

5. Scenario Outputs

One of the greatest strengths of a travel demand model is its ability to demonstrate how the transportation system responds to changes in either the supply (such as the roadway network and transit system) or the demand (including the number of households, population, and employment levels). By comparing the baseline conditions of a model to one that incorporates proposed changes, it is possible to evaluate whether the change would have a significant impact on travel within the modeled area or if a proposed mitigation strategy would supply an adequate remedy. For this reason, travel demand models are used during several stages of the planning and design processes.



Review Scenario Results

1. Are the results provided in a format that you can access?
2. Can you readily read and interpret the results?
3. Do the results make sense?
4. Are you able to defend the results?

Model Outputs

At a minimum, the model scenarios for a project should be compared to the base year scenario, the horizon year no-build scenario, and each other. These comparisons form the foundation of the project's travel demand modeling narrative. They enable the project team to assess how effectively a scenario meets the project's needs relative to a no-build condition and the other proposed scenarios. The comparisons typically encompass the performance measures identified by the project team and may be comprehensive. Common metrics include comparisons of traffic volumes, vehicle miles traveled (VMT), vehicle hours traveled (VHT), volume-to-capacity ratios, select link analysis, select node analysis, and travel patterns.

Often, the outputs from the travel demand model and performance measure comparisons are utilized to support the selection of a preferred alternative among multiple proposed transportation projects. Given the multitude of available outputs, it can be challenging to identify which ones convey significant information. When determining which outputs provide meaningful insights, it is advisable to focus on those that markedly differ among the alternatives. For example, if the volume on a particular roadway in one scenario is significantly higher or lower than that of the same roadway in another scenario, this disparity warrants attention. The relative impacts should be evaluated in relation to the project's objectives and its Purpose and Need.

Modeling project scenarios and evaluating outcomes can be a repetitive process. Automating the retrieval of results from the modeling software presents significant advantages. By implementing automation, we can allocate more time to evaluate the scenarios in relation to the project's objectives rather than merely focusing on retrieving outputs. This approach also enables us to dedicate additional resources to uncovering meaningful insights that effectively illustrate how well the scenarios align with the project's goals.

Basic Concepts

Distance: Travel demand models measure distance in miles. If the distance metric of the source data for a transportation network is not given in miles, it must be converted.

Impedance: Impedance is a measure of inconvenience between an origin and a destination. The greater the impedance between two zones, the less likely it is for a trip to occur between those two zones. Typical impedances include distance, travel time, and tolls, essentially costs to the driver in terms of time, money, or both.

Matrix: Matrices are data structures with rows and columns, where the rows typically represent production end or origin TAZs, and the columns typically represent attraction end or destination TAZs. The individual cells of each matrix contain values such as trips and travel times and are read as the value going from the row TAZ to the column TAZ (e.g., 100 trips from TAZ 1 to TAZ 2).

Origin-Destination (OD): OD trip tables in person trip analyses have been directionally balanced for use in traffic assignment, which has obscured the relationship between the trip and its corresponding land use data.

Periods: The duration that a model represents. This typically refers to traffic assignment. Typical durations for travel demand models include a 24-hour day and/or several multi-hour times-of-day. Generally, travel demand models do not provide results for hourly or peak-hour periods. Traffic simulation models may have periods of one hour or less.

Person Trips: Person trips measure the movements of individuals throughout the modeled area. Person trips help us to understand the impacts to users of the transportation system as well as their purpose of travel.

Productions / Attractions (P/A): Trip tables that have not yet been directionally balanced contain P/A data. This makes it possible to analyze trips with respect to the land use data used for trip generation.

Tours: A tour is a sequence of trips arranged chronologically from the first trip of the period to the last trip of the period. In Florida, only activity-based models generate data that can be analyzed at the tour level.

Travel Time: Travel time refers to the duration it takes to complete a trip from its origin to its destination. This is typically measured in minutes. It can be aggregated by secondary factors, like type of roadway facility or type of vehicle, and can be converted into hours for providing certain metrics such as vehicle-hours-traveled or hours of delay.

Trips: Trips are the movements between TAZs that connect trip ends to each other.

Trip Ends: Trip ends indicate the level of trip-making activity generated at a TAZ. These are regarded as productions at the residence or home location and attractions at the employment or activity center location.

Trip Table: A specific type of matrix that describes the person or vehicle trips between zones.

Vehicle Trips: Vehicle trips measure the movement of vehicles. Vehicles can contain more than one person. The relationship between a vehicle and its associated occupants for a trip is referred to as auto occupancy. Vehicle trips help us understand the impacts on the system itself.

Types of Outputs

There are multiple types of model outputs that can be gathered to support the decision-making process. The selection of which ones are used is highly dependent on the performance measures identified during conversations with the project team, particularly those that indicate the level of precision and accuracy required for the project and the project coordinator.

Productions

Description

Productions inform you of the number of trips generated at each TAZ, primarily based on residential land use data. These are typically given in-person trips, though in some cases, such as for trucks and commercial vehicles, they are given in-vehicle trips. The number of productions in a TAZ is typically dependent on a combination of datasets, which may include the number of dwelling units or households, the number of persons per household, income, and the availability of automobiles. Productions are given by trip purpose. The typical person-trip purposes in Florida models are:

- Home-Based Work (HBW).
- Home-Based School (HBSc).
- Home-Based Shopping (HBSh).
- Home-Based Social-Recreational (HBSR).
- Home-Based Other (HBO).
- Non-Home-Based Work (NHBW).
- Non-Home-Based Other (NHBO).

Uses

Spatially Analyze Trip Making: Since productions are generated at the TAZ level, it is possible to see where trips are being produced. Productions should correlate to populated areas and can be analyzed directly or as trip densities.

Summarize Trips: For most purposes, trips are typically balanced to productions. This means that productions determine the number of trips generated in the model. Summarizing productions gives a good idea of the overall number of person trips in the model.

Attractions

Description

Attractions let you know where trips want to go. Attractions are generated based on employment, school enrollment, and other activity center-driven land use data. As with productions, these are typically given as person trips according to the same trip purposes used for trip productions. Attractions are typically balanced against productions for most purposes, which means that the model will adjust the number of attractions to match the number of productions.

Uses

Spatially Analyze Trip Making: Since attractions are generated at the TAZ level, it is possible to see to where trips are being attracted. Attractions should correlate to employment-driven activity centers and can be analyzed directly or as trip densities.

Activity Chains (ABM)

Description Activity chains are a trip data format generated by activity-based models (ABM). The activity chain describes an individual's trip-making behavior over a 24-hour period, with each record indicating the origin, destination, activity type, and duration of the activity. The result is a travel record for everyone in the model, similar to a household survey travel diary.

Uses **Analyze Household Trip Characteristics:** Trip chains are based on simulated households and individuals modeled by a population synthesizer. This allows you to analyze trip-making characteristics by individuals by households. Unlike traditional trip models, which can only be studied at the aggregate TAZ level, trip chains can be analyzed for similar households across different TAZs.

Traditional Trip Analysis: By parsing the activity chain file, it is possible to analyze productions and attractions and build trip matrices that can be analyzed in the same way as traditional trip models.

Assess Trip Chains: One of the great benefits of having activity chains is that trips can be analyzed based on more practical interactions. Whereas a traditional trip model would require you to analyze two separate trips—one from home to work and another from home to shopping—activity chains allow you to assess activities that span from home to work, to shopping, and back to home.

Skim Matrices

Description Skim matrices show accumulated impedances from each origin to each destination. Impedance values are accumulated along the path that is the most convenient route from origin to destination. The most common impedances are:

- Distance.
- Time.
- Toll.
- Fares.
- Transfers.

