Development of a New Process for Determining Design Year Traffic Demands

Final Report
April 2007

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16. Abstract

We as researchers should continuously ask how to improve the models we rely on to make financial decisions in terms of the planning, design, construction, and maintenance of roadways. This project presents an alternative tool that will supplement local decision making but maintain a full appreciation of the complexity and sophistication of today's regional model and local traffic impact study methodologies. This alternative method is tailored to the desires of local agencies, which requested a better, faster, and easier way to evaluate land uses and their impact on future traffic demands at the sub-area or project corridor levels. A particular emphasis was placed on scenario planning for currently undeveloped areas. The scenario planning tool was developed using actual land use and roadway information for the communities of Johnston and West Des Moines, Iowa. Both communities used the output from this process to make regular decisions regarding infrastructure investment, design, and land use planning. The City of Johnston case study included forecasting future traffic for the western portion of the city within a 2,600-acre area, which included 42 intersections. The City of West Des Moines case study included forecasting future traffic for the city's western growth area covering over 30,000 acres and 331 intersections. Both studies included forecasting a.m. and p.m. peak-hour traffic volumes based upon a variety of different land use scenarios. The tool developed took GIS-based parcel and roadway information, converted the data into a graphical spreadsheet tool, allowed the user to conduct trip generation, distribution, and assignment, and then to automatically convert the data into a Synchro roadway network which allows for capacity analysis and visualization. The operational delay outputs were converted back into a GIS thematic format for contrast and further scenario planning. This project has laid the groundwork for improving both planning and civil transportation decision making at the sub-regional, super-project level.

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EXECUTIVE SUMMARY

Introduction

We as researchers should continuously ask how to improve the models we rely on to make financial decisions in terms of the planning, design, construction, and maintenance of roadways. This project presents an alternative tool that will supplement local decision making but maintain a full appreciation of the complexity and sophistication of today's regional model and local traffic impact study methodologies.

Background

Local agencies within Iowa, which are dealing with growth, trying to provide for future roadway capacity needs, and under pressure from fiscal limitations, have expressed the desire for more options in developing traffic forecasts at the city network level. These agencies have expressed the desire for a tool that meets the following criteria:

- Local agencies requested that this new scenario planning tool be based upon land use classification, which is similar to the predication of future water and sewer needs, rather than more traditional regional planning socioeconomics.
- The tool was anticipated to provide planning at a more detailed level than a regional model, but not at the driveway level of detail, as with a traffic impact study.
- The tool was to be focused on the arterial level, and the desire was to be able to input various potential future land use scenarios and evaluate a.m. and p.m. peak-hour roadway operations under these conditions.
- The tool was expected to provide an alternative to traditional planning methods, particularly in new growth and fringe sub-area locations.
- The tool was expected to improve the ability to forecast future right-of-way needs, given the merging of planning and operations capabilities.

Objective

The objective of this research is to develop a supplementary tool that would assist in the forecasting of future peak hour vehicle traffic demand at the local roadway level. This project lays the groundwork for improving both the efficiency and effectiveness of transportation planning and civil design/operations. Agencies asked that this tool serve both planning and engineering staff needs, and it was to rely on common traffic capacity, visualization, and calculation tools.

State of the Practice

The state-of-practice information provided is by no means a comprehensive description of transportation planning and traffic modeling. Rather, this summary selectively highlights planning and forecast issues relevant to developing and using an alternative forecasting tool and to other issues of interest to local agencies. Examples of model accuracy are provided for regional models and traffic impact studies.

Analysis of Growth and Demand

The ability to forecast travel within high-growth areas relies on the ability to predict land uses and population change. This is especially true when forecasting travel to plan for the development of areas that currently include large tracts of land with an unknown use. Traffic forecasts, whether using a travel demand model or the Institute of Transportation Engineers (ITE) *Trip Generation Manual*, can vary widely by type of use. The traffic forecast tool developed as part of this research predicts travel as a function of land use, as defined by ITE land use codes. This report provides state and community development and growth information in an effort to understand rates and types of growth occurring within the central Iowa market place. This effort also examined rates of growth and land uses as developed along specific high-profile corridors.

Scenario Planning Using Existing Models

Land use models are available specifically to forecast land use at the regional level, a level similar to many urban transportation network models. However, a key difference is that land use models take the transportation system as an input, whereas the transportation network models take land use as an input. This difference is a manifestation of the classic land use-transportation relationship and is a criticism of both types of models. Recent efforts in some high-growth states attempt to integrate both of these objectives, at least at the regional level. There is significantly more activity along these lines in air quality non-attainment areas. In general, the level of detail to be expected from these models is not sufficient to facilitate the local traffic engineering and design decision making process. This task considered whether existing land use or demand models could be used directly for scenario planning and whether a densified TransCAD model could be used to replicate the higher level of roadway detail desired and used by the scenario planning tool. The first step was to identify the relevant land use planning models and to discuss their capabilities. The second step was to complete a case study using a densified TransCAD network using parcel-level development and planning data from a real community.

Alternative Forecast Technique

This research developed an alternative method to forecast traffic that is tailored to the desires of local agencies. These agencies requested a better, faster, and easier way to evaluate land uses and their impact on future traffic demands at the sub-area or project corridor levels. This method should be considered as a supplement, and does not replace the need for either the regional model or local traffic impact studies. A particular emphasis was placed on scenario planning for currently undeveloped areas. The discussions for a scenario planning tool originated from issues within two different central Iowa communities (Ankeny and West Des Moines). The scenario planning tool was developed using actual land use and roadway information for the communities of Johnston and West Des Moines. Both communities used the output from this process to make regular decisions regarding infrastructure investment, design, and land use planning.

The City of Johnston case study included forecasting future traffic for the western portion of the city. This study area was approximately 2,600 acres and included 42 intersections. Both a.m. and p.m. peak hour forecasts were made based upon different land use scenarios.

The City of West Des Moines case study included forecasting future traffic for the city's western growth area. This study area was ten times that of Johnston's, and included 30,000 acres and 331 intersections. Both a.m. and p.m. peak hour forecasts were made based upon different land use scenarios. The tool was then able to process this information to allow an analysis of demand and trip generation, distribution, and assignment using the Synchro capacity and SimTraffic visualization programs. The delay information was brought back into the GIS format.

Conclusions

This project has laid the groundwork for improving both planning and civil transportation decision making at the sub-regional, super-project level. The research provided the following:

- A response to local agencies' desire to have an intermediate planning tool that would provide quick answers to changes in land use at the local roadway level
- Support to practitioner decision making through a graphical representation of land use and network capacity information
- A tool that has been demonstrated at multiple scales within growing communities (Johnston case study at 2,600 acres, West Des Moines case study at over 30,000 acres)
- A tool that can use the same land use database as water and sewer modeling to conduct land use and roadway capacity scenario planning
- A planning tool that functions at a more detailed level than a regional model, but not at the driveway level of detail, as with a traffic impact study
- A tool focused on the arterial level, with the ability to input various potential future land use scenarios and evaluate a.m. and p.m. peak-hour roadway operations under these conditions
- A tool that serves as an alternative to traditional planning methods, particularly in new growth and fringe sub-area locations
- A tool to improve sub-area traffic forecasting through an analysis of multiple scenarios and to allow for an assessment of future right-of-way needs, given the merging of planning and operations capabilities
- A tool that serves both planning and engineering staff needs and that relies on common traffic capacity, GIS visualization, and calculation tools

The scenario planning tool was developed and tested for one large developing sub-region and applied successfully to another. The tool could be considered for application in other similar high-growth or infill areas. Interested analysts should contact the research team or the city staff of West Des Moines or Johnston, Iowa, for more details on applicability and resource requirements.

Future Efforts

The work of the task force should be continued and focused on making the tool interface easier to use. These efforts would benefit all users, including local agencies and consultants. Professionals from both groups have expressed a strong desire to use the tool on a variety of projects; however, training would be a requirement at this point. Since the tool is very graphical, these future efforts could add documentation to the input screens and simplify input and viewing of critical output information. This research effort focused on developing the tool. Future efforts should focus on the usability of the tool in terms of user interface and convenience.

1. INTRODUCTION

Forecasting future traffic is a key input into the planning, design, maintenance, and overall budgeting processes of Iowa's local communities. Forecasts that are either too high or too low can have extremely negative impacts, particularly in areas of accelerated growth. While at the regional level travel forecasts made using travel demand (network) models can be perfectly acceptable, at sub-regional or local levels these tools may not provide the level of detail needed by traffic and highway engineers. Several published reports give perspective to the magnitude of potential issues related to traffic forecasting.

Accurate traffic forecasts are critical to arriving at the right capacity for transportation infrastructure and are critical to obtaining valid results from the cost-benefit analyses, environmental impact assessments, and social impact studies that typically form the basis for decisions about whether to build new transportation infrastructure (*1*).

- A recent international report presented the results from the first statistically significant study of traffic forecasts in transportation infrastructure projects. For 50% of road projects, the difference between actual and forecasted traffic is more than ±20%; for 25% of road projects, the difference is larger than ±40%. Highly inaccurate traffic forecasts combined with large standard deviations translate into large financial and economic risks (*2*).
- An examination of the regional forecasting model for Hennepin County, Minnesota, found that forecasted volumes were not accurate enough to correctly assign the number of lanes needed (accuracy rates of 54% for local streets, 55% for county roads, and 67% for state trunk highways) (*3*).
- A study for the Kansas DOT found a poor correlation between what was forecasted in 1970 and what actually happened in terms of socioeconomic and demographic data, which are the major inputs used by travel demand models to forecast future traffic volumes on road links (*4*).

Forecasting is concerned with determining what the future *will* look like, rather than what it *should* look like. The latter is the job of planning. The forecast is an input to the planning model. A forecasting model can be used in an attempt to find out what the world will look like if you leave it alone, make different assumptions about the future, or make changes (*5*).

Because of the stakes involved, researchers should continuously ask how to improve the models practitioners rely on to make financial decisions in terms of the planning, design, construction, and maintenance of roadways. This project presents an alternative tool that will supplement local decision making but maintain a full appreciation for the complexity and sophistication of today's regional model and local traffic impact study methodologies.

As a first step, this research developed a new scenario planning tool that bridges the gap between land use planning and roadway design and operations. The tool developed can be thought to fit somewhere between a macro (regional or network-level) planning model and a micro (driveway-level) traffic impact study. The tool was developed and applied within two very different high-growth Iowa communities.

1.1. Background

Local agencies within Iowa that are dealing with growth, trying to provide for future roadway capacity needs, and under pressure from fiscal limitations have expressed the desire for more options in developing traffic forecasts at the city network level. These agencies expressed the desire for a tool with the following features:

- Local agencies requested that this new scenario planning tool be based upon land use classification, which is similar to the predication of future water and sewer needs, rather than more traditional regional planning socioeconomics.
- The tool was anticipated to provide planning at a more detailed level than a regional model, but not at the driveway level of detail, as with a traffic impact study.
- The tool was to be focused on the arterial level, and the desire was to be able to input various potential future land use scenarios and evaluate a.m. and p.m. peak hour roadway operations under these conditions.
- The tool was expected to provide an alternative to traditional planning methods, particularly in new growth and fringe sub-area locations.
- The tool was expected to improve the ability to forecast future right-of-way needs, given the merging of planning and operations capabilities.

