Texas A&M Transportation Institute | TRANSPORTATION Policy Research CENTER

Future Needs in Travel Forecasting: Advanced Models and Planning Techniques

If there is one theme that sets the stage for transportation policy discussion, it is this: based on our experiences and developments over the last 30 years, our future world may be wildly different from anything we can imagine today. Transportation is included in this coming transformative change, which will take place incrementally with periodic disruption from advanced technologies and how society adapts and uses them. Are we effectively preparing our transportation system for the demographic and technological changes on the horizon?

Traditional travel forecasting models and techniques currently in use at the Texas Department of Transportation and other local agencies in Texas require a large amount of manual work and cannot possibly account for the complicated nature of how human communications and the transportation system will continue to evolve. To guide Texas toward a transportation system that supports the state's economy and quality of life, new advanced tools and models are needed to help policy makers make forward-looking infrastructure investment decisions. These tools and models must be based on reliable data regarding the public's needs, expectations, and anticipated travel behaviors.

Today, many advanced transportation models are computerized representations of the complex infrastructure, personal travel behavior, and commodity flows in our transportation system and were developed several decades ago. Recent technology innovations and access to an increasing array of data are now making it possible to more accurately capture the impact of changes on the transportation system using new modeling techniques.

In combination with scenario-based planning, new emerging planning methods can consider the costs and benefits of multiple alternative futures that can be evaluated when considering the allocation of finite resources. Policy decisions on future mobility needs will be better informed by:

- Developing and refining the modeling tools used for planning future investments.
- Taking advantage of new technologies that generate more accurate and precise supporting data (such as global positioning/cellular systems).
- Creating opportunities for collaborative development of the new tools, data, and processes that can evolve the planning process and address the current shortcomings in informing decisions about future mobility changes.

This document provides an overview of why and how change is needed in the way travel patterns are forecasted and transportation planning is conducted, and how transportation policy relates to and can affect that change. Details about exactly why and how the forecasting techniques and models are evolving, as well as the specifics of where current methods fall short, are provided in a forthcoming technical report.

Policy and Forecasting: How Do They Relate?

Figure 1 illustrates the interaction between transportation policy, travel behavior, data, and forecasts.

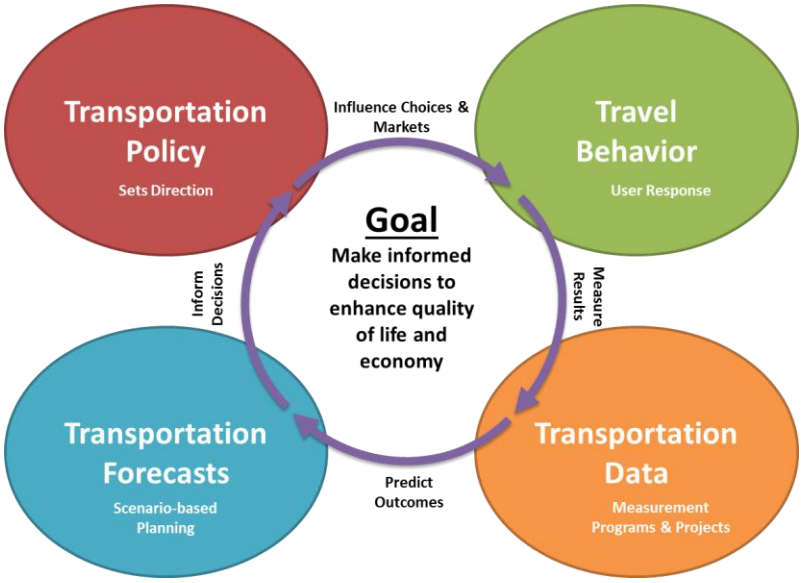


Figure 1. Interaction between Transportation Policy, Travel Behavior, Data, and Forecasting.

Transportation Policy

When policy changes, the market of transportation supply and demand can be influenced. Taxation policies, funding initiatives, and other actions taken by decision makers influence travel behavior and the choices people make.

Travel Behavior

Users of the transportation system change their choices according to the options they have, accounting for cost and convenience.

Transportation Data

Changes in travel behavior are carefully measured by collecting data and studying the transportation system and when, where, how, and why people travel.

Transportation Forecasts

The data are used to design and calibrate models that support scenario-based planning using the data obtained by observing travel behavior, which resulted from policy decisions.