Uses **Measures of Accessibility:** By correlating certain skim matrices with land-use data, it is possible to quantify the population within a certain travel time radius of specific activity centers. This forms the basis for analyzing accessibility, allowing you to measure the change in the number of people within a certain travel time to activities, such as jobs, based on improvements to the transportation network.

Analyze Changes in Travel Costs: Impedance values can change from scenario to scenario. Analyzing the skim matrices between scenarios can show how different cost elements are affected by the input changes in the scenarios themselves. For example, travel times may remain similar. Still, travel distances may increase between certain origins and destinations, indicating that a longer but faster route is being utilized in this scenario.

Trip Tables

Description

Trip tables are matrices that show the number of trips between one TAZ to another. Trip tables can be given in terms of person trips or vehicle trips. If the model includes mode choice, then separate trip tables for each mode of travel should also be available, allowing the modeler to analyze modes such as single-occupant vehicle (SOV), high-occupancy vehicle (HOV), bus, rail, bike, and/or pedestrian. If the model includes a truck component, then truck trips can also be analyzed from the trip table.

Uses

Analyze Trip Movements: In scenarios where trip distribution is recalculated, it is possible to measure the change in trip locations by analyzing the trip tables. The modeler should focus on specific groups of origins and destinations to identify the changes more readily. Matrices can be aggregated to cluster individual TAZs into districts or other larger geographies, making changes to trip movements easier to interpret.

Evaluate Mode Shifts: Similarly, if scenario changes are made to any of the travel modes, the change in trip tables can be used to describe the magnitude of mode shift. For example, suppose a new bus route is introduced as part of a scenario. In that case, comparing the change in trip tables between the scenarios can provide an indication of how many and which trips shift between the travel modes.

Select Link / Select Node Analysis

Description

Select Link Analysis preserves the origin and destination flows of all trips utilizing a specific link and indicates the vehicles traversing a specific roadway or corridor. Similarly, Select Node Analysis preserves trip flows using a specific node, typically a centroid representing a development of interest to the project.

Uses

Visualize Traffic Flows: Preserving the O-D flows for a specific location provides a practical way to view how traffic is utilizing that location. The network paths taken often inform available analysis methods.

Performance Measure Analysis: The select link and select node analyses isolate the traffic flows for a specific location or corridor, allowing for an understanding of where vehicles at that location or on the corridor are coming from and going to. This provides crucial information for assessing the impacts of proposed projects, changes in land use, or the effectiveness of mitigation strategies. Comparing select link or node analyses from different scenarios can provide insight into how the transportation network is adapting to changes introduced in the network or land-use data.

Estimated Volumes

Description	<p>Estimated volumes are a key output from the travel demand model. They represent the number of predicted vehicle trips on the roadway network. Oftentimes, this information is stratified by the model's time periods and travel modes. A typical Florida model will have outputs for SOVs, HOVs, and trucks, provided both daily and by time period (AM, Midday, PM, and Night).</p>
Uses	<p>Scenario Comparisons: Estimated volumes will change when the model's inputs change. Comparing scenarios to each other allows the project team to see how the inputs have caused traffic to shift. It can also inform the project team as to how the scenarios might compare across key performance measures.</p> <p>Estimate Congestion Levels: Volumes are a key component in calculating numerous performance measures that inform the project team, and ultimately the decision-makers, about the congestion levels on the roadway system. They are used to calculate various metrics, including volume-to-capacity ratios, vehicle miles traveled, and vehicle hours traveled. Apart from demand modeling, they are often used to inform the development of peak-hour design volumes during the project's design phases.</p> <p>Develop Growth Factors and Traffic Forecasts: Model volumes are often used in conjunction with traffic count data to develop growth factors and traffic forecasts for various project types.</p>

Volume-to-Capacity Ratios

Description	<p>Volume-to-Capacity Ratios (VC Ratio) compare the model output vehicle volume to the roadway volume capacity, providing a measure of how congested the roadway is estimated to be.</p>
Uses	<p>Estimate Congestion Levels: As a roadway's VC ratio increases, the estimated congestion level increases. Without sufficient capacity, vehicles take longer to travel the road, resulting in decreased volumes. A VC ratio of 1.0 or above indicates a highly congested area of the network. Travel demand models allow for the volume on the road to exceed its capacity. This occurs when the surrounding roadways are also severely congested, and there is no alternative route for the vehicles to use. When this occurs in a travel demand model, it results in a significant delay on the link. Many models use VC ratios as a broad-brush estimation for a roadway's Level of Service.</p>

Measures of Effectiveness

Measures of Effectiveness (MOE), also known as performance measures, are metrics derived from travel demand model outputs that inform the decision-making process. It is the differences between the values of MOEs compared among various scenarios that provide the requisite data by which conclusions concerning model analyses can be drawn. MOEs should be calculated using reasonable methodologies that can be readily explained and demonstrated. The computation of a novel MOE should be conducted in collaboration with the stakeholders of a modeling project to ensure that all parties involved understand the nature of the MOE, the methods used for its calculation, and the proper interpretation of the MOE.

This guidance identifies some MOEs for use in Florida modeling, along with their calculation methods. The information provided here is specifically tailored for use in travel demand models. Correlations to metrics offered in the FDOT Source Book are given when relevant.

Name	Vehicle-Miles-Traveled
Abbreviation	VMT
Source Book Metric	Vehicle Miles Traveled
Definition	VMT is the aggregate value of the distance, measured in miles, traveled by all vehicles along a network. The network could be an entire model network, a subarea, a corridor, or a single link. The network can be further subdivided by link characteristics, such as facility type, area type, or jurisdictional boundaries.
Interpretation	VMT represents the intensity of vehicular travel on a network. Increases in Vehicle-Miles-Traveled (VMT) may be associated with negative outcomes, as traffic growth is correlated with increased congestion, vehicle emissions, and fuel consumption. VMT can increase because more vehicles are traveling along the network, vehicles on the network are traveling longer distances, or both. Many other vehicle-related metrics, such as fuel consumption and emissions, are calculated as functions of VMT.

Methodology

$$VMT = \sum_{L=1}^n V_L D_L$$

Where:

L is a link on the network.

n is the total number of links on the network.

V is the modeled volume on a given link.

D is the length of the link in miles.

VMT is vehicle miles traveled.

Name	Person-Miles-Traveled
Abbreviation	PMT
Source Book Metric	Person Miles Traveled
Definition	PMT is an aggregate value, expressed in miles, of the distance traveled by all individuals along a network. The network could be an entire model network, a subarea, a corridor, or a single link. The network can be further subdivided by link characteristics, such as facility type, area type, or jurisdictional boundaries.
Interpretation	PMT represents the mobility of individuals traveling on a network. PMT can increase because more people are traveling along the network, people on the network are traveling longer distances, or both.
Methodology	$PMT = \sum_{L=1}^n V_L D_L O_L$ <p>Where:</p> <ul style="list-style-type: none"> <i>L</i> is a link on the network. <i>n</i> is the total number of links on the network. <i>V</i> is the modeled volume on a given link. <i>D</i> is the length of the link in miles. <i>O</i> is the average auto occupancy on the link (calculated from a model-wide average or by occupancy-based volume purposes if the model assigns trip by occupancy). PMT is person miles traveled.