Communities are searching for a tool that would combine land use planning with arterial operations, such as those shown in Figure 1. Within the regional model, these operations are not accounted for at the design level. Agencies have expressed concern about the lack of resources, personnel, or data to support modifying the regional model to be more effective at the project design level. Duane Wittstock summarized these concerns:

> To be clear, the regional model meets the needs for the area; however, when we are projecting demand on our local streets, we need more roadway detail, the ability to quickly evaluate scenarios, the ability to speak a common language with developers (land uses versus socioeconomic factors), and most importantly the knowledge of how much right-of-way to reserve now as opposed to later when prices have skyrocketed. (*6*)

Figure 1. Peak-hour p.m. congestion: University Avenue, West Des Moines, IA

This research effort focused on matching land use patterns and roadway conditions to create a link between land use intensity, peak hour forecasts, and operational-based capacity. The method is based on a GIS platform similar to that highlighted in the literature, as noted below:

> Transportation network characteristics and land use patterns are not often used, thereby making the assumption that transportation level-of-service is not an important factor affecting trip rates. Thus, most trip production models cannot predict the impact of future accessibility and land use changes. However, inclusion of these variables should be considered, especially since the GIS environment reduces the difficulty in capturing land use and accessibility factors. (*7*)

This project lays the groundwork for improving both efficiency and effectiveness of transportation planning and civil design/operations. Agencies asked that this tool serve both planning and engineering staff needs and that it rely on common traffic capacity, visualization, and calculation tools.

This report documents the efforts made in developing this scenario planning tool and in demonstrating the use of the tool within real communities that are dealing with growth issues within hard-to-plan sub-areas of their communities.

1.2. Objectives

The objective of this research is to develop a supplementary tool that will assist in forecasting future peak hour vehicle traffic demand. Local agencies requested that this new scenario planning tool be based upon land use classification, similar to the prediction of future water and sewer needs, rather than more traditional planning socioeconomics. The tool was anticipated to provide planning at a more detailed level than a regional model, but not at the driveway level of a traffic impact study. The tool was to be focused on the arterial level and have the ability to input various potential future land use scenarios and evaluate roadway operations under these conditions. The tool was expected to provide a supplement to traditional planning tools, particularly in new growth and fringe locations. This tool was expected to improve the ability to forecast future right-of-way needs, given the merging of planning and operations capabilities. For example, the tool should allow a practitioner to increase and decrease land uses within a corridor or study area, and then to determine geometric design and capacity needs for a single roadway or network of roadways. The tool's features were to focus on assisting communities in gaining a clearer perspective of future right-of-way, capacity, access, land-use, roadway, and budgetary needs.

1.3. Scope

Six specific tasks were completed to satisfy the research objectives:

- **Task 1, Establish a Technical Advisory Committee (TAC)**. The TAC consisted of county engineers, city engineers, city/department of transportation (DOT) planners, and other stakeholders.

- **Task 2, Document the State of the Practice**. Provide a literature review that summarizes the efforts other agencies have made towards improving the accuracy and ease of developing traffic forecasts for civil roadway design.
- **Task 3, Analyze Growth and Demand**. Identify the types of development occurring within the Iowa's growth areas by type of land use and growth rates.
- **Task 4, Scenario Planning Using Existing Models**. Provide a commentary as to why a new tool is necessary, as opposed to commercially available existing tools.
- **Task 5, Develop and Demonstrate Alternative Traffic Forecast Technique**. Establish an alternative method to develop traffic forecasts that is tailored to the civil design process. The goal of such a tool is to meet the demand from agencies for a "better, faster, easier" tool. The focus was on sub-area or project corridor levels, since this method is not proposed to be a substitute for today's regional models.
- **Task 6, Final Report and Technology Transfer**. Prepare a technical document summarizing the findings of the research and demonstrating the practicality and feasibility of the results.

1.4. Technical Advisory Committee

The project principal investigator assembled and coordinated all work through a project TAC. The TAC consisted of the following Iowa practitioners:

Practical Use Group

- **Chair**. Mr. Duane Wittstock, City Engineer, City of West Des Moines, IA
- **Member**. Mr. Doug Ollendike, City Planner, City of Clive, IA
- **Member**. Mr. Jim George, County Engineer, Dallas County, IA
- **Member**. Mr. David Wilwerding, City Planner, City of Johnston, IA

Modeling Group

- **Member**. Dr. Reg Souleyrette, Professor, Iowa State University (ISU)
- **Member**. Mr. Phil Mescher, Office of Systems Planning, Iowa DOT
- **Member**. Mr. XuDong Chai, Doctoral Student, ISU
- **Member**. Mr. Paul Hanley, Professor, University of Iowa, Iowa City, IA

National Perspective

- **Member**. Mr. Steve Hofener, President, Traffic Engineering Consultants, OKC, OK
- **Member**. Mr. Kenneth Stone, Ret. Professor of Economics, ISU

Other individuals providing input

- Mr. Tom Kane, Director for the Des Moines Area MPO
- Mr. Mark Perington, Principal, Snyder and Associates, Inc., Ankeny, IA
- Mr. Todd Butler, Vice President, Traffic Engineering Consultants, Inc., OKC, OK

These groups met on an infrequent basis over the course of the project to discuss research findings, apply the modeling tool as case studies within specific communities, and obtain feedback on critical project milestones and tool features.

2. STATE OF THE PRACTICE

The state-of-the-practice information that follows is by no means a comprehensive description of transportation planning and traffic modeling. Volumes of documents are available solely on regional modeling tools, data sources, and methodology. Rather, this summary selectively highlights planning and forecast issues relevant to developing and using an alternative forecasting tool and to other issues of interest to local agencies.

2.1. Forecasting

Local agencies rely on forecasts as an input for the planning and investment process. The term "forecast" is defined as "to estimate how a condition will be in the future (*8*)." Traffic forecasts are used for several key purposes in transportation policy, planning, and engineering: to calculate the capacity of infrastructure, e.g., how many lanes a bridge should have; to estimate the financial and social viability of projects, e.g., using cost-benefit analysis and social impact analysis; and to calculate environmental impacts, e.g., air pollution and noise (*9*).

Traffic forecasts are completed at all levels of detail. For example, regional forecasts provide orders of magnitude in terms of volumes and include pass-through traffic within the region. Local roadway forecasts are often used for corridors and sub-areas within a community and include a much denser roadway network. Traffic impact analyses may include each driveway of a proposed development and only those roads adjacent to the site. The Oregon DOT Best Practices for Traffic Impact Studies summarizes the three common methods for forecasting future traffic (*10*):

- **Regional Travel Demand Models**. These are the best tools for forecasting over long timeframes. Because models are typically developed in conjunction with land use plans, this method can provide a reliable forecast for urban areas. Metropolitan Planning Organization (MPO) models are available for the areas of the state located within a MPO.
- **Cumulative Analysis.** This method is most suitable for smaller urban areas, or a portion of a large urban area (if a travel demand model is not available), where there is useful local information about future projects. This method projects future traffic volume by adding the estimated traffic generated by all approved, but not yet opened, developments in the study area. Long-term forecasts should also include the effects of future developments on undeveloped lands. This method requires the traffic impact study to list the anticipated developments and corresponding trip generation rates.
- **Growth Trends**. Most suitable for rural areas with stable growth rates, this methodology involves estimating growth rates based on regression analysis from historical data.

This research developed tools to conduct the cumulative style of analysis within a sub-area. The tool was demonstrated within two case study communities, both of which are within the Des

Moines metropolitan area. Regional model practices further described are specific to the Des Moines Area MPO. Other agency data sources, practices, and tools may vary significantly.

2.1.1. Regional Model

The Des Moines Area MPO collects and uses forecasted socioeconomic data for forecasting traffic on the regional network. By collecting, analyzing, and making future projections with socioeconomic data, the MPO can predict where people are going to live, work, shop, and travel on a daily basis. This data is the basis for the travel demand model, which uses socioeconomic data to mimic future traffic patterns and thus identify future needs of the transportation system.

The MPO has developed a travel demand model using Caliper's TransCAD software. This model was developed in accordance with the Year 2030 Long-Range Transportation Plan. The base year of the model is the Year 2000, and the model includes traffic forecasts for Year 2005, Year 2010, Year 2020, and Year 2030 (*11*).

Since the regional model is based upon forecasted socioeconomic information, in the year 2030 local agencies are presented with a challenge in evaluating short-term scenarios. Communities may also want to evaluate short-term scenarios that do not conform to the balanced growth limits set forth for each community within the regional model.

The regional model level of detail presents additional challenges to local agency planning. The road network in the regional model consists of major roads, such as freeways, expressways, and major or minor arterials (with major and minor collectors sometimes being omitted). This leads to insufficient spatial details for a number of design-level decisions (e.g., for conducting intersection analysis). In addition, even though the mathematical models that simulate human travel behaviors have been significantly enhanced during last several decades (e.g., the evolution of traffic assignment from an All-or-Nothing approach to Stochastic User Equilibrium), the models still have certain limitations in real applications. As a result, it is not unusual that the regional model's trip assignment would show a busy intersection as having very low or even zero turning movement volumes.

Another issue faced by local agencies is that the modeling process is not transparent for users, especially for those not who are not skilled users. The TransCAD program itself is considered expensive, with the majority of costs in the staffing, training, and data management required. Planning at the local level is more project-specific and on an as-needed basis. Manipulating the regional model to provide local agency roadway design details requires hand smoothing and the opportunity to introduce error in the results, which complicates running multiple scenarios. A smaller or sub-area scenario planning tool, based upon land use as opposed to socioeconomics, would provide a different approach to projecting future vehicle volume demand.

A wide variety of travel demand models are in use. A listing is provided by the FHWA's *Traffic Analysis Toolbox, Volume II* (*12*). Available travel demand modeling tools include

- b-Node Model: http://mctrans.ce.ufl.edu/store/description.asp?itemID=482
- CUBE/MINUTP: www.citilabs.com/minutp/index.html
- CUBE/TP+/Viper: www.citilabs.com/viper/index.html
- CUBE/TRANPLAN (Transportation Planning): www.citilabs.com/tranplan/index.html
- CUBE/TRIPS (Transport Improvement Planning System): http://citilabs.com/trips/index.html
- EMME/2: www.inro.ca/products/e2_products.html
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- MicroTRIMS: http://mctrans.ce.ufl.edu/store/description.asp?itemID=483
- QRS II (Quick Response System II): http://my.execpc.com/~ajh/index.html
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- TModel: www.tmodel.com
- TransCAD: www.caliper.com/tcovu.htm
- TRANSIMS (Transportation Analysis Simulation System): http://transims.tsasa.lanl.gov

2.1.2. Traffic Impact Analysis Software

There are three prominent software tools available to assist in conducting traffic impact analysis: TRAFFIX, TEAPAC, and WinTASS (*13*). These programs assist at the driveway and local roadway level, but the focus of this research falls somewhere between this driveway level and the regional level.

2.2. Model Application

Models are constructed in an effort to allow for reasoning and are almost always based upon information that is known to be incomplete or not ideal. Models are in a constant state of updating, which complicates reviewing past forecasts in an effort to improve methodology. Regardless of the planning level, agencies are challenged when applying the traditional four-step planning method to their situation.

Investigations into traffic forecasting needs and traffic forecasting practices by the South Dakota DOT, as well as in other states with similar traffic forecasting conditions, failed to identify a traffic forecasting model that was suitable for implementation by the South Dakota DOT. Most traffic forecasting models being applied on a statewide basis are based on urban scenarios, a situation that presents significant problems for sparsely populated, primarily rural states that have limited resources, personnel, and data to support these models. Subsequent research efforts led to the development of a new South Dakota DOT 20-year traffic forecasting procedure that is consistent with traffic forecasting conditions in South Dakota and is based on data that is readily available. The new procedure, which incorporates significant improvements in the traffic forecasting process, represents the first step toward the future development of significantly enhanced traffic forecasting software at the South Dakota DOT (*14*).

