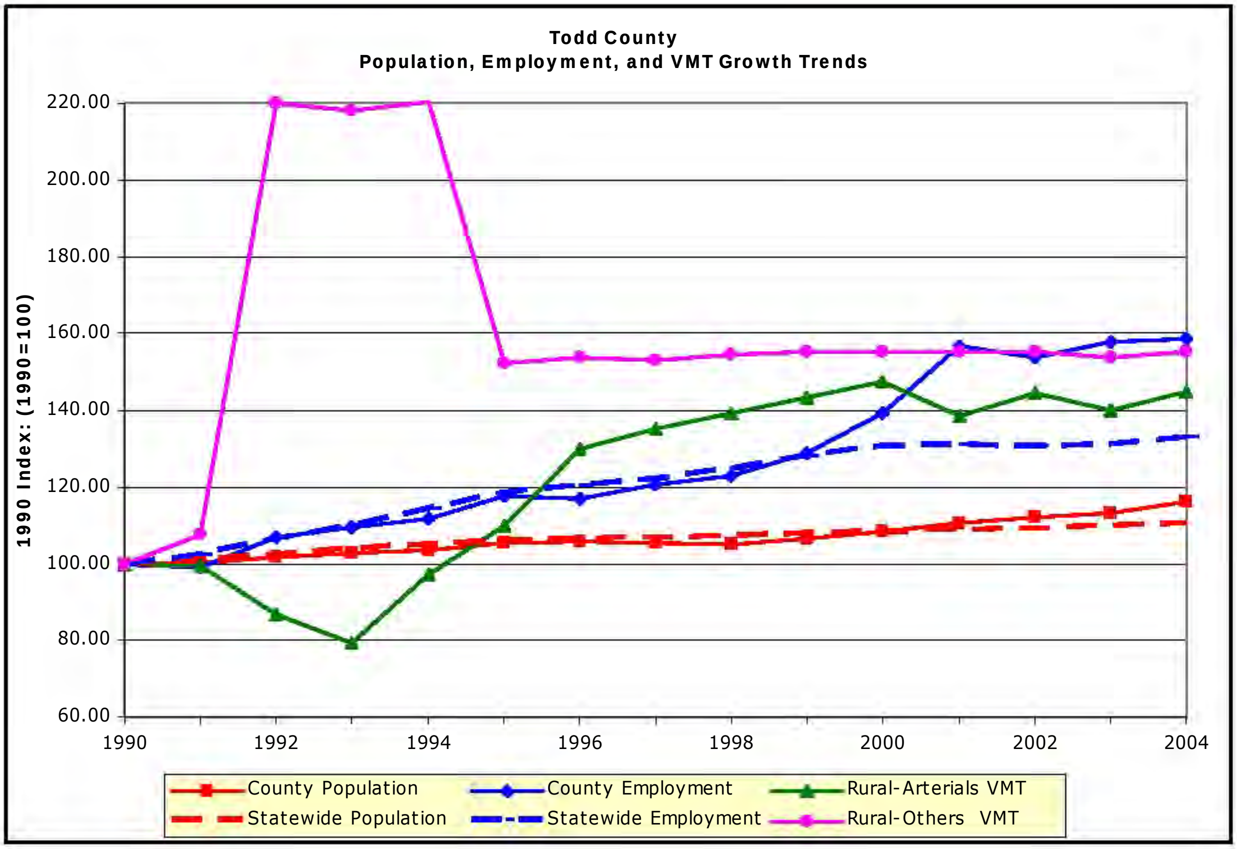

Clay County
Population, Employment, and VMT Growth Trends
1990 Index: (1990=100)
180.00
160.00
140.00
120.00
100.00
80.00
60.00
1990
1992
1994
1996
1998
2000
2002
2004
County Population
County Employment
Rural-Arterials VMT
Rural-Others VMT
Statewide Population
Statewide Employment
Urban-Arterials VMT
Urban-Others VMT


Lawrence County
Population, Employment, and VMT Growth Trends
1990 Index: (1990=100)
180.00
160.00
140.00
120.00
100.00
80.00
60.00
1990
1992
1994
1996
1998
2000
2002
2004
County Population
Statewide Population
Rural-Arterials VMT
Urban-Arterials VMT
County Employment
Statewide Employment
Rural-Others VMT
Rural-Interstate VMT
Urban-Interstate VMT
Urban-Others VMT


Meade County
Population, Employment, and VMT Growth Trends
220.00
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
1990 Index: (1990=100)
1990
1992
1994
1996
1998
2000
2002
2004
County Population
Statewide Population
Statewide Employment
Rural-Interstate VMT
Rural-Arterials VMT
Rural-Others VMT
Urban-Interstate VMT
Urban-Arterials VMT
Urban-Others VMT


Pennington County
Population, Employment, and VMT Growth Trends
180.00
160.00
140.00
120.00
100.00
80.00
60.00
1990 Index: (1990=100)
1990
1992
1994
1996
1998
2000
2002
2004
County Population
Statewide Population
Statewide Employment
Rural-Interstate VMT
Rural-Arterials VMT
Rural-Others VMT
Urban-Interstate VMT
Urban-Arterials VMT
Urban-Others VMT


Roberts County
Population, Employment, and VMT Growth Trends
1990 Index: (1990=100)
160.00
150.00
140.00
130.00
120.00
110.00
100.00
90.00
1990
1992
1994
1996
1998
2000
2002
2004
County Population
County Employment
Rural-Interstate VMT
Rural-Arterials VMT
Statewide Population
Statewide Employment
Rural-Others VMT


Todd County
Population, Employment, and VMT Growth Trends
1990 Index: (1990=100)
220.00
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
1990
1992
1994
1996
1998
2000
2002
2004
County Population
County Employment
Rural-Arterials VMT
Statewide Population
Statewide Employment
Rural-Others VMT

5.4.5 Relationship of VMT with Employment and Population

The relationship of population and employment to explain variation in countywide VMT was analyzed using a simple linear regression technique. A simple linear regression analysis involves one dependent variable and one independent variable.

Simple linear regressions with historical VMT as the dependent variable and population and employment as independent variables were performed using data from 1984 to 2004. It is important to note that population is not directly used in the current 20-year traffic forecasting procedure. However, implied in the review and analysis of the current traffic forecasting procedure under Task 5 was to validate the applicability of the linear regression technique to produce 20-year forecasts in South Dakota counties that have been experiencing a mix of population growth in some areas and a decline in other areas. Linear regressions of population with VMT is included here partly to examine if the linear regression technique is a valid method to use in South Dakota counties and partly as an exploratory analysis of potential independent variables to use directly in forecasting county level VMT.

The following conclusions can be drawn from the linear regressions results in Table 5-14:

- The results indicate that, generally, population is not a good predictor for countywide VMTs. Only two counties exhibit limited significant relationship of population with VMT: Todd County exhibits acceptable/desirable R^2 for *Arterials Passenger* and *Class 10-13* categories while Brown County shows desirable R^2 for *Class 5-9*. However, considering the limited sample of 8 counties analyzed in this review, the relationship of population should be further examined when updating the 20-year forecasting factors for the 66 counties. Population forecasts are relatively easier to obtain than employment and other socioeconomic variables. Thus, population can be a useful variable in counties where a linear relationship exists.
- Employment shows some significant relationships, particularly for routes designated as "rural." Acceptable/desirable R^2 are exhibited for most categories in Brown, Clay, Pennington, Roberts, and Todd counties. The only two categories that show no relationship with employment are *Other Passenger* and urban *Arterial Class 5-9*.
- The employment regressions with VMT also show significant relationship in counties with relatively lower population, such as Todd and Roberts counties. These results are in contrast to the results using county business data where no apparent relationship exists for these size counties (refer Table 5-10).
- The relationship of employment and VMT should be further explored, particularly in smaller counties. The results in Table 5-14 were obtained using unadjusted data for arterials and other functional class, which could have influence on the linear fit. Employment forecast can be obtained from commercially available databases at a modest cost.

Table 5-14 R-Square Values: Population, Employment, and VMT Regression Results

	Area Type and Functional Class	Brown County		Buffalo County		Clay County		Lawrence County		Meade County	Pennington County	Roberts County		Todd County	
		Pop.	Emp.	Pop.	Emp.	Pop.	Emp.	Pop.	Emp.	Pop.	Pop.	Pop.	Emp.	Pop.	Emp.
RURAL	Interstate (Passenger)	-	-	-	-	-	-	0.2127	0.0080	0.5806	**0.6581**	0.5776	**0.7424**	-	-
	Interstate Class 5-9 (Commercial)	-	-	-	-	-	-	0.5455	0.0102	**0.7705**	0.0111	0.5104	0.5167	-	-
	Interstate Class 10-13 (Commercial	-	-	-	-	-	-	0.1168	0.0005	0.4627	**0.6454**	0.5762	**0.7989**	-	-
	Interstate Total (Commercial)	-	-	-	-	-	-	0.3917	0.0055	**0.6714**	0.1540	0.5896	**0.6748**	-	-
	Interstate Total	-	-	-	-	-	-	0.1935	0.0108	0.5177	0.5532	0.5615	**0.6871**	-	-
	Arterials (Passenger)	0.1860	**0.8266**	0.4555	0.3168	0.0382	**0.6686**	0.0111	0.0209	0.1688	0.1686	0.4661	**0.7799**	0.6144	**0.6379**
	Arterials Class 5-9 (Commercial)	**0.7938**	0.1005	0.0949	0.1424	0.2180	0.0767	0.0658	0.0095	**0.7882**	0.4344	0.0053	0.0287	0.2764	0.2678
	Arterials Class 10-13 (Commercial)	0.5703	**0.6046**	**0.7950**	**0.7549**	0.1229	**0.6031**	0.0190	0.0488	0.3923	**0.7999**	0.3682	**0.7884**	**0.7554**	**0.8538**
	Arterials Total (Commercial)	0.1573	**0.8311**	0.0700	0.0262	0.0125	**0.6122**	0.1708	0.0346	**0.7608**	0.0746	0.4811	**0.6783**	**0.6003**	**0.6464**
	Arterials Total	0.2059	**0.8183**	0.4756	0.2376	0.0446	**0.6714**	0.0005	0.0035	0.2876	0.2071	0.4394	**0.6907**	0.5905	**0.6170**
	Other (Passenger)	0.0053	0.3760	0.0682	0.1227	0.4474	0.0291	0.1327	0.0047	0.0370	0.1798	0.5103	0.5192	0.0009	0.0022
	Rural Total	0.1228	0.0268	0.4502	0.2416	0.0011	**0.6744**	0.0277	0.0077	0.0257	0.3167	0.2595	0.5638	**0.6310**	**0.6439**
URBAN	Interstate (Passenger)	-	-	-	-	-	-	0.0003	0.0056	0.5982	**0.7506**	-	-	-	-
	Interstate Class 5-9 (Commercial)	-	-	-	-	-	-	0.0149	0.0425	0.3129	**0.7309**	-	-	-	-
	Interstate Class 10-13 (Commercial	-	-	-	-	-	-	0.0004	0.0809	0.2424	**0.6176**	-	-	-	-
	Interstate Total (Commercial)	-	-	-	-	-	-	0.0084	0.0560	0.2996	**0.7200**	-	-	-	-
	Interstate Total	-	-	-	-	-	-	0.0005	0.0004	0.5409	**0.8881**				
	Arterials (Passenger)	0.0074	**0.6704**	-	-	0.2972	0.2056	0.2350	0.0050	0.3232	0.5855	-	-	-	-
	Arterials Class 5-9 (Commercial)	0.0920	0.2030	-	-	0.0528	0.1398	0.0928	0.0007	0.0693	0.0008	-	-	-	-
	Arterials Class 10-13 (Commercial)	0.5486	0.4917	-	-	0.1614	**0.6370**	0.0409	0.0235	0.2876	**0.7763**	-	-	-	-
	Arterials Total (Commercial)	0.1724	**0.7914**	-	-	0.0334	0.2093	0.09849	0.01418	0.3328	0.5786	-	-	-	-
	Arterials Total	0.0001	**0.7389**	-	-	0.2055	0.2356	0.21653	0.00898	0.3169	**0.6278**	-	-	-	-
	Other (Passenger)	0.1579	0.0049	-	-	0.5736	0.0171	0.04508	0.04484	0.2208	0.0558	-	-	-	-
	Urban Total Total	0.0004	**0.6956**	-	-	0.2274	0.2190	0.2131	0.0104	0.3225	0.5074	-	-	-	-
	County Total	0.0694	0.0050	0.4502	0.2416	0.0117	0.0009	0.1720	0.0120	0.5720	**0.7302**	0.5615	**0.6871**	**0.6310**	**0.6439**

5.4.6 Validation of 20-Year Traffic Forecasting Factors

This section presents in detail the calculated 20-year VMT factors and annual percent growth using the original historical VMT data, as well as results after making appropriate changes to the data. Statewide growth is referred to check for reasonableness of the calculated factors and annual growth by categories.

Tables 5-15 to 22 provide a summary of results by county. Rows labeled "Original" refer to the results using the unadjusted historical VMT data while rows labeled "Changed" refer to results with the following adjustments and changes — removing some outliers, adjusting shifts in VMT due to reclassification, changing the starting year of the regression analysis for some categories, aggregating some categories, and using a combination of data smoothing by the Moving Average technique.

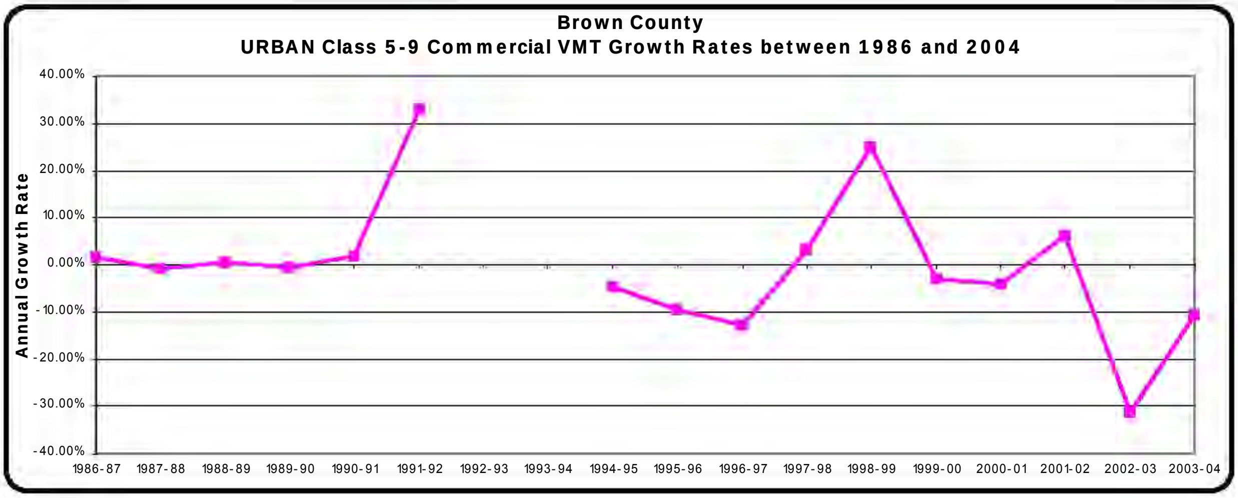
Results reflecting the same value for "original" and "changed" means no adjustment was applied because either the linear fit is already good or the data pattern indicates that a linear regression is not suitable. Categories highlighted in "yellow" means adjustment was made, which did not substantially improve the goodness of fit to a desirable value.

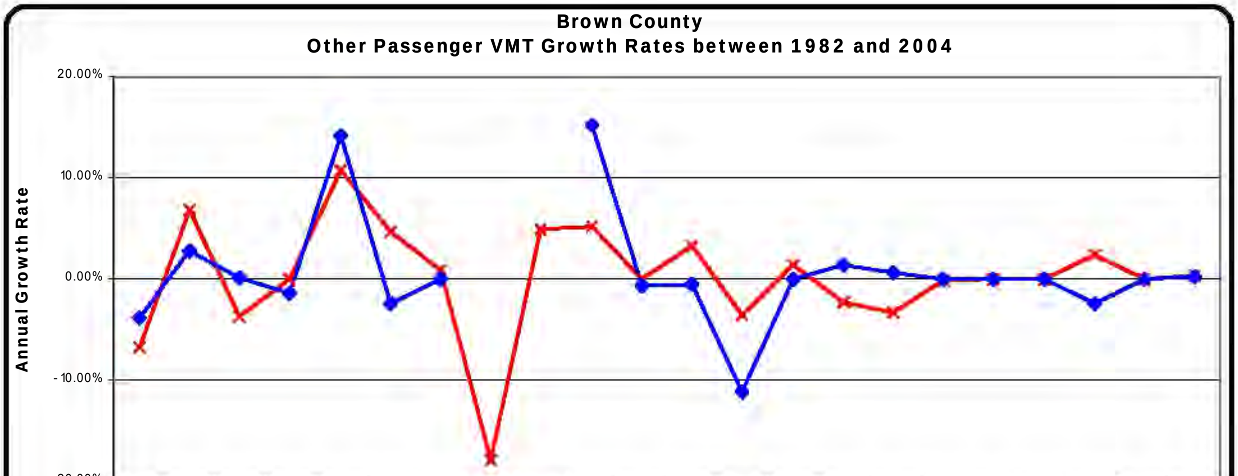
Brown County

- The higher R^2 for rural commercial vehicles and Urban Class 10-13 is attributed to a change in the starting year of the regression analysis to year 1994.
- Adjustment to Urban Class 5-9 was not attempted as the plot shown on the next page reveals a non-linear pattern.
- Data outlier for rural Other Passenger Class did not substantially improve the linear fit. The plots on the next page show hardly any growth since 1995.

Table 5-15 20-Year VMT Factors and Annual Growth by Functional Class for Brown County

		RURAL				URBAN			
		ARTERIALS			OTHER	ARTERIALS			OTHER
		Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger	Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger
R-Square	Original	**0.8345**	0.1197	**0.8908**	0.1137	**0.7446**	0.2665	**0.7851**	0.0063
	Changed	**0.8345**	**0.8523**	**0.9307**	0.5324	**0.7446**	0.2665	**0.8481**	0.4085
% Annual Growth	Original	1.002%	**-0.421%**	5.108%	0.887%	1.339%	1.449%	4.434%	**-0.059%**
	Changed	1.002%	**-3.344%**	5.108%	1.091%	1.339%		5.517%	**-0.452%**
20-Yr Factor	Original	1.221	0.919	2.283	1.193	1.305	1.333	2.382	1.213*
	Changed	1.221	0.506	2.709	1.242	1.305		2.927	0.913





	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04
Urban	-6.72%	6.80%	-3.72%	-0.04%	10.82%	4.74%	0.91%	-17.89%	4.95%	5.23%	-0.04%	3.25%	-3.52%	1.45%	-2.33%	-3.33%	-0.12%	0.00%	0.00%	2.37%	-0.01%	0.42%
Rural	-3.79%	2.82%	0.18%	-1.44%	14.15%	-2.39%	0.06%			15.21%	-0.62%	-0.53%	-11.10%	-0.03%	1.38%	0.66%	0.03%	0.00%	0.00%	-2.37%	0.00%	0.19%

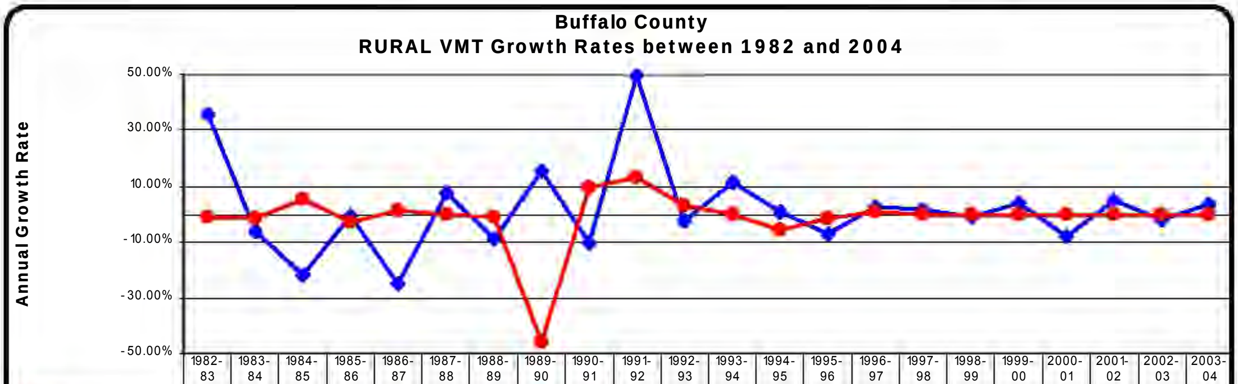
Buffalo County

No improvement in Arterial Passengers, refer to growth analysis trend, oscillating normal for traffic

- Table 5-16 summarizes the results for Buffalo County.
- Adjustment to Arterials Passenger Class did not substantially improve the linear fit. Annual VMT growth from 1994 has been marginal and fluctuated every other year as the plot depicts. An average growth percentage can be assumed for this class.
- Factor for Class 5-9 was derived by aggregating the VMTs of commercial vehicles. Data smoothing was applied using the moving average method before applying the linear regression. The starting year of the regression is changed to year 1994.
- Other Passenger Class has shift in VMT in 1990. The regression start year was adjusted instead of adjusting the VMT data.