Name	Congested Travel Time
Abbreviation	n/a
Source Book Metric	Not a Source Book metric but congested travel time correlates to Travel Time.
Definition	Congested travel time refers to the time it takes for a vehicle to travel a specified distance while navigating through traffic. Despite its name, congested travel time refers to any travel time calculated when considering the presence of all vehicles on the network (i.e., a fully loaded condition), even if the number of vehicles present does not reach the level that causes traffic congestion.
Interpretation	Increases in congested travel time may indicate that demand is approaching or exceeding supply and that some form of mitigation, such as developing a transportation plan and implementing transportation projects, may be warranted.
Methodology	Congested times are calculated using a volume delay function. Florida models typically use a UROAD factor to reduce the available capacity on the network, thereby achieving a reasonable allocation of trips during assignment. As a result, the default calculation of capacity-dependent metrics, such as congested travel time, may be overstated. It is recommended that congested travel times be recalculated using a post-processor. The FDOT Source Book provides several methodologies for calculating travel speeds. These can also be used to calculate average travel times per link.

Name	Vehicle-Hours-Traveled
Abbreviation	VHT
Source Book Metric	Not a Source Book metric, but VHT correlates to Travel Time * Vehicle Volume.
Definition	VHT is the aggregate value of congested driving time, expressed in hours, for all vehicles traveling along a network. The network could be an entire model network, a subarea, a corridor, or a single link. The network can be further subdivided by link characteristics, such as facility type, area type, or jurisdictional boundaries.
Interpretation	VHT is a measure of congestion on a network, especially when used to compare between different model scenarios. Increases in VHT are typically associated with negative outcomes, as they represent an increase in congestion. VHT can increase because more vehicles are traveling along the network, capacities in the network have been reduced (such as by removing travel lanes or reducing network connectivity), or both.
Methodology	$VHT = \sum_{L=1}^n \frac{V_L T_{CL}}{60}$ <p>Where:</p> <ul style="list-style-type: none"> <i>L</i> is a link on the network. <i>n</i> is the total number of links on the network. <i>V</i> is the modeled volume on a given link. <i>T_c</i> is the congested travel time of the link in minutes. VHT is vehicle hours traveled.

Name	Free Flow Vehicle-Hours-Traveled
Abbreviation	FFVHT
Source Book Metric	Not a Source Book metric, but FFVHT correlates to Threshold Travel Time * Vehicle Volume.
Definition	FFVHT is the aggregate value of free-flow driving time, expressed in hours, for all vehicles traveling along a network. The network could be an entire model network, a subarea, a corridor, or a single link. The network can be further subdivided by link characteristics, such as facility type, area type, or jurisdictional boundaries.
Interpretation	FFVHT represents an idealized state in which all vehicles can travel along the network without experiencing congestion. FFVHT is not an MOE in and of itself but is used to calculate other MOEs such as hours of delay.
Methodology	$FFVHT = \sum_{L=1}^n \frac{V_L T_{FL}}{60}$ <p>Where:</p> <ul style="list-style-type: none"> <i>L</i> is a link on the network. <i>n</i> is the total number of links on the network. <i>V</i> is the modeled volume on a given link. <i>T_F</i> is the free flow travel time of the link in minutes. VHT is vehicle hours traveled.

Name	Average Congested Speed
Abbreviation	n/a
Source Book Metric	Average Travel Speed
Definition	Average congested speed is an aggregate value of travel speeds along the network under congested conditions.
Interpretation	Average congested speed is a measure of congestion on a network, especially when used to compare between different model scenarios. Decreases in average congested speed are typically associated with negative outcomes, as they represent an increase in congestion. Average congested speed can decrease because more vehicles are traveling along the network, capacities in the network have been reduced (such as by removing travel lanes or reducing network connectivity), or both.
Methodology	$S_c = \frac{\sum_{L=1}^n (VMT_L * S_L)}{\sum_{L=1}^n VMT_L}$ <p>Where:</p> <ul style="list-style-type: none"> <i>L</i> is a given link on the network. <i>n</i> is the total number of links on the network. VMT is vehicle miles traveled. <i>S_L</i> is the congested speed on a given link. <i>S_c</i> is the average congested speed for the network.

Name	Job Accessibility by Auto
Abbreviation	n/a
Source Book Metric	Job Accessibility by Auto
Definition	The total number of jobs reachable by auto within a travel time threshold.
Interpretation	Job accessibility by auto is a measure of economic opportunity. Increases in job accessibility by automobile are associated with positive outcomes, as more workers are perceived as having greater access to jobs.
Methodology	$A = \frac{\sum_{i=1}^m \sum_{j=1}^n W_i E_j f(T_{ij})}{\sum_{i=1}^m W_i}$ $f(T_{ij}) = \begin{cases} 1, & T_{ij} \leq T_U \\ 0, & T_{ij} > T_U \end{cases}$ <p>Where:</p> <ul style="list-style-type: none"> <i>W_i</i> is the number of workers in origin zone <i>i</i>. <i>E_j</i> is the number of jobs in destination zone <i>j</i>. <i>T_{ij}</i> is the travel time between zones <i>i</i> and <i>j</i>. <i>T_U</i> is the travel time threshold. <i>m</i> is the total number of origin zones. <i>n</i> is the total number of destination zones. <i>A</i> is the job accessibility by auto.

Communicating Results

Modeling results should provide information that benefits the study's target audience. The target audience and their needs must be carefully considered so that information can be provided in a way that is most useful to them. These considerations should also take into account how the information will be used and the level of technical expertise the audience may possess. The value of a study ultimately hinges upon the ability for information generated by the study to be understood and acted upon by its intended target audience.

Target Audience

Each type of audience will have particular needs with respect to the information they will receive. Information should be tailored to maximize its relevance to a particular type of audience. Below is a brief list of considerations on the nature of information that should be conveyed to specific target audiences.

Type of Audience	Nature of Information
Stakeholders	<ul style="list-style-type: none"> • Supports the decision-making process • Highlights key metrics • Makes clear the differences between options
Technical Experts	<ul style="list-style-type: none"> • Highlights the methodology used • Supplemented with quantitative data • Sufficient detail to support the next level of analysis
The Public	<ul style="list-style-type: none"> • Highlights the message being communicated • Highly visual • Concise presentation

Communication Strategies

The following strategies should be considered when communicating results to the target audience:

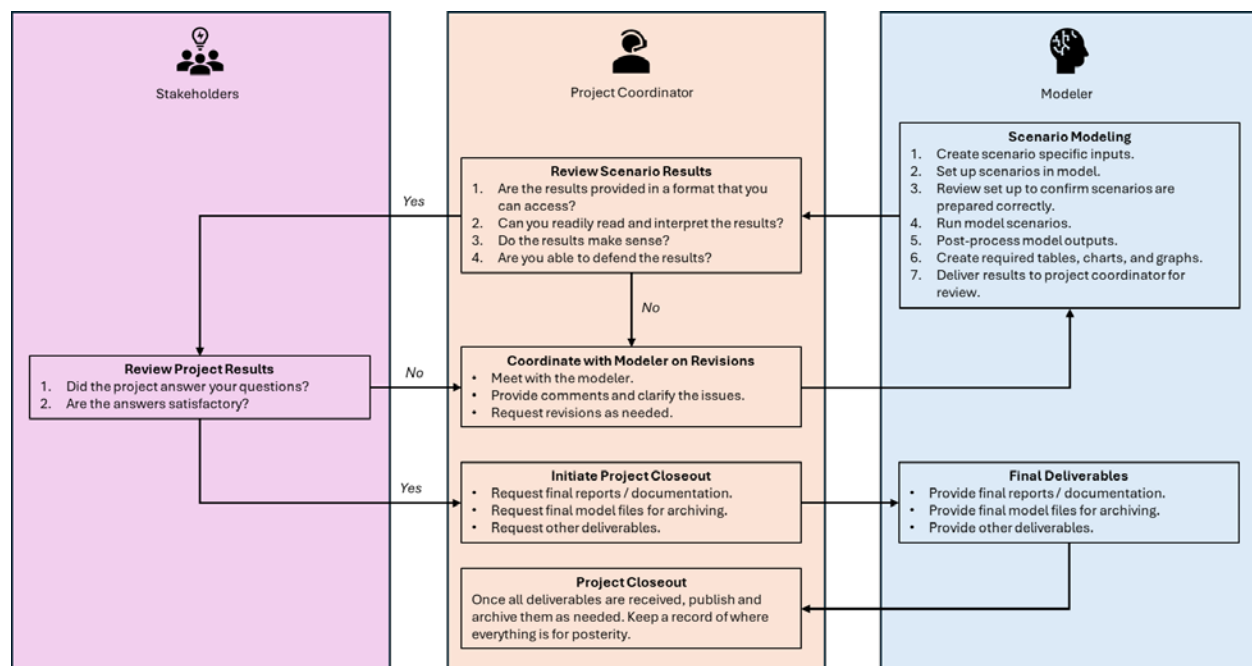
- Use graphical representations of data whenever possible to communicate information more effectively.
- Avoid using jargon and explain any technical terms that must be used in clear, non-technical language.
- Have someone with a similar level of technical knowledge to the target audience review the materials intended to communicate the results.
- All information should be provided in high-level executive summaries that quickly convey the necessary information at a level of detail sufficient to meet the target audience's needs.