2.3. Model Accuracy

Several published reports give perspective to the magnitude of potential issues related to traffic forecasting.

A recent international report presented the results from the first statistically significant study of traffic forecasts in transportation infrastructure projects. The sample surveyed is the largest of its kind, covering 210 projects in 14 nations worth US$58 billion. The study shows with very high statistical significance that forecasters generally do a poor job of estimating the demand for transportation infrastructure projects. For 50% of road projects, the difference between actual and forecasted traffic was more than ±20%; for 25% of road projects, the difference was larger than ±40%. Highly inaccurate traffic forecasts combined with large standard deviations translate into substantial financial and economic risks (*15*).

Similarly, an examination of the regional forecasting model for Hennepin County, Minnesota, found that forecasted volumes were not accurate enough to correctly assign the number of lanes needed. The review found accuracy rates of 54% for local streets, 55% for county roads, and 67% for state trunk highways. The analysis showed overwhelming evidence that Hennepin County needed to play an active role in the refinement and enhancement of the regional model so that it could be used for county planning, operations, and design (*16*).

A study for the Kansas DOT found a poor correlation between what was forecasted in 1970 and what actually happened in terms of socioeconomic and demographic data, which are the major inputs used by travel demand models to forecast future traffic volumes on road links. In this case, however, it was found that 98% of the major streets had the number of lanes correctly estimated based on the 1994 Highway Capacity Manual's planning level of service (LOS) criteria. Similar to the research project at hand, this Kansas study proposed a framework to incorporate a robustness analysis in urban transportation planning in conjunction with urban travel demand software (*17*).

In an attempt to quantify the deficiencies in travel models, two Iowa case studies (Ames and Marshalltown) of actual 1970s models developed for small urban areas were contrasted 20 years later. In a comparison of volumes, both models produced an R2 of 0.69, and approximately 20% of the street segments fell outside a range of two standard deviations for the error in a single traffic count. The Ames model accurately estimated the correct number of lanes for 95.9% of streets. Only 3 street segments were underestimated, and 18 were overestimated, for the 20-year horizon. The Marshalltown model was found to be 96.9% accurate, with three street segments underestimated and six overestimated. With respect to planning for investment in these small communities, the model provided sufficient traffic volume information to construct the appropriate number of lanes. Overestimation of the horizon-year population was a problem in both case studies and is likely to be a problem for overly optimistic planners in many small communities (117% of the actual Ames population and 153% for Marshalltown). Based on an examination of the results for the two case studies, the models did reasonably well in forecasting base year traffic, but did not perform well on an individual street-by-street basis in the horizon year (*18*).

Moreover, the traffic forecasting risk research carried out by Standard & Poor's Ratings Services has, to date, concentrated on the nature and extent of optimism bias. Empirical evidence suggests that toll road forecasts have, on average, overestimated traffic by 20%–30%. In 2002, Standard & Poor's published for the first time the results of a study evaluating the outturn performance of toll road traffic forecasts (see "Credit Implications of Traffic Risk in Start -Up Toll Facilities," published on August 15, 2002, on RatingsDirect, Standard & Poor's web-based credit analysis system). The key conclusions focused on errors and optimism bias after the first year of operations. The error range was considerable, stretching from projects that had underperformed by 70% to projects that had overperformed by 20%. The error distribution was also skewed, suggesting the presence of systematic optimism bias. The mean error was negative 30%. On average, forecasts overestimated traffic demand by about 30% (*19*).

The University of Texas evaluated the uncertainty between standard integrated models of transportation and land use. Variances in land use and travel predictions were analyzed over time. The results indicated that output variations were most sensitive to the exponent of the link performance function, the split of trips between peak and off-peak and several trip generation and attraction rates. The authors found that, 20 years into the future, final uncertainty levels (as measured by coefficients of variation) due solely to input and parameter estimation errors are on the order of 38% for total regional peak-period vehicle miles traveled (VMT), 45% for peak-period flows, and 50% and 37 % for residential and employment densities, respectively (*20*).

2.4. Variation in Traffic Impact Studies

The ability to forecast peak-hour travel is dependent on the ability to predict future land use and/or population characteristics. Even with a known land use, the actual traffic demands during peak hours can vary widely, as illustrated in the studies below.

The South Dakota DOT reviewed six discount superstores, two home improvement stores, and one grocery store to determine whether the trip generation rates and projected traffic met or exceeded the traffic projections documented in the Institute of Transportation Engineers (ITE) Trip Generation Rates. The study found that the trip generation rates for all land uses identified in the traffic impact studies and the ITE manual were consistently low for all but two locations. Four discount superstores and both home improvement stores had trip generation rates that exceeded the recommended rates found in the ITE manual. The Pierre, South Dakota, Super Wal-Mart exhibited the highest trip generation rate, which was 59.7% higher than the ITE rate during the average weekday a.m. peak hour, and 57.5% higher during the p.m. peak hour. The average weekday 24-hour rate was 54% higher than the ITE rate. The city of Pierre is located in a relatively rural part of the state, but serves a large economic trade area with limited discount shopping opportunities (*21*).

The Oregon DOT completed a trend analysis of actual traffic impact studies (TIS) in an effort to develop an overall traffic impact best practice methodology (*22*). A detailed summary of the key findings for nine evaluation criteria follows:

- Leasable Space/Land Use Assumptions
    1. Eight of the twelve sites were built as planned in the TIS.
    2. Three of the four sites not built as planned were retail sites. One site (Wal-Mart) was not expanded as predicted in the TIS; another (Home Depot) did not include retail buildings as predicted in the TIS; and another (Barger Crossing) included land uses that were not assumed in the TIS.
    3. The one site that was not built as planned in the TIS was underdeveloped. This site (Five Oaks West) did not anticipate an economic recession and similarly zoned land in the area.

- Intersection Traffic Growth
    1. The three sites with predicted intersection traffic growth within 20% of the actual intersection traffic growth were retail sites. The predicted land uses at each of these sites were consistent with the actual land uses.
    2. Two TISs overpredicted intersection traffic growth by more than 50%. This occurred because these TISs overpredicted site development.
    3. There were no identifiable trends in intersection traffic growth for the other seven sites.

- Peak-Hour Trip Generation
    1. The predicted peak-hour trip generation for six TISs was not within 50% of actual peak-hour trip generation. Five sites overpredicted, and one underpredicted, peak-hour trip generation.
    2. The predicted peak-hour trip generation for four TISs were within 20% of the actual peak-hour trip generation; two of these sites were office and two were retail.
    3. The predicted peak-hour trip generation for four of the six retail sites was off by more than 35%.

- Daily Trip Generation
    1. Two TISs overpredicted daily trip generation by more than 50%. The sites were built as planned and were one land use (prison and church); therefore, the trip generation analysis was likely conservative.
    2. Two retail sites analyzed daily trip generation, and both underpredicted daily trip generation by more than 20%.
    3. There were no identifiable trends in trip generation for the other two TISs; 6 of the 12 TISs did not analyze daily trip generation.

- Trip Distribution
    1. Two TISs predicted trip distribution within 20% of the actual trip distribution. Access control, no infrastructure improvements, and stagnant growth in the site

    vicinity may explain why trip distribution was within 20% of the actual trip distribution.
  2. The variance for three TISs was more than 35% between predicted and actual trip distribution because development in the vicinity of the sites was not predicted. For example, the Five Oaks development did not predict growth to the east of the site at the US 26 and Cornelius Pass interchange.
  3. Two TISs, representing two of the four retail sites with trip distribution data available, predicted trip distribution within 20% to 34% of the actual trip distribution.

- Total Intersection Traffic
  1. Total intersection traffic predictions for seven TISs were within 20% or less of the actual total intersection traffic. No trends could be identified on the type of development (land use) or location.
  2. Two TISs overpredicted total intersection traffic by more than 50%. These sites are in areas where traffic growth was predicted but did not occur; the actual total intersection traffic volumes were lower than predicted.

- Selected Individual Turning Movements
  1. No TISs predicted individual turning movement volumes within 20% of actual turning movement volumes.
  2. Four TISs overpredicted individual turning movements by more than 50%. Turning movement volumes were lower than predicted for three of the sites because the predicted annual growth rate was higher than the actual annual growth rate. The turning movement volumes for the fourth site were affected by an actual trip generation that was higher than predicted.
  3. Three TISs underpredicted individual turning movement volumes by 50% or more. Additional land uses and buildings were added to two of the sites. No determination could be made for the large difference between actual and predicted turning movement volumes for site.

- Intersection Operations
  1. The predicted LOSs at five sites were consistent with the actual LOS estimates for all analyzed intersections. These five sites also were built as planned in the TIS, and intersection traffic was within 20% of the actual intersection volume.
  2. For two sites, the actual LOS for a majority of the analyzed intersection was worse than the TIS prediction. This may have occurred because of additional site development not included in the TIS.
  3. For one site, the actual LOS estimates for all three analyzed intersections were better than predicted because the development was approximately 30% built.

- The following summarizes the nine criteria analyzed in the case study sheets. The criteria where the TIS predictions were most consistent with actual conditions were
  1. Interviewee Level of Satisfaction
  2. Site Built as Planned

- The criteria where the TIS predictions were partially consistent with actual conditions were
  1. Intersection Operations
  2. Total Intersection Traffic
  3. Daily Trips Predicted
  4. Trip Distribution
  5. Intersection Traffic Growth

- The criteria where the TIS predictions were least consistent with actual conditions were
  1. Peak-Hour Trips Predicted
  2. Individual Turning Movements

2.5. GIS Component to Model Urban Growth

The National Oceanic and Atmospheric Administration's Coastal Service Center took a hybrid approach to modeling and predicting urban growth in the metropolitan Charleston, South Carolina, region. Future urban growth was simulated based on different growth scenarios that related urban area growth to population growth. A logistical model was found useful for identifying significant predictors and has achieved high prediction success rates for all land use categories as a whole, with moderate success rates for urban use over a 21-year time span. The report states that, although urban land use is a complex system that imposes a challenge for science and practice, GIS-based urban growth modeling can provide quantified, visualized, spatial information on the future that is otherwise difficult to obtain (*23*).

2.6. Smart Growth, Land Use, and Other Ideas

Smart growth initiatives can influence land uses, densities, roadway capacity, and overall trip distribution. A recent overview addressed several propositions about the relationships between transportation, land use, and smart growth (*24*). The research sought to clarify the following propositions commonly made by smart growth advocates: building more highways will contribute to more sprawl, building more highways will lead to more driving, investing in light rail transit systems will increase densities, and adopting new urbanism design strategies will reduce automobile use. Based on available research into the transportation-land use connection and its role in smart growth efforts, the following reasonable conclusions were drawn:

- New highway capacity will influence where growth occurs.
- New highway capacity might increase travel a little.
- Light rail transit can encourage higher densities under certain conditions.
- New urbanism strategies make it easier for those who want to drive less to do so.

3. ANALYSIS OF GROWTH AND DEMAND

Traffic forecasts, whether using a travel demand model or the ITE *Trip Generation Manual* (*25*), vary widely by type of use. The traffic forecast tool developed as part of this research predicts travel as a function of land use, as defined by ITE land use codes. ITE's informational report provides trip rates by a variety of land-independent variables such as acres, square footage, number of employees, etc. Using a one-acre parcel as an example, a freestanding discount superstore produces 20 p.m. trips (in and out), while a fast food restaurant with a drive-up window has 578 p.m. trips. A one-acre parcel was chosen for comparative purposes only, since both uses typically require much larger areas. Figure 2 illustrates these and other land uses.