Table 5-16 20-Year VMT Factors and Annual Growth by Functional Class for Buffalo County

		ARTERIALS			OTHER
		Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger
R-Square	Original	0.1188	0.0099	**0.8848**	**0.6294**
	Changed	0.1477	**0.7612**	**0.9001**	**0.8760**
% Annual Growth	Original	0.741%	0.601%	4.268%	0.265%
	Changed		-3.120%	5.095%	-0.052%
20-Yr Factor	Original	1.159	1.000	2.307	1.054
	Changed		0.531	2.701	0.990



	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
Arterials (Passenger)	35.56%	-6.23%	-21.97	-0.79%	-25.29	7.64%	-9.08%	15.33%	-10.39	49.68%	-2.58%
Other (Passenger)	-1.06%	-1.49%	5.42%	-2.91%	1.22%	-0.32%	-0.93%	-45.79	9.31%	13.06%	2.96%

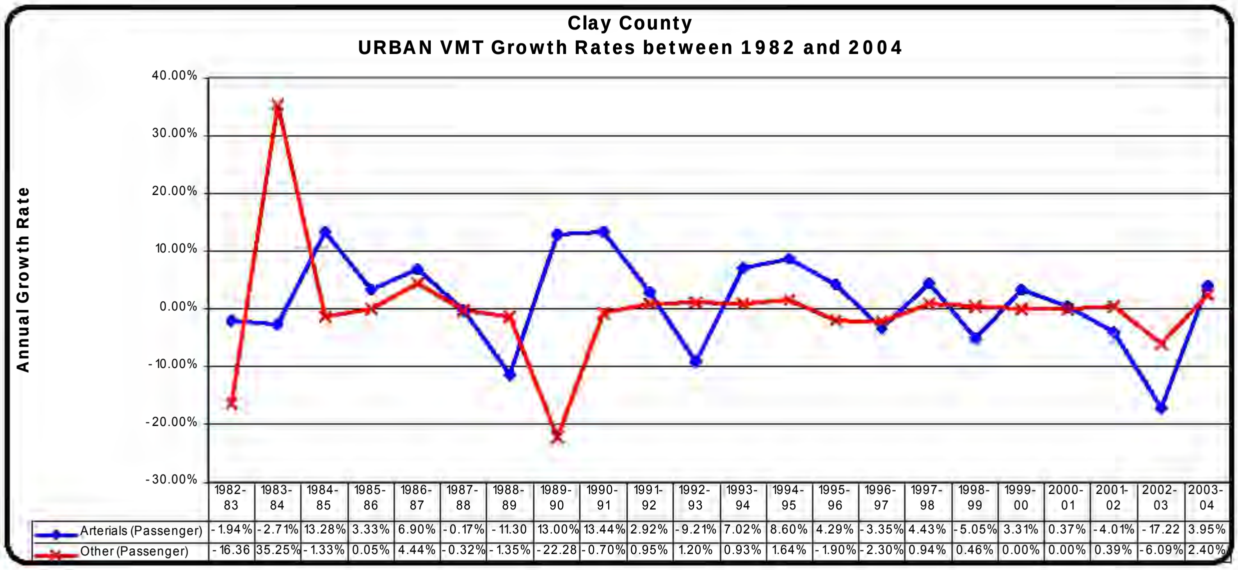
	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04
Arterials (Passenger)	11.19%	0.76%	-6.94%	2.35%	1.45%	-1.30%	4.07%	-8.29%	4.96%	-1.89%	3.31%
Other (Passenger)	-0.46%	-5.58%	-1.39%	0.57%	-0.08%	-0.11%	0.00%	0.00%	-0.08%	0.00%	-0.19%

Clay County

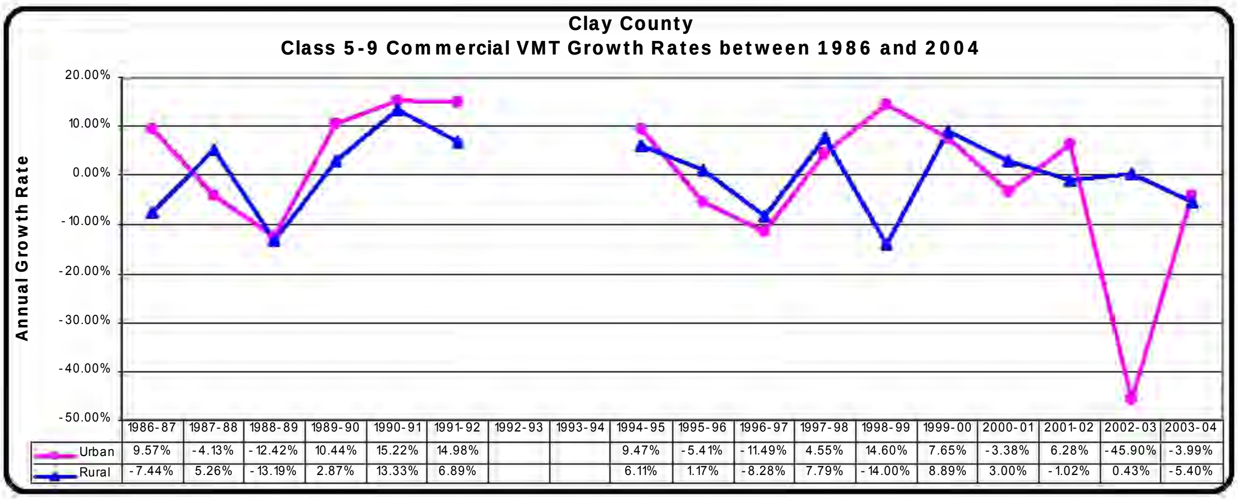
- Table 5-17 summarizes the results for Clay County.
- The ending year of the regression was changed to 2002 for rural Other Passenger Class to exclude the lower VMT data attributed to a shift in VMT due to reclassification.
- Starting year of the regression was adjusted to 1994 for Class 10-13.
- The plot for urban Arterials Passenger indicates a non-linear growth that fluctuates from year to year. An average growth percentage can be assumed for this class.
- The plots for Class 5-9 show a non-linear growth and fluctuating pattern. An average growth percentage can be assumed for this class.
- Adjustment to rural Other Passenger Class did not substantially improve the linear fit. The plot indicates a marginal growth from 1995 with shift in VMT in 2002. An average growth percentage can be assumed for this class.

Table 5-17 20-Year VMT Factors and Annual Growth by Functional Class for Clay County

		RURAL				URBAN			
		ARTERIALS			OTHER	ARTERIALS			OTHER
		Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger	Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger
R-Square	Original	**0.8179**	0.2706	**0.8688**	0.1542	0.5929	0.1593	**0.8293**	0.3774
	Changed	**0.8179**	0.2706	**0.9087**	**0.8395**	0.5929	0.1593	**0.8722**	0.1272
% Annual Growth	Original	1.665%	0.608%	4.270%	0.785%	1.282%	0.319%	4.269%	0.072%
	Changed	1.665%		3.800%	1.418%			3.800%	
20-Yr Factor	Original	1.391	1.129	2.308	1.169	1.290	1.066	2.307	1.015
	Changed	1.391		2.100	1.325			2.100	



	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04
Arterials (Passenger)	-1.94%	-2.71%	13.28%	3.33%	6.90%	-0.17%	-11.30	13.00%	13.44%	2.92%	-9.21%	7.02%	8.60%	4.29%	-3.35%	4.43%	-5.05%	3.31%	0.37%	-4.01%	-17.22	3.95%
Other (Passenger)	-16.36	35.25%	-1.33%	0.05%	4.44%	-0.32%	-1.35%	-22.28	-0.70%	0.95%	1.20%	0.93%	1.64%	-1.90%	-2.30%	0.94%	0.46%	0.00%	0.00%	0.39%	-6.09%	2.40%



	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04
Urban	9.57%	-4.13%	-12.42%	10.44%	15.22%	14.98%			9.47%	-5.41%	-11.49%	4.55%	14.60%	7.65%	-3.38%	6.28%	-45.90%	-3.99%
Rural	-7.44%	5.26%	-13.19%	2.87%	13.33%	6.89%			6.11%	1.17%	-8.28%	7.79%	-14.00%	8.89%	3.00%	-1.02%	0.43%	-5.40%

Lawrence County

- Table 5-18 summarizes the results for Lawrence County.
- Shift in VMT for interstate from rural to urban was adjusted using the method outlined in Section 2.2.1. The adjustment resulted in high R^2 with the exception of urban Class 5-9.
- Factor for urban Class 5-9 was derived by aggregating the VMTs of commercial vehicles and adjusting the starting year of the regression to 1994.
- Adjustment to rural Arterials Passenger Class did not substantially improve the linear fit. The plot indicates a non-linear, fluctuating pattern. An average growth percentage can be assumed for this class.
- Data outlier for urban Arterials Passenger was removed that resulted in better linear fit.
- Data smoothing was applied using the moving average method before applying the linear regression. The starting year of the regression is changed to year 1994.
- Shift in VMT for urban Other Passenger Class occurred in 1990. The regression start year is changed to 1992 instead of adjusting the VMT data since growth after 1992 remains very low.

Table 5-18 20-Year VMT Factors and Annual Growth by Functional Class for Lawrence County

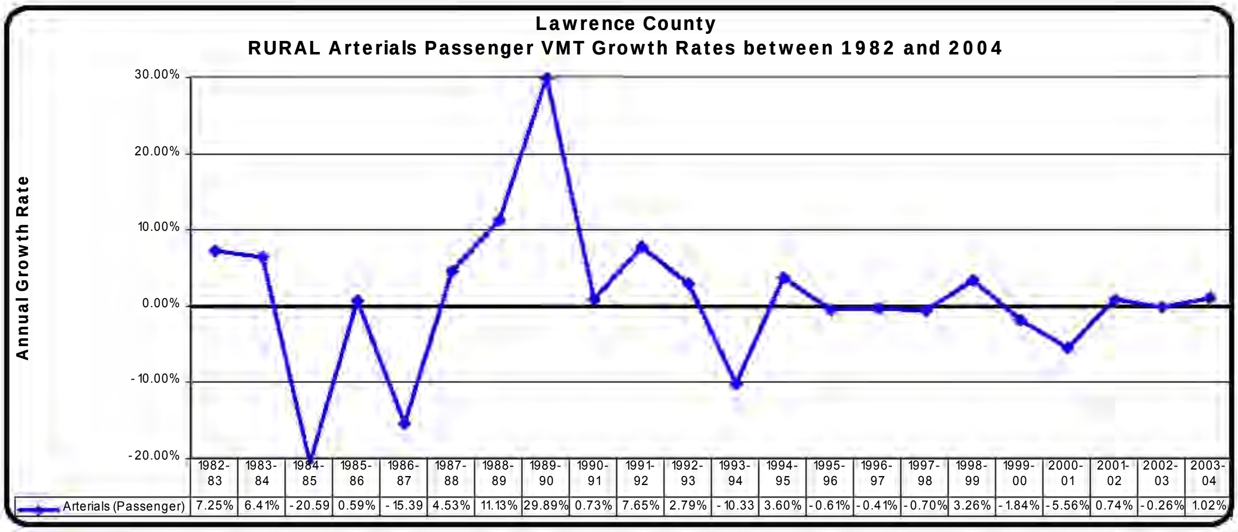
RURAL

		INTERSTATE			ARTERIALS			OTHER
		Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger
R-Square	Original	**0.7947***	0.4919*	**0.8989**	0.3057	0.1156	**0.9024**	0.3712
	Changed	**0.8884**	**0.7383**	**0.9132**	0.3339	**0.9361**	**0.8419**	**0.7332**
% Annual Growth	Original	2.040%	1.567%	3.991%	0.887%	-1.070%	4.187%	0.208%
	Changed	2.151%	1.488%	3.469%		-8.075%	5.120%	-0.248%
20-Yr Factor	Original	1.498	1.365	2.187	1.193	1.029**	2.271	1.142
	Changed	1.531	1.344	1.978		0.186	2.715	0.951

URBAN

		INTERSTATE			ARTERIALS			OTHER
		Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger
R-Square	Original	0.3284*	0.4919*	0.4429*	**0.7935**	**0.7166**	**0.7258***	**0.7638**
	Changed	**0.7707**	**0.7006**	**0.7006**	**0.7728**	**0.9281**	**0.9281**	**0.7660**
% Annual Growth	Original	2.547%	3.999%	4.759%	3.039%	3.167%	4.370%	2.254%
	Changed	1.840%	3.272%	3.272%	2.101%	3.518%	3.518%	0.383%
20-Yr Factor	Original	1.654	2.191	2.534	1.820	1.866	2.353	1.562
	Changed	1.440	1.904	1.904	1.516	1.997	1.997	1.079

** Sharp increase/significant decrease in 2004 VMT due to reclassification from rural to urban*
*** Adjusted factor using business data*



Meade County

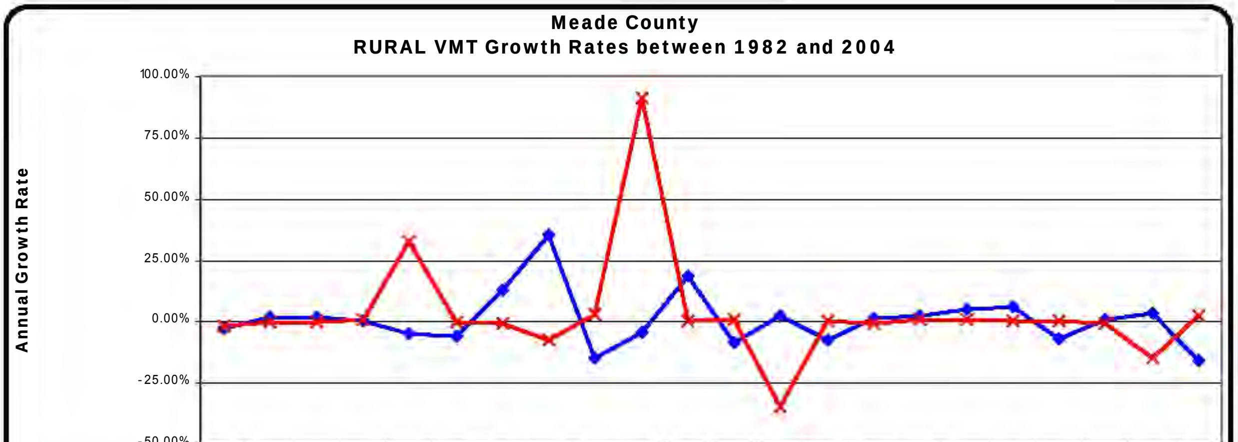
- Table 5-19 summarizes the results for Meade County.
- Shift in VMT for interstate from rural to urban was adjusted using the method outlined in Section 2.2.1.
- Factor for rural Class 5-9 was derived by aggregating the VMTs of commercial vehicles and adjusting the starting year of the regression to 1994.
- Adjustment to rural Arterials Passenger Class and Other Passenger Class did not substantially improve the linear fit. The plot indicates a marginal growth from 1995 with shift in VMT in 2002. An average growth percentage can be assumed for these classes.

Table 5-19 20-Year VMT Factors and Annual Growth by Functional Class for Meade County

		RURAL						
		INTERSTATE			ARTERIALS			OTHER
		Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger
R-Square	Original	**0.9062**	**0.7620**	**0.9084**	0.4155	0.4821	**0.8745**	0.1655
	Changed	**0.9327**	**0.9014**	**0.9055**	0.4155	**0.8499**	**0.8585**	0.4595
% Annual Growth	Original	1.993%	1.507%	4.036%	0.913%	-3.958%	4.211%	1.280%
	Changed	2.062%	1.371%	3.479%		-7.585%	3.886%	
20-Yr Factor	Original	1.484	1.349	2.206	1.199	0.745**	2.282	1.290
	Changed	1.504	1.313	1.982		0.206	2.144	

		URBAN						
		INTERSTATE			ARTERIALS			OTHER
		Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger
R-Square	Original	0.4058*	0.4724*	0.4165*	**0.7704***	0.2847	**0.6473***	0.5445
	Changed	**0.8231**	**0.7238**	**0.7137**	**0.8328**	**0.8942**	**0.8942**	**0.7547**
% Annual Growth	Original	2.865%	4.046%	4.762%	1.750%	0.917%	4.339%	1.363%
	Changed	2.341%	3.099%	3.286%	1.577%	3.126%	3.126%	1.262%
20-Yr Factor	Original	1.759	2.210	2.535	1.415	1.200	2.338	1.311
	Changed	1.589	1.841	1.909	1.367	1.851	1.851	1.285

** Sharp increase/significant decrease in 2004 VMT due to reclassification from rural to urban*
*** Adjusted factor using business data*



	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04
Arterials (Passenger)	-2.88%	1.70%	1.89%	0.27%	-4.80%	-5.91%	12.97%	35.01%	-14.78	-4.48%	18.46%	-8.95%	2.38%	-7.71%	1.30%	2.26%	4.66%	5.69%	-7.08%	0.94%	3.50%	-15.90
Other (Passenger)	-1.70%	-0.18%	-0.16%	0.75%	32.45%	-0.09%	-0.95%	-7.59%	2.75%	91.10%	0.03%	0.46%	-35.06	0.38%	-0.77%	0.59%	0.48%	0.00%	0.00%	-0.92%	-14.97	2.09%

Pennington County

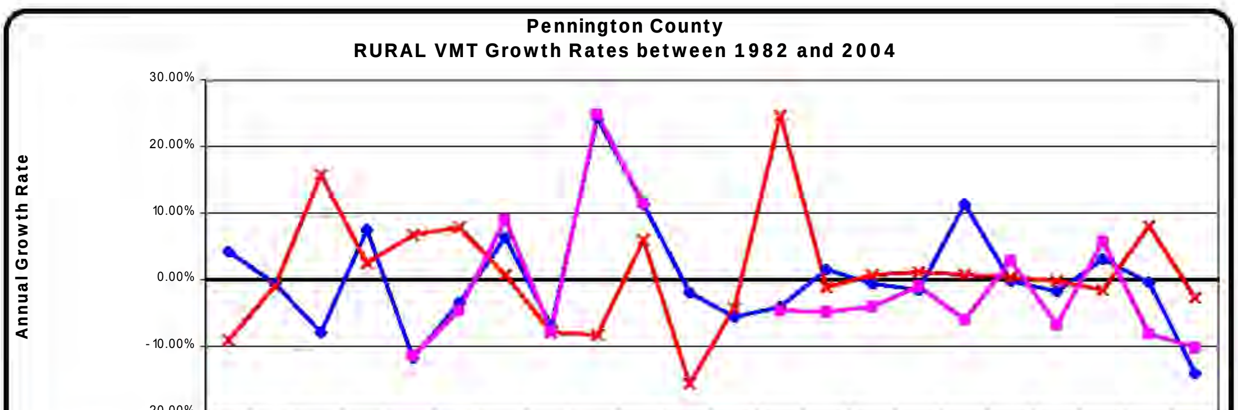
- Table 5-20 summarizes the results for Pennington County.
- Shift in VMT for interstate from rural to urban was adjusted using the method outlined in Section 2.2.1. The adjustment resulted in high R^2 with the exception of urban Class 5-9.
- Factor for urban Class 5-9 was derived using the factor for Class 10-13. The regression was adjusted to start from 1994.
- Starting year of the regression was adjusted to 1994 for Class 10-13.
- Adjustment to rural Arterials Passenger Class, rural Class 5-9, and rural Other Passenger Class did not substantially improve the linear fit. The plot indicates a non-linear, fluctuating pattern. An average growth percentage can be assumed for these classes.
- Adjustment to urban Other Passenger Class did not substantially improve the linear fit. The plot indicates a flat growth from 1994. An average growth percentage can be assumed for this class.

Table 5-20 20-Year VMT Factors and Annual Growth by Functional Class for Pennington County

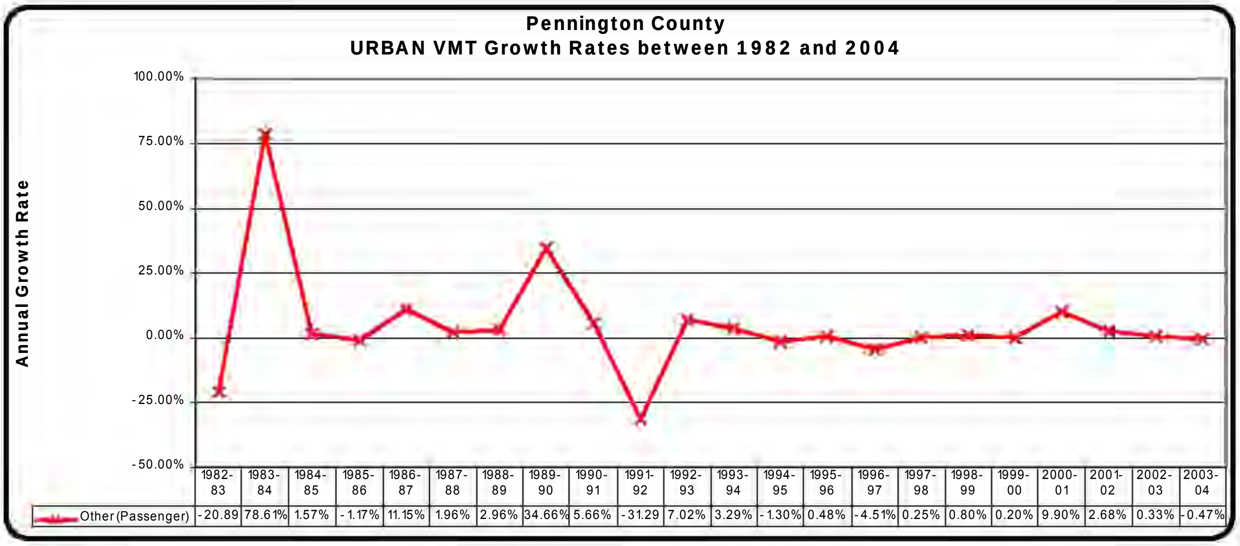
		RURAL						
		INTERSTATE			**ARTERIALS**			**OTHER**
		Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger
R-Square	Original	0.4625	0.0258	**0.7582**	0.3607	0.2315	**0.8704**	0.2049
	Changed	**0.7931**	**0.7931**	**0.8116**	0.3607	0.2315	**0.7865**	0.2049
% Annual Growth	Original	1.084%	0.329%	3.990%	0.734%	-1.239%	4.217%	0.545%
	Changed	1.250%	0.534%	3.451%			4.826%	
20-Yr Factor	Original	1.241	1.068	2.187	1.158	1.013**	2.284	1.115
	Changed	1.282	1.112	1.971			2.567	

		URBAN						
		INTERSTATE			**ARTERIALS**			**OTHER**
		Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger
R-Square	Original	**0.7803***	**0.7377***	0.5851*	**0.8274**	0.0436	**0.7422**	0.3845
	Changed	**0.853**	**0.7867**	**0.7637**	**0.8274**	**0.8638**	**0.8638**	0.3845
% Annual Growth	Original	2.764%	3.846%	4.648%	1.401%	0.503%	4.394%	1.341%
	Changed	2.608%	3.144%	3.314%	1.401%	3.599%	3.599%	
20-Yr Factor	Original	1.725	2.127	2.481	1.321	1.106	2.363	1.305
	Changed	1.674	1.857	1.919	1.321	2.028	2.028	

* Sharp increase/significant decrease in 2004 VMT due to reclassification from rural to urban
** Adjusted factor using business data



	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04
Arterials (Passenger)	4.24%	-0.62%	-7.85%	7.49%	-11.72	-3.49%	6.36%	-6.89%	24.23	11.42%	-2.00%	-5.53%	-4.10%	1.56%	-0.66%	-1.60%	11.33%	-0.11%	-1.78%	3.03%	-0.40%	-14.09
Other (Passenger)	-9.04%	-0.98%	15.71%	2.43%	6.77%	7.81%	0.83%	-7.87%	-8.36%	5.93%	-15.63	-4.28%	24.53	-1.17%	0.84%	1.17%	0.68%	0.40%	-0.19%	-1.48%	8.02%	-2.66%
Class 5-9 (Commercial)					-11.26	-4.65%	9.05%	-7.75%	24.79	11.46%			-4.58%	-4.90%	-4.10%	-0.93%	-6.02%	2.85%	-6.71%	5.71%	-8.16%	-10.14

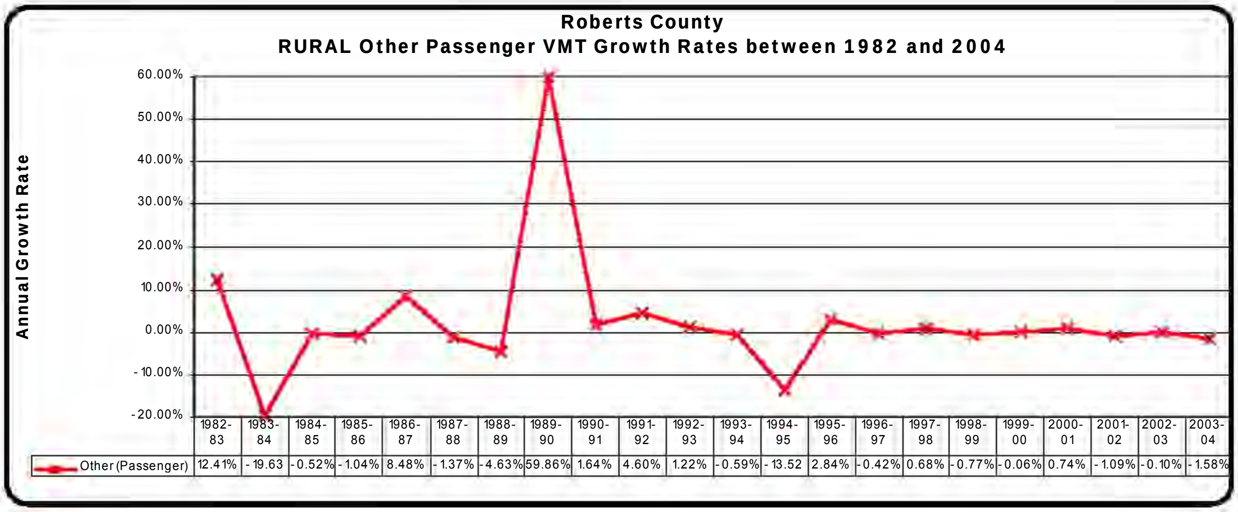


Roberts County

- Table 5-21 summarizes the results for Roberts County.
- Starting year of the regression was adjusted to 1982 for Arterials Passenger Class.
- Factor for Class 5-9 was derived by aggregating the VMTs of commercial vehicles and adjusting the starting year of the regression to 1994.
- Starting year of the regression was adjusted to 1994 for Class 10-13.
- The plot for Other Passenger Class indicates a flat growth from 1995. Regression starting from 1995 combined with data smoothing technique did not substantially improve the linear fit. An average growth percentage can be assumed for this class.