Making Outputs Relevant

When presenting outputs, be sure to highlight the key findings that summarize the information to support the decisions made by stakeholders. This information should naturally align with any recommendations being made, such that the target audience can easily see the connection between the information being presented and the conclusions being drawn. Any model results presented in tabular or graphical formats should be accompanied by a brief narrative that explains how the results relate to real-world impacts and policy goals.

One of the benefits of using a travel demand model is the ability to analyze various scenarios and compare the results between them. Often, stakeholders will need to make decisions concerning which of several options represents the best choice. Results intended for comparison between scenarios should be presented together to facilitate meaningful comparisons. For example, presenting metrics from different scenarios as separate rows or columns in a table or using distinct symbols for each scenario on a chart or graph.

Developing and presenting model results for use by stakeholders may involve an iterative process of communication and review between the modeler, the project coordinator, and the stakeholder, as demonstrated in the image below.



Data Visualization

The visualization of data makes seemingly complex information more accessible to the target audience. It achieves this by directing the audience's attention to the most relevant pieces of information derived from the model results. Visualizations can often make the implications of the data being presented more obvious to the target audience by drawing attention to intuitive relationships that are recognizable to the reader. These include the differences between large and small, high and low, different colors and patterns, and progressive arrangements such as before and after.

When developing visualizations, it is essential to focus on a specific metric that serves as the primary means of communicating information to the target audience. Attempting to portray too many metrics at once will only serve to confuse the reader. Tailor the level of detail of the visualization to the needs of the target audience, displaying only enough data to inform the reader. Consider levels of aggregation that are appropriate for summarizing the model results and conveying them in a visual format. Supplement visualizations with brief narratives or descriptions to orient the reader.

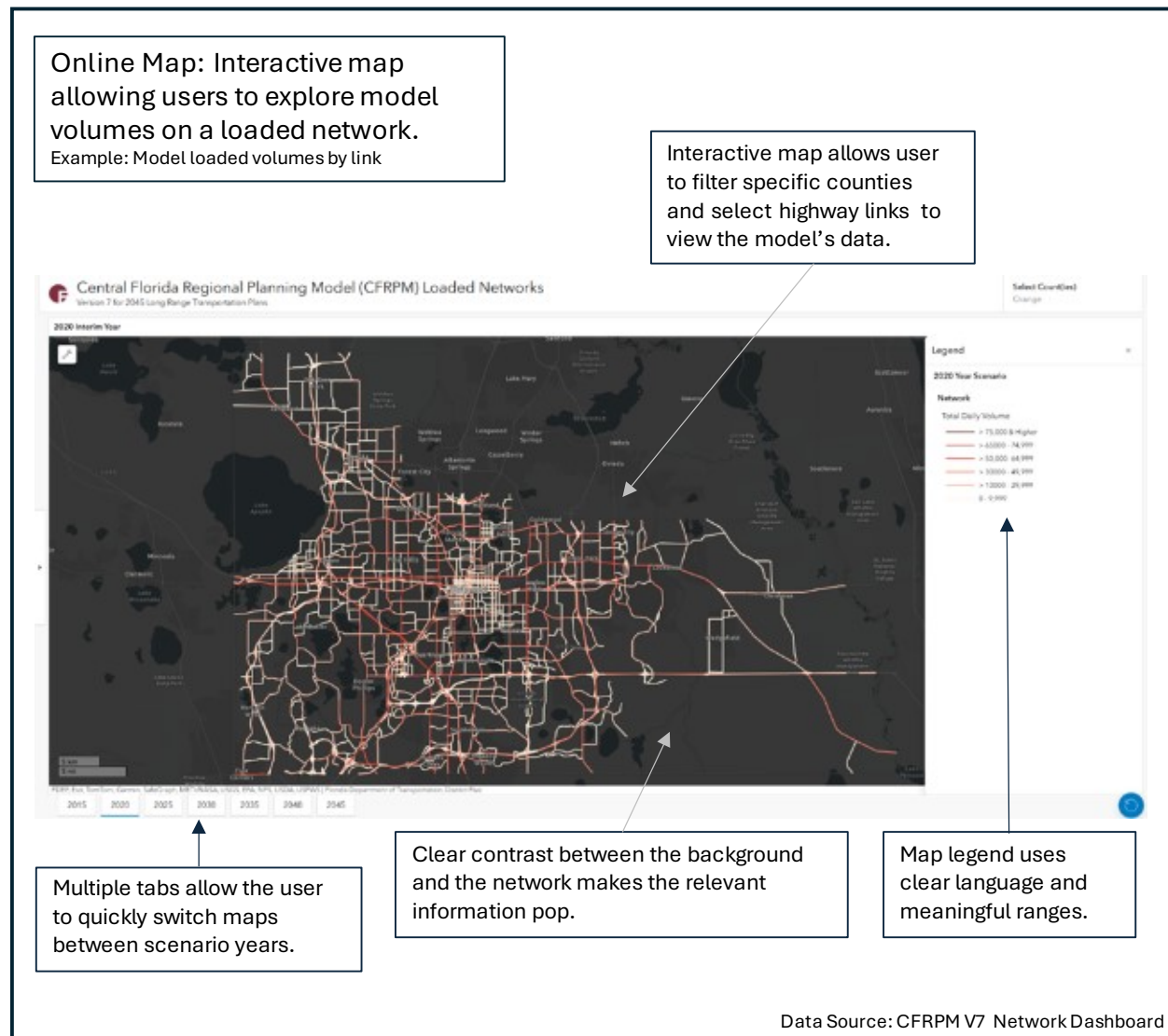
Consider the following general categories of presenting data:

Manner of Presentation	Key Concepts
Tables	<ul style="list-style-type: none"> • Present data in a structured, easy-to-read format • Highlight key metrics and comparisons • Include summary statistics (e.g., averages, totals) for quick insights • Use conditional formatting to emphasize significant values or trends
Graphs / Charts	<ul style="list-style-type: none"> • Create clear, accessible charts and graphs to illustrate key findings • Use different types of graphs (e.g., bar charts, line graphs, chord diagrams) to convey various aspects of the data • Ensure graphs are labeled clearly with titles, axes, and legends
Maps	<ul style="list-style-type: none"> • Use maps to show spatial patterns in travel behavior or traffic volumes • Color themes can be used to represent different data ranges, demonstrate hotspots of activity, and show changes over time • Size themes can be used to represent quantitative data spatially, such as using bandwidths to demonstrate traffic volumes • Chart themes integrate graphical elements like pie charts or bar graphs directly into maps to reinforce or summarize information presented on the map • Isochrones visualize travel time or accessibility gradients in multi-colored contours • Interactive digital maps allow users to engage with the data, enabling features like zooming, panning, and clicking on data points for more information • Dashboards can enhance the user experience by providing dynamic data visualization
Infographics	<ul style="list-style-type: none"> • Combine text, data, and visuals to provide a summary-level overview • Infographics simplify complex information • Incorporate storytelling elements

The following section presents several examples of data visualizations suitable for model-related data. The images for CFRPM v7 and the FDOT Sourcebook data are taken from their respective dashboards. All other examples in this document were created using the sourced data.