Simple Formulas No Longer Suffice

In the past, growth in population and the demand it placed on the transportation system had been met with a simple formula: build more capacity to meet the demand. This formula worked for many decades. As urban areas grew, roads were built and expanded; the interstate system was built out. However, growing demand outpaced the ability to keep up with building capacity to meet the need. Travel forecasting was straightforward as well: build models that replicate existing behavior, and then apply future population and employment growth to show where the greatest deficiencies in capacity are.

Now a change in this pattern is taking place. The advancement of computing and automated vehicle technology, along with the interconnectedness of people, things, and activities through the use of technology, has changed the landscape of transportation. It is clear that the future of transportation is linked to the advancement of computing technology—and transportation behavior in the future will not be simply more of the same behavior of the past. People will have a myriad of options when it comes to their mobility, and in some cases, people will substitute virtual connection for mobility. The allocation of their time and financial resources will change along with increasing options. The time of day when they choose to travel will be associated with the cost of those choices. All of these options for mobility are creating complexity where once there were patterns and stability. Something that was simple to forecast has now become very complicated.

Transportation Planning Information: What Has Changed in the Past 20 Years?

More Demand and Congestion Management Strategies

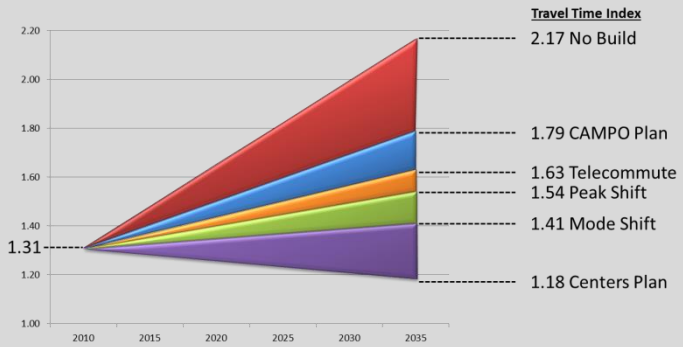
The past several decades have seen an increasing demand placed on transportation facilities while it is increasingly difficult to expand the capacity to handle the demand. In Texas and across the United States, transportation planning has grown beyond the typical response of increasing the amount of transportation supply by exclusively building more roads. Today, more use of demand management and congestion management strategies provides a focus on making the existing system more efficient and effective.

Case Study: Austin Chamber of Commerce

A 2013 study by the Texas A&M Transportation Institute (TTI) for the Austin Chamber of Commerce illustrates the potential effects of changing travel behavior on total travel demand over a 30-year planning period. TTI measured the potential effect of various trip reduction strategies on the Travel Time Index, the ratio of congested peak travel time to off-peak travel time.

Various strategies were tested, including:

- **No Build**: Using 2035 population and employment on the 2010 network capacity.
- **CAMPO Plan:** Building out projects in the Capital Area Metropolitan Planning Organization (CAMPO) 2035 Plan with the addition of managed lanes on I-35.
- **Telecommute**: Reducing home-to-work (and the reverse) trip making by 10 percent.
- **Peak Shift**: Moving 12 percent of all travel out of the peak 7–9 a.m. period; 5 percent was shifted to earlier hours, and 7 percent was shifted to after 9 a.m.
- **Mode Shift**: Taking an additional 11 percent of single-occupant vehicles off the road by moving them to transit, biking, or walking during the AM peak period.
- **Centers Plan**: Implementing the CAMPO goals for activity centers and changing the travel behavior to represent more local capture of trips within centers.



The study showed that to realize reduced congested travel, the region would need to adopt an "all of the above" focus that includes using demand reduction strategies in addition to building more capacity. The wedges of the graphic illustrate how regional leaders can move toward better roadway transportation conditions by blending behavioral changes with traditional capacity solutions. This study shows that the transportation needs of tomorrow will likely be very different than what has been experienced in the past.

VMT Growth Rate Declining but VMT is Growing

While the population continues to grow, and the *total number* of vehicle miles traveled (VMT) has been growing, there has been a declining trend in the growth *rate* of VMT (Figure 2). The recession in 2008 and 2009 contributed to this decline in the rate of growth. From 2004 to 2013, Texas population increased by 18 percent. Over the same time period, VMT increased only 6.9 percent (*1*). Specific causes of this mild decline in VMT growth rate have been proposed, but the general consensus is that a variety of demographic and socioeconomic conditions contribute

to this trend. Additionally, Texas is a crossroads for North American freight movement, which significantly contributes to VMT on the statewide level.