Table 5-21 20-Year VMT Factors and Annual Growth by Functional Class for Roberts County

		INTERSTATE			ARTERIALS			OTHER
		Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger
R-Square	Original	**0.9290**	**0.7789**	**0.9151**	**0.7755**	0.0349	**0.9151**	0.4437
	Changed	**0.9379**	**0.7789**	**0.8410**	**0.7853**	**0.8413**	**0.9064**	0.5386
% Annual Growth	Original	2.676%	2.083%	4.040%	1.525%	0.267%	4.265%	1.354%
	Changed	2.583%	2.083%	4.381%	1.636%	1.545%	5.170%	
20-Yr Factor	Original	1.696	1.510	2.208	1.354	1.055	2.305	1.309
	Changed	1.665	1.510	2.358	1.383	1.359	2.741	

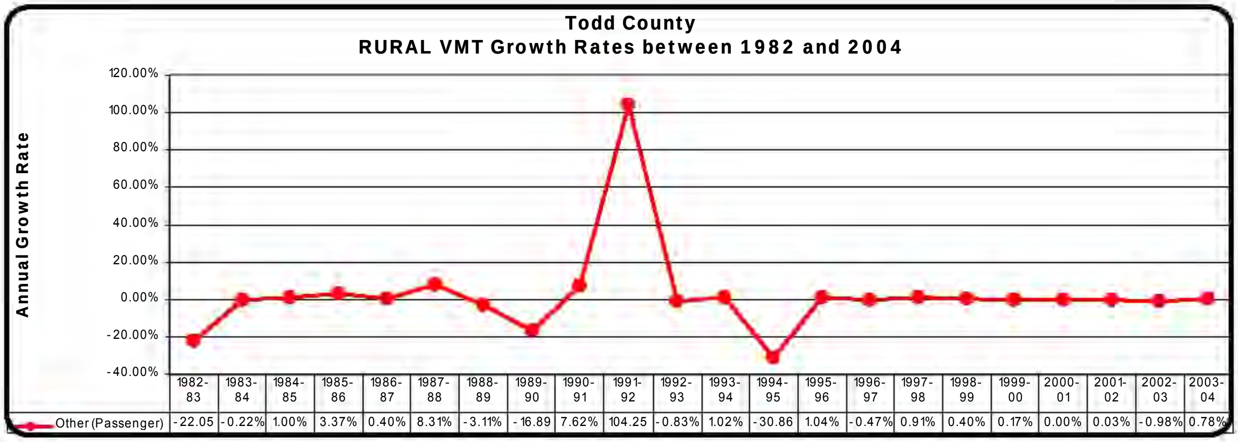


Todd County

- Table 5-22 summarizes the results for Todd County.
- Starting year of the regression was adjusted to 1990 for Arterials Passenger Class.
- Factor for Class 5-9 was derived by aggregating the VMTs of commercial vehicles and adjusting the starting year of the regression to 1994.
- Starting year of the regression was adjusted to 1994 for Class 10-13.
- Data smoothing was applied using the moving average method before applying the linear regression. The starting year of the regression is changed to year 1994.
- Data outliers are present for Other Passenger Class prior to 1995. After 1995, the plot for Other Passenger Class indicates a flat growth. Regression starting from 1995 combined with data smoothing technique did not substantially improve the linear fit. An average growth percentage can be assumed for this class.

Table 5-22 20-Year VMT Factors and Annual Growth by Functional Class for Todd County

		ARTERIALS			OTHER
		Passenger	Class 5-9 Commercial	Class 10-13 Commercial	Passenger
R-Square	Original	0.2162	0.1365	**0.8669**	0.2137
	Changed	**0.7852**	**0.6162**	**0.8335**	0.4616
% Annual Growth	Original	1.112%	0.931%	4.184%	1.241%
	Changed	2.320%	2.182%	4.933%	
20-Yr Factor	Original	1.247	1.204	2.270	1.280
	Changed	1.582	1.540	2.620	



5.5 SUMMARY OF REVIEW FINDINGS RECOMMENDATIONS

5.5.1 Review Findings

The purpose of the review and analysis of the 20-year traffic forecasting procedure is to validate its applicability to South Dakota counties that have been experiencing growth in some areas while a decline in population in some other areas. The 20-year traffic forecasting procedure was originally developed in 1999 and since then it has not been validated. The traffic forecasting factors were based on a county level analysis of VMT and indirectly on business growth.

This chapter of the report details the review, analysis, and validation of the 20-year traffic forecasting factors. The input data and methodology were examined, and limitations and weaknesses of the procedure were identified. Statistical quality tests of linear regression models of historical VMT and county business data were examined. Relationship of population and employment as variables to predict VMT was also explored.

The thorough review and analysis of the forecasting procedure indicates the following findings:

- There is an issue of data integrity. Some data outliers and shifts in VMTs due to reclassification are present in the data. There is a need to review the historical VMT data to remove outliers and adjust for changes in VMT from rural to urban. The effect of lane-mile shifts due to reclassification needs to be accounted.
- Linear regression technique is a suitable method to use in all categories where a linear fit exists in the historical VMT. A measure of goodness of fit is the coefficient of linear determination, R^2. As discussed in Section 5.3.3, an R^2 value of 0.70 is considered desirable goodness of fit while an R^2 above 0.60 is considered acceptable.
- Results of linear regressions on the historical VMT data showed only 44 percent (or 32 out of 73) of the categories have the desirable R^2. After making corrections to the historical VMT data — by removing some outliers, adjusting shifts in VMT due to reclassification, changing the starting year of the regression analysis for some categories,

aggregating some categories, and using a combination of data smoothing by the Moving Average technique — the number of categories with desirable R^2 has increased to 74 percent, or 54 out of 73 categories.

- The increase in the number of categories that exhibit desirable linear fit underlines the importance of data integrity check.
- The analysis indicates the use of a combination of forecasting techniques, including use of growth factor for categories that exhibit marginal annual growth. Moving Average method can be used to "smoothed" the fluctuations in the historical data as exhibited in *Other Passenger* and *Class 5-9* categories. Linear regressions can then be applied after data smoothing.
- The use of business data to adjust the 20-year VMT factors largely for *Class 5-9 Commercial* categories should not be applied. The assumed truck factors derived from the business data has no direct correlation with commercial VMTs.
- Data on total county business pattern (i.e., the sum of Group I and Group II business data), however, can be used as a variable to predict VMTs for *Interstate Passenger* (both rural and urban) and rural Arterials (*Passenger* and total *Commercial*) categories. Moreover, the results suggest that total county business pattern may explain variation in VMTs in counties with larger population, such as Pennington, Brown, Meade, and Lawrence counties.
- Countywide employment indicates some relationship with VMTs. It also shows some relationship for smaller counties in contrast to the county business pattern where no relationship exists for smaller counties.
- Results of regressions at the statewide level show a strong relationship of interstate passenger and arterials passenger with population and employment. Rural *Other* passenger category does not have a good linear fit for employment.
- The statewide results provide a good option of extending the forecasting process that accounts for population, employment, or other significant variables to derive 20-year travel forecasts. The analysis would be a kind of "top down" approach where VMTs growth factors are derived at the state level then apportioned to county level and by the defined categories. This type of approach is similar to the Ohio DOT VMT forecasting procedure, although the ODOT procedure does not allocate at the county level, rather disaggregate the VMT by rural and urban and then by functional classes.
- Lastly, the review and analysis of the 20-year traffic forecasting procedure under Task 5 was to validate the applicability of the linear regression technique to produce 20-year forecasts in South Dakota counties that have been experiencing a mix of population growth in some areas while a decline in other areas. The results of analyses indicate that population has no effect on the current implementation of linear regression technique to

forecast 20-year VMTs. Whether counties are experiencing growth or decline in population has no bearing on the applicability of the linear regression method. The pattern of growth by functional class dictates the applicability of a linear regression or any other best-fitting technique to use.

5.5.2 Recommendations

Based on the identified weaknesses of the current 20-year traffic forecasting procedure, it is recommended that SDDOT enhance the current procedure. The study recommends the following changes to enhance the current traffic forecasting process:

(1) Ensure data integrity

The detailed review and analysis of historical VMT data demonstrates the need to ensure a quality data set for use in the 20-year traffic forecasting procedure. It is imperative that historical VMT data should be reviewed to remove data outliers and make necessary adjustment for shifts in VMTs due to reclassification.

Apply the method outlined in Section 2.2.1 *(Method 3: Linear Projections of VMT by Functional Class, with Adjustments to Correct for Changes in Functional Class Categories)* to adjust the shifts in VMT due to reclassification. This method has been applied in this analysis to adjust for the interstate VMTs in Lawrence, Meade, and Pennington counties, as well as the statewide arterials and interstate VMTs.

(2) Year to use as a starting point for the regression analysis

After making the necessary adjustments to the historical VMT data, the starting year for the regression analysis should be reviewed. As shown in the historical VMT plots, some categories show sharp increases at some point and then moderating or leveling later. Typical of this trend is exhibited by Class 10-13 commercial where sharp increase in VMTs occurred in 1994. There are a couple of reasons for the sharp increase in VMT. After 1994, VMT has been calculated using HPMS data. Moreover, VMT data by county was not broken down by functional class until 1994. These changes in VMT calculation and aggregation have created some shifts, as exhibited by Class 10-13.

The regression analysis should use 1994 as a starting point rather than going back to 1986 for trucks. Starting year for other categories, such as *Other* class, should be reviewed as well.

VMT data for 2005 and 2006 are already available. Adding two more years of data provides 12 years of historical VMT data, which is sufficient for long term prediction. Moreover, population, employment, and VMT growth indicate moderate growth/decline from mid 1990s.

(3) Apply different procedures to derive 20-year factors for VMTs

SDDOT should consider using different procedures to forecast VMTs based on the amount of historical and expected growth.

(a) Use constant growth rate in counties with only marginal increase in VMTs. Linear projection of VMT based on estimated growth factor (Method 1) outlined in Section 2.2.1 can be applied for categories such as *Class 5-9 Commercial* and *Other* class.

(b) Use linear regression or a combination of techniques. The technique used should be one that best fits the data. Use linear regression method for categories that exhibit a good linear fit. Use a combination of techniques, for example, a Moving Average to "smoothed" the data, prior to applying a linear regression. Use other function, for example, an exponential function, if this provides a better fit to the data. It is important, however, to ensure that the long term forecast is within reasonable expected growth.

(4) Aggregate categories

If appropriate, aggregate some categories to obtain a good linear fit. For example, Class 5-9 generally has poor linear fit. By combining the two commercial categories, an estimate for Class 5-9 can be derived. Aggregating data is a common practice. For example, it is common to start the VMT estimate at the statewide level since there is higher confidence in VMT data on the state highway system. Based on a statewide growth, estimate of growth at the county level is allocated based on population, or other socioeconomic data. Further, the VMT growth is allocated by functional class, for example interstate and non-interstate.

(5) Adjustment to the 20-Year VMT Factors

It is recommended not to apply the current adjustment approach. Ensure that a good linear fit exists; if not, use a different forecasting technique as outlined above.

(6) Explore socioeconomic explanatory variables

(a) Further explore the relationship of employment data and VMT, particularly for smaller counties. The present analysis indicated some significant relationship. Commercially available forecast socioeconomic data at a county level, for example Woods and Poole economic data, is readily obtained at a modest cost. VMT projections using sound forecast socioeconomic data usually produce better factors.

(b) Explore the applicability of using the combined data on county business pattern (i.e., the total of Group I and Group II business data), particularly in counties with larger population. The results of analysis in Table 5-10 indicate that total business data have significant relationship with Arterials VMTs, mainly for *Urban Passenger* and total *Commercial* categories.

(b) Further explore the applicability of population as a variable in counties where a linear relationship exists. Population forecast is easily obtained than other socioeconomic data.

(7) Update the traffic forecasting factors annually using updated VMT and socioeconomic data.

(8) Develop standardized spreadsheet templates with graphic capability to facilitate analysis and interpretation of data trend.

6.0 DATA, COSTS, AND REQUIRED RESOURCES

Task 6. Identify the type of economic, demographic, passenger, freight, or other data that could be used to develop regional and statewide travel demand forecasts, as well as the costs and other resources necessary to obtain the data.

6.1 INTRODUCTION

One major obstacle in developing travel forecasting models is good data appropriate to the level of required analysis. The quality of the model largely depends on its input data. As the saying goes "garbage in, garbage out." The cost associated with obtaining quality data is usually the biggest factor to consider. This chapter outlines the types of data needed for different travel demand modeling options and discusses the data needs, costs, and required resources for a potential travel model option for South Dakota.

6.2 DATA, INFORMATION NEEDS, AND SOURCES

Travel demand models are very data intensive and there is a direct relationship between the quality of the data and the quality of the model. The major data requirements include:

- **Socioeconomic data** or population and employment data is vital to generate travel data at the zonal level and for future tripmaking.
- **Highway data,** such as geometric and operation data are critical for building an accurate model network.
- **Travel behavior data** from household surveys or transferable data from the Nationwide Personal Transportation Survey is important for understanding the purposes of trips and determining accurate trip patterns from zone to zone.
- **Traffic data**, especially volume data on each link and vehicle classification at the external stations, is vital for calibration/ validation.
- **Land use data**, and especially land use projections, are important to assist in making projections into the future.

Though data may be used differently, each of the travel modeling options presented in Chapter 2 uses similar supporting socioeconomic and travel behavior data. For example, population and employment data are required for each option. The level of detail at which these data are collected, processed, and applied will depend upon the model option selected. The same applies to travel behavioral data.

Typically, statewide models rely primarily on existing, currently available, public domain data, supplemented to a limited degree by commercial (proprietary) data sources and primary data collection. The extent to which commercial or primary data sources are used and collected depends upon the detail and sophistication of the model option being applied. Many national, regional, and state specific data sources are already available for building first-version statewide travel models, such as a simple network model framework that could be a potential starting model for South Dakota.

Section 6.4.1 outlines the data and resources currently available at SDDOT.

6.2.1 Socioeconomic Data

Socioeconomic data to support travel modeling are available from several sources:

- employment data from state agencies monitoring workforce statistics
- census data
- white pages databases available at most software outlets.

Employment data from government agencies are typically considered private and are protected from dissemination, at least in their most disaggregate form, by law. Many public planning agencies can obtain permission to use these data, however, provided they do not disclose the identity and characteristics of individual employers. Data containing business addresses, number of employees and business function (through the use of industrial codes) can easily be geocoded and used to calculate zonal attractions. Census data, available at block and block-group levels, include population, household occupancy and income levels. “White-pages” data generally contain addresses for all households and businesses in the study area, which can be geocoded in the same manner as the employment data and aggregated to a traffic analysis zone level.

Statewide travel forecasting model systems require geographic representation of demographic or economic information as a primary input into the model. A transportation analysis zone system is implemented that represents the geographic information within the model. It is important that the zone system reflect an appropriate aggregation of the population (county, census tract, or other) and can be readily updated as additional data are collected, and as the agency modeling needs change and become more sophisticated over time. Table 6.1 presents a summary of socioeconomic data requirements by type of modeling option. Woods & Poole is an example of a proprietary dataset that contains population and employment by county and 5-year increments of forecasts out to 2030. Woods & Poole can be used to supplement both national (Census) and statewide sources of socioeconomic information for all modeling options.

Table 6-1 Socioeconomic Data Requirements

Modeling System	Common Data Requirements
Demand estimation & link factoring	• Census or state estimates and forecasts of population and employment by county or sub county area
Simple network	• Same as demand estimation and link factoring • Detailed census data, including Census Transportation Planning Package and County Business Patterns
Basic four-step	• Same as simple network • Spatial attributes, such as area, water, vacant land • Area type definitions (urban core, urban, suburban, rural) • Demographic data on age and household characteristics (household size, income, auto availability, school enrollment, employment) • MPO model demographic data and special generators
Integrated freight and/or passenger	• Same as basic four-step • Market segmented data (rail, freight, etc.) • Commercial data sources on employment • Additional data for special generators

Source: New Mexico Multimodal Study: Travel Modeling Approach – Task E Report, NMDOT

Demand Estimation and Link Factoring

Sketch planning techniques typically require only simple base year demographic data, such as total population and employment at the county or census tract level. These data are readily available from U.S. Census publications or associated with standard travel forecasting software. Forecasts of these demographic data are also readily available from public domain, state, national, and commercial sources. Zonal geography would typically be defined at the county level, or if a slightly higher resolution were desired, based on an aggregation of census tracts.

Simple Network Models

In addition to the data attributes typically found in sketch planning tools, population and household data is available from the decennial census Standard File 1, and employment data is available from Standard File 3 and the 2000 Census Transportation Planning package (CTPP) at a detailed level. County Business Patterns (CBP) data also can be used to generate county control totals for base year conditions.

Basic Four-Step Models

Geographic data typically consists of spatial attributes such as area, water, vacant land, among other attributes. Geographic data becomes more important at this level of modeling, because passenger travel is defined at the person trip level. Therefore, intrazonal trips that never enter the highway or other networks begin to account for a measurable number of trips. The CTPP 2000 allows future census data tabulations to be transferred over to a different zone system, such as a statewide model.

In applying a four-step model, additional zonal attributes may be required to differentiate travel sheds within the state. Items such as area type (e.g., urban core, urban, suburban, rural) may have to be identified based on land use patterns, population or employment concentrations, or the density of the transportation network. Even in a basic model, zonal demographic data becomes more detailed and tends to include items such as age and household characteristics (household size, median income, auto availability, school enrollment, and employment).

Traffic analysis zones (TAZ) from MPO (regional) travel models can be used as a starting point for developing a statewide model zone structure for this modeling option. The geographic boundaries of the MPO zones are designed to match the census geography. MPO zonal data is an excellent source of employment data, particularly in the case of future year forecasts. Data estimates and forecasts developed for urban areas provide information on areas with the highest employment concentration. These data are also already approved by the regional agency and formatted for travel modeling. MPO models also often contain information on large activity centers that can be treated as special generators in a statewide model.

Integrated Freight and Passenger Four-Step Models – Multimodal

In addition to the demographic data used to support basic four-step models, a multimodal model requires stratification of socioeconomic data by market segments for passenger rail and freight, among others. Market segmented data can be obtained from the U.S. Census, travel behavior surveys, and commercially available datasets, e.g., Woods & Poole Economics, Inc.

Among the useful resources for market stratification are the U.S. Census Public Use Micro Sample (PUMS) data and the 2000 CTPP Part 2 data (population and household characteristics). PUMS data can be used to calculate the distribution of households by income group or other metrics. The full range of population and housing information collected in the Census Supplementary Surveys is available in PUMS.

There are also commercial sources of employment data that are highly useful in developing zonal employment data. Two such examples are Woods & Poole (available at county level) and Info USA geocoded employment data. The Info USA data was used by the U.S. Census Bureau to develop the "Work-Up" zonal employment data during the late 1990s.

At this level of modeling, additional attention must also be given to special generators. Special generators are unique land use activities with trip productions and attractions identified outside the normal travel demand modeling chain. Typical examples might be airports, regional medical centers, large universities, and military bases. Often targeted traffic counts or special generator surveys are required to identify and capture the travel characteristics of special generators.

6.2.2 Network Characteristics Data

Statewide roadway network data are used in the modeling process. Networks are developed to represent a variety of roadway characteristics (lanes, capacities, and speeds, among others) to forecast intercity travel demand and through-state travel.

Network data should match the granularity of the zone system developed. The networks must contain transportation system geometry and attributes consistent with the level of analysis being performed. Sources for network geography include the South Dakota GIS-based highway network and local roads system, MPO regional model networks, the FHWA functional class maps, and Census Tiger Line files.

As the sophistication of each modeling option increases, the required geographic and network breadth and detail increase as well. Detailed analysis requires a large inventory of attributes that may be difficult to obtain for the entire state. In addition, multimodal models require network layers for non-highway modes. Rail, air, water, or pipeline networks might need to be constructed and have additional individual attribute requirements. Table 6.2 summarizes the network characteristic data required for each modeling option, with additional detail provided below.

Table 6-2 Network Data Requirements

Modeling System	Common Data Requirements
Demand estimation & link factoring	• Basic highway route geography and roadway functional class
Simple network	• Basic network of roadway links consistent with zone structure • Length of each link, posted or typical speeds, capacities, and functional class
Basic four-step	• Same as simple network • Basic network information for transit mode • Number of lanes, signalized intersections, congested speeds or travel times, constrained capacities, and other related attributes
Integrated freight and/or passenger	• Same as basic four-step • Transit, rail, air, and marine network data, as appropriate • Mode-specific freight and passenger attribute data for appropriate modes

Source: New Mexico Multimodal Study: Travel Modeling Approach – Task E Report, NMDOT

Demand Estimation and Link Factoring

Sketch planning models do not typically require a full network, although basic highway route geography might be required to associate various roadways with the appropriate zones for aggregation purposes. Network attribute requirements are usually minimal with only a few parameters, such as functional class used to help aggregate tables or estimate statistically significant coefficients.

Simple Network Models

Simple network models are used to generate vehicle trips from origin to destination and route travel assignments for individual facilities defined in the highway network. Network resolution should be consistent with zonal geography. Link attribute data requirements are generally not complex. Primary attributes include those contained in all network-based travel models such as the length of each link, posted or typical speeds, and capacities for each facility by functional class. These data can often be obtained or calculated from GIS line layers of the roadway system maintained by the state.

Basic Four-Step Models

The required network data becomes more complicated with this modeling option. In addition to items that are relatively easy to capture, such as distance, travel speeds, capacities, and functional class, additional items may be needed that require further research or mathematical calculation. Typically, these items include number of lanes, signalized intersections, congested speeds or travel times, constrained capacities, among others. Additional information may be needed on transit networks, often coded as an attribute within the roadway network.