Visualization Examples

Online maps allow users easy access to model data curated by the project team. The use of online mapping enables a single point of editing and maintenance while allowing multiple users to view and interact with the data simultaneously. This greatly increases version control while reducing the opportunity for error. The interactivity of an online map also allows the user to zoom, pan, filter, and otherwise position the map to allow for a greater focus on areas of particular interest.



Online mapping applications allow for multiple maps to be arranged on tabs that will enable the user to switch easily between maps, making it easier to compare data between scenarios. Maps should include both information-bearing imagery as well as background imagery. Background imagery helps to provide additional context to the map and may consist of place names and street names that help spatially orient the reader. Information-bearing imagery are those map elements that are intended to communicate information to the reader, such as

traffic volumes. Maps should use high contrast between background imagery and information-bearing imagery to make the map easier to read.

Model dashboards build upon the concept of an online map by integrating various data elements. These elements, such as tables and charts, are integrated in a way that the information displayed in various elements is updated based on the user's selection of specific features in a single element. This allows the user to drill down into a specific set of features, such as a model TAZ, and display information about that TAZ. Selecting multiple features, such as multiple TAZs, allows for on-the-fly aggregation of the relevant data to provide higher level summaries.

Model Dashboard: Interactive map and table platform allowing users to explore model data and display summaries.
Example: Model zonal data by TAZ and by county

Interactive map allows user to select TAZs and view the model's data.

CFRPM7 ZDATA Summary: 2015 Base Year
Aggregate Values

County	# Zones	Single-Family Occupied DUs	Single-Family
Brevard	951	198,882	
Flagler	251	34,417	
Indian River	115	16,263	
Lake	506	127,088	
Marion	627	133,099	

CFRPM7 ZDATA Summary: 2015 Base Year
Percentages

Co...	% ...	% ...	% ...	% ...	% ...	% ...	% ...
Bre...	76.09	5.51	12.37	5.72	14.8	17.71	67.49
Fla...	89.16	10.6	11.73	5.26	8.42	21.64	69.94
Ind...	84.17	0	5.56	6.16	14.77	35.37	49.85
Lake	67.74	5.57	10.18	4.13	11.11	19.62	69.27
Ma...	88.48	9.91	4.42	5.6	14.98	20.98	64.04

CFRPM7 ZDATA Summary: 2015 Base Year
Ratios

Co...	Pop...	Emp...	Emp...	Auto...	Stud...	Hotel...
Brev...	2.13	0.45	0.97	1.73	0.64	2.5
Flag...	2.62	0.25	0.67	1.79	0.4	2.5
Indi...	2.45	0.31	0.77	1.76	0.37	2.43
Lake	2.2	0.41	0.9	1.79	0.37	2.5
Mar...	2.21	0.33	0.74	1.61	0.42	2.5

Central Florida Regional Planning Model (CFRPM) Region

TAZ 4000

TAZ	4000
City TAZ #	464,468
County	Orange
FDOT Geographic District	5 District 5
2015 Single-Family DUs	390
2018 Single-Family DUs	401
2025 Single-Family DUs	404
2038 Single-Family DUs	407
2045 Single-Family DUs	409
2048 Single-Family DUs	411
2045 Single-Family Pop	1,155
2025 Single-Family Pop	1,189
2038 Single-Family Pop	1,194
2018 Single-Family Pop	1,203
2015 Single-Family Pop	1,210
2040 Single-Family Pop	1,215
2045 Single-Family Pop	1,219
2015 % SF DUs Vacant	9.68

Summary Data for Selected Zones

TAZ	2015 Single-Family DUs	2045 Single-Family DUs	2015 Single-Family Pop	2045 Single-Family Pop	2015 Multi-Family DUs	2045 Multi-Family DUs
4000	390	411	1,155	1,219	42	48
Summary	390	411	1,155	1,219	42	48

CFRPM7 ZDATA Summary: 2045 Horizon Year
Aggregate Values

County	# Zones	Single-Family Occupied DUs	Single-Family
Brevard	951	248,933	
Flagler	251	63,279	
Indian River	115	22,118	
Lake	506	202,115	
Marion	627	176,598	

CFRPM7 ZDATA Summary: 2045 Horizon Year
Percentages

Co...	% ...	% ...	% ...	% ...	% ...	% ...	% ...
Bre...	75.25	5.96	12.85	5.68	14.6	17.48	67.92
Fla...	87.96	10.87	11.71	5.13	8.41	21.57	70.02
Ind...	84.18	0	5.56	6.16	14.75	35.38	49.87
Lake	87.87	5.68	9.92	3.9	10.91	20.69	68.19
Ma...	87.65	9.31	3.92	5.33	15.21	24.58	60.21

CFRPM7 ZDATA Summary: 2045 Horizon Year
Ratios

Co...	Pop...	Emp...	Emp...	Auto...	Stud...	Hotel...
Brev...	2.15	0.54	1.15	1.74	0.48	2.5
Flag...	2.54	0.27	0.7	1.8	0.33	2.5
Indi...	2.54	0.28	0.71	1.76	0.39	2.52
Lake	2.23	0.49	1.1	1.79	0.35	2.5
Mar...	2.21	0.39	0.86	1.6	0.4	2.5

On-the-fly data summaries for groups of TAZs are possible by selecting multiple TAZs on the map.

Multiple tables provide top-level summaries of model data. The pop-out feature of the tables allow the user to get more information.