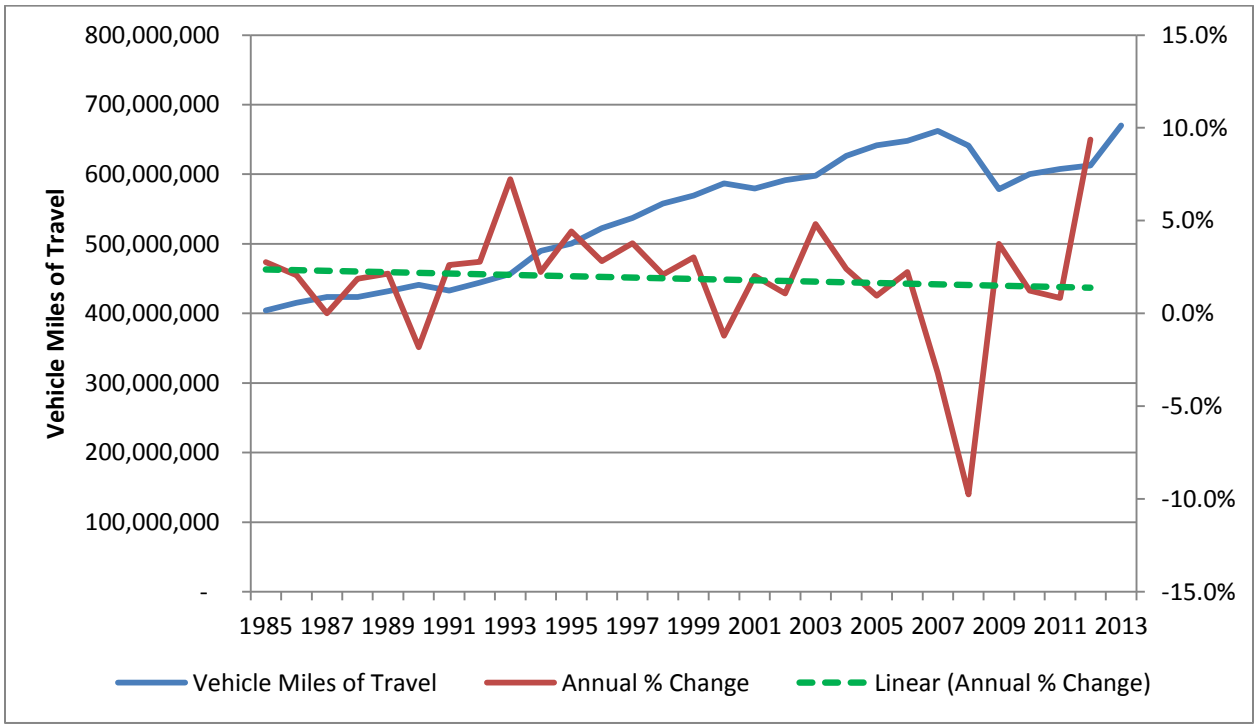


Figure 2. Texas Statewide VMT and Annual Percentage of VMT Change.

Changes in Urban Planning

Urban planning practice has changed. Urban planners have shifted focus in land use planning, moving toward integrated land use. The land use code has changed from strict single-use zoning to focus on form, density, cost, and socioeconomic considerations.

Increased Environmental Factors

Society in general in the United States and globally has increased its environmental awareness. An increased level of attention has been paid to the effect that transportation has on the livability of residents—analyzing the impact of the built environment over time and stressing greater emphasis on sustainability.

Advancing Technology

Technology has changed and is continuing to have a significant impact on society and transportation. Technology is already affecting the way in which Texans work, go to school, shop, and play. The horizon for innovations like connected or autonomous vehicle fleets grows closer every day, while online shopping, distance education, and telecommuting are already established as alternatives to travel/trip making.

Water and Energy Costs and Availability

Texas' use of energy and water supplies is also a critical component to analyze as transportation plans are developed. Water scarcity, conservation, and cost may affect the distribution of population. Energy sources, availability, and cost will drive lifestyle choices and therefore transportation options.

Trade and Globalization Trends and Policies

Trade and globalization have significantly affected transportation in Texas over the past several decades. Most notable was the effect of the North American Free Trade Agreement, while other trade policies such as coordinated, in-time delivery also changed how goods flow across the state. Trade policy has changed the availability of goods from all over the world and the choices that Texans enjoy today.

How Have Social and Economic Trends Affected Development of Prediction Tools?