Integrated Freight and Passenger Four-Step Models – Multimodal

In addition to the standard highway network geography and link attribute data contained in the modeling options defined earlier, a multimodal model may require the development of transit, freight, and other networks. Included in the National Transportation Atlas Database (NTAD) developed and distributed by the Bureau of Transportation Statistics (BTS) is information relating to airports, rail, and waterway networks. The rail network and waterway system are both line networks that can be linked to a statewide highway network with points.

The rail networks are provided to BTS from the Federal Railroad Administration (FRA). The waterway network included with the NTAD is from the U.S. Army Corps of Engineers. The airport files contained in the NTAD include all public and private use airports. Flight information, including number of passengers and daily flights, is not included, but is available through sources developed by the Federal Aviation Administration (FAA).

An airport-to-airport network, as developed by the FAA, shows all commercial flights operating between public use airports. The network can be limited to include only those flights entering or leaving the state as well as intrastate travel. Data on the number of flights, passengers, and carriers is available on a link basis. Each route is designated as a link with the endpoints being the airports.

6.2.3 Travel Behavior Data

Travel behavior data are an important component of most modeling systems. These include trip generation rates, average trip distances or trips by type, and other related data. These data are collected using a variety of methods. Table 6.3 summarizes the appropriate data and methods for each modeling option, with additional detail provided below.

Table 6-3 Traveler Behavior Data Requirements

Modeling System	Common Data Requirements
Demand estimation & link factoring	• No trip-based parameters
Simple network	• Trip rates and travel distances borrowed from other sources or imputed using origin-destination matrix estimators • Often use typical ranges from Federal sources • Basic commodity flow data for freight models
Basic four-step	• Parameters estimated: Trip generation by purpose (work, non-work, school, etc.); trip length frequency by purpose; and vehicle occupancy rates. • Method: Typically estimated from surveys, some national, but often conducted locally • Passenger data sources: NHTS, CTPP, household surveys, intercept surveys, external station surveys, workplace surveys, special generator surveys, and travel time surveys • Freight data sources: Quick Response Freight Manual, Freight Analysis Framework (FAF), Commodity Flow Survey (CFS), establishment surveys, truck intercept surveys, TRANSEARCH
Integrated freight and/or passenger	• Same as basic four-step

Source: New Mexico Multimodal Study: Travel Modeling Approach – Task E Report, NMDOT

Demand Estimation and Link Factoring

No trip-based parameters are used in this modeling option and, therefore, are not required to support model development.

Simple Network Models

Travel behavior coefficients and parameters, such as trip rates and travel distances for this type of model, are usually either borrowed from other sources or imputed at an aggregate level through the use of synthesis tools, such as origin-destination matrix estimators. The FHWA-sponsored Transportation Model Improvement Program (TMIP) and the BTS are both excellent sources for finding "typical" ranges of data values for this purpose.

Commodity flow data is required to estimate simple freight models within the context of simple network models. Several sources, including the latest CFS from the U.S. Census, FAF data from the FHWA, and proprietary datasets (such as TRANSEARCH), can be used to estimate freight demand (see detailed descriptions of these freight data under Basic Four-Step Models).

Basic Four-Step Models

Four-step models are traditionally person trip based and require travel behavior parameters related to the household or the individual. These parameters include trip generation by purpose (work, non-work, school, shop, others); trip length frequency by purpose; and vehicle occupancy rates, among others. Although some of these parameters can be borrowed from other similar models, best practice dictate the estimation of these parameters from primary travel surveys. There are numerous sources of national, state, and local survey data that may already be available. For many parameters, primary data collection will be required. Various available and proprietary data typically used to support basic four-step models include:

Passenger

Nationwide Household Transportation Survey – A national survey of short-and long-distance travel last conducted in 2001 and next scheduled for 2008.

CTPP 2000 Journey-to-Work Data – Collected every 10 years as part of the U.S. Census to be replaced by the American Community Survey collected annually with a small cumulative sample survey.

Household Surveys – Locally conducted surveys that provide information on household characteristics and trips being generated by households, including household composition, individual residents, vehicle information, and trip-making information. These data are used to stratify trip rates by purpose for use in trip generation models. Average trip length and trip length frequency distributions can be used in trip distribution models. In some cases, transit trips are over-sampled and detailed transit trip-making information can be collected to support mode choice modeling.

Vehicle Intercept Surveys – Locally conducted surveys that provide information on trips, auto occupancies, and trip purposes being made in a region. This information can be used to support the trip generation and trip distribution elements of the basic four-step model.

External Station Surveys – Locally conducted surveys that provide information on trips being made in, out, and through a region. Trip origin and destination data are collected to develop the proportion of external-local and external-through trips. An external trip length frequency distribution can also be developed. These data are used in both trip generation and trip distribution models.

Workplace Surveys – Locally conducted surveys that provide information on the attraction (workplace) end of trips. Employees and patrons are interviewed to collect their trip-making characteristics. These data are used to develop trip attraction rates by purpose for trip generation and trip length frequency distributions for trip distribution.

Special Generator Surveys – Locally conducted surveys that provide information on trips being produced and attracted by activity centers considered unique in their trip-making characteristics. Similar to workplace surveys, these data are used to develop special generator attraction rates and trip length frequency distributions.

Travel-Time Surveys – Locally conducted surveys that provide information on speeds and delays for sampled roadways. These data can be used to develop average travel times on both sampled roadways and between major activity centers.

Freight

Quick Response Freight Manual – The FHWA-developed guide that provides national and region-specific trip generation and trip distribution parameters by heavy-duty truck types for use in four-step truck modeling.

Freight Analysis Framework (FAF) – The FHWA developed data that provides truck flows by heavy-duty truck types on the primary transportation system in states and regions.

Commodity Flow Survey (CFS) – U.S. Census survey that provides detailed origin and destination data of commodity flows for all 50 states, including internal, external, and internal-to-external flows.

Establishment Surveys – Similar to workplace surveys, these locally conducted surveys provide information on commercial truck activity. The data collected can be used to develop commercial truck trip rates and trip length frequency distributions.

Truck Intercept Surveys – Locally conducted surveys that provide information on trip origins and destinations, commodities transported, and other characteristics of truck trip-making in a region. This information can support truck trip generation and trip distribution modeling.

TRANSEARCH Dataset – TRANSEARCH is an annual, nationwide database of freight traffic flows between U.S. county or zip code markets, with an overlay of flows across modes (truck, rail, water, air). This proprietary database draws from a variety of data sources covering commodity volume and modal flow, including a long-term, proprietary motor carrier traffic sample, proprietary railroad data, and numerous commercial and Federal government surveys. To compose the database, these multiple and diverse information sources are cast together in a single consistent format.

6.2.4 Calibration and Validation Data

Models are typically calibrated and validated against existing known information, such as traffic counts, to ensure that the models are producing reasonable results. As with all of the other data sources, more sophisticated data are used depending on the type of model. Table 6.4 summarizes the data requirements, which are developed in more detail below.

Table 6-4 Calibration and Validation Data Requirements

Modeling System	Common Data Requirements
Demand estimation and link factoring	• Goodness-of-fit statistics (0.70* and above) for regression models used to estimate VMT
Simple network	• Traffic counts: Automatic Traffic Recorder, Accumulative Count Recorder, HPMS traffic data, weigh-in-motion (WIM) data
Basic four-step	• Same as simple network, but more data will be required
Integrated freight and/or passenger	• Same as basic 4-step • Comparable data for freight volumes and transit, rail, and aviation boardings

Source: New Mexico Multimodal Study: Travel Modeling Approach – Task E Report, NMDOT
$^*R^2$ is 0.80 as stated in the New Mexico Multimodal Study

Demand Estimation and Link Factoring

Models of this type are not validated in the same sense that more complete or sophisticated models are calibrated and validated. Typically, model calibration is carried out with standard statistical tests to determine the statistical significance or goodness of fit of coefficients and constants.

Simple Network Models

The validation of a simple network-based model is relatively straightforward, and is usually performed by matching the base year traffic assignments obtained from the model to observed traffic counts. Specific data sources for count data used in validation are presented below under basic four-step models.

Basic Four-Step Models

Traffic counts and travel time survey data are the primary data source used to calibrate travel models. Traffic counts by roadway functional class and vehicle classification are available from many incidental and recurring sources. The following list provides a sample of some of these sources:

Automatic Traffic Recorder (ATR) Volume Data – States collect traffic counts for 24 hours a day, 365 days a year at some permanent locations. These data are used to develop directional distributions, validation screen-lines, seasonal factors, and VMT.

Accumulative Count Recorder (ACR) Traffic Data – These data are collected over a 24-hour period, including all axles passing a point. Counted or estimated vehicle classification data is used to determine axle to vehicle ratios to apply to axle counts. Seasonal factors calculated from ATRs are applied to ACR counts to develop average annual daily traffic (AADT).

Highway Performance Monitoring System (HPMS) Traffic Data – These data are designed to provide an inventory of all on-system roads and other public roads that are functionally classified. Additional data collected includes the number of lanes, median widths, shoulder widths, and other basic road attributes. These data are collected and accumulated by states for submission to the FHWA using the above sources.

Recurring Saturation Count Programs – Programs of this type consist of making recurring ACR traffic counts on a rotating basis. These data are typically used in the validation and calibration of urban travel demand models, but have comparable utility for statewide modeling.

Vehicle Classification Data – Counts typically consist of 24-hour samples that categorize vehicle classifications.

Truck Weigh-in-Motion (WIM) Data – Collects traffic volumes by vehicle classification and weight. WIM data are collected at sites primarily on Interstates and major U.S. Highways.

6.2.5 Forecast Data

Forecast data are used as a key component in estimating future travel demand. Table 6.5 presents a summary of the forecast data items that are typically required to support each modeling option. Additional detailed information follows.

Table 6-5 Forecast Data Requirements

Modeling System	Common Data Requirements
Link factoring	• Future population and employment forecasts • Projected increases in roadway miles from Statewide Transportation Improvement Program (STIP)
Simple network	• Projected future network based on STIP, long-range transportation plan, or other related sources • Future population and employment forecasts
Basic four-step	• Same as simple network, but more data will be required
Integrated freight and/or passenger	• Same as basic four-step • Comparable data for freight, transit, rail, and aviation networks

Source: New Mexico Multimodal Study: Travel Modeling Approach – Task E Report, NMDOT

Demand Estimation and Link Factoring

These models usually require projected increases in aggregate roadway miles, other roadway attributes (such as programmed and funded improvement projects), and future estimates of population and employment.

Simple Network Models

Typically, data sources for developing future forecasts come from the state's STIP, LRTP, and Metropolitan Transportation Plans. Forecast networks include existing facilities, plus those programmed for construction. Some data reconciliation is required to address the timelines of the various sources. Detailed networks for non-highway modes are not normally forecast. Future forecasts of population and employment are also required.

Basic Four-Step Models

As with simple network models, existing plus committed projects from the STIP, LRTP, and regional sources are required. Alternative multimodal projects are identified for future forecasting using basic four-step models. Coding proposed projects requires increased interaction with project sponsors and stakeholders to properly define the policy, operational, or physical characteristics of the associated projects for testing and alternatives analysis.

6.2.6 Proprietary Data

Proprietary data considers many different sources, uses, cost ranges, and delivery schedules. Some, such as Woods & Poole, can be purchased to provide another source of socioeconomic forecast data, readily available for the entire state of South Dakota for a nominal cost of up to $400. Many of the data sources identified in this section fall within this cost range.

One of the previously mentioned data sources is very costly, the TRANSEARCH freight database. Typically, the cost for the South Dakota DOT or any other state or regional agency will need to be negotiated depending on the level of modeling and analysis required. For example, the TRANSEARCH database can be purchased to describe commodity flows for four modes (truck, rail, air, and water) at the county-level within South Dakota. This data could also include aggregated Bureau of Economic Analysis (BEA) regions outside of South Dakota to better assess the impacts of through freight movements impacting the state's highway network. The TRANSEARCH database can also be structured to provide routing information for highway flows at additional cost. TRANSEARCH data can be purchased for all or some counties within the state. This price fluctuates depending on the state, the number of counties to be assessed, the total tons moved, and the types of features desired. Depending on these variable, base year data costs between $25,000 and $100,000. Future forecast data could almost double the initial investment for base year data (very often, agencies develop their own future forecast data from available resources at a lower cost rather than purchase this future data).

Table 6-6 Comparison of Data and Resources Required By Model Type

DATA TYPE	DEMAND ESTIMATION AND LINK FACTORING	SIMPLE NETWORK MODELS	BASIC FOUR-STEP MODELS	INTEGRATED FREIGHT AND PASSENGER FOUR-STEP MODELS
SOCIOECONOMIC DATA	• Census or state estimates and forecasts of population and employment by county or sub county area	• Same as sketch planning tools • Detailed census data, including Census Transportation Planning Package and County Business Patterns	• Same as simple network • Spatial attributes, such as area, water, vacant land • Area type definitions (urban core, urban, suburban, rural) • Demographic data on age and household characteristics (household size, income, auto availability, school enrollment, employment) • MPO model demographic data and special generators	• Same as basic four-step • Market segmented data (rail, freight, etc.) • Commercial data sources on employment • Additional data for special generators
NETWORK DATA	• Basic highway route geography and roadway functional class	• Basic network of roadway links consistent with zone structure • Length of each link, posted or typical speeds, capacities, and functional class	• Same as simple network • Basic network information for transit mode • Number of lanes, signalized intersections, congested speeds or travel times, constrained capacities, and other related attributes	• Same as basic four-step • Transit, rail, air, and marine network data, as appropriate • Mode-specific freight and passenger attribute data for appropriate modes
TRAVEL BEHAVIOR DATA	• No trip-based parameters	• Trip rates and travel distances borrowed from other sources or imputed using origin-destination matrix estimators • Often use typical ranges from Federal sources • Basic commodity flow data for freight models	• Parameters estimated: Trip generation by purpose (work, non-work, school, etc.); trip length frequency by purpose; and vehicle occupancy rates. • Method: Typically estimated from surveys, some national, but often conducted locally • Passenger data sources: NHTS, CTPP, household surveys, intercept surveys, external station surveys, workplace surveys, special generator surveys, and travel time surveys • Freight data sources: Quick Response Freight Manual, Freight Analysis Framework (FAF), Commodity Flow Survey (CFS), establishment surveys, truck intercept surveys, TRANSEARCH	• Same as basic four-step

CALIBRATION / VALIDATION DATA	• Goodness-of-fit statistics (0.70* and above) for regression models used to estimate VMT	• Traffic counts: Automatic Traffic Recorder, Accumulative Count Recorder, HPMS traffic data, weigh-in-motion (WIM) data	• Same as simple network, but more data will be required, such as traffic counts along screenlines, cutlines, or cordon lines	• Same as basic 4-step • Comparable data for freight volumes and transit, rail, and aviation boardings
FORECAST DATA	• Future population and employment forecasts • Projected increases in roadway miles from STIP	• Projected future network based on STIP, long-range transportation plan, or other related sources • Future population and employment forecasts	• Same as simple network, but more data will be required	• Same as basic four-step • Comparable data for freight, transit, rail, and aviation networks
PROPRIETARY DATA			• Same as basic four-step	• Same as basic four-step

Source: New Mexico Multimodal Study: Travel Modeling Approach – Task E Report prepared by New Mexico Department of Transportation
R^2 is 0.80 as stated in the New Mexico Multimodal Study

6.3 REVIEW OF MODELING SOFTWARE

Several transportation planning software packages have been developed and are currently used to automate the four-step process, including the ability to analyze activity-based trips. Examples include TransCAD, VISUM, CUBE Voyager, TP+/VIPER, and EMME to mention a few.

The advent of geographic information system (GIS) technology has greatly enhanced the efficiency and accuracy of network specification and coding. Most of the transportation planning packages have the capability to integrate with GIS and GIS-based applications. VISUM, for example, has graphical user interface and can read and write Environmental Systems Research Institute (ESRI) shape files, which have emerged as a standard cross-platform format for GIS systems, and convert between formats. TransCAD is a GIS-based transportation planning package.

This section presents a summary of current widely used software packages for travel demand modeling. An evaluation of software options suitable for SDDOT is discussed in Section 6.3.6.

6.3.1 Overview of Software Capabilities

Software packages reviewed and summarized include the following: TransCAD, VISUM, CUBE, and EMME. TP+/VIPER is not included since this software package has not been developed to have the advanced capabilities that the other four packages have. TP+/VIPER users have been migrating to CUBE. The Sioux Falls MPO is currently using TP+/VIPER and plans to update to CUBE in 2008.

6.3.2 TransCAD

TransCAD is developed and sold by Caliper Corporation (http://www.caliper.com/). It is a PC-based GIS system for planning, managing, and analyzing the characteristics and performance of transportation systems and capabilities. Information on transportation networks, freight flows, routes, schedules, transportation analysis zones, passenger demand, and transportation system performance can be stored, displayed, and analyzed at any spatial scale. TransCAD provides: easy access to transportation and related geographic data; extended data model to support transportation planning, logistics, routing, operations research, and marketing applications; tools for presenting and visualizing transportation data; a complete toolbox of transportation analysis methods and models; a powerful applications development capability; and multimedia capabilities. TransCAD requires significant user input, including GIS maps and census data files.

The TransCAD modeling component is user-friendly with menus and point-and-click technology provided for developing and applying models. In addition, the pre-programmed applications that reside in the TransCAD software are supplemented by a scripting language called GISDK that allows the user to create macros and batch files for customized modeling and GIS applications. GISDK allows experienced modelers to implement complex customized models.

Another advantage with TransCAD is the seamless GIS component that eliminates the need to transfer data from the modeling package to the GIS software. TransCAD's full-featured GIS allows users to create and edit maps and geographic data sets, produce thematic maps, and perform spatial and geographical analyses without leaving the transportation analysis environment. TransCAD also comes with large read-only geographic databases for display and analysis. It also includes a large collection of analysis tools that are readily accessible to the "non-programmer" without the use of scripting language, including an origin-destination estimator.

TransCAD links with TransModeler, a microsimulation software package, also developed by the Caliper Corporation.

TransCAD has been applied at all levels of geographic scope from national and regional planning all the way down to local planning for all modes of transportation. The major hurdle to using TransCAD, however, is the extensive training required, generally learned through a course taught by TransCAD personnel.

6.3.3 VISUM

VISUM is part of the PTV Vision software suite for transportation planning and operations analyses. It is developed and distributed by PTV America, Inc. (http://www.ptvamerica.com). PTV Vision is the worldwide leading software suite in over 70 countries. However, its use in North America is relatively recent compared to other widely used softwares. PTV Vision provides a full-range of transportation (VISUM, VISUM Information Server, VISEM), operation (VISUM On-line), and control (VISSIM) functions. It enables users to work on a variety of applications. For example, the same user can apply PTV Vision to a planning study that has regional implications as well as to an operational study along an urban roadway where innovative traffic management concepts are evaluated at the roadway and intersection level.

VISUM provides transportation information and planning system for private and public transport, graphical network editing, analysis, evaluation, assignment, forecast and impact calculations. VISUM information server allows web-based access to VISUM for e-planning, team-working, data managing and sharing. VISEM is a useful tool for travel demand forecasting based on activity chains. VISUM-online provides core software components for traffic management centers with real-time forecast of traffic flow on urban roads and motorways.

VISSIM provides a powerful microscopic traffic flow simulation tool for traffic and transit movements with advanced 3D animation.

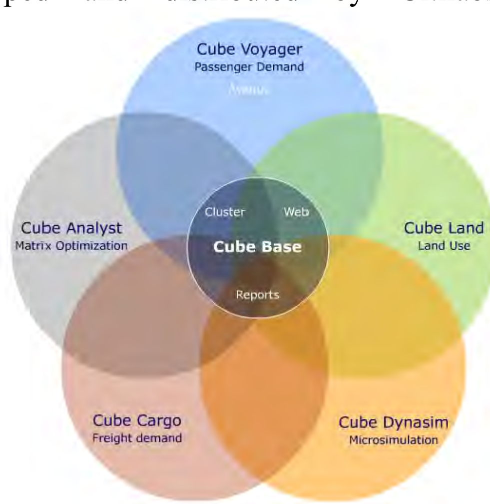
The PTV Vision software suite integrates demand modeling in VISUM with microscopic traffic simulation in VISSIM, providing transportation professionals with the most complete suite of analysis tools. VISUM includes embedded components from other leading software packages: ArcGIS™ for better GIS integration and TRAFFIX™ for Level-of-Service (LOS) and capacity analysis. With TRAFFIX built-in functions, VISUM can be used to analyze intersection LOS instead of using Synchro. VISUM can also produce and post-processed intersection turning movements based on NCHRP 255 methods.

VISUM is used to build conventional four-step models for regional and state-wide planning while also serving as a powerful analysis and data management tool for traffic engineers and transportation planners. A unique strength is detailed public transportation service planning, with a data model for routes and schedules that goes far beyond traditional demand models.

VISUM is user-friendly. It has graphical user interface that makes it easy to learn and easy to use. The interactive editor for all network objects includes single and multiple selections. It is extremely flexible in display and powerful in map design. VISUM provides a COM interface that enables users to create and run customized pre-processing and post-processing utilities and to control advanced multi-stage model runs. It also allows users to describe the entire network in a relational database, making it easy and efficient to exchange with MS Access, MS Excel, ArcGIS, and other software products with relational databases for import and export purposes.

6.3.4 CUBE

Cube is a family of software products developed and distributed by Citilabs (http://www.citilabs.com/). The Cube suite form a complete travel forecasting system providing exceptional, easy to use, capabilities for the comprehensive planning of transportation systems. Cube offers multiple modules that provide different functions for different tasks. Users only need to acquire the modules that they need to complete their tasks, thus reducing their costs.



Cube is comprised of *Cube Base*, which is the core platform that includes the user interface through which one accesses any purchased modules. Cube Base also provides the conduit to ArcGIS. All users must acquire Cube Base and then purchase optional extensions to increase the Cube Base feature set. *Cube Voyager* comprises a library of programs for forecasting urban, regional, and long distance passenger travel demand. It can be used to support the development of basic four-step travel models, as well as innovative modeling systems, including activity-based models. *Cube Avenue* is an optional extension that adds advanced dynamic traffic assignment or "mesoscopic assignment" to Cube Voyager. *Cube Dynasim* provides a library of programs for multimodal microsimulation that can import data from Cube Voyager and Cube Avenue. *Cube Cargo* is a library of programs for forecasting regional and long distance commodity flow and truck demand. *Cube Analyst* provides a library of programs for estimating and optimizing trip tables from traffic counts and other survey data. Lastly, *Cube Land* provides a library of programs for forecasting land use.

Cube Voyager uses a modular and script-based structure allowing the incorporation of any model methodology ranging from standard four-step models, to discrete choice to activity-based approaches. Advanced methodologies provide junction-based capacity restraint for highway analysis and discrete choice multipath transit pathbuilding and assignment. It includes highly flexible network and matrix calculators for the calculation of travel demand and for the detailed comparison of scenarios. It is designed to provide an open and user-friendly framework for modeling a wide variety of planning policies and improvements at the urban, regional, and long distance level.

Although the user interface has greatly improved compared to previous versions, users need to be experienced travel modelers due to complex scripting languages and construction. It assumes good knowledge of mathematics and travel demand modeling by users.