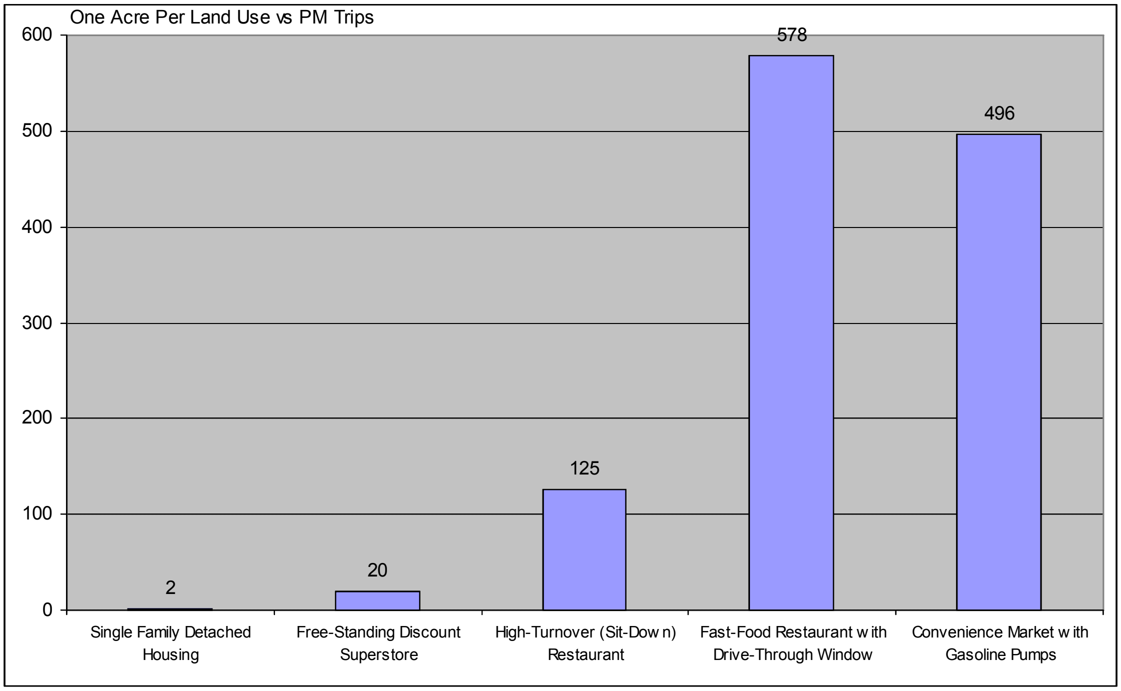


Figure 2. Peak-hour p.m. trips by type of land use

The ability to forecast travel within a high-growth area relates to the ability to predict land uses and population change. This is especially true when forecasting travel for large tracts of land of unknown use. The following task provides a descriptive summary of population changes within Iowa, along with commercial growth within some of the high-growth areas of the Des Moines metropolitan area. As a reference, the metropolitan area is shown in Figure 3.

3.1. Population Change

U.S. Census Bureau data were relied upon to provide a snapshot of population change within the state of Iowa (*26*). Table 1 shows that 34 of 99 counties gained in population from July 1, 2000, through July 1, 2006 (as estimated by the Census Bureau).

The resulting net gain statewide exceeds the total population loss by 53,382 people. Table 1 supports the idea that the majority of growth occurred within the urbanized areas of the state, with over half of the total gain being within Polk and Dallas County (both of which are located within the Des Moines Metropolitan Planning Area).

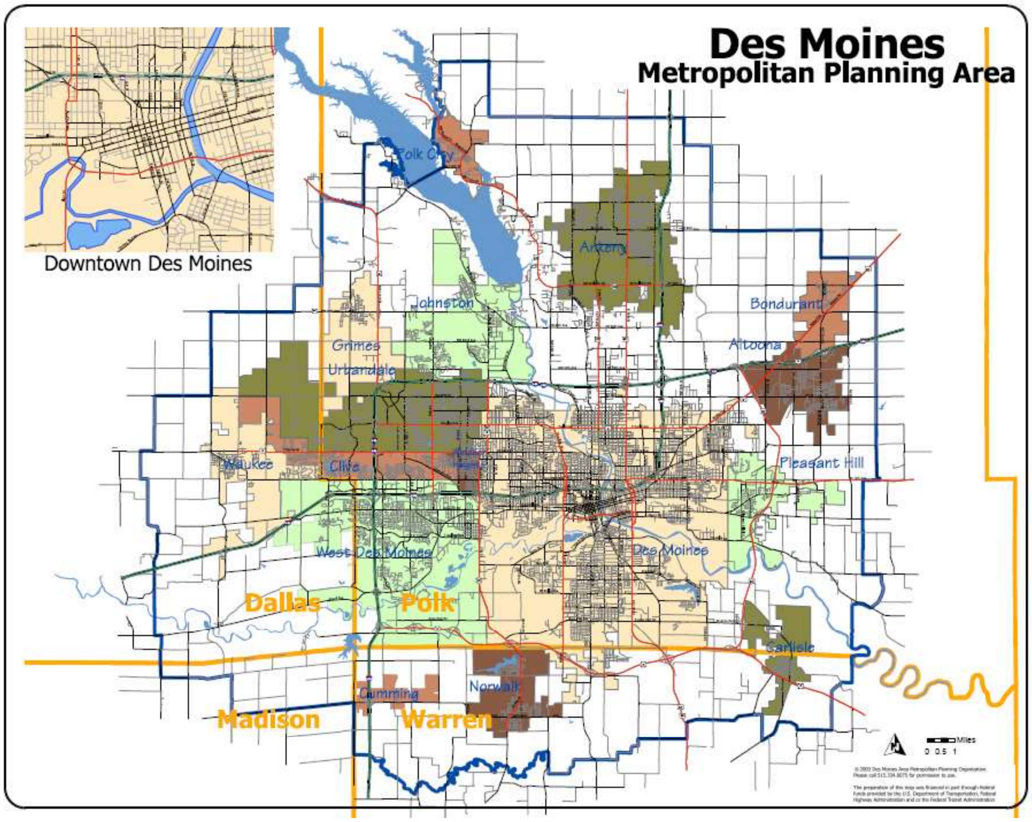


Figure 3. Des Moines Metropolitan Planning Area

Table 1. Iowa population gain/loss

US Census (July 1st, 2000 to July 1st, 2006)

	# Counties	Total Gain/Loss
Gaining Population	34	86,316
Loosing Population	65	(32,934)
Balance=		53,382

Top 5 Gaining	Total Gain	Percent
Polk	33,056	38%
Dallas	13,438	16%
Linn	9,596	11%
Johnson	6,755	8%
Scott	3,877	4%
Total=	66,722	

3.2. Commercial Growth

Commercial land uses are associated with the highest trip generation rates, and therefore any forecasting of land uses should have some feel for what the market can sustain within the planning area. This research relied upon the commercial land use database provided by Polk County to generate a snapshot of commercial growth over time (*27*). Dallas County data were also obtained; however, the data structure includes multiple entries per parcel, which prohibited mapping commercial parcel age accurately. Figure 4 illustrates commercial property across the county by the age of the parcel. The red color indicates new growth areas and the corridors most impacted by these businesses.

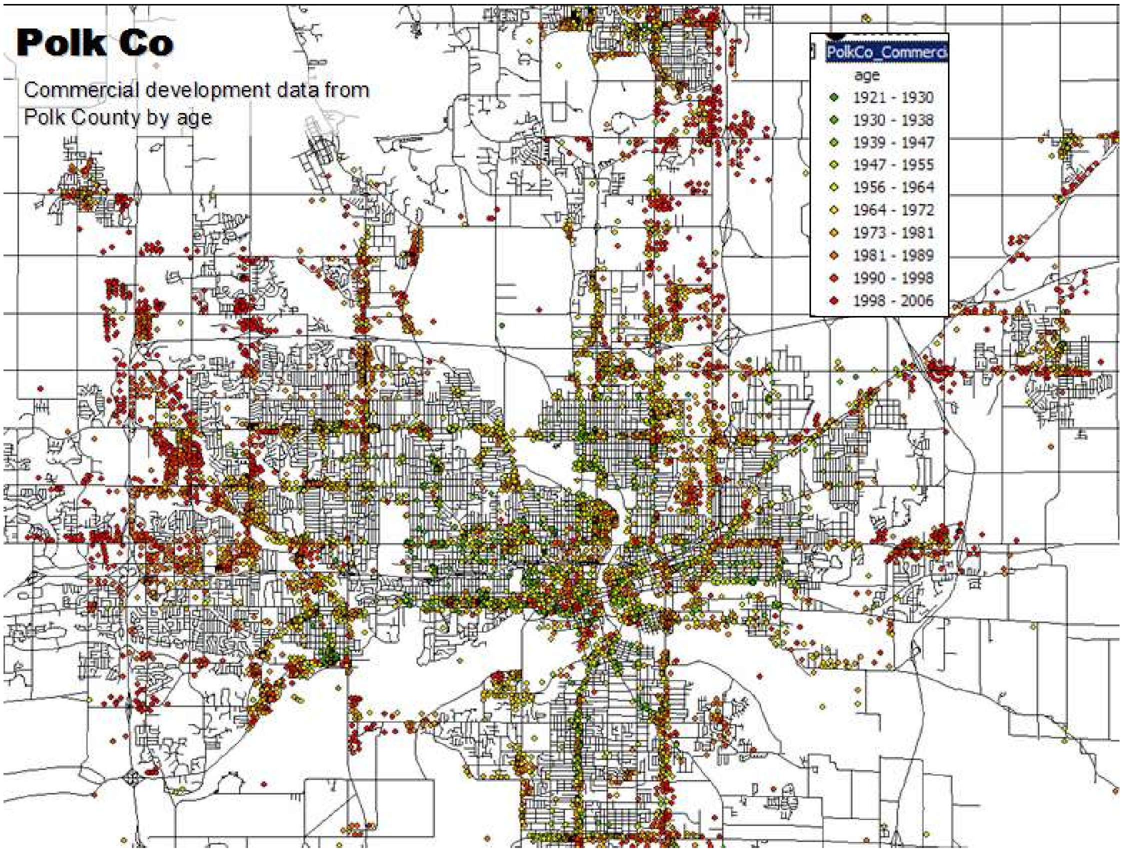


Figure 4. Commercial development within Polk County, by parcel age

The Polk County study evaluated commercial growth by square feet, parcel usage, age, and community; however, these summaries are not complete for much of the new western suburb growth, which lies within Dallas County. Table 2 summarizes the new commercial growth by most frequent type of land use from 1997 through 2006 for Polk County. Table 2 also shows the types of commercial uses that make up the majority of uses (roughly 60% of the total new uses). Common themes suggest that offices and warehouses, followed by discount stores, make up the bulk of new commercial activity in terms of square feet of land area.

Table 2. New commercial parcels by use and city (1997–2006)

New Commercial Land Uses by Type and Community (Only within Polk County) 1997 through 2006

Altoona	
Discount Store	21%
Office and Warehouse	15%
Warehouse/Cold Storage	15%
Mobile Home Park	9%
	60%

Ankeny	
Warehouse	26%
Office and Warehouse	14%
Office	10%
Discount Store	6%
Retail	6%
	61%

Clive	
Office	36%
Discount Store	14%
Shopping Center Strip	10%
	60%

Des Moines	
Office and Warehouse	16%
Golf Course/Club House	16%
Service/Repair	8%
Medium Industrial	7%
Warehouse	6%
Convenience Store	5%
Apartment	4%
	61%

Urbandale	
Office and Warehouse	21%
Office	15%
Warehouse	15%
Apartment with Elevator	9%
	60%

West Des Moines	
Discount Store	14%
Retail	14%
Office	14%
Apartment	7%
Church	7%
Office and Warehouse	6%
	63%

Table 3 shows a rough summary of the rate of growth by the most frequent land use types from Table 2.