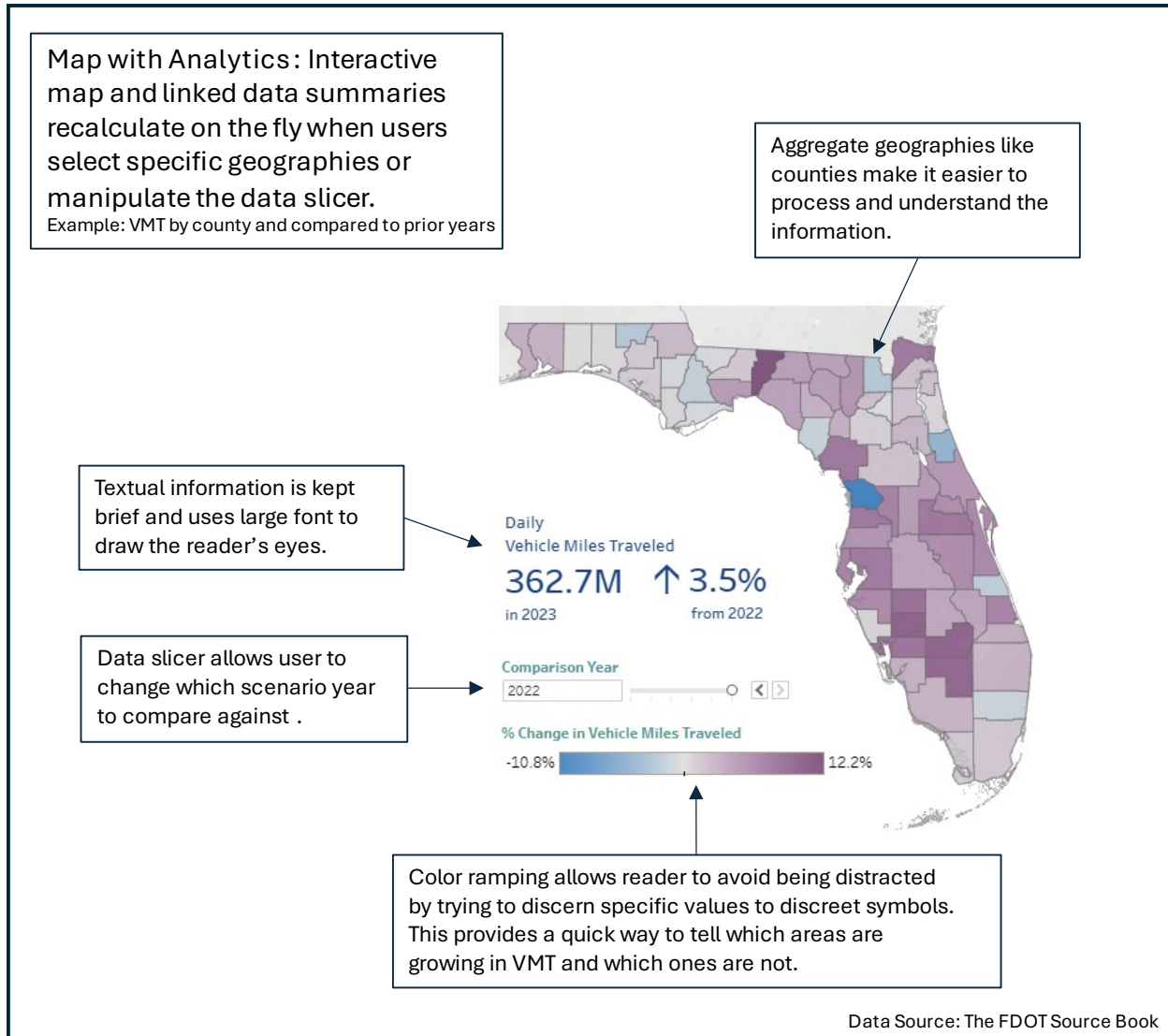
Data Source: CFRPM V7 TAZ Dashboard

The use of filtering can also allow for high-level summaries to be generated on the fly consistent with the needs of the user. Embedded tables can tie directly into the databases used and generated by the model to generate relevant information as needed. These data elements, such as maps, tables, and charts, can be "popped out" or maximized to make the information more legible and drill down into the details as needed.

Systems Forecasting & Trends Office

15

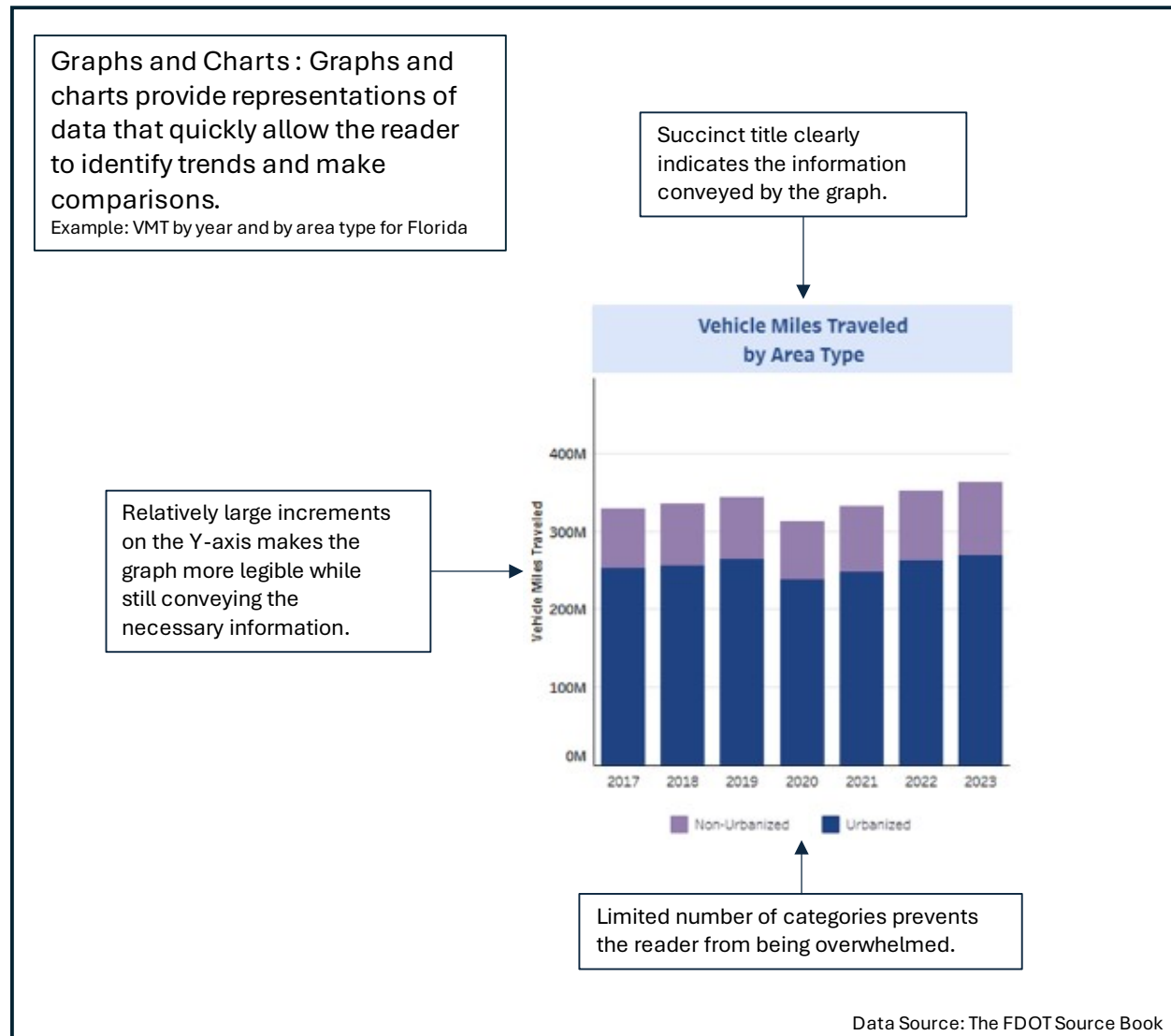
The close integration of various data elements allows for the development of a **map with analytics** that allows for the prominent display of key pieces of information. While these maps are most powerful when used interactively in the form of a dashboard, the resulting imagery can be incorporated easily into reports and presentations.



These maps should be designed in a way that intentionally highlights a particular piece of information that needs to be communicated. When relative metrics are the focus, the intention should be to convey how much more value there is in one location relative to other locations. Heat maps convey this sense well by not focusing on the discreet values associated with each color but rather allowing the reader to quickly survey the map and call out, for example, high-growth versus low-growth areas.