6.3.5 EMME

EMME is a sophisticated multimodal urban transportation planning system produced by Inro Consultants, Inc. in Canada (http://www.inro.ca/en/index.php). EMME (formerly EMME/2) is used worldwide in the development of road and public transportation projects. It provides capabilities similar to other software suites. EMME can be linked to INRO's DYNAMEQ, which is an equilibrium dynamic traffic assignment for use on large, congested networks. It gives planners a view into dynamic traffic conditions and provides rational scenario comparisons. Another INRO product that can be used with EMME is STAN™. STAN is used for strategic planning of national and regional freight transportation.

EMME provides a uniquely flexible, open approach to modeling. The EMME Project organizes all the data associated with a particular study, including EMME databases and attributes, saved views and worksheets, and many media formats (aerial photographs, shapefiles, map symbols). EMME provides graphical user interface (GUI) that allows browsing data with transparency through the Data and Media Explorers. The GUI allows adding shapefiles to EMME Project to display zone polygons and streets behind networks, exporting EMME networks to shapefiles for use in GIS software and Google Earth. Data can be moved to and from spreadsheets, databases, and statistical software with CSV files or custom delimited text file formats.

Despite major improvements in GUI and customization, users need to be experienced travel modelers and possess good knowledge of mathematics and travel demand modeling process to be able to make use of the EMME's capabilities.

6.3.6 Approach to Software Evaluation

The four travel modeling software packages described above compare very closely to one another. The New Mexico DOT study provides an example evaluation guide, duplicated in Table 6.7, which shows the criteria often used to determine a software package that best meets the needs of an agency for travel modeling and transportation planning software. Often, detailed evaluations using these criteria are conducted to identify the appropriate software for a given agency. In many cases, a few key criteria are considered very important for some agencies and not for others. For example, agencies with experienced travel demand modelers on staff often value the "functionality" feature compared to the "support" feature valued by an agency with limited staff resources.

Table 6-7 Example Evaluation Criteria

Measure	Description
Functionality	Is coding simple? Can it effectively map and format results? Can it provide effective performance statistics?
Integration	How simple is it to integrate with microsimulation models? with GIS? with economic and benefit/cost models? perform corridor planning? Assess integrated passenger/freight rail and multimodal solutions?
User Interface	Is the software user-friendly? What level of effort is required to operate the software? What kind of experience is required to operate the software? Is it menu driven?
Support	How often are regular support functions offered? How much does it cost? How useful? What's the response time?
Consistency	How can data be transferred between network databases/maps? Between land use and GIS files? From one software to another? How can model results be compared?
Capabilities	What are the current and future system requirements? What's the total cost?

Source: New Mexico Multimodal Study: Travel Modeling Approach – Task E Report, NMDOT

Two other important considerations in model selection, which are not included in the above criteria, are compatibility with urban/ regional models and user/planner/modeler preference. For South Dakota, the issue of compatibility is of less importance since the MPOs use two different software suites—TransCAD for Rapid City MPO and SIMPCO and TP+/VIPER (CUBE Voyager by 2008) for Sioux Falls. The issue of user preference is neither a factor at this stage since SDDOT does not have a modeler. However, SDDOT already owns a TransCAD license albeit the annual license maintenance for technical support and update is not current. Annual maintenance cost is $995, which should not be an issue as far as budget is concerned.

The research team has extensive use of TransCAD, VISUM, and EMME while familiar with some training with CUBE Voyager. Based on the research team's experience, each software package would provide South Dakota with an excellent basis for statewide travel demand modeling capability. While all four software packages compare very closely to one another in each of the criterion in Table 6-7, each software package has its unique niche. For example, TransCAD has the best GIS compatibility being a GIS-based package. It also has direct processing capability of Census data. However, TransCAD's network and post-assignment analysis is not as good as that of VISUM. VISUM's network, procedures, assignment, and intersection-based analysis with TRAFFIX provide a powerful operation type analysis. VISUM also provides seamless output for use into VISSIM microsimulation. CUBE suite offers excellent freight capability while EMME has powerful matrix and network manipulation tools.

If compatibility with MPOs is a consideration then TransCAD and CUBE Voyager are good candidates. EMME can be easily ruled out as an option for two reasons: one is price for the software license and another is its limited use in the Midwest region. Of the four packages, EMME is the most expensive. Expertise in the use of EMME would be limited within the region, besides a few consultants. Moreover, training for EMME entails higher cost as it is usually offered at INRO's headquarter in Montreal, Canada. VISUM can be one good option with its TRAFFIX and VISSIM seamless integration. Turning movements at intersections are one important forecast data for SDDOT needs. VISUM has the built-in NCHRP 255 function to post-process forecast turning movements providing a handy tool to analyze level-of-service at isolated intersections. Signal timings can be coded into VISUM, properly accounting for intersection delays, which often is the controlling point in congested urban locations.. Operational analysis conducted in regional offices would benefit from the use of microsimulation tool. VISSIM has been used in microsimulation in Sioux Falls. VISSIM has been the widely used tool in terms of project application using microsimulation.

Despite the research team's preference with VISUM, the research team recommends TransCAD since SDDOT already acquired a site license. It is therefore cost effective for SDDOT since the outlay would only be the annual maintenance for technical support and update.

It should be noted that all of the vendors supporting the software packages provide training for their software. Typically, vendors hold training sessions at their office location but often provide on-site training upon an agency's request. In most cases, this training is related to general or advanced travel modeling development, applications, and theory, and is not tailored to a specific agency's travel model. Agency staff can attend these types of training courses conducted by each vendor at cost, sometimes in the range of $1,000 to $1,500 depending on the length (3 to 5 day classes) and content of the course.

Below compares the cost of each software package. All software packages offer a discounted license cost and annual maintenance and technical support for multiple licenses.

Software	License	Annual Maintenance & Technical Support
TransCAD	$10,000*	$995
VISUM	$26,400**	15% of the current purchase price of all licenses
CUBE Voyager	$13,500*	$1,750
EMME	$16000-$24,000*	12% of license contract

** Pricing as of December 2007*
*** Pricing as of 2008. Price is for a PTV suite that includes VISUM (3,000 zones size) and VISSIM*

License for TransCAD and CUBE Voyager are not based on the number of traffic analysis zones whereas VISUM and EMME are priced based on TAZ size. A base license of 2000 zones is assumed as the maximum size for the South Dakota statewide model.

6.4 MATCHING RESOURCES AND NEEDS

This section describes the resources already available at SDDOT and those that need to be acquired. It also presents a synthesis of the stakeholder interviews to weigh in the benefits versus associated costs of model option for South Dakota.

6.4.1 Available Data at SDDOT

Data and resources within the Department that are available for a statewide or a regional model include:

- Networks in GIS that cover the entire state highway and local roads system,
- Traffic counts that cover over 6,600 traffic count locations with over 50 ATR & WIM sites on all functional classification of roads in the state,
- Vehicle classification counts, and
- Vehicle speeds.

6.4.2 Required Additional Data and Resources

From the data and information needs in Section 6.2, it appears data required for modeling demand estimation and link factoring approach is available while most data is available for a simple network model and some data is available for a basic four-step passenger car model. Data can be readily obtained within the Department, at MPOs, Census Bureau, and other sources. However, there are important shortcomings in the available data set for use in a South Dakota statewide travel model. These are discussed below.

Travel Behavior Data

If a four-step approach is chosen, data on long distance trips and recreation/ tourist trip information are significant limitations. Using travel behavior parameters from national data sources would not reflect the rural tripmaking characteristics of South Dakotans. The lack of such data poses significant challenges in estimating trip generation and trip distribution and in the overall calibration.

Origins and Destinations Matrix (Trip Interchanges)

There is no data currently available in South Dakota that provides information on trip origins and destinations for trip purposes other than the Census journey to work data. While national data can be imputed for trip length frequency and distribution, such data would not likely represent the kind of uniquely rural tripmaking characteristics in South Dakota. Travel surveys need to be conducted to collect the desired travel data. Travel surveys, however, entail a large cost. There is an opportunity for a reasonable expenditure on such data collection effort by purchasing an add-on sample in the National Household Travel Survey (NHTS). The 2010 NHTS cost $175 per sample and requires a minimum of 1,500 samples for a total cost of $262,500. In addition to the add-on sample cost, SDDOT would be responsible for drawing a statewide sample plan.

The add-on sample is a less costly option for SDDOT than conducting its own household travel survey. It is important to note that the Sioux Falls MPO and Rapid City MPO are purchasing the add-on sample for the 2010 NHTS. The NHTS surveys will be conducted starting in 2008.

External Travel Origins and Destinations

Another important input to calibrating a statewide model is data on travels that originate or end outside of the state, including those trips that have both origins and destinations outside the state (the so-called through trips). There is no current data on external trips, which poses a great challenge in achieving a reasonable model calibration. The only available information on external travel is the 1995 American Travel Survey. The relevance of this data may be questionable. Since the mid 1990s (refer Figure 5-4), there has been significant shifts in county population where many counties have started to experience a decline. Beyond 2000, some counties have regained population and started to experience growth while others continue to lose population, as the case for Brown and Clay County demonstrate.

Cordon surveys at external locations would provide the needed data; however, such undertaking would be costly (likely in the range $75,000-$120,000 depending on the number of external stations and the number of questions asked).

Forecast Data

Forecast employment is not available. The South Dakota Department of Labor's Market Information Center does not develop a long range employment forecast, such as the 20-year forecast that is vital for SDDOT use. Depending on the model option, there would be a need to acquire employment data. Economic data developed by Woods & Poole cost about $400 to acquire.

Data on Freight

Freight data need to be acquired if the option selected involves freight modeling. Currently, there is a need for truck traffic data.

Purchase of Proprietary Data

Depending on the model option, there would be a need to acquire employment data. Economic data developed by Woods & Poole cost about $400 to acquire. Data on freight would need to be purchased as well if the option chosen involves freight/ trucks. As mentioned in Section 6.2.6, TRANSEARCH data for the base year costs between $25,000 and $100,000. Future forecast data could almost double the initial investment for base year data.

Number of Staff and Expertise in Traffic/Travel Forecasting

Sections 4.2.2 and 4.2.3 highlight the very limited number of Department staff who are currently involved in traffic forecasting. Currently, there is heavy reliance on a couple of very experienced staff for traffic data analysis and forecasting. Moreover, knowledge and expertise in travel demand forecasting and modeling is very limited. There is a compelling need to increase the number of staff to perform traffic forecasting, as well as the need to provide training to enhance knowledge in travel demand forecasting and modeling.

6.4.3 Travel Demand Forecast Needs Evaluation

This section presents an evaluation of uses/ needs identified in Section 4.2 against the four potential statewide model options outlined in Section 2.3.

Current 20-Year Traffic Forecasting Factors

SDDOT stakeholders generally felt the current traffic forecasting process is not meeting their needs. The inability of the current forecasting process to account for factors that will influence future VMT growth, such as population growth, economic growth, land use changes, and major new developments, are major limitations.

The review of the 20-year traffic forecasting procedure in Chapter 5 reveals some shortcomings of this forecasting methodology, which further supports an enhanced travel forecasting process for SDDOT.

Uses and Needs for Travel Demand Forecasts

Interviews with SDDOT stakeholders in Sections 4.2.1 and 4.2.5 highlight the variety of uses and needs of current and forecast traffic data by various SDDOT programs and divisions. Potential travel forecasting approaches outlined in Chapter 2, Section 2.3 are matched to the identified use or need for travel demand forecast, as detailed in Section 4.2. Potential options for travel demand forecasting for South Dakota include demand estimation and link factoring, simple network models, basic four-step models, and integrated freight and passenger four-step models.

The identified uses and perceived needs in Section 4.2 are matched against the four potential statewide model options. A weighting criterion with scale from 1 to 10 is assigned. A scale of 1 means the travel demand option (TDM) is not the suitable tool to use while a scale of 10 means the TDM is the most appropriate tool. This weighting criteria is applied to the evaluation matrix in Table 6-8.

The varying functions among programs and divisions require different levels of details and accuracy of forecast travel data. Some data uses and needs could be derived using less sophisticated forecasting methodology, as the evaluation matrix in Table 6-8 suggests, while other uses could not be satisfied even with a more sophisticated approach, such as a four-step model, without further model fine-tuning.

Other uses requiring a more sophisticated approach may not be essential SDDOT function, e.g., land use planning. Use of GIS mapping provides a valuable tool.

The choice of a model system for SDDOT needs to further consider the level of use of forecast data, for example, how many corridor studies are planned for which a statewide forecasting model would be needed.

Completed, Underway, and Planned Project/ Corridor Studies

SDDOT engages consultants to perform travel forecasting for corridor studies, site impact studies, and long range planning efforts. To weigh the cost of doing in-house with a South Dakota forecasting model versus consultant fees, completed, underway, and planned project/corridor studies were looked at. About six corridor projects in Rapid City, Mitchell, and Aberdeen regions were completed or underway during 2004 to 2006. For the nine planned project/corridor studies to year 2009, less than five projects would involve the use of traffic forecasts.

Estimate of consultant fees for the traffic forecasting component, excluding actual data collection and traffic analysis, is approximately $15,000.

Based on project/corridor needs, the above data suggests that in the immediate future (within the next two years) the need for a travel forecasting model would not be justified. It would cost less for the Department to engage consultants to derive traffic forecasts than to have it done in-house using a SDDOT travel model. It is also important to note that a travel model may need to be fine-tuned (networks and/ or TAZ) to analyze specific projects, requiring more staff time.

Depending on model sophistication, approximate costs to build a statewide travel model (simple network or four-step) range from $150,000 to $600,000.

Table 6-8 Perceived Uses/ Needs versus Potential Travel Demand Model (TDM) Evaluation Matrix

USE / NEED	POTENTIAL STATEWIDE TRAVEL DEMAND MODEL				COMMENTS AND ALTERNATIVE APPROACHES TO MEET USE / NEED
	LINK FACTORING	SIMPLE NETWORK	4-STEP MODEL	INTEGRATED FREIGHT / PASSENGER 4-STEP	
Statewide system planning or system EIS	5	7	10	10	
Regional planning	5	7	10	10	
Corridor planning/ preservation	2	5	10	10	
Bypass studies	1	5	10	10	Simple network model requires assumption of Origin-Destination data. GIS mapping and the use of a standard transportation software package would provide a useful tool for bypass analysis in rural areas.
Project prioritization	1	5	10	10	
Project level traffic forecasts/project EIS	2	4	5	5	TDMs are only partially useful. Network/TAZ fine-tuning is necessary in statewide models and forecasts need post-processing to obtain turning movements at intersections for intersection analysis. AADT growth factor;
Operational level studies	2	4	7	7	TDMs are only partially useful. Network/TAZ fine-tuning may be required and forecasts need post-processing to obtain turning movements for intersection analysis.
Economic development studies	2	5	10	10	
Freight forecasting	1	2	8	10	Freight/truck model using simple network approach, integrated 4-step
Bridge design	3	6	10	10	AADT growth factor
Pavement Design, ESALS	3	6	10	10	AADT growth factor
Safety analysis	1	2	7	7	GIS mapping would be a useful tool

Scale from 1 to 10: "1" means a TDM option is least appropriate to meet use/need while "10" means a TDM option is most appropriate to meet use/need

Traffic impact studies	2	4	7	7	Depending on the details included in the model, TDMs would need fine-tuning if development impacts are localized since TDMs do not usually account for low class roads. In this case, ITE procedures may be more appropriate. Trip rates need to be examined for applicability of the ITE trip rates to the rural tripmaking in South Dakota counties. GIS mapping would be a useful tool
Land use planning	1	2	10	10	GIS mapping of land use would be a useful tool in the absence of a four-step model
Detour analysis	1	5	10	10	Simple network model requires assumption of Origin-Destination data. GIS mapping and the use of a standard transportation software package would provide a useful tool for detour analysis in rural areas with very limited detour options.
Route diversion	1	5	10	10	Simple network model requires assumption of Origin-Destination data. GIS mapping and the use of a standard transportation software package would provide a useful tool in analyzing route diversion in rural areas with very limited diversion options.
Truck weight studies	1	3	5	8	
Growth factors for corridors	7	7	10	10	Link factoring would provide reasonable estimate of growth factors for corridors, particularly in areas with steady growth. GIS mapping of current and future land use and demographic/socioeconomic data can be used to supplement a statewide model using link factoring or simple network approach.
Effect of a corridor improvement on parallel corridors	1	7	10	10	Link factoring would not be able to quantify the effect of changes in route choice due to opening or improvements on parallel routes.
Historical growth factors for different areas of the state	7	7	10	10	GIS mapping of current and future land use and demographic/socioeconomic data can be used to supplement a statewide model using link factoring or simple network approach.
Forecast LOS in the urban fringe area to identify if growth has caused a drop in the LOS	1	3	10	10	GIS mapping of current and future land use and demographic/socioeconomic data would serve a valuable tool. Parcel level data and development plans in those urban fringes would be useful for anticipatory analysis of travel growth.

Scale from 1 to 10: "1" means a TDM option is least appropriate to meet use/need while "10" means a TDM option is most appropriate to meet use/need

6.5 POTENTIAL FORECASTING METHODS FOR SDDOT

6.5.1 Rationale for Statewide Travel Demand Models

The Peer Exchange questionnaires revealed that several states followed a generalized process depicted in Figure 6-1 (NCHRP 358). Accordingly, the modeling process is driven by needs in the form of general environmental and planning factors or by requirements of a specific project, such as a major new highway corridor study. The process is also influenced by the needed level of spatial detail. These needs lead to the development of goals and objectives for the statewide model. The goals may be explicit or implicit, but are most often created in collaboration with decision makers and other stakeholders.

According to NCHRP 358, the actual design of the statewide model is dictated by the established goals; the level of funding available for model development; the state of the practice in statewide modeling; the state of the art in travel forecasting, in general; and the availability and quality of secondary data sources. The design of the model is also influenced by the level of expertise of the DOT staff and their consultants. Primary data sources can supplement secondary data sources, but at much greater cost. As staff expertise increases, the model can be upgraded for better accuracy and applications to a greater variety of policies and projects. The most important feedback loop in the modeling process involves five stages, as shown counterclockwise in Figure 6-1:

- Goals and objectives,
- Model development funding,
- Statewide travel forecasting model,
- Applications to plans and projects, and
- Outreach to decision makers.

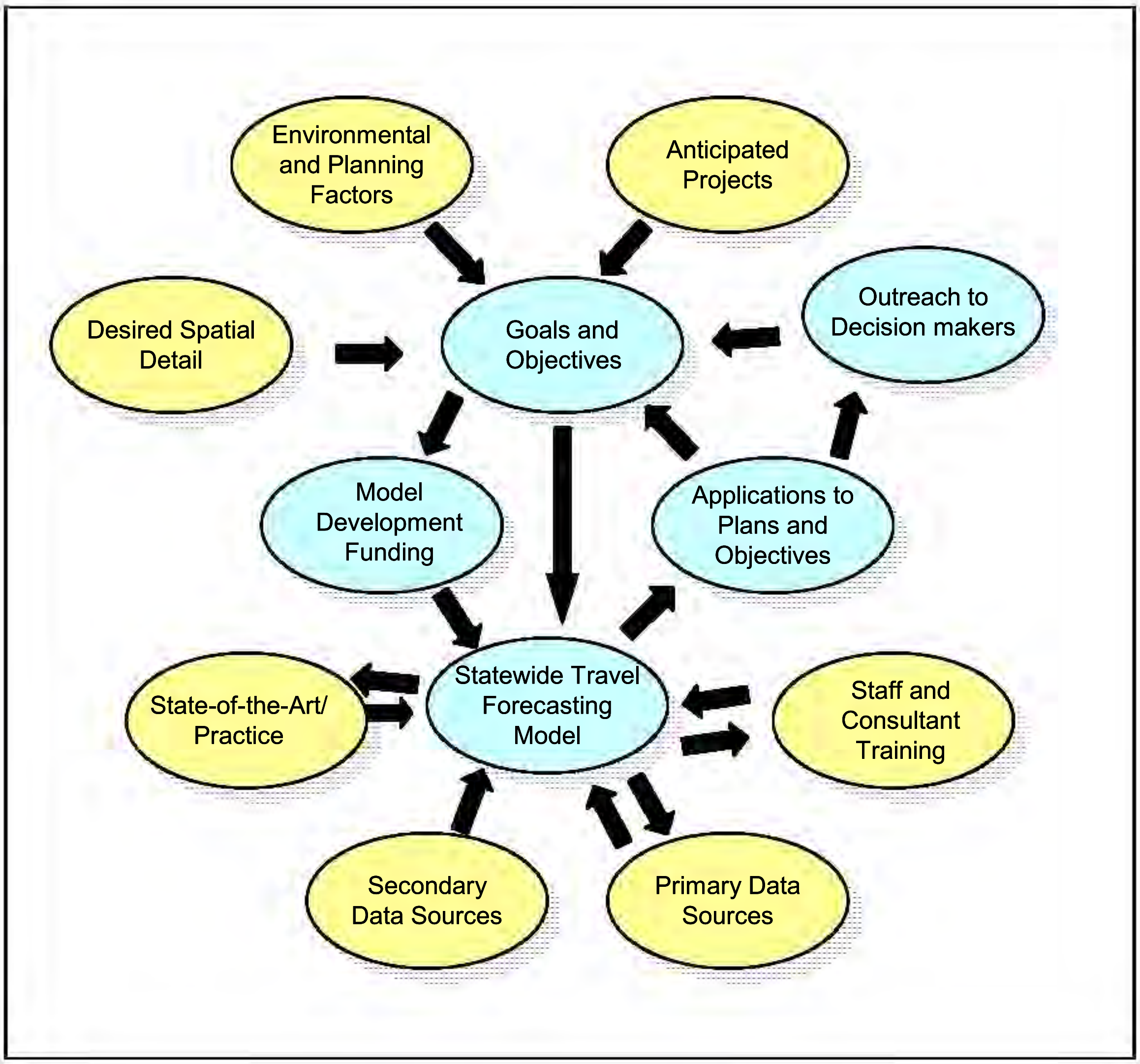
NCHRP 358 states that the successful applications of the model lead to increased awareness and confidence among decision makers, who in turn find additional uses for the model and provide the necessary financial support. Models that fail to continuously prove their utility will eventually be discarded.

From the review of needs and resources in earlier sections, a statewide model development process for South Dakota is lacking the following components:

- Foremost is funding available to build, maintain, and update regularly a statewide model. Under the current budget stream, there is very limited funding for this type of analytical tool.
- Availability of primary data sources on travel behavior data.

- The level of expertise of SDDOT staff is an issue, as well as shortfall in the number of staff.
- There is no major new highway or project planned in the short-term, at least within the next three years, that will provide an impetus for developing either a statewide or a regional model.

These missing components in the model process will play a major role in the final evaluation of the most efficient procedure to develop travel forecasts for South Dakota.



Source: Figure 2 of NCHRP 358

Figure 6-1 Typical Statewide Model Development Process

6.5.2 Value and Use of Statewide Models

The report commissioned by the New Mexico Department of Transportation to evaluate potential statewide model options for New Mexico has summarized potential uses and needs of statewide models, from the most traditional to innovative, that have been used by other State Departments of Transportation (NMDOT, 2007). The following potential uses and needs of statewide models are directly quoted from the New Mexico DOT report.