Table 3. Rate of commercial growth by use and city (1997–2006)

Average Acres Added per Year by Commercial Use and Community (Only within Polk County) 1997 through 2006

Altoona	
Discount Store	6
Office and Warehouse	4
Warehouse/Cold Storage	2
Mobile Home Park	2
	14

Ankeny	
Warehouse	18
Office and Warehouse	9
Office	7
Discount Store	4
Retail	4
	42

Clive	
Office	8
Discount Store	3
Shopping Center Strip	2
	13

Des Moines	
Office and Warehouse	21
Golf Course/Club House	21
Service/Repair	11
Medium Industrial	9
Warehouse	8
Convenience Store	7
Apartment	6
	83

Urbandale	
Office and Warehouse	12
Office	8
Warehouse	8
Apartment with Elevator	5
	33

West Des Moines	
Discount Store	5
Retail	4
Office	4
Apartment	2
Church	2
Office and Warehouse	2
	19

The information in these tables helps illustrate the rates and types of growth occurring within the central Iowa market place. This research also examined rates of growth and land uses as they have developed along specific high-profile corridors, such as University Avenue, as shown in Figure 5. Similar information was used within each of the case study communities where the scenario planning tool was used to forecast future traffic volumes.

Figure 5. University Avenue (West Des Moines)

4. SCENARIO PLANNING USING EXISTING MODELS

This task considered whether existing land use or demand models could be used directly for scenario planning and whether a densified TransCAD model could be used to replicate the higher level of roadway detail desired and used by the scenario planning tool (described in the following section). The first step was to identify the relevant land use planning models and to discuss their capabilities. The second step was to complete a case study using a densified TransCAD network with parcel-level development and planning data from a real community (Johnston, Iowa). While the new scenario planning tool is presented in the following section, the local-level forecasting efficiency of the densified TransCAD model (as a baseline) is compared to that of the new tool at the end of this chapter.

4.1. Existing Models

Land use models are available specifically to forecast land use at the regional level, a level similar to many urban transportation network models. However, a key difference is that land use models take the transportation system as an input, whereas the transportation network models take land use as an input. This difference is a manifestation of the classical land use-transportation relationship and is a criticism of both types of models. Recent efforts in some high-growth states have attempted to integrate both of these objectives, at least at the regional level. There is significantly more activity along these lines in air quality non-attainment areas. In general, the level of detail to be expected from these models is not sufficient to facilitate the local traffic engineering and design decision making process.

Usually, the land use model must assume a control total for a region, and these totals are provided by state-level employment or economic development agencies. The totals are used to constrain local estimates, much as control totals may be used to limit growth in the socioeconomic forecasts used as input for travel network models. In many areas, these totals are not available. Also similarly to travel network models, land use models include complicated technical steps and require political involvement. A discussion of land use models currently under development or within the market follows.

4.1.1. Prototype Programs

Integrated Land Use, Transportation, Environment (ILUTE). ILUTE was developed at the University of Toronto. It is currently available and used in the form of an operational prototype by a consortium of Canadian universities and one American university, which includes (but is not limited to) the University of Toronto, University of Calgary, and California State University, Sacramento. Because this model is only a prototype, the developers have listed ”next steps” that they recommend be completed for the operational prototype to become a working urban simulation model (*28, 29, 30*).

4.1.2. Working Programs

METORPILUS (DRAM/EMPAL/LANDCON). Kent State University (*31*) has written the following about this program:

> Together, DRAM and EMPAL can be used to produce (1) employment location forecasts that reflect changes in the location of households and/or (2) household location forecasts that reflect changes in the location of employers. A third model, LANCON, for LANd CONsumption, takes the calculated demands for residential and employment uses in each zone and estimates the change in each land use category. The models work with between 100 and 300 zones, each of which can contain between 6,000 and 10,000 people. The model also works with between four and eight household types, specified by income and place of residence, and four to eight employment types, located by place of employment.

The model can only be purchased as part of a comprehensive consulting package that includes the custom installation and calibration of the model. Costs will vary based on the application, but installation is well over $100,000.

INDEX. INDEX was introduced by Criterion in 1994. It is a “gravity-type” model. The suite of software functions as a GIS-based neighborhood-to-regional scenario builder. INDEX Plan Builder can be purchased for $3,900, with one year of training and technical support available (*32*).

MEPLAN. MEPLAN was derived from the Lowry model and focuses on the housing market. It employs a LOGIT-type structure. It is an integrated software package that allows users to look at the demand and supply of both land use and transportation and compare the effects of changes in various public policies. More specifically, the model can perform three main functions: (1) determine the effects of transport on the choices of location by residents, employers, developers, and others; (2) determine how land use and economic activity create the demand for transport; and (3) project and evaluate the many impacts that planning decisions will have on land use and transport. The suggested staff needed for the model’s application includes a transport engineer, a planner, and an economist. The model costs around $40,000, which includes the software and training and maintenance costs (*33, 34*). “Strengths include the realistic representation of current and continuing patterns, the close linkages between different industry and household types, and the market-based nature of the model. The weaknesses include the aggregate nature of the model and the possibility of difficulties in establishing realistic, alternative, specific constants (*35*).”

Planning for Community, Energy, Economic and Environmental Sustainability (PLACE3S). The California Energy Commission developed PLACE3S for use with the ArcView GIS platform. It is also a LOGIT-type model and is being used by the Sacramento Council of Governments (SACOG) in conjunction with the MEPLAN model and SACMET (Sacramento’s travel demand model) as part of the SACOG blueprint project. PLACE3S can be run on the internet for no charge (*36*).

Tranus Integrated Land Use and Transport Planning System (TRANUS). The TRANUS model is designed to simulate the probable effects of projects and policies relating to the locations of activities, land use, and the transportation system, and to evaluate these effects from economic, financial, and environmental points of view. The model is operational and has been applied in many countries. It has also been applied in Baltimore, Maryland, and Salem, Oregon (*37*).

UrbanSIM. UrbanSIM, developed by Paul Waddell of the University of Washington, is a software-based model that takes a behavioral approach in treating urban development as the interaction between market behavior and governmental actions. Specifically, the model simulates where households and businesses choose to locate and how governments place constraints on development in the form of land use plans and policies, urban growth boundaries, etc. The software is free and downloadable from http://www.urbansim.org. However, the model is still in development, and experience is limited to four applications: Honolulu, Hawaii, Eugene-Springfield, Oregon, Salt Lake City, Utah, and Seattle, Washington. Using the model requires GIS tools, and calibration of the model to any city requires statistical packages, such as SAS or SPSS, and a LOGIT estimation software package. UrbanSIM also requires integration with a travel model to reflect transportation through accessibility measures contained in the model. Independent reviews of the model have been performed by the U.S. Environmental Protection Agency (2000) and the National Cooperative Highway Research Program (1998) (*38, 39*).

What if? This program is a Lowry gravity-type, GIS-based software package that uses both GIS and non-GIS data input to model the land use process and allow the user to model changes that may result from different policy strategies. Existing GIS databases and new databases can be used with this software. Outputs are maps and tables. This software is currently in working form and for sale by What if?, Inc., http://www.what-if-pss.com/ (*40*).

4.2. TransCAD Case Study

To compare the performance of the TransCAD model to the scenario planning tool, a densified network was created using the Des Moines area travel demand model as a base. This model was then used to forecast future traffic volumes within the City of Johnston’s western growth area. Major intersection forecasts were then compared to those obtained using the scenario planning tool developed in Task 5 of this project.

The methodology included updating the land use plan to current city expectations, creating a denser roadway network to reflect a year 2030 build out, dividing traffic analysis zone areas into sub-areas, creating a trip production-attraction table, and using TransCAD to derive daily model link volumes. These volumes were then compared to the results obtained using the scenario planning tool. This comparison showed a very good fit between models for the a.m. and p.m. total entering intersection volumes. For example, regional travel demand models are generally calibrated to within 30% to 40% error using root mean square error (RMSE). The Des Moines MPO model is calibrated to 35.8% RMSE. Compared to the scenario planning tool developed in this project, as discussed in the following section, the densified TransCAD model produced 12.5% RMSE for the a.m. peak hour and 16.7% RMSE for the p.m. peak.

The conclusion of this effort was that the TransCAD model could be used on a denser sub-area of the network to produce results similar to those of the scenario planning tool. However, conducting the analysis was a significant effort and is likely beyond the scope of many city planning agencies. Significant levels of expertise and time are required to manipulate the regional model to the local level of detail. Also, with the densified regional model, there is limited opportunity to modify the travel flows to match local or engineering experience. A relatively high software investment and personnel cost is also associated with using the regional model at the project and local agency level.

5. ALTERNATIVE FORECAST TECHNIQUE

This task developed an alternative method to forecast traffic that is tailored to the desires of local agencies. These agencies requested a better, faster, and easier way to evaluate land uses and their impacts on future traffic demands at the sub-area or project corridor levels. This method should be considered as a supplement, and it does not replace the regional model or local traffic impact studies. A particular focus was placed on scenario planning for undeveloped areas. These agencies expressed the desire to have a tool with the following features:

- Local agencies requested that this new scenario planning tool be based upon land use classification, which is similar to the predication of future water and sewer needs, rather than more traditional regional planning socioeconomics.
- The tool was anticipated to provide planning at a more detailed level than a regional model, but not at the driveway level of detail, as with a traffic impact study.
- The tool was to be focused on the arterial level, and the desire was to be able to input various potential future land use scenarios and evaluate a.m. and p.m. peak hour roadway operations under these conditions.
- The tool was expected to provide an alternative to traditional planning methods, particularly in new growth and fringe sub-area locations.
- The tool was expected to improve the ability to forecast future right-of-way needs, given the merging of planning and operations capabilities.
- Agencies asked that this tool serve both planning and engineering staff needs and rely on common traffic capacity, GIS visualization, and calculation tools.

This task documents the efforts made in developing this scenario planning tool and in demonstrating the use of the tool within real communities that are dealing with growth issues within specific sub-areas of their communities.

5.1. Background

The discussions for a scenario planning tool originated from issues within two different central Iowa communities, Ankeny and West Des Moines.

5.1.1. Ankeny

In 1999, the City of Ankeny was fortunate in landing a Super Wal-Mart along the underdeveloped Delaware Avenue corridor. The parcel brought with it an assessed value of over $13 million and employment. At the time, the traffic impact study used existing traffic plus new trips from the site to size up the adjacent intersection needs. This scenario is depicted in Figure 6.

When developments populate a corridor one at a time, the result is often that the last development ends up paying for the capacity improvements needed system wide. In this case, the scenario planning tool would have allowed the city to not only look at the new Super Wal-Mart, but also include the anticipated impacts of growth on the commercially zoned land on both sides of the road north of this site.

Super Wal-Mart

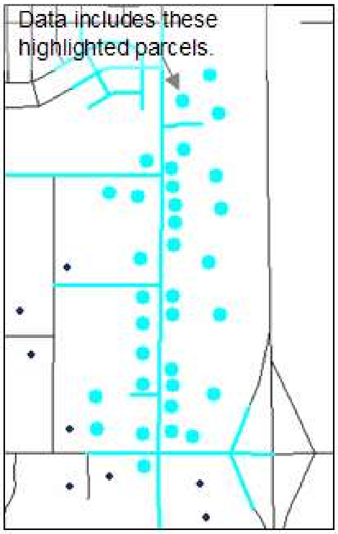
1002 SE NATIONAL DRIVE

Assessment	$ 13,436,000
Total Acres	22.003
Finished Area	205,110
Year Built	1999
Asphalt Paving	460,000
Concrete Paving	78,000

Figure 6. Ankeny's Delaware Avenue corridor in 1990

Table 4 shows a history of commercial development along this section of Delaware Avenue from 1994 through 2006 (*41*). The corridor has attracted over 144 acres of commercial development, of which 58% is either discount or retail use.