Prediction tools—travel forecasting models—have not kept pace with the dramatic changes in transportation demand. The rapid changes of the past decade and continued trends in the same direction drive the need for significant changes to how we forecast transportation usage. Changes in travel behavior are impacting travel choices, such as vehicle sharing, which traditional travel-demand models do not explicitly include. Traditional testing of added road capacity is not detailed enough to test operational changes made to make the existing capacity more efficient. Modelers today are expected to test a variety of added-capacity and demand-response treatments to effectively plan for the future.

Why Do Current Methods Fall Short?

Complicated Nature of Necessary Inputs

The current state of the practice in travel-demand forecasting is a function of measuring travel behavior as it exists today. That is, travel demand is forecasted based on measured travel behavior from surveys and other observational methods conducted in the (recent) past. No existing model can predict the scenarios presented here. All state-of-the art models rely on professional inputs of key variables: regional characteristics of population, employment, and infrastructure, in addition to many other inputs. On the demand side, these largely have to do with human behavior, such as people's travel time tolerance or sensitivities to the cost of travel. On the supply side, these inputs include regional operational characteristics like roadway capacities and speeds.

Required Manual Work

Accordingly, existing forecasting procedures require a large amount of manual work. Computer programs aid this work, but largely it is work of coordination and prediction by regional planners rather than by computer programs. This is especially the case with population and employment inputs.

For population, forecasters receive a 100 percent sample every 10 years from the U.S. Census. However, this sample lacks many key inputs that affect travel demand, such as household income and vehicle ownership. This information is often obtained from other U.S. Census data of much smaller sample sizes. Other information, such as employment estimates and characteristics, is more difficult to obtain with reasonable accuracy.

Lack of Sensitivity to Changing Variables Outside the Transportation Realm

Most common demand alternatives can be explained as changes in the geographical distribution of population, employment, economics, and/or trade combined with changes in individual or economic travel. Other significant changes, some with limited likelihood but with potentially large impact, could be modeled as scenarios in addition to commonly forecasted alternatives. These demand scenarios are then placed against various transportation system designs and tested in models. The models need to be sensitive to choices that people would make, given the wide array of mobility options.

For example, prolonged Texas droughts could lead to severe water shortages. Hypothetically, such a crisis could cause a drastic shifting of population to another region of the state or the United States. This would render current plans for increased infrastructure moot, while policy makers in the region(s) that the population shifted to would be caught off guard. In this case, it could be speculated that overall travel demand would be constant but would have shifted to another region.

Alternatively, the Austin region could continue to grow while high-speed Internet connectivity increases in rural areas. Again hypothetically, this could allow population to spread to rural areas distant from the urban core and take advantage of telecommuting options. In this scenario, the population would spread, and individual travel demand would decrease, resulting in decreased regional travel demand.

To accommodate such complicated scenario planning, current travel forecasting practices need to be rethought.

Scenario Planning

Again, how future travel demand is forecasted and how the usefulness of those forecasts is judged are currently a function of the past. These past observances include the use of historic measures of demand, such as traffic counts and transit ridership, and behaviorally based measures taken from travel surveys.

While this practice has served a useful purpose and is quite adequate for near-term forecasts, travel-forecasting professionals are being increasingly asked to engage in scenario-based planning (*2*, *3*). Scenario-based planning considers multiple alternative futures that might deviate gradually—and sometimes radically—from past trends. Policy makers are then asked to consider each of these alternative futures as equally valid when considering the allocation of finite resources.

Scenario planning is not intended to predict specific futures. Instead, the concept is to pre-suppose future events and then assess their impacts. Then, policy makers can *prepare* for various outcomes. Scenario planning is more about preparation than prediction.

Limitations of Current Planning Processes

Currently, some federal regulations present a hindrance to this type of scenario planning. Air quality conformity analysis in non-attainment regions requires that travel forecasts demonstrate that the long-range plans fall within specific targets for emissions (*4*). While scenario planning is not specifically forbidden, the accuracy and documentation of models used in air quality analysis make scenario planning in these areas a risky proposition, considering the consequences of not meeting federal air quality conformity mandates.

Additionally, federal requirements call for Metropolitan Transportation Plans to be fiscally constrained. This limits the usefulness of these types of plans for considering various scenarios. Too often, future forecasts of funding availability are based on recent past trends, which have been historically low. Proper scenario planning, which allows policy makers to prepare for various outcomes, would need to supplement these federally required planning documents. This could be done as a scenario planning exercise prior to production of long range plans.