Supports Transportation Planning and Policy

Traditionally, statewide models have been developed as an analysis tool to support statewide transportation policy and planning. As these modeling systems have become easier and less expensive to implement and apply through increased computing power on the desktop, the potential uses of statewide models have increased almost as fast. These models have typically been used to:

- Assess statewide passenger and freight flows to support statewide system policy plans and investment analyses including the Long-Range Transportation Plans (LRTP), LRTP elements such as the Multimodal Strategic Plan, Toll Feasibility, Freight Plans, Transit Plans, and Statewide Transportation Improvement Programs;
- Support many departments and divisions within an agency, including environmental for air quality planning, engineering for design study reports and detailed scoping, and planning for a variety of needs;
- Address "what-if" subregional, long-distance and regional corridor, and multimodal (transit, freight, highway) system-level transportation investments and impacts in rural and small urban communities and regions in a state;
- Provide a single software platform to streamline all model components and support the development and application decision support systems;
- Provide a tool for responding to management and legislative requests for statewide travel statistics; and
- Enhance Highway Performance Monitoring System (HPMS) data with travel model-based forecasts as opposed to the use of traffic trend estimates that many state DOTs use for future forecasting.

Supports State, Regional, and Rural Planning and Policy Needs

Statewide travel models, as they have been developed by many state DOTs, can be used to support rural transportation planning, policy, and programming conducted by state DOT districts and regions, as well as by Regional Planning Organizations (RPOs), Councils of Governments (COGs), and Metropolitan Planning Organizations (MPOs). Statewide models can be used to:

- Support the long-range transportation planning process for MPOs, COGs, and RPOs that do not have modeling systems or available travel demand data;

- Provide outputs for all movements and modes that are external to regions in the state (including augmenting external trip-making for established regional models);
- Connect with regional models in other states to perform cross-border freight, rail, and highway systems and corridor evaluations;
- Provide travel and socioeconomic statistics for use by the COGs and MPOs with modeling systems for use in urban area model validation and calibration; and
- Support program and capital project needs, deficiencies, and project solution evaluations for state DOTs with a set of augmented and consistent transportation planning tools.

Provides Repository of Consistent Travel Behavior and Socioeconomic Data

Increasingly, state DOTs are struggling with data consistency, warehousing, and the development of database systems that can be used to share information among divisions, districts, and regional agency partners. A statewide model provides the following advantages:

- Provides a repository of consistent socioeconomic data used to support statewide and regional planning;
- Provides a repository of travel behavior and demand information and performance measures at the statewide level;
- Provides a consistent base and forecast year of travel behavior information that could be used to compute statewide daily and hourly volumes, freight and transit demand, vehicle miles traveled (VMT) by functional classification, and can be used to support the development of the Strategic Multimodal Plan, Transit Plan, Rail Plan, Highway Plan, and other statewide planning elements; and
- Provides data to assess the interrelationship between land use and transportation, including both the impacts of changes in development patterns and policies on transportation conditions and needs and the impacts of changes in the transportation system on future development patterns.

Integrates With Other Analytical Tools for System and Corridor Evaluations

Statewide travel models can be used to integrate with a variety of analysis tools to support system and corridor planning. Depending on the modeling option selected and implemented, this could include integration with:

- Microsimulation software packages (VISSIM, Paramix, Dynasim, others) for detailed transportation and traffic operations analysis of freight, transit, and highway systems;

- Economic and benefit/cost models such as Regional Economic Models, Inc. (REMI) and the Highway Economic Requirements System – State Version (HERS-ST) for use in assessing the economic impacts of all types of systems;
- Performance-based analysis tools (environmental, safety, fuel consumption, mobility/accessibility) to prioritize and rank capital projects for the LRTP;
- Management systems for bridge, pavement, safety, maintenance analysis as well as preservation analysis related to assets such as bridge and pavement; and
- Statewide Geographic Information System (GIS) and highway information systems.

6.5.3 Potential Benefits from a Statewide Travel Forecasting Tool

Developing and maintaining a statewide travel forecasting model involves significant resources in terms of cost and staff time. The cost and time expended largely depends on the level of model functionality and the availability of reliable data and skilled personnel. A well-conceived forecasting model usually outweighs the large outlay in model development. Statewide models have proven to be versatile tools in assisting in the development of both statewide and metropolitan area plans. Experience with several states using statewide models indicate their use of such models as means for forecasting rural projects, freight planning, corridor studies, traffic impact studies, economic development studies, air quality conformity analysis, major environmental impact studies, project prioritization, and many other planning needs.

The appropriate travel forecasting tool designed to meet the needs of South Dakota will undoubtedly deliver benefits to future planning of the state's transportation system. The SDDOT will have an effective planning tool that it can use for:

- Analyzing travel patterns within the state to improve highway planning
- Preparing long range plans
- Analyzing route diversion impacts
- Analyzing the capacity and safety impacts associated with increased or diverted truck travel on state routes
- Corridor preservation, reconstruction and resurfacing strategies

6.5.4 Statewide Travel Model Development Major Challenges

There are several major challenges in developing a statewide travel demand model for a rural state like South Dakota. These include large traffic analysis zones (TAZ), adequate data on travel behavior, data on external trips, long-distance trips resulting in multiday trips, and trip interchanges between sparsely/ low populated TAZs.

Large TAZ

There is the difficulty of adequately covering large geographic areas in sufficient detail, particularly in sparsely populated areas. Figure 6-2 shows an example of TAZ from 2000 Census. The lines in red outline the TAZ boundary. The blue lines define the county boundary. As shown, many TAZs cover an entire county. Urbanized areas have finer TAZs as depicted for the Sioux Falls MSA and Rapid City MSA. The 2000 Census TAZ defined 581 TAZs for the entire state.

Defining smaller TAZs, which increases the number of zones, does not pose a problem as far as software and computing speed. However, finer zones would require more resources in terms of data and calibration. Finer zones are not necessarily required in those sparsely populated areas as Figure 6-3 indicates. The state quick facts presented in Section 3.3.2 show South Dakota is a close second to Montana with 96.2% of roadways classified as rural miles.

One major drawback of having large TAZs is that the model cannot be used to analyze projects in those counties that are contained in a single TAZ since traffic inside the TAZ is not assigned to streets within the TAZ. Trips inside a TAZ are considered purely internal trips. Therefore, large TAZs are limited to analyze project level and traffic impact studies.

The review on statewide travel forecasting models in NCHRP 358 reveals the work in a few states that have experimented with spatial aggregation by modeling so-called subzones during the assignment step to remove the errors associated with large zones. This approach is still in the experimental stage and its benefits are still not certain.

Low Volumes/ Low Growth Areas

As depicted in Figure 6-3, a large portion of the state is low populated with very little growth, if not declining, as mentioned in Section 5.3.1. Significant portions of the state highway and local roadway system carry very low volumes. Some local roads carry only on average 25 vehicles per day.

Origins and Destinations Matrix (Trip Interchanges)

There is no data currently available in South Dakota that provides information on trip origins and destinations for trip purposes other than the Census journey to work data. While national data can be imputed for trip length frequency and distribution, such data would not likely represent the kind of uniquely rural tripmaking characteristics in South Dakota. Travel surveys need to be conducted to collect the desired travel data. Travel surveys, however, entail a large cost. There is an opportunity for a reasonable expenditure on such data collection effort by purchasing an add-on sample in the National Household Travel Survey (NHTS). The 2010 NHTS cost $175 per sample, which is cheaper than if the state conducts its own travel survey.

External Travel Origins and Destinations

Another important input to calibrating a statewide model is data on travels that originate or end outside of the state, including those trips that have both origins and destinations outside the state (the so-called through trips). There is no current data on external trips, which poses a great challenge in achieving a reasonable model calibration. The only available information on external travel is the 1995 American Travel Survey. The relevance of this data may be questionable. About the mid 1990s (Figure 5-4), there was significant shifts in county population where many counties started to experience a decline. Beyond 2000, some counties regained population and started to experience growth, while others continue to lose population as the case for Brown and Clay County demonstrate.

Cordon surveys at external locations would provide the needed data; however, such undertaking would be costly (likely in the range $75,000-$120,000 depending on the number of external stations and the number of questions asked).

Long Distance Trips/ Multiday Traffic Assignment

The long distance to traverse the vastness of the state would require multiday journeys. There is no data available on multiday tripmaking activities in South Dakota, which is needed for calibrating a statewide model. Data on long distance tripmaking characteristics in other states, particularly on rural travel, is currently not available. Multiday trips pose an issue in static traffic assignment procedures, which models a 24-hour timeframe.

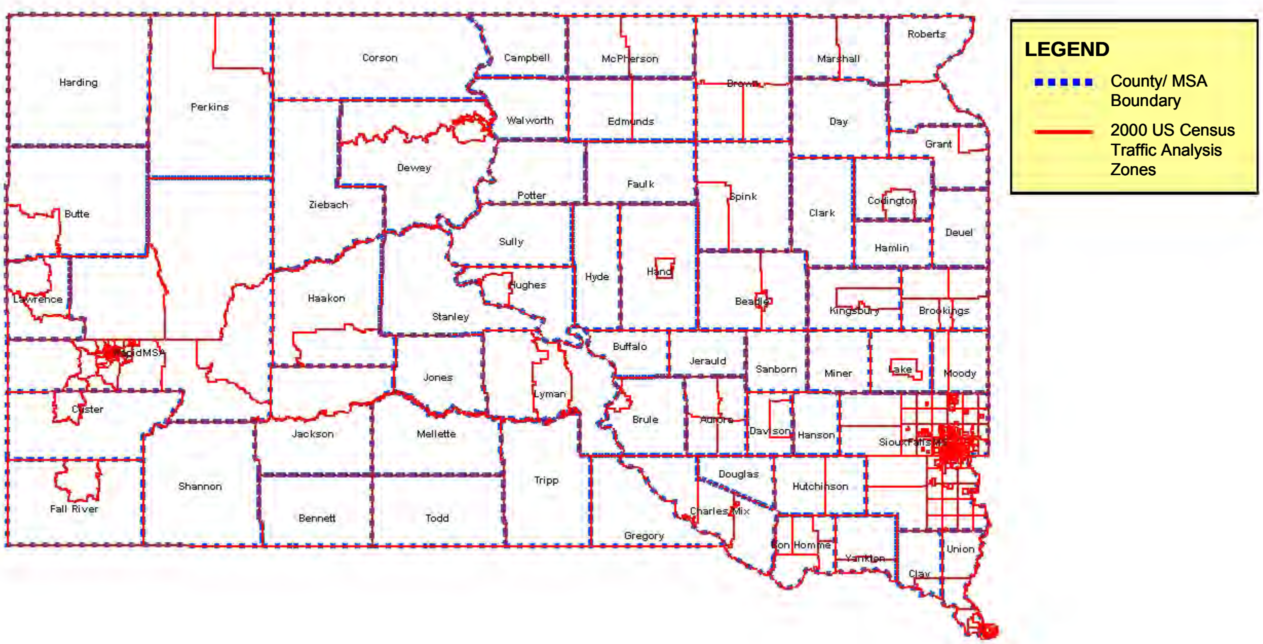


Figure 6-2 Example Traffic Analysis Zones for South Dakota

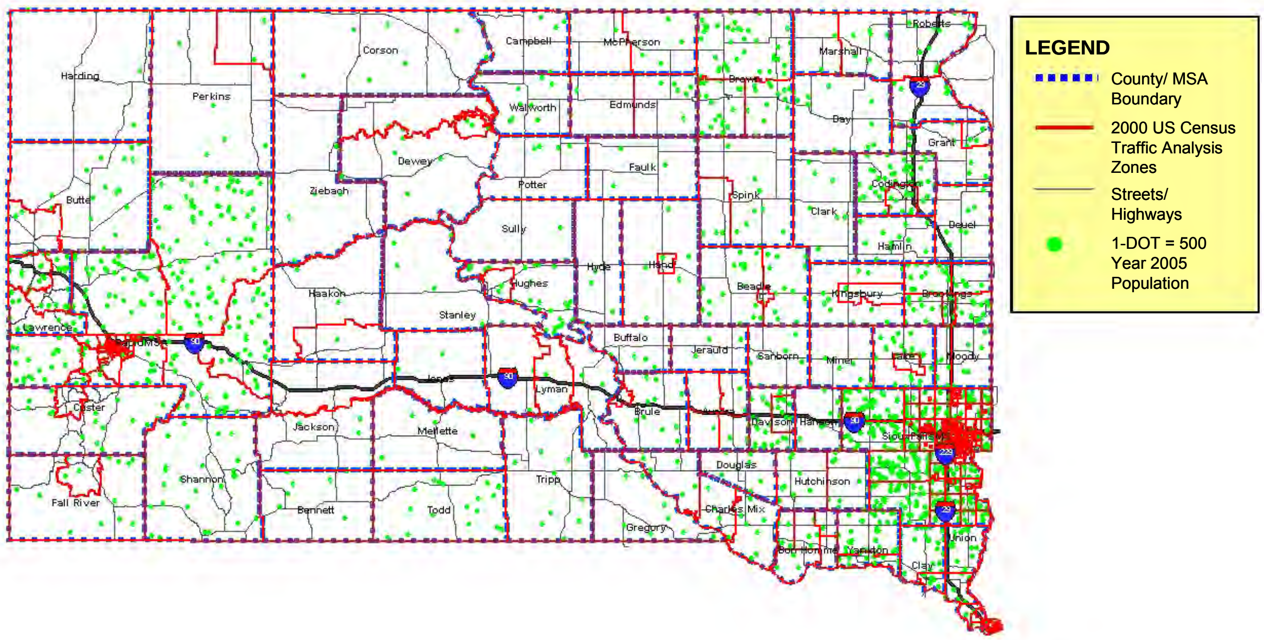


Figure 6-3 Population Distribution by Traffic Analysis Zones

6.5.5 Statewide Travel Demand Model Options

Based on needs and resources, the inverted triangle in Figure 6-4 depicts the potential statewide forecasting options for SDDOT. The integrated freight and passenger four-step is considered the least practical option (both needs and budget considerations). The basic four-step model can be either passenger cars only or trucks only, or it can have both passengers and trucks, similar to the Iowa DOT approach.

The inverted triangle represents the ratio of expected benefits to costs. It indicates diminishing ratio of benefit over cost to the point where cost far outweighs the benefits. While a basic 4-step passenger model would meet most of SDDOT needs more satisfactorily than the other two simpler methods, the cost to build and maintain the model would far outweigh the expected benefits from fewer project applications. Table 6-9 compares potential benefits and costs by model option.

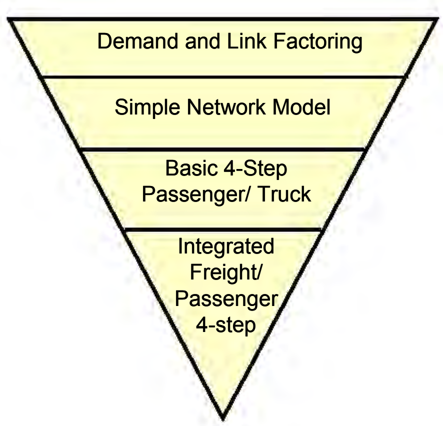


Figure 6-4 Potential Statewide Forecasting Models for SDDOT

Table 6-9 Potential Benefits and Costs for TDM Options

Travel Demand Model Approach	Benefits	Cost (Statewide Model)
Demand estimation and link factoring	Low	Low ($25,000-$50,000)*
Simple network model	Moderate	Moderate ($150,000-$450,000)
Basic-four step for passenger car only	High	High ($350,000-$600,000)
Integrated freight/ passenger 4-step	High	Very High (> $600,000)

* Cost could be much lower since SDDOT already has historical VMTs and it has networks in GIS with experienced GIS personnel.

The current Department budget constraint, however, would weigh heavily on the type of forecasting tool that SDDOT could practically afford to build and maintain.

Section 7.3 provides a more detailed comparison matrix of benefits and costs, including advantages and disadvantages.

One of the objectives of this research study is to determine the uses and benefits of a statewide model. The interviews of SDDOT stakeholders strongly emphasize the desire for a better forecasting approach than the current 20-year traffic forecasting process. Based on the uses/needs identified, the research team created an evaluation matrix in Table 6-8, summarizing several considerations used in evaluating the practicality of a statewide model for South Dakota.

While it is possible to build a statewide travel model using available data, the applicability of such a model would likely fall short to meet many of the identified uses and needs. The lack of travel behavior data to reflect rural tripmaking characteristics in South Dakota would be one significant shortcoming of a statewide travel model (STM). Geographical coverage with very low traffic dictates coarse or large traffic analysis zones, which practically limits, if not render worthless, the STM for project level analysis.

Taking all considerations, the research team does not find the current and short-term need for travel forecasting to justify the substantial cost to build, maintain, and update a four-step statewide model that requires Origin-Destination data. Demand estimation and link factoring can be readily developed using the enhanced 20-year traffic forecasting procedure and GIS networks. The feasibility of various TDM options is shown in the evaluation matrix in Table 7-3.

6.5.6 Regional Model Option

One of the objectives of this research study is to determine the uses and benefits of a regional instead of a statewide model. During discussion with the Technical Panel, the Black Hills area was mentioned to be a potential candidate for a regional application. The Black Hills area covers several counties, with the primary counties of Pennington, Lawrence, Custer, Fall River, and portion of Meade.

As discussed in earlier sections, the largely rural characteristics of South Dakota—with a large portion of the state low populated and with a significant portion of the state highway system carrying very low traffic volumes—makes a statewide travel model less practical and ineffective tool to best meet the needs of SDDOT. Regional models would be a more effective and practical planning tool, as well as cost effective, to build, maintain, and update.

A pragmatic regional model approach that ITD District 6 has recently adopted could be emulated for a region like the Black Hills area. SDDOT region could take the lead role of coordinating communities like what ITD District 6 has been going through. Improved coordination with local communities to establish partnership with local planners would prove beneficial to both SDDOT and local communities, as demonstrated in the ITD District 6 experience.

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7.0 RECOMMENDED APPROACH TO TRAVEL DEMAND FORECASTING IN SOUTH DAKOTA

Task 7. Prepare a technical memorandum that summarizes the work performed in Tasks 1-6 and provide recommendations on the most efficient process and resource needs to produce travel demand forecasts for the SDDOT. Discuss the costs, benefits, advantages, disadvantages, and feasibility of the recommended forecasting alternatives.

7.1 INTRODUCTION

The purpose of this research study is to evaluate the most appropriate travel demand forecasting tool that is most responsive to the needs of SDDOT. Like many other state agencies, the SDDOT has to do more with less funding for transportation infrastructure, operation, maintenance, and planning. The travel demand forecasting functionality has to be tailored to SDDOT's needs and constraints while maximizing benefits.

This chapter presents the study recommendations the research team found to meet SDDOT's needs and constraints. Section 7.2 outlines the recommended approach while Sections 7.3 to 7.6 provide the details. The last Section 7.7 describes the alternative approaches to derive travel demand forecasts. It presents the rationale for the recommended approach to travel demand forecasting in South Dakota outlined in Section 7.2.

7.2 RECOMMENDED APPROACH

As discussed in Section 6.5.5, the research team does not find the current and short-term need for travel forecasting to justify the substantial cost to build, maintain, and update a statewide model that requires Origin-Destination data. A statewide model of sketch planning level type is recommended as a starting model following enhancements to the existing traffic forecasting procedures. Demand estimation and link factoring can be readily developed using the enhanced 20-year traffic forecasting procedure and GIS networks. The feasibility of various TDM options is shown in the evaluation matrix in Table 7-3.

7.2.1 Executive Summary of Recommendations

Figure 7-1 presents a schematic of the recommended changes to the current SDDOT traffic forecasting process. The recommendations are grouped into four general categories that correspond to implementation timeframes. For example, recommendation **R1** includes changes requiring immediate implementation. Chapter 8 outlines the proposed implementation timeframes for each recommendation. Elaborate discussion of each recommendation is presented in subsequent sections.

R1. Recommended Changes to the 20-Year Traffic Forecasting Procedure

A. Enhancements to the 20-Year Traffic Forecasting Procedure

B. Increase the Number of Staff Trained in Traffic Forecasting

C. Develop and Implement "Traffic Use Procedures" Guidelines

D. Develop a Database of Travel Forecasting Data

R2. Short-Medium-Term Enhancements

D. Use GIS for Simple Network and Land Use Mapping

E. Use of a Standard Transportation Planning Package for Simple Network and Mapping

F. Invest in National Household Travel Survey Add-on Sample

R3. Statewide Sketch Planning Model Option

R4. Future Enhancements

D. Regional Model

E. Freight/ Truck Statewide Model

F. Statewide Passenger Car Model

The above recommendations are the most practical changes that can be implemented considering largely the SDDOT's budgetary constraint. The recommended changes represent an incremental process towards building a statewide travel forecasting capability at SDDOT when the need for one is justified.

According to NCHRP 358, many states found it useful to stage the development of the model, adjusting capabilities as the budget permitted. California, New Jersey, Ohio, Oregon, and Virginia are examples of states with a deliberate staging process—building a limited model to address immediate needs and expanding upon this model to address a greater range of issues.

A similar staging approach is followed by New Mexico and Iowa. Both states are currently in the development of their statewide models. New Mexico is starting with a simple network type passenger car model that would link to existing and proposed microsimulation and sketch planning tools. Iowa is starting with a 4-step passenger car and truck model.

The South Dakota DOT has a strong GIS capability with good coverage of the state highway and local roadway systems. The research team recommends making use of the Department's GIS to enhance travel demand forecasting and traffic analysis and transportation planning in general at SDDOT. Options to link GIS to a standard transportation software package for use in small-scale or project-level traffic analysis is also recommended. Future enhancements are also included.

