Travel Demand Models

Travel demand models are planning tools to help planners, engineers, decision-makers, and policymakers understand how people move from one place to another using various modes of transportation, most often in cars and transit but in some cases also as bicyclists and pedestrians.

This introduction will define a travel demand model and lay out the value it provides planners, engineers, and decision-makers. It also provides a broad overview of model types, uses, and requirements.

What is a Travel Demand Model?

A travel demand model is a set of mathematical formulas used to model or represent the choices people make when traveling. Models take into account factors that influence travel behavior, including population and employment growth, land use patterns, transportation infrastructure, and travel costs. By analyzing these factors, travel demand models can estimate future travel patterns and help inform decisions related to transportation investments, urban development, traffic management, and resiliency.

Value of Travel Demand Modeling

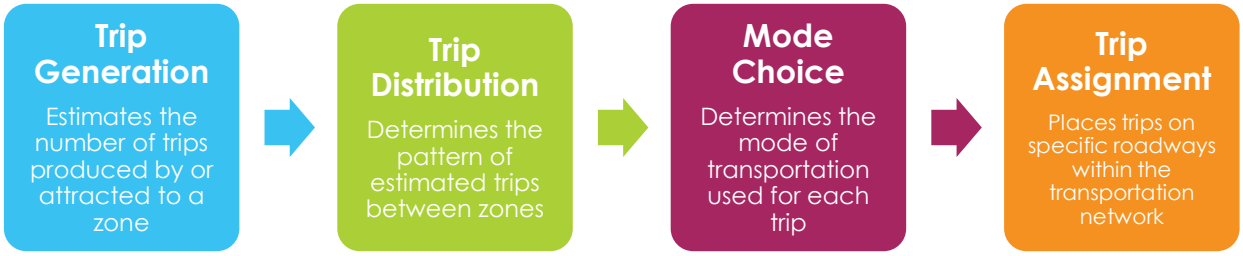
As an essential part of the transportation planning process, travel demand models support sustainable and efficient transportation planning practices. There is a consistent need to understand the dynamics of population and travel patterns to predict future behavior. Travel demand models are the path to that understanding with proven forecasting and data analysis methodologies that repeatedly and confidently provide reliable results. The methodologies were developed with public and professional input and the models calibrated and validated to ensure they mimic the closest representation of actual data. This confidence is a direct result of what fuels the model – reliable data from reputable sources. In addition to the model, this trusted data is useful for processes and analyses in the planning process that fall outside the model chain. Modeling outputs provide forecasts to understand potential impacts to the transportation system. Valid forecasts of future behavior help decision-makers plan for needed investment in transportation infrastructure to meet the demands on the future transportation system.

Types of Models

The two predominant types of models for passenger trip analysis are the four-step, trip-based model and the activity-based model. Each type has advantages and disadvantages, and the decision of which type to use depends on the planning objectives and data availability. Other model types include commodity, supply chain, and urban truck models that forecast freight and other non-passenger trip activity.

Four-Step Trip-Based Model

Four-step models are trip-based and follow a sequence of four steps. This model estimates the number of trips made between different origins and destinations within a region. The four steps include:



These steps are often implemented at the regional level to forecast travel demand over a long time-horizon. While these models provide valuable insights into the broad, overall travel patterns of a region, they may oversimplify individual travel behavior.

Activity-Based Model

Activity-based models are more detailed than trip-based models. They simulate the daily activities of individuals, such as work, school, shopping, recreation, and other personal trips. They also estimate the timing, duration, location, and mode of each activity. Activity-based models allow for a more realistic representation of travel behavior and can capture the interactions between different activities and modes. However, this level of simulation requires detailed data, which often has limited availability. Also, the more complex model framework may be challenging to develop and implement, given the high computational requirements and added components of these models.

Uses of Models

Travel demand models provide detailed, quantitative information that can be applied to many types of projects and assessments. The following describes uses for models in planning, project prioritization, and other specialized uses.

Planning

Travel demand models serve as planning tools in the transportation planning process. The results of these models are used by decision-makers to inform future transportation policy, infrastructure investment, resilience planning, emergency management, and air quality impacts. Models can be used in several ways in the planning process including the follow examples.

Long Range Transportation Plans

The most common and earliest use of travel demand models is for the development of Long Range Transportation Plans. Models are used to forecast future travel patterns and assess the need for and feasibility of transportation infrastructure investments over a certain planning horizon. Planners use the model to evaluate different scenarios and strategies for managing growth, improving mobility, and enhancing accessibility within the planning region.

Land Use and Scenario Planning

Going beyond assessing transportation improvements, travel demand models help assess the implications of land use changes on the transportation system. Models can simulate interactions between land use patterns and travel behavior, so planners can test various scenarios to identify transportation impacts and needs of new developments.

Resilience Planning

Travel demand models allow planners and emergency managers to test the resilience of the roadway network in their region. This is done by assessing the capacity of the transportation network in the event of large-scale disruptions, represented by disconnecting specific network links to evaluate the downstream impacts of damaged or closed roads. The information is used to guide long term infrastructure planning.

Project Evaluation and Prioritization

Travel demand models can be used to evaluate the impacts of specific transportation projects based on travel behavior, congestion, air quality, and operational impacts. The results are used by planners, engineers, and decision-makers to analyze and assess which projects to prioritize and fund. The following are additional uses of the model in project evaluation and prioritization.