Transportation Forecasting in the Future

In research and in limited practice, the future of forecasting is increasingly focused on simulation of individuals—the daily activity choices that define their daily travel patterns, whom they travel with, the modes they use, and the routes they choose. This modeling approach is more adept than traditional, aggregate modeling methods at answering difficult, policy-sensitive questions about issues like transportation system pricing, user responses to a complex set of travel options, and

how information technology will affect transportation. Future forecasting models must, generally speaking, account for:

- Advanced vehicle and infrastructure technology and the impact of big data.
- Highly advanced personal communications and information technology.
- Changing demographics and how they affect travel behavior preferences.

Information technology is already enabling the capture of mountains of data—commonly referred to as big data—regarding trends in individual travel behaviors. As behavioral changes occur, transportation planners can populate advanced travel-demand models using an unprecedented magnitude of data from categories that include:

- **Social/demographic changes**. The age, travel mode choices, and access to technology of tomorrow's population will directly impact travel behavior.
- **Energy, water, and transportation**. Recent drought conditions point to the need to examine long-term climate impacts on where populations choose to live. Likewise, how and where the energy sector develops will directly impact how the state's economy grows.
- **Socioeconomic changes**. The impact of resource development, the population's education level, and the recent trend of global businesses adapting to meet local needs can all potentially impact how and when individuals choose to travel and live.
- **Technology changes**. Personal technology (e.g., smartphones), increasing access to the Internet in rural areas, and advanced vehicle/infrastructure innovations all impact the nature of travel. Transportation itself could fundamentally change because the need to be personally and immediately present in a given location (e.g., the need to commute from home to office) might change.
- **How freight moves**. New *behavior-based modeling* of current and future shipping practices may provide more reliable forecasting data than traditional modeling methods have.

Future modeling tools will need to account for a greater complexity of individual choices resulting from these factors. To effectively support decision making, models will be more:

- **Dynamic**. Models will account for travel-time variations related to system conditions, rather than assuming all people in a given zone travel at the same time.
- **Disaggregated**. Models will allow for individual behavioral choices rather than representing groups of users as an average of behavior.
- **Simulation based**. Models will account for more complex travel patterns that vary in terms of mode choice, time of day, car sharing, and interaction with other members of the

same household, making models more realistic by simulating linked trip making and accounting for the individual choices and responses of entire populations.

- **Stochastic (*5*).** Models will use advances in choice theory to analyze the probability of user choices, rather than relying on observed, static rates.

Benefits of Future Forecasting Models for Policy Makers

As modeling moves to a more dynamic-based method that relies increasingly on the huge influx of information supplied by big data sources, decision makers can benefit in the following ways:

- **Accounting for uncertainty**. Modern methods of statistical analysis are allowing transportation planners to form models that account for variability and error directly, which can be used to provide decision makers with an assessment of risk and uncertainty.
- **Predicting impacts**. Based on individual preferences and choices, these models are more adept than traditional, aggregate methods at predicting the effects of policy-sensitive variables, such as cost.
- **Visualizing through simulation**. Simulation techniques are useful in forecasting personal transportation choices and predicting how individual vehicles flow through the traffic stream. These techniques will be fundamental in simulating future urban environments where many vehicles and systems could be automated.
- **Forecasting with alternative scenarios.** Scenario planning will be the key to getting the most value from forecasting and providing the creativity necessary to inform policy makers of the potential of transformative changes. Prudent financial forecasting and projection of existing behavior are essential to developing a baseline forecast policy makers can use to assess the potential impacts of multiple scenarios.

More robust forecasting tools can help decision makers formulate effective policy based on realistic individual behaviors and the needs of businesses.

Creating an Environment for Advancing the Technology of Planning

Efforts to leverage these new approaches for better decision making are most effective in a collaborative environment involving several key transportation planning stakeholder groups. These groups include the following:

- Public agencies and their policy makers, who plan transportation systems and will have a role in implementation of new techniques.
- Stakeholders and the public to provide input and weigh in on potential futures in a comprehensive scenario-based planning process.
- Universities to research new methods and build the skilled human resources needed to advance forecasting practice.

Potential Near-Term Actions

It is impractical for existing planning organizations in Texas to suspend current planning activities and change course immediately. Currently, transportation agencies are incrementally improving forecasting techniques—individually—according to their own local needs and resources. The state would gain value from collaboration among agencies and stakeholders to focus on implementation of new modeling techniques and future scenarios, giving planning agencies a venue for vetting ideas without disrupting existing processes.

Transportation in Texas has benefitted in the past from transportation modeling and forecasting. Today, transportation is changing in transformative ways—and will continue to do so. As planners gather more data from a variety of sources, new modeling techniques are emerging. These techniques need to be made available to all planning agencies and incorporated into the process of making robust decisions about transportation investments.

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