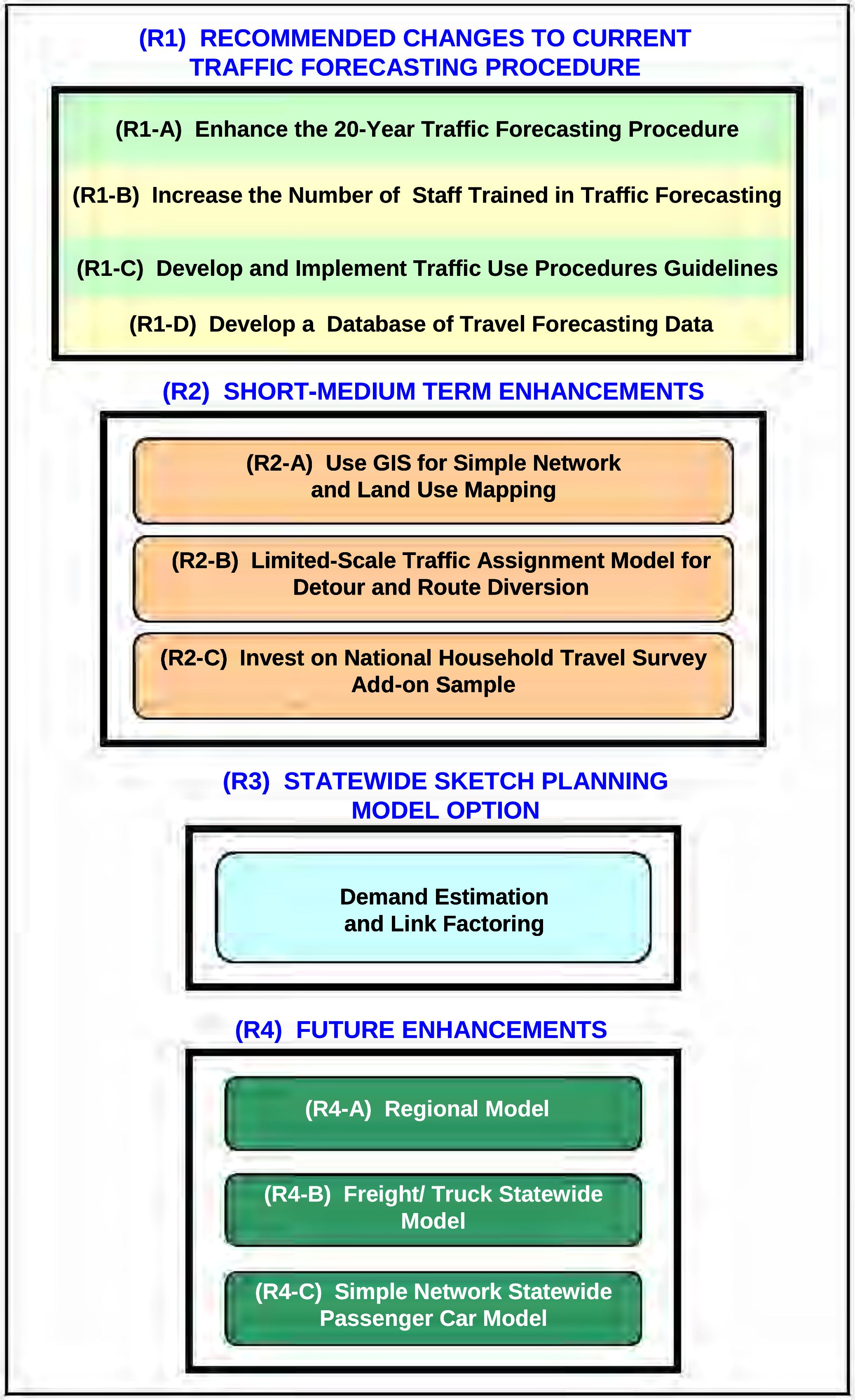

Figure 7-1 Recommended Changes and Enhancements to Current SDDOT Traffic Forecasting

7.3 RECOMMENDED CHANGES TO THE 20-YEAR TRAFFIC FORECASTING PROCEDURE (R1)

7.3.1 Enhancements to the 20-Year Traffic Forecasting Procedure (R1-A)

Section 5.5.2 details the recommendations to enhance the current 20-year traffic forecasting procedure. The study recommends the following changes to enhance the current traffic forecasting process:

(1) Ensure data integrity

The detailed review and analysis of historical VMT data demonstrates the need to ensure a quality data set for use in the 20-year traffic forecasting procedure. It is imperative that historical VMT data should be reviewed to remove data outliers and make necessary adjustment for shifts in VMTs due to reclassification.

Apply the method outlined in Section 2.2.1 *(Method 3: Linear Projections of VMT by Functional Class, with Adjustments to Correct for Changes in Functional Class Categories)* to adjust the shifts in VMT due to reclassification. This method has been applied in this analysis to adjust for the interstate VMTs in Lawrence, Meade, and Pennington counties, as well as the statewide arterials and interstate VMTs.

(2) Year to use as a starting point for the regression analysis

After making the necessary adjustments to the historical VMT data, the starting year for the regression analysis should be reviewed. As shown in the historical VMT plots, some categories show sharp increases at some point and then moderating or leveling later. Typical of this trend is exhibited by Class 10-13 commercial where a sharp increase in VMTs occurred in 1994. There are a couple of reasons for the sharp increase in VMT. After 1994, VMT has been calculated using HPMS data. Moreover, VMT data by county was not broken down by functional class until 1994. These changes in VMT calculation and aggregation have created some shifts, as exhibited by Class 10-13.

The regression analysis should use 1994 as a starting point rather than going back to 1986 for trucks. Starting year for other categories, such as *Other* class, should be reviewed as well.

(3) Apply different procedures to derive 20-year factors for VMTs

SDDOT should consider using different procedures to forecast VMTs based on the amount of historical and expected growth.

(a) Use constant growth rate in counties with only marginal increase in VMTs. Linear projection of VMT based on estimated growth factor (Method 1) outlined in Section 2.2.1 can be applied for categories such as Class 5-9 and *Other* class.

(b) Use linear regression or a combination of techniques. The technique used should be one that best fits the data. Use linear regression method for categories that exhibit a good linear fit. Use a combination of techniques, for example, a Moving Average to "smoothed" the data prior to applying a linear regression. Use other functions, for example an exponential function if this provides a better fit to the data. It is important, however, to ensure that the long term forecast is within reasonable expected growth.

(4) Aggregate categories

If appropriate, aggregate some categories to obtain a good linear fit. For example, Class 5-9 generally has poor linear fit. By combining the two commercial categories, an estimate for Class 5-9 can be derived. Aggregating data is a common practice. For example, it is common to start the VMT estimate at the statewide level since there is higher confidence in VMT data on the state highway system. Based on a statewide growth, estimate of growth at the county level is allocated based on population, or other socioeconomic data. Further, the VMT growth is allocated by functional class, for example interstate and non-interstate.

(5) Adjustment to the 20-Year VMT Factors

It is recommended not to apply the current adjustment approach. Ensure that a good linear fit exists; if not, use a different forecasting technique as outlined above.

(6) Explore socioeconomic explanatory variables

(a) Further explore the relationship of employment data and VMT, particularly for smaller counties. The present analysis indicated some significant relationship. Commercially available forecast socioeconomic data at a county level, for example, Woods & Poole economic data, is readily obtained at a modest cost. VMT projections using sound forecast socioeconomic data usually produce better factors.

(b) Explore the applicability of using total business pattern, particularly for larger counties. The results of analysis indicate that total business data has some significant relationship for some categories.

(c) Further explore the applicability of population as a variable in counties where a linear relationship exists. Population forecasts are more easily obtained than other socioeconomic data.

(7) Update the traffic forecasting annually using updated VMT and socioeconomic data.

(8) Develop standardized spreadsheet templates with graphic capability to facilitate analysis and interpretation of data trend.

7.3.2 Increase the Number of Staff Trained in Traffic Forecasting (R1-B)

As highlighted in the SDDOT stakeholders interviews, there is a need to increase the number of staff with skills in traffic forecasting. Likewise, there is a need to provide training to enhance knowledge and skills in the following:

- Use and application of the Institute of Transportation Engineers (ITE) trip generation procedures
- Process and manipulate Census data for use in transportation analysis
- Basic understanding of travel demand surveys and the application of survey data
- Understand general traffic forecasting theory and the process of traffic forecasting and modeling, including quick response method of analysis
- Understand the application of forecast data

7.3.3 Develop and Implement "Traffic Use Procedures" Guidelines (R1-C)

In view of the recommended changes in the SDDOT traffic forecasting procedure and the desire to increase the number of Department staff who would be trained in traffic/ travel forecasting, it is imperative for SDDOT to develop "traffic use procedures" guidelines. "Traffic use procedures" guidelines would provide guidance on traffic data collection, processing and data editing procedures, outlining procedures on VMT adjustments and "smoothing" of historical VMT data, systematic guidelines for traffic forecasting, and thorough documentation.

The guidelines can also serve as a manual to facilitate training. Systematic guidelines for traffic forecasting can improve the development and documentation of a forecast to ensure accuracy and repeatability. Thoroughness of documentation ensures the quality of traffic forecasts with results repeatable and justifiable to others besides the responsible engineer. Standardize forecasting procedures and data sets ensure that forecasts are easier to review, interpret, and update.

7.3.4 Develop a Database of Travel Forecasting Data (R1-D)

Developing a database of travel forecasting data at SDDOT enables the Department to build incremental datasets that will be useful for developing regional models and later a statewide model. Such a database will serve as a repository of travel related information that can readily assist in various types of analysis and mapping. Information that can be stored in the travel forecasting database include, but are not limited, to the following:

- Socioeconomic data
- Data on travel characteristics
- Land use data, such as parcel level datasets

- Data collected and used in project-specific models or any non-MPO traffic models. A good example is the model developed for the City of Watertown
- Data on special trip generators or trip generation rates
- Traffic impact studies data
- Intersection controls and access management related data

7.4 SHORT-MEDIUM-TERM ENHANCEMENTS (R2)

Other options to enhance travel demand forecasting and traffic analysis and transportation planning in general at SDDOT include the use of the Department's GIS capability. GIS can also be linked to a standard transportation software package for use in small-scale or project-level traffic analysis. A medium-term enhancement would be an investment to obtain good travel data from a household travel survey.

7.4.1 Use GIS for Simple Network and Land Use Mapping (R2-A)

The SDDOT GIS would provide a useful tool for many of the uses and needs identified by stakeholders. GIS mapping provides a handy tool for showing existing and future land use. Parcel level data would be very useful to show proposed developments, particularly commercial developments that would likely impact the state highway system. Demographics and socioeconomic data can be easily mapped over the highway system.

7.4.2 Use of a Standard Transportation Planning Package for Simple Network and Mapping (R2-B)

The strength in GIS capability at SDDOT can be augmented with a standard transportation planning software described in Section 6.3. GIS is very much at the heart of transportation planning tools providing links to data that drives the models. Figure 7-2 depicts an example using TransCAD that shows a map of mean travel time and mode of travel in South Dakota counties. Software packages have been developed to the point that they are more user-friendly than they were in the past, although knowledge and understanding of travel demand forecasting theory and modeling concept is required.

Area engineers would largely benefit from having a transportation software package to link with GIS. Such a tool would be handy for project level analysis and traffic impact studies. Once trained, area engineers and other SDDOT would be able to use the software package on limited or small-scale traffic assignment model for detour and route diversion analysis.

SDDOT already owns a TransCAD license, which is currently kept under Project Development.

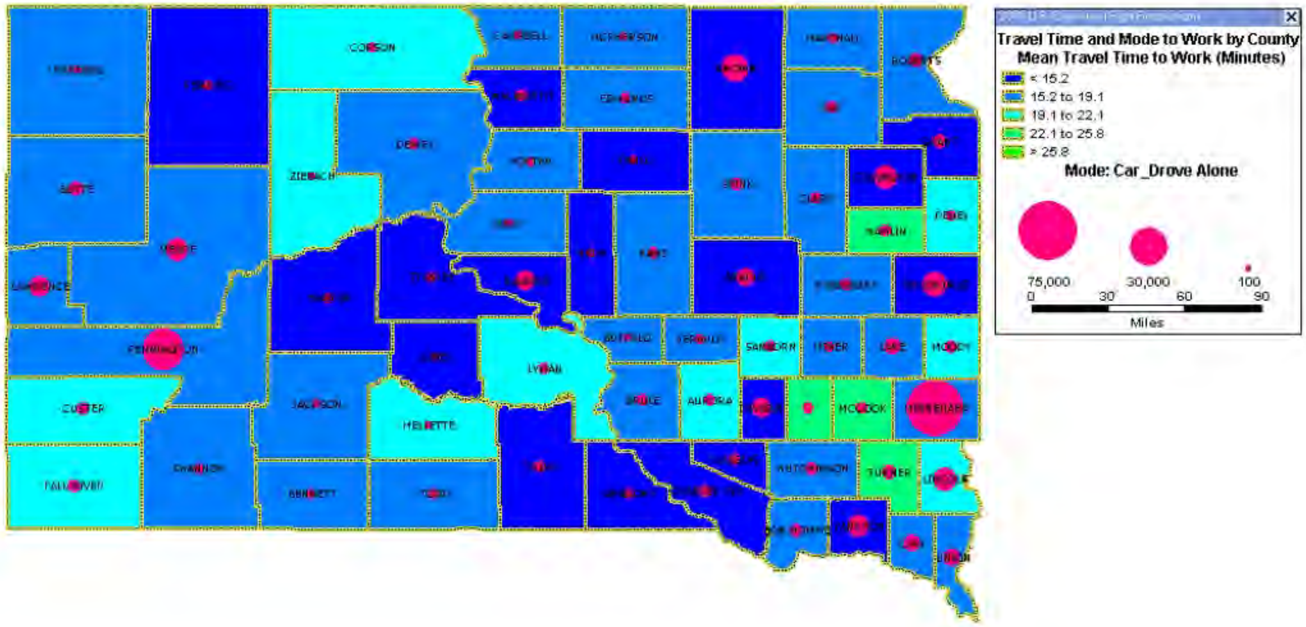

Figure 7-2 Example of the Use of TransCAD for GIS-Based Mapping/ Analysis

7.4.3 Invest in National Household Travel Survey Add-on Sample (R2-C)

Section 6.4.2 details the need for good data on tripmaking characteristics of South Dakotans. An efficient approach to obtaining quality travel data from a travel survey is to purchase an add-on sample through the National Household Travel Survey. The 2008 add-on sample costs $175 per completed survey and requires a minimum of 1,500 samples. The next NHTS schedule is fast approaching in 2008. It is not feasible to participate for this survey since sampling frame would need to be drawn and submitted to NHTS. It is already late for this coming 2008 survey schedule. NHTS has plans to conduct a more frequent survey than the current five-yearly interval. Considering budgetary constraint at SDDOT, the NHTS schedule appears fitting for SDDOT.

7.5 STATEWIDE SKETCH PLANNING MODEL OPTION (R3)

The review of data needs and available resources suggests that a demand estimation and link factoring approach can be developed as a statewide model option. The enhancements recommended to the 20-year traffic forecasting procedure would pave the way to extend the capability to incorporate socioeconomic and other potential explanatory variables. Population and employment are found to have some explanatory power for some categories in some counties. For those categories that do not show a good linear fit, aggregation of categories could be explored. Growth rates from population and employment data can also be assumed for those categories with marginal annual VMT growth.

Demand estimation and link factoring method was used in the Arizona DOT MoveAZ Plan. This method was used to update future HPMS travel forecasts. Factoring traffic volumes is less resource intensive than other approaches, but assumes that the underlying travel behavior in a region will not change. This approach is valid if the underlying trip distribution pattern is unlikely to change, if minimal changes in auto occupancy or mode split are expected, and if congestion on existing roads or the opening of new roads is not likely to result in a change in route choice. The VMT forecast for the MoveAZ Plan is based on population and employment forecasts as well as historical traffic counts.

7.6 FUTURE ENHANCEMENTS (R4)

Many states found it useful to stage the development of the model, adjusting capabilities as the budget permitted. In addition, experiences in many states and planning agencies indicate where many models were initiated because of a very specific issue or project that provides the impetus or triggers. Implementation of future enhancements suggested in Figure 7-1 would be largely driven on a needs basis. Table 7-1 below outlines potential triggers.

Table 7-1 Potential Triggers for Future Enhancements

Enhancement	Potential Triggers
Regional Model	• Future new major projects • Development pressures with regional impacts
Freight/ Truck Statewide Model	• Future expansion of ethanol plants • Capacity and safety impacts associated with increased or diverted truck travel on state routes that intermodal facilities adjacent to highways creates
Statewide Passenger Car Model	• Statewide long range planning requiring linkages with economic models • Corridor planning and bypass studies • Data on travel behavior and forecast socioeconomic data, and most importantly, funding availability

7.6.1 Regional Model (R4-A)

As outlined in Section 6.4.4, SDDOT could emulate the approach now being implemented at ITD District 6. To assist smaller communities in dealing with traffic growth in their areas, which could later pose problems with the state highway system, SDDOT could take the lead in coordinating regional transportation planning. The database set up as part of the recommended changes to traffic forecasting would allow SDDOT to build regional models when a need for it arises.

Future new major projects or development pressures with regional impacts would provide a strong catalyst for such a regional model.

7.6.2 Freight/ Truck Statewide Model (R4-B)

A simple network model approach applied in the Eastern Colorado Mobility Study and in the North Dakota DOT freight studies could be a potential model option for South Dakota when a need arises in the future to justify developing a statewide model for freight/ truck. Future expansions of ethanol plants would provide strong impetus for such a model. Likewise, the capacity and safety impacts associated with increased or diverted truck travel on state routes that intermodal facilities adjacent to highways creates would provide additional catalyst for a statewide freight/ truck model.

SDDOT could engage university research centers to develop a statewide freight/truck model similar to the freight studies undertaken by the Upper Great Plains Transportation Institute (UGPTI) for NDDOT. In developing the economic model to analyze, UGPTI has developed a simple network type model that includes trucks and passenger cars.

7.6.3 Statewide Passenger Car Model (R4-C)

Typical experiences in other states and planning agencies indicate that many models were initiated because of a very specific issue or project. For example, the need to evaluate corridor plans triggered the development of statewide models in Indiana and Missouri. Potential economic impacts associated with widening much of the state's two-lane highway system to four lanes provided the drive for the Montana statewide model. On the other hand, most statewide models were initiated because of a realization of system-wide forecasting needs. The need to evaluate and respond to air quality conformity analysis or system environmental impact statement provided impetus in other states for a statewide model. The Iowa DOT realized its needs for a statewide model as an important tool for forecasting auto and truck travel in the state, as well as other major planning efforts such as corridor analysis and policy evaluations.

When the need arises in the future to justify developing a statewide model for passenger car, a simple network model approach adopted by the New Mexico DOT could be implemented for South Dakota as a starting model. Impetus for developing such a statewide model may arise in response to the following needs:

- Corridor planning – assess the need for corridor level economic development studies and/ or intercity corridor and statewide planning. A need for a better forecasting tool for use in corridor planning is already a current issue identified by stakeholders.
- Bypass studies – stakeholders identified the need for a better forecasting tool for use in bypass studies.
- Respond to management and legislative requests for statewide travel statistics, as well as support for statewide system policy plans and investment analyses.

- Availability of good data on travel behavior and forecast data and most importantly, availability of funding.

7.7 ALTERNATIVE APPROACHES TO DERIVE TRAVEL DEMAND FORECASTS

Section 4.2.6 identifies the uses and needs for credible travel forecasts in various divisions/ programs at SDDOT. Potential statewide travel model options that would satisfactorily meet each use/ need are identified. Statewide travel demand models are proven valuable forecasting tools; however, the degree to which statewide models meet the needs rely heavily on the details the models are specified. Models need to be designed according to the intended purposes. Thus, there are uses and needs of forecast travel data for which statewide models are not the most suitable or practical tools. Demand estimation and link factoring type statewide model for South Dakota, the most practical and feasible model that can be built with the currently available data, would not be the suitable forecasting tool for many project level applications, operational analyses, and traffic impact studies. The rationale for selecting a statewide model option is discussed in detail Sections 6.4 and 6.5.

7.7.1 Data Needs and Available Resources

Sections 6.4.1 and 6.4.2 detail the available resources and needed data to develop a statewide or a regional travel demand forecasting tool for South Dakota. While there are currently available data that can be used for model development, there are major limitations of the available data set that can be used to develop a model that has the desired capability to meet many of the travel forecast needs identified by divisions/ programs. It would entail a large initial cost to obtain the desired data on travel characteristics, long-distance travel information, and data on external travel.

Data needs and resources plays a key role in evaluating the most appropriate forecasting tool for South Dakota considering the Department's budgetary constraint.

7.7.2 Cost and Feasibility Criteria

This section outlines the weighting criteria for cost and feasibility that are used in ranking the recommended approach in Section 7.3

Cost

The cost estimate range includes the following components:

- Cost to acquire proprietary data,
- Software license and annual software maintenance and technical support,
- Model development that includes data preparation and development of demographic and socioeconomic forecast,

- Annual on-going maintenance and model update (assuming in-house staff performing the necessary maintenance and update),
- Required highly experienced modeler/ planner to take charge of model development oversight with consultants and responsible for maintenance and update, and
- Training to increase the number of staff and enhance the knowledge and skills in travel demand forecasting and modeling.

These criteria are applied in the evaluation matrix in Table 7-2.

Cost Criteria			
1	Low	≤ $60,000	Cost would be much less, if only staff time is involved in the analysis that does not include employment and other socioeconomic variables.
2	Low to Moderate	$60,000-$150,000	Cost includes the purchase of economic data (Woods & Poole).
3	Moderate	$150,000-$350,000	Cost includes the purchase of economic data (Woods & Poole).
4	High	$350,000-$600,000	Cost includes the purchase of some proprietary data, such as economic data.
5	Very High	> $600,000	Cost includes a large proportion for proprietary data, such as freight data.

Feasibility

The criteria used in evaluating the feasibility of a travel forecasting option are outlined below. The evaluation matrix in Table 7-2 reflects these criteria.

Feasibility Criteria		
1	High	In-house capability, data available within SDDOT, low cost option, no training necessary, and require the least effort.
2	Moderate to High	Low to moderate model development and maintenance/update cost, does not require additional staff, modest data acquisition cost, only require in-house training, and only require low level effort.
3	Moderate	Moderate model development and maintenance/update cost, some proprietary data, no additional staff required, require some understanding of travel demand forecasting and modeling, skill level, and require moderate level effort.
4	Low	High model development and maintenance/update cost, require 0.25-0.5 FTE staff, significant proprietary data, require outside training in travel demand forecasting and modeling, require high skill level, and require high level effort.
5	Very Low	Very high model development and maintenance/update cost, require 1.0 FTE, expensive proprietary data, require outside training in travel demand forecasting and modeling, require high skill level, and require high level effort.

7.7.3 Summary Evaluation

From the review of needs and resources in earlier sections, a statewide model development process for South Dakota is lacking the following:

- Foremost is funding constraint where there is very limited funding available for model development,
- Availability of primary data sources mainly on travel behavior data,
- The level of expertise of SDDOT staff is an issue, as well as shortfall in the number of staff, and
- There is no major new highway or project planned in the short-term, at least within the next three years, that will provide an impetus for model development.

The uses/needs evaluation with travel demand model options in Section 6.4 suggested that a demand estimation and link factoring approach is a feasible option considering the existence of good historical VMT data. Using the enhanced 20-year traffic forecasting procedure and GIS networks, it is feasible to develop such a statewide sketch planning tool.

Table 7-2 and 7-3 presents the evaluation matrix of statewide model and other approaches, as well as future enhancements.

Table 7-2 Data Needs and Available Resources Matrix by Alternative Approaches to Derive Travel Demand Forecasts

ALTERNATIVE APPROACH	SOCIO-ECONOMIC/ NETWORK DATA	TRAVEL BEHAVIOR DATA	CALIBRATION/ VALIDATION DATA	FORECAST DATA	PURCHASE PROPRIETARY DATA	SOFTWARE/ MAINTENANCE REQUIREMENTS	ADDITIONAL STAFFING REQUIRED	TRAINING REQUIRED
ENHANCED 20-YEAR TRAFFIC FORECASTING FACTORS	●	N/A	N/A	◉*	◉*	○*	○	○
REGIONAL MODEL	●	◉	●	◉	◉	●	◉	●
LINK FACTORING	●	N/A	●	◉	◉	○	○	◉
SIMPLE NETWORK MODELS	●	◉	●	◉	◉	●	◉	●
BASIC 4-STEP MODELS	●	◉	◉	○	◉	●	●	●
INTEGRATED FREIGHT & PASSENGER 4-STEP	●	◉	◉	○	●	●	●	●

* If using employment data as an independent variable, there is a need to purchase for a proprietary data. Moreover, there is a need to develop a program to automate the regression graphically.