Table 4. Commercial growth along Delaware Avenue (1994–2006)



Delaware Ave - Commercial Development 1994 to 2006

By Year:	Acres
1994	17
1996	2
1997	4
1998	6
1999	22
2000	42
2001	16
2002	16
2003	9
2004	5
2005	2
2006	4
total=	144

By Type of Use:	Percent
Discount Store	25%
Retail	23%
Shopping Center Strip	17%
Warehouse	12%
Office and Warehouse	7%
Restaurant	6%
Private School	4%
Banks/Savings and Loan	3%
Convenience Store	2%
Auto Service	1%
Car Wash	1%
total=	100%

Developing the scenario planning tool could help the city plan for future growth and critical right-of-way prior to developments being at the site plan stage. This corridor level of analysis is the ideal level of application for the tool (i.e., larger than a typical traffic impact, smaller and in more detail than the regional model).

Figure 7. Delaware Avenue corridor and side street conditions (peak times), 2006

5.1.2. West Des Moines

The City of West Des Moines has experienced significant commercial and residential growth over the last five years. This growth is a result of large-scale development in the southwest quadrant of the city. A new regional mall added over two million square feet of retail, and across the street from this Wells Fargo constructed an office complex with an ultimate build-out of 13,000 employees per day. Table 5 illustrates this growth through commercial construction valuations by year (*42*). As shown, commercial construction in 2004 alone added over $287 million in property valuation. For 2006, the commercial uses are further defined, with retail representing over half the new uses.

Table 5. West Des Moines commercial construction valuation (2002–2006)

Year	Added Valuation	
2002	$	15,174,732
2003	$	146,511,627
2004	$	287,631,919
2005	$	86,878,860
2006	$	91,226,617

2006 By Use

Retail	51%
Office	27%
Industrial	22%

Figure 8 illustrates the area under planning review due to the significant growth within the West Des Moines area. The 280-acre parcel represents the new mall, and the 160-acre parcel depicts the new Wells Fargo office complex. To get ahead of growth and to determine future right-of-way needs, the city expanded the land use and traffic forecast area, as shown by the dashed line In Figure 8, to an area exceeding 13,000 acres.

Figure 8. City of West Des Moines western growth planning area

The initial efforts to plan for this area relied upon a regional model; however, the information wa required to provide design-level details for roadways and intersections that were under design. It was also found that the regional model travel flows were difficult to translate into peak-hour demands, and it was difficult to exchange intersection flow data with other traffic analysis programs. Ultimately, the large area shown in Figure 8 was planned using the new scenario tool developed as part of this research. Anticipated land uses for the area were assigned and a.m. and p.m. peak-hour trips were calculated for all relevant intersections. This effort will be further described later in this report. Figure 9 shows an example of the construction activities currently underway in this rapidly developing portion of the city.

Figure 9. City of West Des Moines Large Scale Construction

5.2. Concept

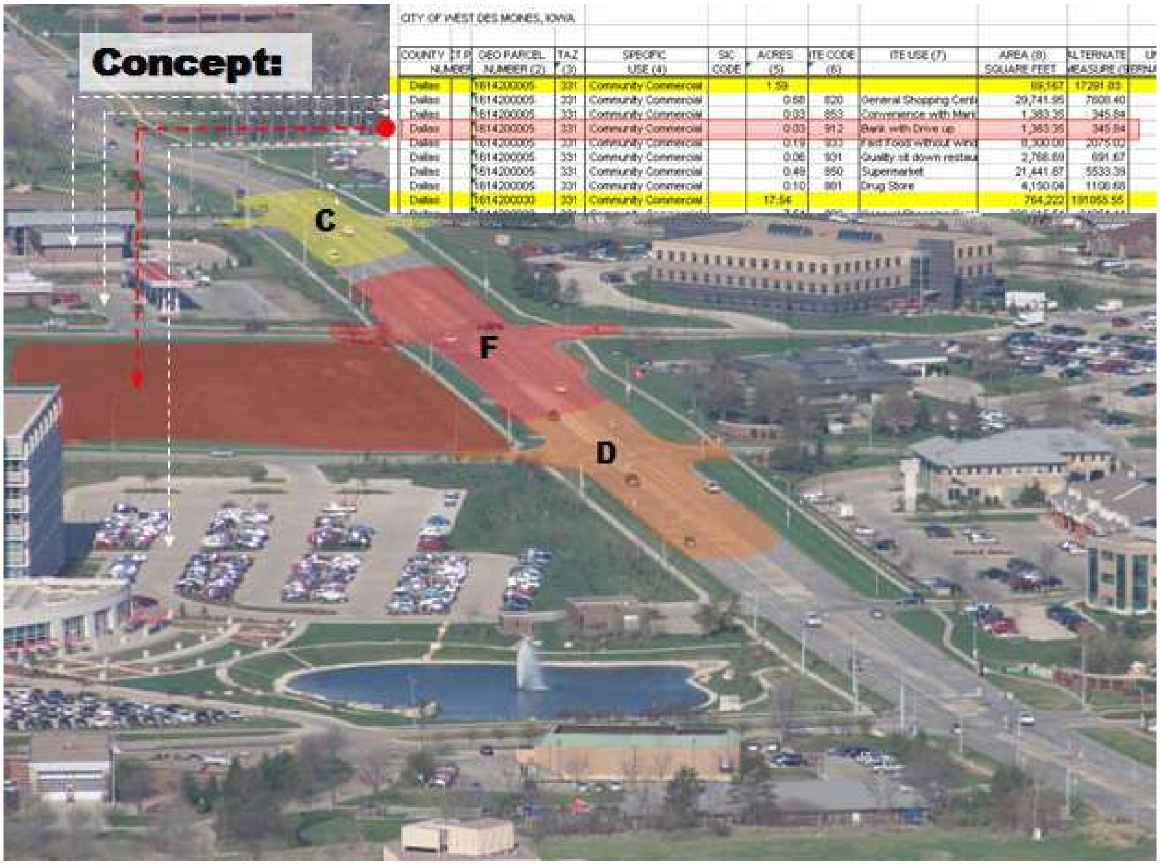
Based upon the expectations of local agencies, the scenario planning tool concept was to build a traffic forecast tool that would do the following:

- Take advantage of the existing land use planning database already maintained by the agencies in a GIS format
- Take land use information and a GIS depiction of the roadway network and automatically create a geographic environment with trip productions assigned at the parcel level
- To provide the ability to manually distribute trips in a visual format and at the parcel level for both a.m. and p.m. peak hours
- Take peak-hour intersection volumes directly into a traffic analysis program that would automatically build the roadway network
- Take operational outputs in terms of levels of service out of the traffic analysis program and replace them into a GIS environment
- To create a tool that responds to changes in land uses and provides feedback to the user in terms of forecast traffic volumes and levels of service

As shown in Figure 10, any type of land use could be assigned to the vacant parcel shown. The scenario tool then calculates the impacts this assignment has on the adjacent intersections (and any other intersections included within the entire system). As will be shown below, the performance information can be brought back into the GIS graphical format as well.

5.3. Level of Detail

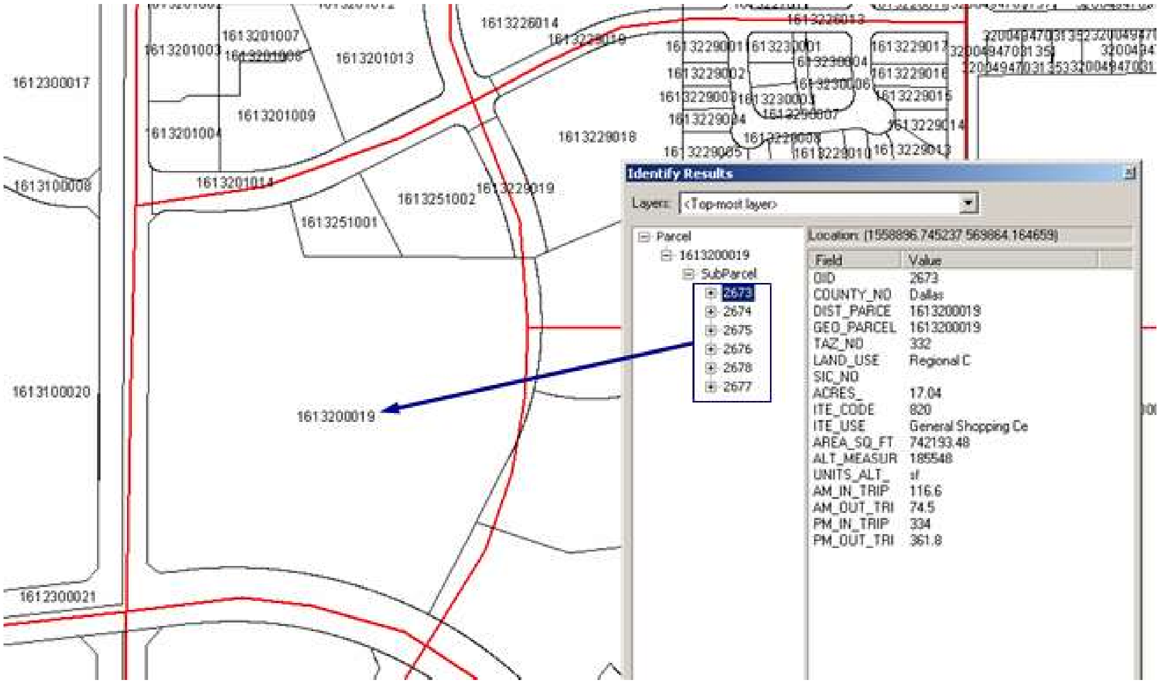
The scenario planning tool allows a community to choose the level of detail used for land use and roadway information. Figure 11 shows an example from the City of West Des Moines case study, in which parcel information is stored in a GIS format and multiple uses can be rolled up into the overall parcel. Each "+" sign within the blue box can be clicked to display the data for a different land use. This data includes the physical size of the parcel, the use, and the calculated peak-hour trips in and out. Notice also that not all residential roadways are included within the model. Storing and viewing this information within GIS format improves the transparency of the development process.