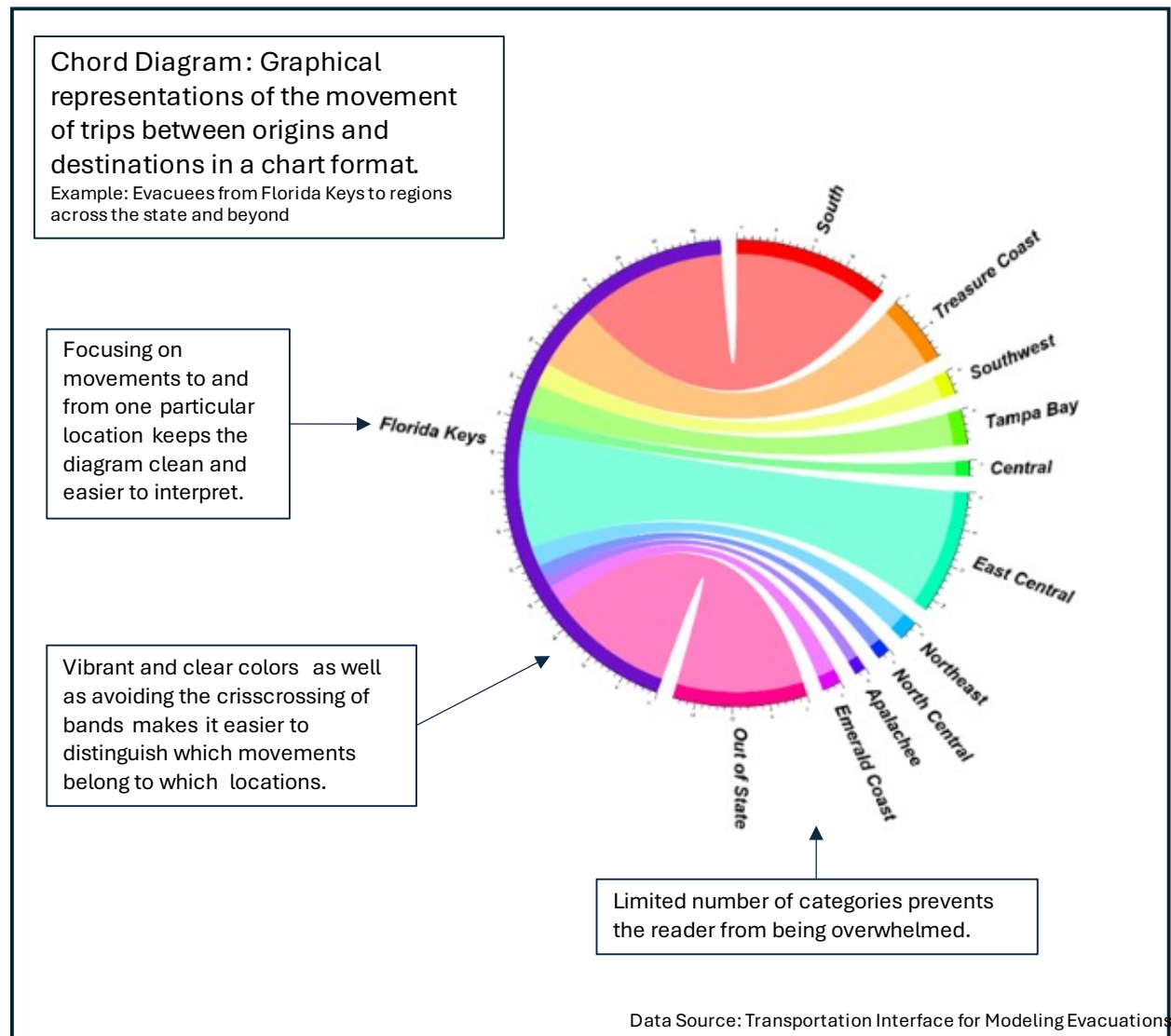
The textual and numerical information presented in the map should be limited to just the key points that need to be communicated. The use of large fonts not only makes it easier to see and digest this information but also focuses the attention of the user on the main point of the information being communicated.

Graphs and charts represent another way to visualize data. These visualizations make use of limited quantitative benchmarks combined with symbols showing the intensity of some metric in a way that makes drawing comparisons and inferring trends an intuitive process. While there are a large variety of chart and graph styles available, they all share similar elements. This includes the use of symbolism that shows relative levels of magnitude combined with a quantitative element such as an axis that allows the user to interpret the differences in magnitude.



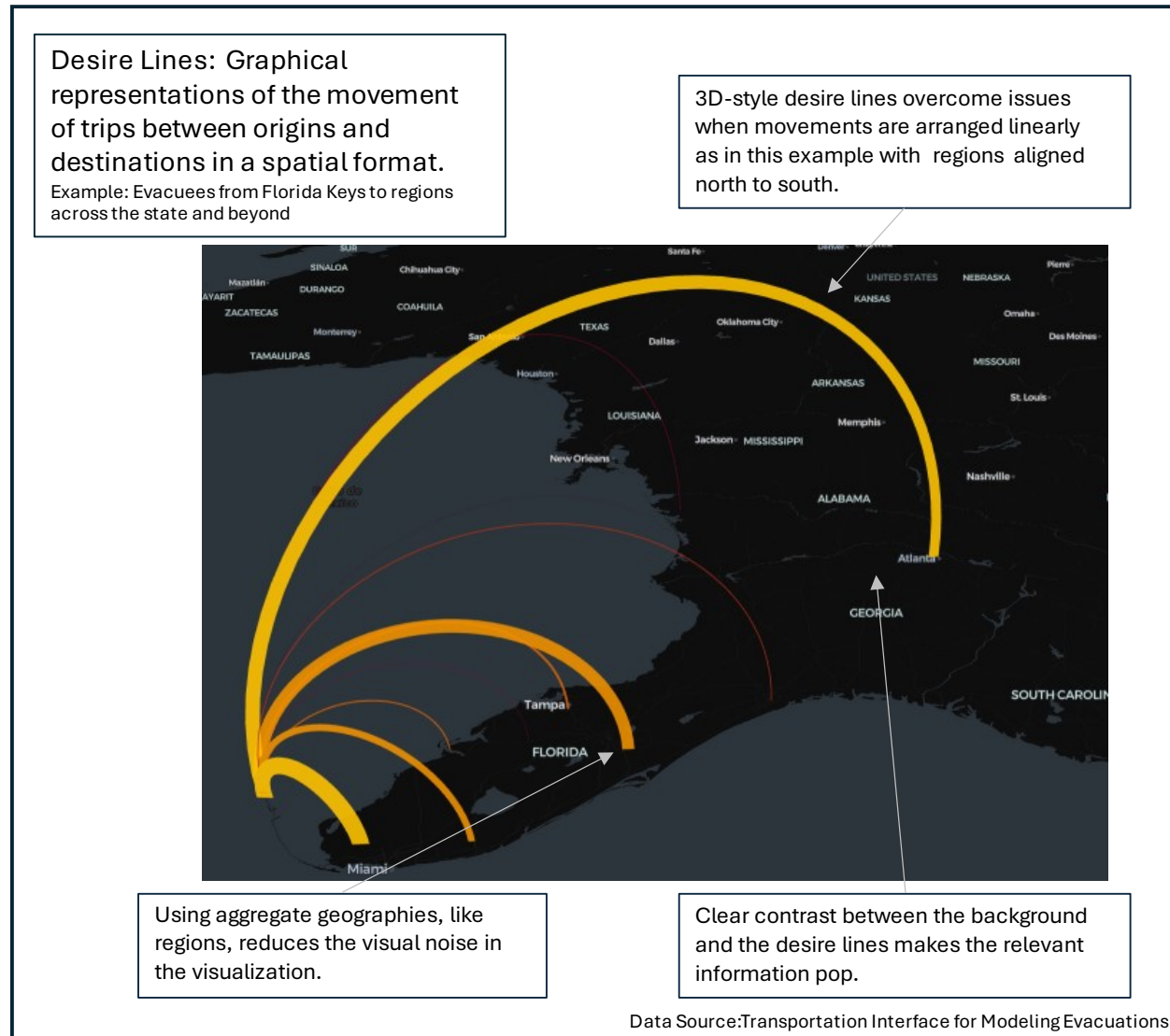
Furthermore, charts and graphs should have clear and succinct titles that indicate the nature of the information being communicated, as well as clear labels that identify magnitudes, categories, and subgroupings. Elements in the graph should be aligned in a way that is consistent with the nature of the information, such as showing historical information in a way such that by scanning the data, the reader naturally looks from earlier data to more recent data. The number of categories and subgroupings should be kept to an intelligible minimum. This should be no fewer and no more than what is needed to be able to draw meaningful comparisons. Too many categories may result in visual noise, making it difficult for the reader to effectively interpret the information.