LEGEND

Socioeconomic/Network/ Travel behavior/ Calibration/ Validation/ Forecast Data:
● Available; ◉ Partially Available; ○ Not Available; N/A Not Applicable

Proprietary Data:
● Freight and economic data; ◉ Economic data; N/A Not Applicable

Software/ Maintenance Requirements:
● Required; ○ Not Required

Additional Staffing Required:
● 0.5 to 1 FTE; ◉ 0.25 to 0.5 FTE; ○ No additional staff required

Training Required:
● Need outside training; ◉ Only in-house training to train more staff in other programs on traffic forecasting; ○ No training required

Table 7-3 Evaluation Matrix of Alternative Approaches to Derive Travel Demand Forecasts

ALTERNATIVE APPROACH	ADVANTAGES	DISADVANTAGES	BENEFITS	COSTS	FEASI-BILITY
Enhanced 20-Year Traffic Forecasting Factors	• VMT data by functional class is readily available for cars and trucks • Involves the least cost compared to other travel demand modeling methods • Easy to maintain and update • No software license & maintenance required • Does not require consultants to enhance the procedure	• Does not explicitly account for factors that will influence future VMT growth, such as population growth, economic growth, land use changes, and major new developments. As a result, it will not be very accurate for an area that is expecting a significant change in growth rate (either more rapid or slower) from the historical rate. • Not sensitive to expected changes in transportation investments or policies. Any additional traffic growth associated with new facilities will need to be analyzed separately. Future upgrades of facilities to higher classifications will not be reflected. • VMT factors are not useful to analyze several planning needs, which include route diversion impacts prior to corridor improvements, corridor studies, site impact studies, and studies to identify the capacity and safety impacts associated with increased or diverted truck travel on state routes. • Do not account for the impacts of land use developments, e.g., assess the impacts of a mini-mart or a mall.	• Provide reasonable forecast with the least cost considering limitations in travel data needed to develop a better forecasting tool, such as the four-step model.	1	1
Regional Model	• Depending on model specification (i.e., simple network or 4-step), provides route-level traffic forecasts and system performance, such as VMT and VHT over a region	• Require consultants to develop the model	• Depending on model specification, provides better forecast than the highly aggregate VMT 20-year forecasting or demand estimation and link factoring approaches	3	3-4*
Link factoring	• Current SDDOT 20-year traffic forecasting procedure can be readily extended to relate to employment or other socioeconomic variables • Readily available forecasts at the county level from state and/or reasonably priced commercial sources • Can be implemented with existing	• Not network or trip based • Trip generation, distribution, mode choice, or travel assignments on networks are not performed.	• Provides a high-level (county or urban area) estimate of total demand for travel • Can be used to support the development of state transportation plans • Can provide aggregate information about the transportation system	2	2

	spreadsheet software (e.g., Microsoft Excel) • Low level of application effort and training required • Does not require consultants to calibrate		• Can be used in the early stages of transportation system analysis to develop a conceptual understanding of performance		
SIMPLE NETWORK MODEL	• Provides route-level traffic forecasts and system performance, such as VMT, Vehicle Hours of Travel (VHT), and energy consumption	• No in-house travel demand modeling capability, thus would require consultants to develop the model	• Provides better forecast than demand estimation and link factoring • Meets some of the uses and needs	3	3
BASIC 4-STEP MODEL	• Forecast traffic by route segment and system performance measures, such as VMT and VHT. Statistical basis for comparing the costs and non-economic benefits of projects and aggregate information about non-highway mode market share and demand • better understanding travel patterns	• Need an experienced planner/ modeler to oversee the model development and its regular maintenance and update. • Large TAZs is a significant issue for project level analysis	• Provides reliable forecast and meets many of stakeholders uses and needs	4	4
INTEGRATED FREIGHT & PASSENGER 4-STEP MODEL	• Same as basic four-step • Can be linked to economic models like HERS-ST • Forecast roadway segment passenger and freight forecasts by mode and vehicle type, system performance measures, such as VMT and VHT, link by link non-highway passenger travel and freight transport forecasts (person trips or commodities), tabulations of economic productivity and cost effectiveness, and integrated features for tradeoff analysis	• Same as basic four-step • High cost involve to acquire commercially available freight data, such as TRANSEARCH and Global Insight	• Same as basic four-step • Provide better freight assessment	5	5

** Feasibility ranking for a regional model would depend on the type of model formulation, i.e., whether a simple network or a basic four-step approach.*

8.0 SYSTEMS REQUIREMENTS AND IMPLEMENTATION PLAN FOR SDDOT TRAVEL DEMAND FORECASTING

Task 9. ***Based on SDDOT concurrence with the recommended travel demand forecasting process, develop a systems requirements document and implementation plan that addresses data collection and management, analytical tools, hardware, software, and necessary training, along with costs and implementation timeframes to either enhance the SDDOT's current travel demand forecasting process or establish a new process.***

8.1 DATA COLLECTION, DATABASE MANAGEMENT, AND DOCUMENTATION

8.1.1 Data Collection

Implementation of the recommended changes to the 20-year traffic forecasting procedure will not require new data collection efforts. The traffic data collection program already in place at the Transportation Inventory Management program is already sufficient. Likewise, a statewide sketch planning model option of demand estimation and link factoring type will not require additional data collection besides acquisition of forecast socioeconomic data, such as the commercially available Woods & Poole socioeconomic data. Existing historical county level VMT by functional class and good roadway network coverage in GIS for the entire state are readily available.

Developing a database of travel forecasting data will require gradual acquisition of relevant data, as they become available. As described earlier in Section 7.3.4, information that can be stored in a travel forecasting database include, but are not limited, to the following:

Socioeconomic Data	Land Use Data
Data on Travel Characteristics	Data on Special Trip Generators
Data Collected and Used in Project-specific Models	Trip Generation Rates
Traffic Impact Studies Data	Intersection Controls and Access Management Related Data

8.1.2 Database Management

The recommended enhancements to the 20-year traffic forecasting procedure require visual/graphical analysis. As mentioned in Section 4.4.2, graphing of historical traffic counts by individual count locations and the ability to perform statistical analysis and projection by regression analysis, can be easily programmed as an additional functionality of the existing Traffic Data Management System (TDMS). The historical VMT determined from the HPMS process can be stored in the TDMS and statistical analysis and 20-year forecasts can be performed.

The Bureau of Information and Telecommunications (BIT) would need to develop the required additional TDMS functionality. The Transportation Inventory Management program would need to coordinate with BIT staff with respect to specification and implementation timeframe of the additional TDMS functionality.

8.1.3 Documentation

The Transportation Inventory Management program will be responsible in developing and implementing the recommended “traffic use procedures” guidelines outlined in Section 7.3.3.

8.2 HARDWARE AND SOFTWARE NEEDS

8.2.1 Hardware

There is no special hardware required for the recommended enhancements to SDDOT traffic forecasting procedure.

8.2.2 Software

There are two proprietary softwares needed to implement the recommended changes to SDDOT traffic forecasting procedure. One is ArcGIS and the other is TransCAD for travel demand modeling. SDDOT currently has licenses for both software’s. The annual maintenance for the TransCAD license, however, is not current. SDDOT would need to pay the required annual maintenance of $995 to keep its license current, which entitles SDDOT for technical support and software update.

8.3 STAFFING REQUIREMENTS, OPINIONS OF COST, AND IMPLEMENTATION TIMEFRAMES

Table 8.1 summarizes the staffing requirements, opinions of cost, and implementation timeframes of the recommended changes to traffic forecasting at SDDOT.

Table 8-1 Staffing Requirements, Opinions of Cost, and Implementation Timeframes

Recommendation	Staffing Requirements	Opinions of Cost	Implementation Timeframe
(R1) Changes to the 20-Year Traffic Forecasting Procedure			
(R1-A) Enhancements to the 20-Year Traffic Forecasting Procedure	Implementation of the recommended changes to the current 20-year traffic forecasting procedure will not require new staff. However, more staff time from the Transportation Inventory Management program will be needed.	Staff time plus $400 if purchasing Woods & Poole socioeconomic data	Immediate
(R1-B) Develop and Implement "Traffic Use Procedures" Guidelines	This will only require staff time from the Transportation Inventory Management program.	Staff time	Immediate
(R1-C) Develop a Database of Travel Forecasting Data	This will require staff time from the Transportation Inventory Management program and the Bureau of Information and Telecommunications.	Staff time	Within one year and on-going
(R2) Short-Medium-Term Enhancements			
(R2-A) Use GIS for Simple Network and Land Use Mapping	This will not require additional staff, but will require more staff time largely from the GIS section.	Staff time	Within one year and on-going
(R2-B) Use of a Standard Transportation Planning Package for Simple Network and Mapping	This will not require additional staff, but will require more staff time. User of such standard transportation planning package is most strategically located under Project Development. The other option is the GIS section with supervision from a planner from Project Development.	$995 (annual software maintenance cost)	Within one year and on-going
(R2-A) Invest in National Household Travel Survey Add-on Sample	This will not require an additional staff, but would require staff time to devise the household survey sampling frame.	$262,500*	Medium-term that coincide with the next NHTS survey, most likely within the three to 5 years.

Recommendation	Staffing Requirements	Opinions of Cost	Implementation Timeframe
R3 Statewide Sketch Planning Model Option	This will not require additional staff, but will require more staff time from the Transportation Inventory Management program.	$25,000-$50,000	Short to medium-term
R4 Future Enhancements			
(R4-A) Regional Model	This will require an additional staff (0.25 to 0.5 FTE)	$150,000-$350,000	Long-term (not in the next 5 years)
(R4-B) Freight/ Truck Statewide Model	This will require an additional staff (0.50 to 1.0 FTE)	$150,000-$350,000	Long-term (not in the next 5 years)
(R4-C) Statewide Passenger Car Model	This will require an additional staff (0.50 to 1.0 FTE)	$$350,000-$600,000	Long-term (not in the next 5 years)

** This is only a minimum estimate based on the minimum of 1,500 samples required by NPTS. For a statewide sample, it will likely require more than the 1,500 minimum samples.*

8.4 TRAINING

Section 7.3.2 outlined the required training needs to enhance skills in traffic and travel demand forecasting and modeling, manipulation of Census data, understanding of travel demand surveys and application of forecast data, use of ITE procedures, and GIS.

Table 8.2 provides a list of some types of training and memberships that SDDOT staff can avail. The list is not exhaustive.

Table 8-2 Training

Type of Training	Cost	Agency
GIS	Staff time	In-house
ITE Procedures	Staff time	In-house
Census Data Manipulation	Varies	ESRI on-line, Census and other free on-line tutorials
Travel Forecasting/Modeling	$1,500 per person	Five-day training in TransCAD held at Caliper Corporation office in Boston, MA.
Webinars on Various Traffic Impact and Other Traffic Related seminars	From $250	Institute of Transportation Engineers
Travel Model Users Group Membership	Free Membership	Midwest Travel Model Users Group, which includes South Dakota
Travel Forecasting Overview	Free for Government Employees	National Transit Institute, The State University of New Jersey at Rutgers

Other good sources of relevant information pertaining to travel demand forecasting and modeling are:

- Travel Model Improvement Program (TMIP) clearinghouse (http://tmip.fhwa.dot.gov)
- TRIS Online is a public-domain web-based version of the Transportation Research Information Services (http://ntlsearch.bts.gov/tris) .
- Transportation Research Board publications

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Appendices

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APPENDIX A

SDDOT STAFF INTERVIEW QUESTIONNAIRE

Travel Demand Forecasting Overview and Purpose of Stakeholder Interview

Travel Demand Forecasting

A task policy-makers often face is to make a choice between various transportation scenarios. One of the procedures available to help make informed decision is Travel Demand Forecasting. Travel demand forecasting is the process used to predict travel behavior and resulting demand for a specific future time frame, based on assumptions dealing with demographics, socioeconomic characteristics, land use, the number and characteristics of tripmakers, data on freight, and the nature of the transportation system. Travel demand forecasting utilizes a travel demand model and attempts to answer questions such as:

- How many trips will be made in the future? Where will these trips come from and where they will be going to?
- How future trips will be served? Which transportation corridor to preserve?
- Which transportation systems will become congested in the future?
- How many ridership will a new transportation service attract?
- How many tons of commodities will be transported on which routes?

Purpose of Stakeholder Interview

The following interview questions are designed to determine policies, requirements, uses, and benefits of travel demand forecasting tools within SDDOT, as well as to identify processes and systems in SDDOT that have needs for travel demand data.

Program / Division: ____
Program / Division Contact: ____
Title / Position: ____
Survey Contact Phone Number: ____

Direction: Please check all that apply.

A. Present Use and Sources of Traffic Forecasting Factors or Other Data

1. Does your program/division use traffic forecasting factors or other traffic data?

Measure	Yes	No	Comments
VMT			
AADT			
Peak hour traffic volumes			
Number of crashes			
Freight ton-miles			
Other			

2. What are the sources of your current traffic forecasting factors or other traffic data?

- ☐ Historical counts
- ☐ Raw traffic counts
- ☐ SDDOT 20-Year traffic forecasting factors
- ☐ MPO models
- ☐ Other______________________

3. What have been the major uses of traffic forecasting factors or other traffic data in your program/ division? Please rank the **Top 5** uses.

- ☐ Statewide system planning or system EIS
- ☐ Regional planning
- ☐ Corridor planning/preservation
- ☐ Bypass studies
- ☐ Project prioritization
- ☐ Project level traffic forecasts/project EIS
- ☐ Operational level studies
- ☐ Economic development studies
- ☐ Freight/intermodal planning
- ☐ Rail planning
- ☐ Airport planning
- ☐ Air quality conformity analysis
- ☐ Intercity bus planning
- ☐ Bridge design
- ☐ Pavement design, ESALS (equivalent single-axle loads)
- ☐ Safety analysis, crash “hot spot” analysis
- ☐ Traffic impacts studies
- ☐ Land use planning
- ☐ Inputs to economic modeling
- ☐ Long-term investment studies
- ☐ Detour analysis
- ☐ Work zone planning
- ☐ Truck weight studies
- ☐ Weigh station location
- ☐ Other______________________

B. Existing Policies, Staffing and Training Requirements

4. Does your program/division have policies for the use of traffic forecasting factors or other traffic data? If so, can we get a copy?

5. Do you have documented or undocumented procedures for collecting and forecasting traffic data? If so, please provide an example.

6. How many staff in your program/division have experience in forecasting traffic data?

7. What type of training would be needed to develop skills in forecasting traffic data in your program/division?

8. Does your program/division get any traffic data or forecasts from other states? If so, what type of data (e.g., VMT, AADT, peak hour traffic, ton-miles, etc.)?

C. Role of Traffic Forecasting Factors in Programming/Budgeting

9. Which programming and budgeting process does your program/division contribute to? Please provide an example (e.g., STIP, pavement management, bridge design, etc.).

10. How are current measures of travel forecasts and traffic data (e.g., VMT, AADT, etc.) used to allocate budget resources to various uses such as capital expansion, operations, and maintenance/ preservation?

11. Are current travel demand or projected future travel growth used to determine staffing or skills requirements within your program/division? Please provide examples, such as how many design engineers or traffic engineers are needed due to projected traffic in SDDOT, areas, and regions.

12. How are current or projected future travel forecasts or traffic data used to plan the locations or distribution of SDDOT programs, services, or field locations? Please give examples, such as new interchanges, traffic impact studies, bypass studies, etc.

D. USE OF GEOGRAPHIC INFORMATION SYSTEMS (GIS)

13. Does your program/division use GIS for storing data and networks? If so, what type of data do you store?

☐ Yes
☐ No
Type of data stored:____
____

14. How many staff with GIS skills are in your program/division?

____

E. ADDITIONAL TRAFFIC DATA NEEDS

15. Does the existing SDDOT traffic forecasting process meet your program/division traffic data needs?

☐ Yes
☐ No

16. If the existing SDDOT traffic forecasting process does not meet your traffic data needs, in which areas are additional traffic data needed?

☐ Identification of corridors that should be targeted for preservation
☐ Identification of corridors that should be targeted for capacity expansion, multi-modal development, or other strategies for congestion relief.
☐ Identification of bottlenecks that should be targeted for capacity expansion, multi-modal development, or other strategies for congestion relief.
☐ Identification of highway segments with safety improvement needs.
☐ Identification of existing and forecast freight movement needs, which could lead to changes in investment in roadway preservation.
☐ Identification of which corridors are crucial to the state's long-term economic growth.
☐ Other (please specify)____

APPENDIX B

MPO STAFF INTERVIEW QUESTIONNAIRE

Travel Demand Forecasting Overview and Purpose of Stakeholder Interview

Travel Demand Forecasting

A task policy-makers often face is to make a choice between various transportation scenarios. One of the procedures available to help make informed decision is Travel Demand Forecasting. Travel demand forecasting is the process used to predict travel behavior and resulting demand for a specific future time frame, based on assumptions dealing with demographics, socioeconomic characteristics, land use, the number and characteristics of tripmakers, data on freight, and the nature of the transportation system. Travel demand forecasting utilizes a travel demand model and attempts to answer questions such as:

- How many trips will be made in the future? Where will these trips come from and where they will be going to?
- How future trips will be served? Which transportation corridor to preserve?
- Which transportation systems will become congested in the future?
- How many ridership will a new transportation service attract?
- How many tons of commodities will be transported on which routes?

Purpose of Stakeholder Interview

The following interview questions are designed to determine policies, requirements, uses, and benefits of travel demand forecasting tools within SDDOT, as well as to identify processes and systems in SDDOT that have needs for travel demand data.

MPO: ____
MPO Contact: ____
Title/Position: ____
Survey Contact Phone Number: ____

Direction: Please check all that apply.

A. Present Use and Sources of Travel Demand/Traffic Forecasting or Other Traffic Data

1. Does the MPO have a regional travel demand model?

☐ No (Proceed to Question #2)
☐ Yes

If Yes, please describe the features of the model and provide a copy of model documentation.

Software platform: TransCAD, TRANPLAN/VIPER, Cube Voyager and TP+/VIPER, VISUM, EMME/2, TModel2
Model type: passenger only, freight only, integrated passenger and freight
Modes modeled: passenger auto, local bus
Time period modeled: AM peak hour, PM peak hour, Off-peak hours, 24-hours (weekday, average)
Number of traffic analysis zones (TAZ):_______________
Model structure: 3-step (Trip Generation, Trip Distribution, Trip Assignment), 4-step, etc

2. Does the MPO use traffic forecasting factors or other traffic data?

Measure	Yes	No	Comments
VMT			
AADT			
Peak hour traffic volumes			
Turning movement counts			
Number of crashes			
Freight ton-miles			
Other			

3. What are the sources of your current traffic forecasting factors or other traffic data?

☐ Historical counts
☐ Raw traffic counts
☐ SDDOT 20-Year traffic forecasting factors
☐ MPO models
☐ Other___________________________

4. What have been the major uses of the regional travel demand model? Please rank the **Top 5** uses.

- ☐ Regional planning
- ☐ Corridor planning/preservation
- ☐ Bypass studies
- ☐ Project prioritization
- ☐ Project level traffic forecasts/project EIS (project level modeling)
- ☐ Operational level studies
- ☐ Transportation demand management strategies (testing of TDMs)
- ☐ Transportation system management strategies (testing of TSMs)
- ☐ Congestion management strategies
- ☐ Economic development studies
- ☐ Freight/intermodal planning
- ☐ Rail planning
- ☐ Airport planning
- ☐ Air quality conformity analysis
- ☐ Intercity bus planning
- ☐ Bridge design
- ☐ Pavement design, ESALS (equivalent single-axle loads)
- ☐ Safety analysis, crash “hot spot” analysis
- ☐ Traffic impacts studies
- ☐ Land use planning (testing land use scenarios)
- ☐ Inputs to economic modeling
- ☐ Long-term investment studies
- ☐ Detour analysis
- ☐ Work zone planning
- ☐ Truck weight studies
- ☐ Weigh station location
- ☐ Other________________________________

B. DATA FOR PASSENGER MODEL DEVELOPMENT

5. What were the primary sources of travel behavior data?

- ☐ MPO household surveys
- ☐ Census journey-to-work data
- ☐ Census Transportation Planning Package
- ☐ Public-Use Microdata Samples (PUMS)
- ☐ American travel Survey
- ☐ National Household Travel Survey
- ☐ ITE Trip Generation
- ☐ NCHRP Report 365
- ☐ NCHRP Report 187
- ☐ On-board bus surveys
- ☐ Roadside surveys
- ☐ Other________________________________

6. What were the primary sources of household socioeconomic data?

- ☐ Census Transportation Planning Package
- ☐ Other US Census
- ☐ MPO databases
- ☐ GIS maintained by MPO
- ☐ GIS maintained by another agency within South Dakota
- ☐ GIS maintained by a neighboring state
- ☐ A regional economic model
- ☐ Local property tax records
- ☐ School enrollment data
- ☐ Commercial data vendor (provide a list and the cost of acquiring the data)
- ☐ Federal agency other than Census
- ☐ Other________________________________

7. What were the primary sources of traffic data?

- ☐ MPO counts
- ☐ SDDOT counts
- ☐ MPO travel times
- ☐ Highway Performance Monitoring System
- ☐ MPO speeds
- ☐ Counts, speeds, or travel times from another agency
- ☐ Other________________________________

8. What were the primary sources of network data?

- ☐ TIGER
- ☐ SDDOT road inventory or management system
- ☐ Highway Performance Monitoring System
- ☐ Neighboring state agency road inventory(s) or management system(s)
- ☐ Bus published information
- ☐ Other________________________________

9. Please list any data collection effort the MPO conducted to complete the model. Also, please indicate the cost involved in the data collection effort.

10. What passenger data couldn't you get that you wish you could?

11. Were there serious problems with completeness of any passenger data set?

☐ Yes (Explain)____
☐ No

C. Model Development, Cost, Staffing and Training Requirements

12. How long did it take to develop the model? _________ months

13. How much did it cost to develop the model? ___________dollars

14. Who was primarily involved for the model development? Please indicate the percentage involvement.

☐ MPO staff ________% Number of staff involved ______________
☐ Consultants __________%

15. How many MPO staff are dedicated to maintaining/using the model (include estimates of partial time for multitasked staff)?

16. What training programs do MPO staff attend to obtain skills/expertise in the use of the model or its results?

D. Validation

17. Has the regional model been validated?

☐ Yes
☐ No (If No, skip all remaining questions in ?)

18. What data were used to validate the model?

☐ Passenger vehicle counts
☐ Counts of passengers on buses
☐ Truck counts
☐ Origin-destination studies
☐ Commuting OD flows from Census
☐ Comparisons to average values from similar MPOs or cities
☐ Comparisons to average values from own travel surveys
☐ Known trip length frequency distribution(s)

- Transportation Planning Package (CTPP)
- ☐ Comparisons to national trip generation default values
- ☐ Other________________________________

19. What were the validation criteria?

- ☐ Link root mean square error (RSME) by volume strata
- ☐ Correlation coefficient between link volume forecasts and counts
- ☐ Link absolute deviation
- ☐ Screenline count absolute deviation
- ☐ Cordon count absolute deviation
- ☐ VMT by functional classification absolute deviation
- ☐ Other________________________________

20. Did you use the “Model Validation and Reasonableness Checking Manual”?

- ☐ Yes
- ☐ No

21. How well did it validate? ____

E. USE OF GEOGRAPHIC INFORMATION SYSTEMS (GIS)

22. Does the MPO use GIS for storing data and networks? If so, what type of data do you store?

- ☐ Yes
- ☐ No

Type of data stored:____
____

23. Were network data obtained from a GIS database?

- ☐ Yes (Explain) ____
- ☐

24. How many MPO staff have advance GIS skills (i.e, skills in creating GIS layers, etc)?

____

F. FREIGHT / COMMERCIAL VEHICLE MODEL

25. If the MPO regional model includes freight, please describe the scale/level of detail.

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