Project Development and Environment (PD&E)

Travel demand models are a key tool in conducting PD&E studies. By considering model outputs in PD&E studies, agencies can make data-driven decisions that balance transportation needs with environmental stewardship, ensuring sustainable and effective transportation solutions. This can be achieved by using the model to conduct needs assessments, alternatives analyses, and air quality analyses.

Subarea Modeling

Subarea modeling is a focused approach within the broader context of travel demand modeling. It is used to forecast travel in a smaller region, such as corridors and central business districts, with finer detail. These models can be either stand-alone or a small area within an existing modeled region. The purpose of these models is to capture traffic patterns, turning movements, forecast future travel demand, and evaluate project or policy impacts with better accuracy over a smaller, more confined area.

Microsimulation Modeling

Microsimulation modeling is the most refined level of travel demand modeling, providing insights that a larger regional model cannot. Microsimulation is often used to analyze corridor- and intersection-level performance assessing traffic flow and congestion. These models can assess signalized, unsignalized, and roundabout intersections, simulating various signal timings and configurations to optimize traffic flow.

Interchange Justification Reports (IJRs)

The development of IJRs can benefit from the insights provided by travel demand models. Models can provide data-driven insights to support the need for new or modified interchanges. Subarea or microsimulation models especially can generate detailed information on the impacts a new or improved interchange will have on traffic flows and its capability to handle future travel demand.

Project Design

Travel demand models can be used to test the effectiveness and efficiency of transportation design. The proposed roadway design can be integrated into the models' highway network and the traffic volumes and speeds can be assessed to determine whether or not the project will improve travel conditions.

Transportation Systems Management and Operations (TSM&O)

Using both regional and microsimulation models, transportation planners and engineers can make informed decisions on strategies to improve safety, travel time reliability, reduce congestion, and improve the overall efficiency of the existing transportation infrastructure. The two types of models can be used to assess impacts of improvements on the broader transportation network as well as identify areas in need of improvement. These models can test potential improvement scenarios/solutions to determine the best course of action for the current and future transportation landscape.

Specialized Uses

Hurricane Evacuation Modeling

Planning for hurricane evacuation is another way the model provides value to planners, and decision-makers. In the critical times of storm preparedness, county emergency

managers can use model outputs to guide evacuation route planning as hurricanes approach the state.

Economic Modeling

Travel demand models may be used to provide inputs for economic studies. The typical approach uses the model output link and trip behavior like number and type of trips between travel analysis zones, vehicle miles traveled, and associated delay to inform economic model tools like Regional Economic Models, Inc. (REMI). The economic tool provides economic impacts like annual employment, delay reduction, and efficiency benefits of the transportation investment scenarios being studied.

Emissions Modeling

Mobile source air pollution is another factor evaluated by planning agencies. Models provide the current and forecast transportation activity inputs such as distribution of trips by mode, vehicle type, road type such as restricted and unrestricted access, urban and rural, and travel speeds to the U.S. Environmental Protection Agency's (EPA) Motor Vehicle Emission Simulator (MOVES) tool. The MOVES tool uses the information, in addition to meteorological data, fuel formulation data, vehicle registration mix, and fuel type mix to determine the output of tracked pollutants. In Florida, this information has been used in inventorying processes for air quality monitoring.

Requirements for Modeling

Modeling standards have been a mainstay in Florida for over 30 years. Florida has approached modeling with a crafted set of standards that model developers and appliers have been encouraged to follow. Though they are not required, Florida's modeling community continues to use these standards to generate consistent, defensible models that give their users confidence in the results. These standards were developed by the Transportation Forecasting Forum (formerly known as the Florida Model Task Force), which has served as a body of decision-makers for Florida's modeling community, focusing on the advancement of Florida's modeling practice as technological improvements and greater levels of model detail increasingly became available.

Federal law addresses the need to use and improve models for project analyses and infrastructure investments. The Infrastructure Investment and Jobs Act (IIJA) of 2021 directly addresses the need to use travel demand data and modeling to make informed transportation investment decisions. IIJA directs the US DOT to conduct a study no less than every five years to gather travel data and travel demand forecasts from a representative sample of States and metropolitan planning organizations (MPOs). The collected data is compared with observed data and used for developing guidance for States and MPOs to use in forecasting travel demand for future investments in transportation improvements. US DOT also seeks opportunities to support States' and MPOs' transportation planning processes by providing data to improve the quality of transportation plans, models, and travel demand forecasts.

Purpose and Use of the Manual

The purpose of the FDOT Travel Demand Modeling Manual (TDMM) is to provide guidance and direction to transportation planners, engineers, decision-makers, and policymakers on the development and use of travel demand models in Florida. The manual is organized in two volumes

- Developing a Travel Demand Model
  - Overview of the Model Development Process
  - Preparing for Model Development
  - Preparing Model Data
  - Developing and Refining the Model
  - Resources
- Using a Travel Demand Model
  - Defining a Specific Use of Model
  - Understanding Precision and Accuracy Requirements
  - Running a Baseline
  - Changing Inputs
  - Generating Outputs
  - Communicating Model Outputs