Certain diagrams can also be used to demonstrate more complex interactions. A **chord diagram** makes it easy to show the movement of trips between origins and destinations. These diagrams ascribe sections of the circumference of a circle to different locations. The bands moving between sections of the circumference give a sense of the relative magnitudes of the movements between locations. The clarity of a chord diagram can be enhanced by using aggregate geographies such as counties, districts, or regions to reduce the number of potential locations. While these diagrams can display movements both to and from multiple locations, focusing on a single destination or point of origin at a time can reduce visual clutter.



Typically, chord diagrams coordinate the color of the bands with the origin of the trips; however, when focusing on a single point of origin, it may be more visually appealing to color code the bands according to destination. Accompanying such a diagram with a brief explanation will make it easier for the reader to interpret the information being presented. Thought should be given to how the locations represented along the circumference are ordered. For example, consider organizing the locations from closest to farthest from a particular point of reference. Showing a color-coded map corresponding to the colors in the diagram can also help with this.

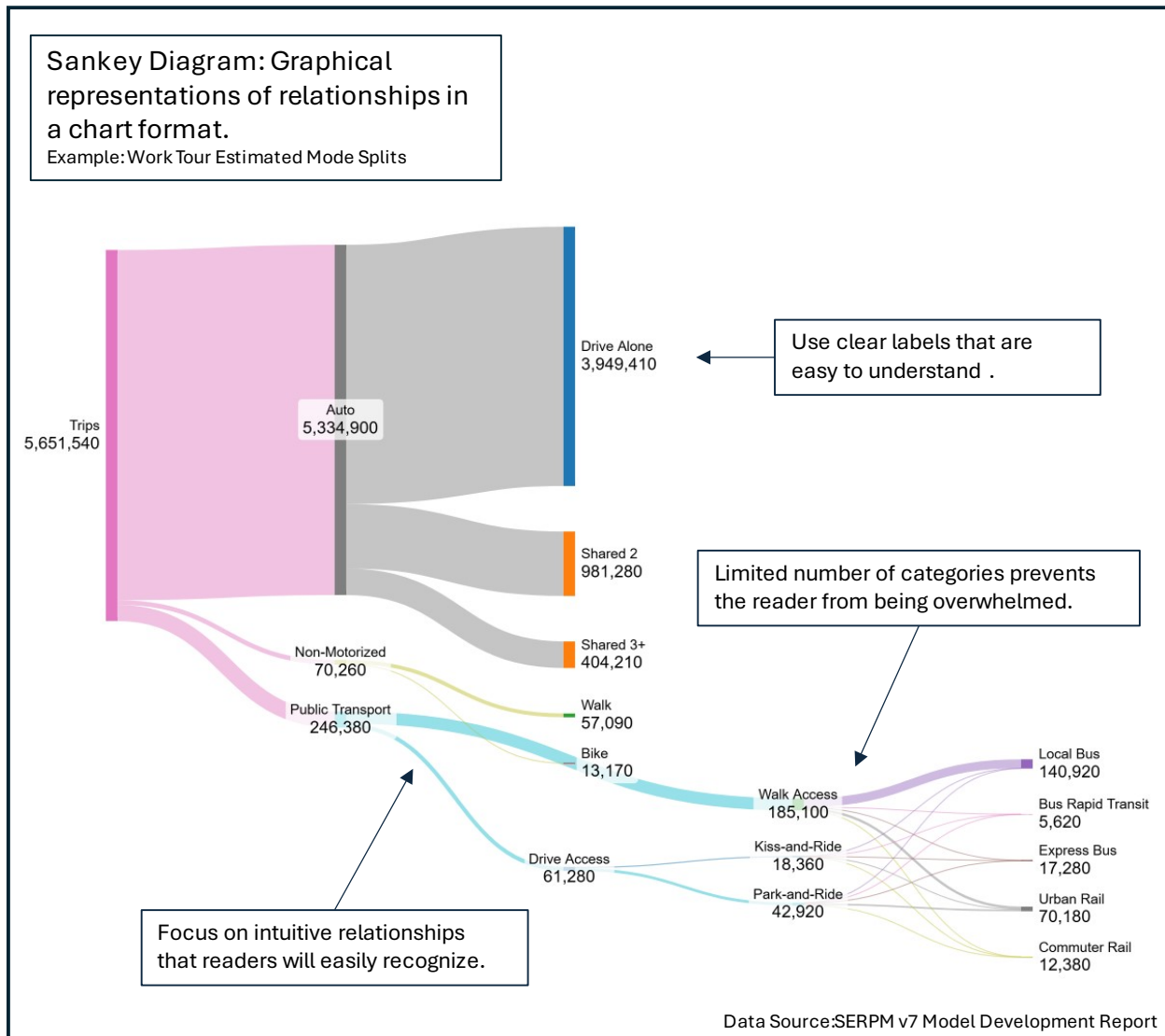
Relationships between origins and destinations can also be displayed visually using a **desire line** map. The thickness and color scheme of the lines drawn between origins and destinations can be used to visualize the magnitude of the relationships between them. Typical relationships from a travel demand model shown this way are trips moving from one area to another. Those outputs are generally provided at a TAZ-to-TAZ level and, when presented at that scale, can prove to be too cluttered as well as misleading. Aggregating origin-destination data to larger and more meaningful geographies makes it easier to understand and interpret this information.



While desire lines have typically been presented using flat 2-dimensional imagery, the resulting images could make it difficult to distinguish different lines if the relevant destinations were close to one another or arranged linearly, such as when multiple destinations are arranged from south to north. Rendering desire lines using 3-dimensional imagery allows the lines to be more clearly distinguished from one another, making it easier to understand what is happening in the image.

Desire lines are typically displayed on a map, so as with other mapping approaches, there should be a clear visual contrast between the information-bearing imagery of the map and the background imagery of the map.

A **Sankey diagram** can show more complex relationships than other data visualizations. While they can be used to demonstrate relatively simple interactions like origin-destination flows, they excel at visualizing tiered relationships or changes over time. Common non-transportation examples include energy flow diagrams. These diagrams can often make it easier for readers to navigate information that would otherwise need to be presented in data-dense tables that can be difficult for many people to interpret.



Sankey diagrams should focus on clear relationships that flow naturally from one level to the next. The reader should be able to intuit easily what the image is trying to convey. Consider how many tiers of data need to be portrayed and keep the number of categories at each tier to a manageable number. Sankey diagrams can quickly become overcrowded and thus negate the benefit of using them.