CITY OF WEST DES MOINES, IOWA

COUNTY	CT P NUMBER	GEO PARCEL NUMBER (2)	TAZ (3)	SPECIFIC USE (4)	SIC CODE	ACRES (5)	ITE CODE (6)	ITE USE (7)	AREA (8) SQUARE FEET	ALTERNATE MEASURE (
Dallas		1614200005	331	Community Commercial		1.59			69,167	17291.83
Dallas		1614200005	331	Community Commercial		0.68	820	General Shopping Cent	29,741.95	7608.40
Dallas		1614200005	331	Community Commercial		0.03	853	Convenience with Mark	1,383.35	345.84
Dallas		1614200005	331	Community Commercial		0.03	912	Bank with Drive up	1,383.35	345.84
Dallas		1614200005	331	Community Commercial		0.19	933	Fast Food without Wind	8,300.00	2075.02
Dallas		1614200005	331	Community Commercial		0.06	931	Quality sit down restau	2,766.69	691.67
Dallas		1614200005	331	Community Commercial		0.49	850	Supermarket	21,441.87	5533.39
Dallas		1614200005	331	Community Commercial		0.10	881	Drug Store	4,150.04	1106.68
Dallas		1614200030	331	Community Commercial		17.54			764,222	191055.55

Figure 10. Scenario planning tool concept



Location: (1558896.745237 569864.164659)

Field	Value
OID	2673
COUNTY_NO	Dallas
DIST_PARCE	1613200019
GEO_PARCEL	1613200019
TAZ_NO	332
LAND_USE	Regional C
SIC_NO	
ACRES_	17.04
ITE_CODE	820
ITE_USE	General Shopping Ce
AREA_SQ_FT	742193.48
ALT_MEASUR	185548
UNITS_ALT_	sf
AM_IN_TRIP	116.6
AM_OUT_TRI	74.5
PM_IN_TRIP	334
PM_OUT_TRI	361.8

Figure 11. Scenario planning tool parcel and roadway detail

5.4. Scenario Planning Tool Methodology

This research developed a software tool that takes land uses and a roadway network from a GIS format and generates a spreadsheet tool that allows trip distribution and assignment. The distribution and assignment effort can be done manually, by shortest path, or through manually creating multiple paths. The generated intersection volumes and roadway network are then processed for input into a commercially available traffic analysis program in which traffic signal timing, queue lengths, delay, and other performance features can be fully evaluated. As a final step, the outputs from the operational analysis can be brought back into the GIS environment by color or other thematic legends. A full user's manual has been prepared for using the tool and for converting operational analysis information back into the GIS format. These documents were not included within this report, but are available online at Iowa State University's Center for Transportation Research and Education project website (http://www.ctre.iastate.edu/research/detail.cfm?projectID=1103299779), along with the developed software.

5.5. Scenario Planning Tool Case Studies

The scenario planning tool was developed using actual land use and roadway information for the communities of Johnston and West Des Moines. Both communities used the output from this process to make regular decisions regarding infrastructure investment, design, and land use planning. This section summarizes each case study.

5.5.1. City of Johnston Case Study

This section summarizes the application of the scenario planning tool within the City of Johnston.

Purpose. The tool assisted staff in conducting land use and transportation programming within the western portion of the city. The city was developing its Capital Improvements Plan for this underdeveloped portion of the city and needed guidance on roadway costs, along with input for negotiations with both residential and commercial development within the area.

Scope. The study area is shown within the dashed lines of Figure 12 and covers over 2,600 acres. The analysis was performed, from the limits of NW 86th Street to Highway 141, for the following roadway segments:

- NW 54th Avenue
- NW 62nd Avenue
- NW 70th Avenue
- NW 86th Street
- NW 100th Street

Figure 12. City of Johnston Study Area

Analysis. The research effort included a review of existing travel patterns and anticipated future land uses; a review of future roadways within the study area; development of a GIS-based land use database; trip generation, distribution, and assignment; and an analysis of demand using the Synchro capacity and SimTraffic visualization programs. The analysis included assessing the impact of new growth at 42 existing and future intersections. The degree to which an area was subdivided depended on the mix of land uses and the ingress/egress routes assumed. Complex areas were subdivided more to allow for higher levels of detail in the analysis. The tool developed as part of this study allows for the acreages within any sub area to be changed and then calculates the resulting traffic volume changes throughout the study area. For example, within a specific sub-area the city may wish to evaluate the traffic impacts of 100 acres versus 50 acres of commercial and then understand the traffic impacts at each of the intersections within the study area. The analysis of future conditions required populating large tracts of undeveloped land with specific uses. To improve the accuracy of this process, field studies were conducted to document trip production into and out of both industrial and commercial uses within the Johnston area.

Trip generation calculations were based on the ITE *Trip Generation*, 7th Edition, and were supplemented with additional Des Moines metro market local values, where available. The methodology for obtaining new volume impacts begins with inputting the acres of each type of land use. As shown in Figure 13, these acres can be obtained via Arc View (the city's graphic-based planning tool with exported tabular data) or simply by typing in the information. Once the acres are set, the tool then calculates total trips in and out of the parcel and distributes these trips across all study intersections. These intersection volumes are automatically formatted for use in the traffic analysis model. The ability to evaluate a range of land use options helps in sizing up needed roadway geometry to accommodate a range of land use development plans. The future roadway network analyzed is shown in Figure 13.

Figure 13. Study roads and parcels, Johnston, IA

Results. The scenario planning tool evaluated land uses within the study area and, via a capacity analysis and operations tool, arrived at a recommended geometry for all study roadways as required to accommodate the full build-out of the area. Figure 14 provides a sample of how each intersection's geometry was presented to the city council and used by consultants to design and guide capital improvement planning and budgeting.

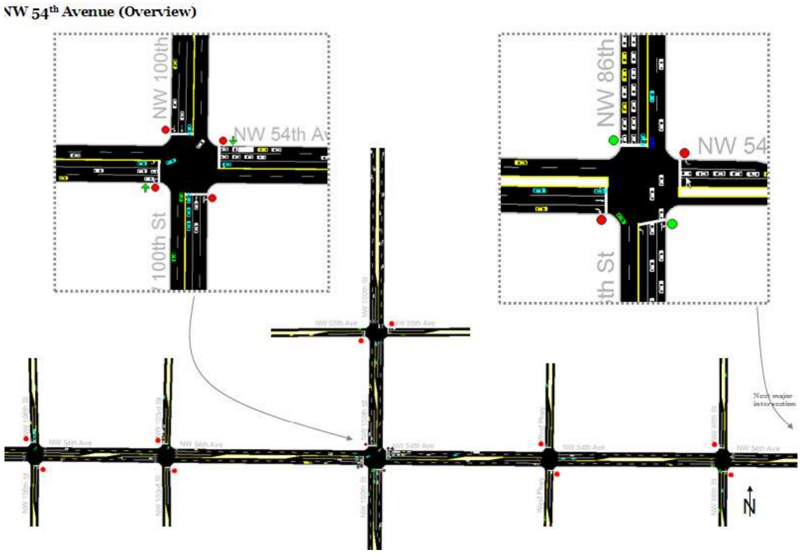


Figure 14. Recommended roadway geometry, Johnston, IA

5.5.2. City of West Des Moines Case Study

This section summarizes the application of the scenario planning tool within the City of West Des Moines.

Purpose. To provide an enhanced planning analysis tool to assist in forecasting traffic demands within the western growth area of the City of West Des Moines; to use this tool while working with city staff to update all land uses and travel distributions within the study area and provide staff with the ability to make roadway geometric assessments, given the rapidly changing scenarios and conditions.

Scope. The study area is shown within the dashed lines of Figure 15. This massive planning area covers over 30,000 acres, 7,000 sub-parcels, 331 intersections, and 1,992 roadway links.

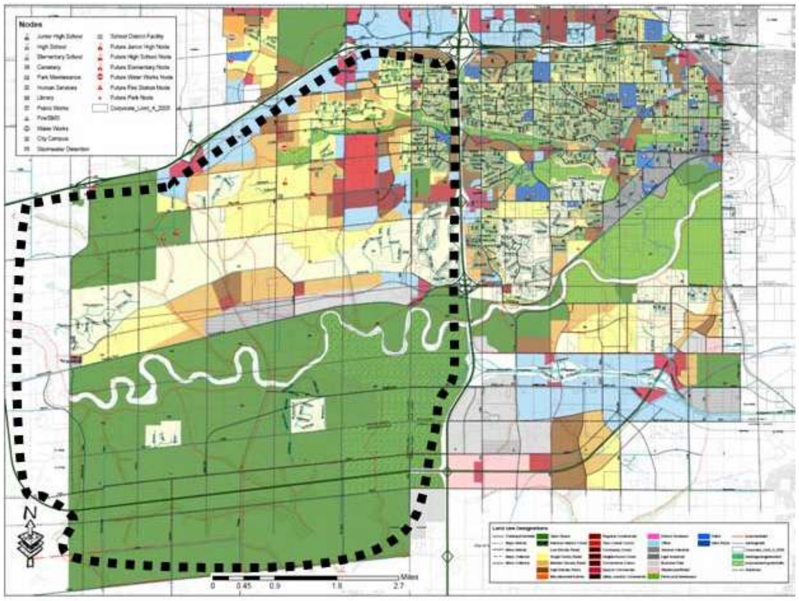


Figure 15. City of West Des Moines study area

Analysis. The research effort required a significant effort by staff to organize all existing and future parcel and roadway information into a GIS format. The tool was then able to process this information to allow analysis of demand and trip generation, distribution, and assignment using the Synchro capacity and SimTraffic visualization programs. The delay information was brought back into GIS format, as shown in Figure 16, with LOS for each intersection shown thematically by color.

Figure 17 shows how the GIS format allows a simple click on any parcel to reveal descriptive (parcel) and calculated information (a.m. and p.m. peak-hour trips).

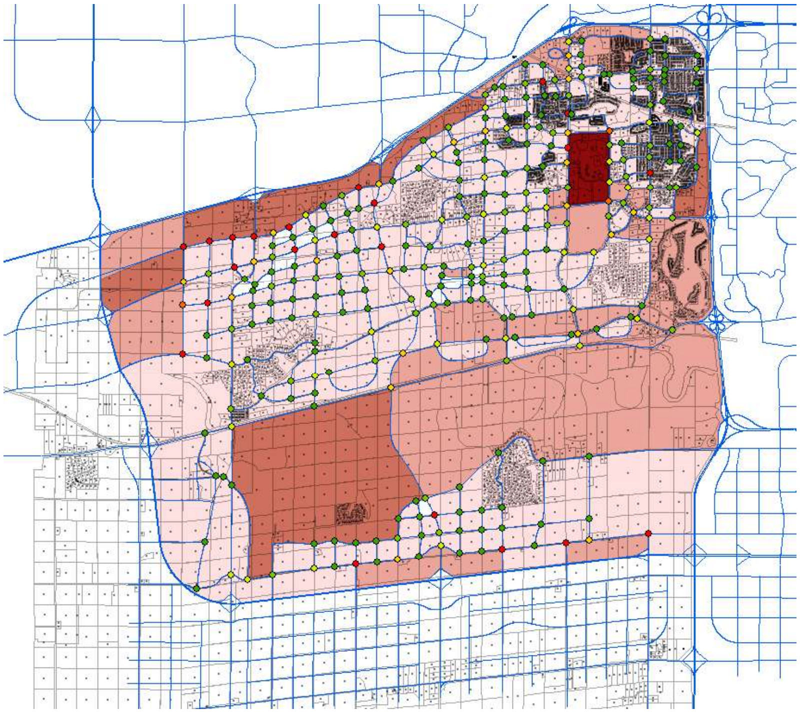
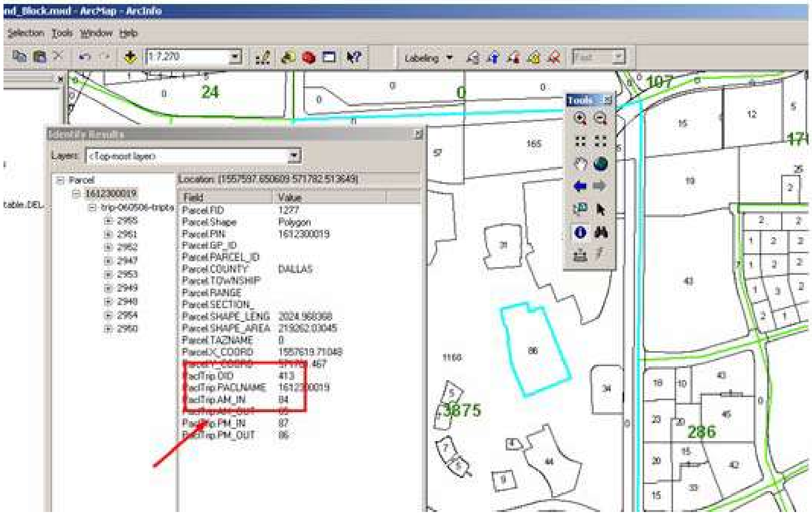


Figure 16. Study roads and parcels, West Des Moines, IA



Location: (1557597.650609 571782.513649)

Field	Value
Parcel.FID	1277
Parcel.Shape	Polygon
Parcel.PIN	1612300019
Parcel.GP_ID	
Parcel.PARCEL_ID	
Parcel.COUNTY	DALLAS
Parcel.TOWNSHIP	
Parcel.RANGE	
Parcel.SECTION_	
Parcel.SHAPE_LENG	2024.960368
Parcel.SHAPE_AREA	219262.03045
Parcel.TAZNAME	0
Parcel.X_COORD	1557619.71048
Parcel.Y_COORD	571782.467
PaclTrip.OID	413
PaclTrip.PACLNAME	1612300019
PaclTrip.AM_IN	84
PaclTrip.AM_OUT	[illegible]
PaclTrip.PM_IN	87
PaclTrip.PM_OUT	86

Figure 17. Parcel information in GIS, West Des Moines, IA

Figure 18 shows how parcel trips are distributed away from the centroid (user-selected percentages in any direction). As shown, this would be for either a.m. or p.m. trips leaving the parcel. Figure 19 shows how trips are assigned to the roadways using one of several methods. The tool allows the user to choose between shortest path, multiple shortest path, or complete manual assignment. The example shows trips leaving the centroid of the parcel to the tip of the arrow (specific access point on the roadway shown). This example also shows how the tool shades the roadway with a red color, of which the width and shade provide feedback on the volume of vehicles using specific routes (for this particular movement out of the parcel at this particular driveway).

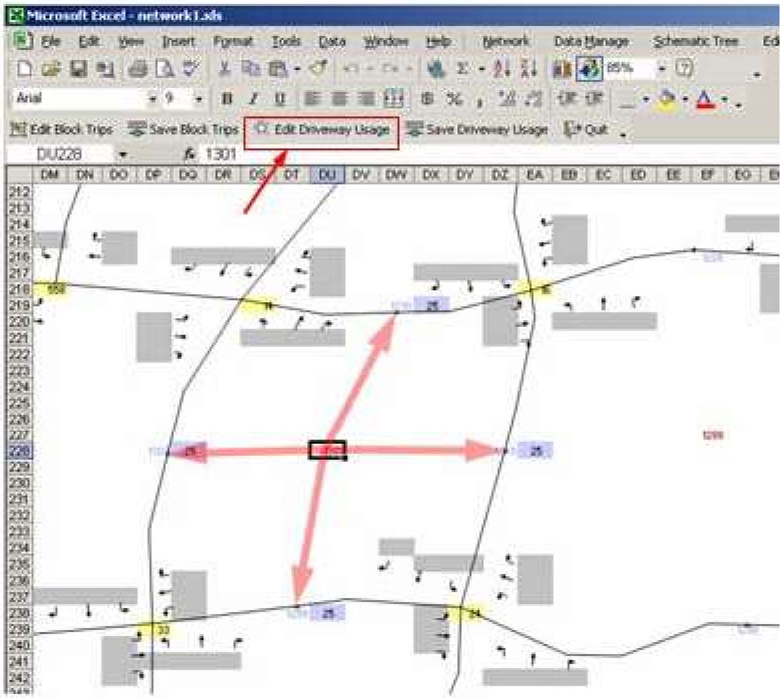


Figure 18. Parcel trip distribution, West Des Moines, IA

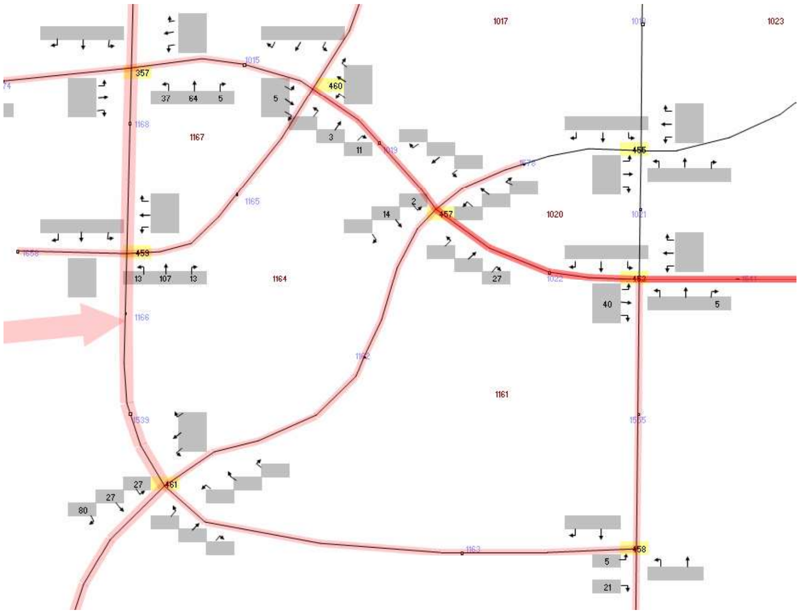


Figure 19. Parcel trip assignment, West Des Moines, IA

Figure 20 shows how the information looks as it is automatically converted into a traffic analysis program (Synchro). All intersections can then be evaluated in terms of meeting capacity demands, turning lane storage, backups, and other measures of effectiveness.

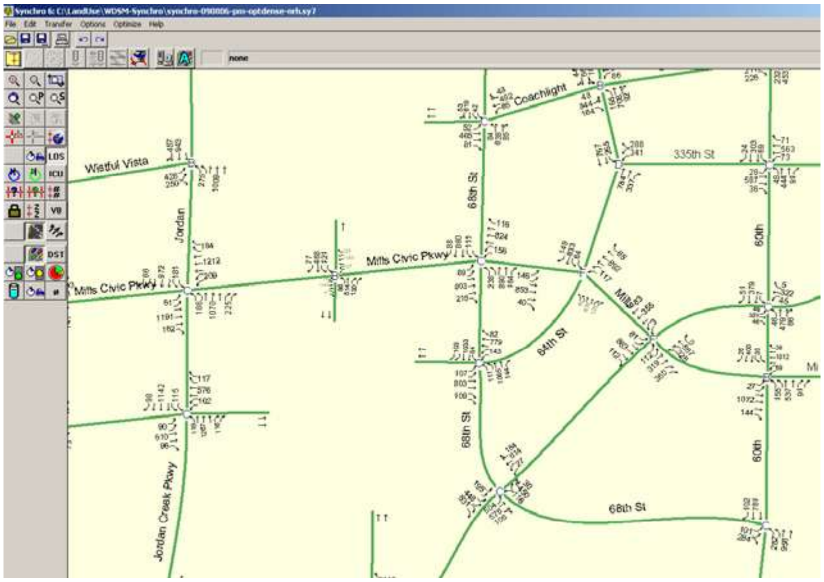


Figure 20. Traffic analysis view, West Des Moines, IA

Results. Figure 21 shows how the traffic analysis information can be brought back into the GIS format to view performance information at any scale.

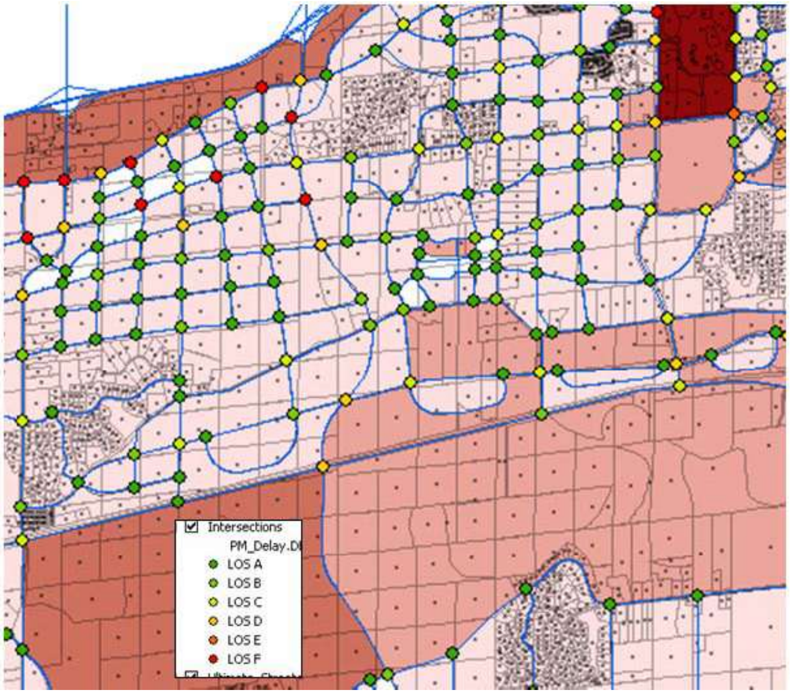


Figure 21. Intersection LOS in GIS format, West Des Moines, IA

The scenario planning tool is an incredible resource for the City of West Des Moines and has been directly credited with saving substantial dollars in establishing right-of-way needs ahead of development. Land uses within the area are in a constant state of change, and maintenance of the land use database is a bonus for both land use and traffic planning.

The City of West Des Moines has incorporated the scenario planning tool as part of its daily business efforts. The outputs from this tool are used to guide growth within this rapidly developing area. Figure 22 shows development and roadways within this area.

Figure 22. Western growth area photos, West Des Moines, IA

6. CONCLUSION

This project has laid the groundwork for improving both planning and civil transportation decision making at the sub-regional, super-project level. The research has provided the following:

- A response to local agencies' desires to have an intermediate planning tool that would provide quick answers to changes in land use at the local roadway level
- Support for practitioner decision making through a graphical representation of land use and network capacity information
- A tool that has been demonstrated at multiple scales within growing communities (Johnston case study at 2,600 acres, West Des Moines case study at over 30,000 acres)
- A tool that can use the same land use database as water and sewer modeling to conduct land use and roadway capacity scenario planning
- A planning tool that functions at a more detailed level than a regional model, but not at the driveway level of detail of a traffic impact study
- A tool focused on the arterial level and having the capacity to input various potential future land use scenarios and evaluate a.m. and p.m. peak-hour roadway operations under these conditions
- A tool that serves as an alternative to traditional planning methods, particularly in new growth and fringe sub-area locations
- A tool for improving sub-area traffic forecasting through analyzing multiple scenarios and assessing future right-of-way needs, given the merging of planning and operations capabilities
- A tool that serves both planning and engineering staff needs and relies on common traffic capacity, GIS visualization, and calculation tools

The scenario planning tool was developed and tested for one large developing sub-region and applied successfully to another. The tool could be considered for application in other similar high-growth or infill areas. Interested analysts should contact the research team or city staff of West Des Moines or Johnston, Iowa, for more details on applicability and resource requirements.

7. FUTURE EFFORTS

The efforts of this research team should be continued and should focus on making the tool interface easier to use. These efforts would benefit all users, including local agencies and consultants. Professionals from both groups have expressed a strong desire to use the tool on a variety of projects; however, training would be a requirement at this point. Since the tool is very graphical, these future efforts could add documentation to the input screens and simplify the input and viewing of critical output information. While this research effort focused on developing the tool, future efforts should focus on the usability of the tool in terms of user interface and convenience.

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