FORECASTING TOOLS IN A TIME OF UNCERTAINTY AND DISRUPTION

How strategic models can help practitioners plan for change

Maren Outwater, PE
Jonathan Slason, PE

RSG
the science of insight

Evaluating complex systems to forecast future conditions has never been simple, but recent disruptive technological changes such as automated, connected, electric, and shared (ACES) mobility options have added additional uncertainty to future forecasts.

In addition to technology, outside shocks to the system such as the COVID-19 pandemic have prompted actions unprecedented in modern times. These actions, and the changes in behavior brought about by the public and private sector efforts to "flatten the curve," will have short- and long-term effects on travel behavior.

Scenario planning tools can help practitioners anticipate and respond to demographic, policy, and travel changes in regions of interest. Responding to changes that have been underway for some time, as well as emerging changes like those brought about by the spread of COVID-19, requires planning tools that can help practitioners analyze the future based on different assumptions.

Ideally, these tools should provide a framework for the evaluation of a range of risk and risk responses. Among those in use, strategic models combine speed and detail, both of which are essential amid changing technological and travel conditions. Strategic models offer practitioners at state, regional, or local levels robust and cost-effective planning capabilities that are normally inaccessible or only achievable with significant resources and expertise.

Tools of the Trade

Over time, scenario planning has grown in usefulness and capability. Scenarios can be developed and analyzed for long-range plans and to understand near-term strategic choices. The recent increase in the availability of data, and the computational power required to analyze these data, has bolstered scenario planning's exploratory analysis capabilities.

Practitioners can undertake scenario planning using myriad methods and tools. While this white paper provides an overview of several tools, its focus is on strategic models, which offer advantages when compared to other tools:

- **Integrated models and network-based travel demand models** incorporate multiple travel, economic, land-use, and other models to represent their diverse, dynamic, and interrelated aspects.
- **Sketch planning tools** are used to produce rough order-of-magnitude travel demand estimates for different scenarios.
- **Strategic models** are travel demand models that use a disaggregate demand representation with an aggregate representation of the transportation network supply. These models can help practitioners quickly analyze hundreds or thousands of scenarios.

By running these tools with a range of input assumptions, practitioners can evaluate the differences between alternatives using a broad range of metrics. Table 1 compares various tools across several criteria.

Strategic models include more complex behavioral representations than sketch planning tools but less network characteristic specificity than travel demand models. They balance rapid computation with accurate representation. By using a high-level zonal geography rather than a network, these tools can quickly evaluate multiple alternative scenarios.

INTEGRATED MODELS AND NETWORK-BASED TRAVEL DEMAND MODELS

Integrated models include a network-based travel demand model onto which they assign trips by origin, destination, mode, and time of day. These types of models are more sophisticated and can produce detailed performance metrics. Longer run times and more complexity make them better suited to exploring a smaller decision space and evaluating fewer variations (e.g., land-use changes, modal availability, congestion pricing). These models require expertise and detailed data to develop and maintain.

One of the biggest barriers to using an integrated model for modeling future scenarios is that coding multimodal networks, especially for future years, is a labor-intensive and time-consuming process. The large number of model parameters and the connections between the models requires more effort and time, which may not be warranted by the analysis.

The design of integrated models relative to other scenario planning tools makes them less nimble. This downside is apparent when forecasting the aggregate impacts of emerging technologies or when exploring scenarios farther into the future where more uncertainty exists. With the political and technological landscape around ACES mobility evolving so quickly, and the travel impact of COVID-19, modeling many scenarios with network-based travel demand models would be cost prohibitive and time consuming.

TABLE 1. COMPARISON OF TOOLS

TOOL TYPE	SPATIAL/ TEMPORAL DETAIL	PERSON/ HOUSEHOLD DETAIL	POLICY SENSITIVITY	RUN TIME	COST
Integrated Model (trip-based)	low-moderate	moderate	moderate	moderate	moderate-high
Integrated Model (activity-based)	moderate-high	high	moderate-high	moderate	moderate-high
Sketch Planning	low	low	low	low	low
Strategic Model	low-moderate	moderate-high	moderate-high	low	low

Source: RSG, 2020

SKETCH PLANNING TOOLS

Sketch planning tools have been around since the early 1990s, coinciding with the rise of geographic information system (GIS) capabilities. Several sketch planning tools operate as extensions to GIS (e.g., CommunityViz), while others use Microsoft Excel spreadsheet models (e.g., Envision Tomorrow and Mixed-Use Trip Generation Model – MXD), independent software (e.g., UrbanFootprint), or online (e.g., SPARC/INDEX) platforms. These tools support various geographic scales, including work at the site, corridor, municipal, regional, or statewide level. The abundance of sketch planning tools is due to their relatively low cost to develop and minimal data requirements. Sketch planning tools excel at producing quick, rough estimates for a limited range of land-use and policy scenarios. To create scenarios, most sketch planning tools require users to define land-use alternatives using GIS visuals that are then linked to spreadsheet analyses. The travel demand estimates of sketch planning tools are simplistic and are often tied directly to land-use types (as opposed to being network based).

One advantage of sketch planning tools is they include diverse sustainability impacts in their analyses. Often, sketch planning tools have modules on health, agricultural impact, and natural resource management. This emphasis makes sense since these tools are focused on a wide range of performance measures/outcomes for a typically less-technical audience. That said, the exact scenario-development capabilities vary widely depending on the tool. In addition, since several sketch planning tools are integrated with mapping platforms, they are—by design—visually robust and can produce high-quality mapped outputs.

STRATEGIC MODELS

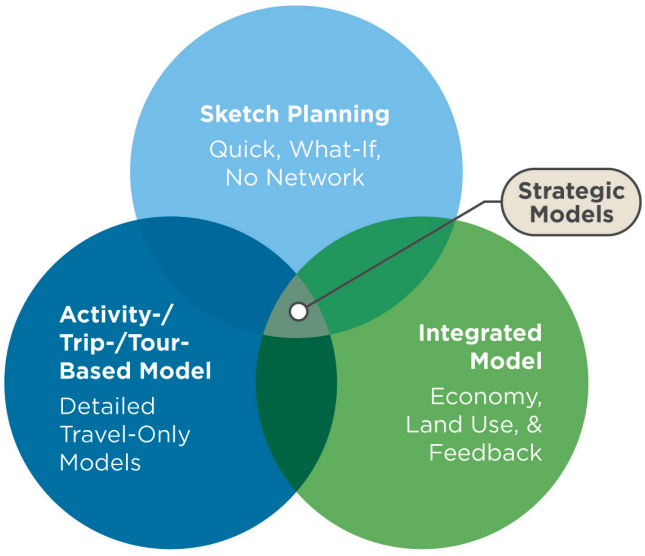
Strategic models occupy a middle ground between sketch planning tools and complex integrated models (Figure 1). They have been implemented in a few different platforms, including in R, an open source data science programming language. Some also have a graphical user interface (GUI) for user interaction and output visualization. Strategic models are useful for exploratory testing. These tests can include evaluating diverse policy and investment alternatives at regional or statewide scales. However, since they do not include network models, they are less appropriate for evaluating specific projects or corridors, like determining if a highway segment should be widened or made into a tollway.

Structurally, strategic models are "disaggregate demand/aggregate supply" models. They combine the rich demographic and socioeconomic detail of simulated households with aggregate treatments of travel (multimodal travel and congestion without using a network or explicit trips). Strategic models simulate a synthetic household population—a characteristic shared with activity-based travel demand models. By creating a synthetic set of individual households, each associated with a household income and vehicle ownership, among other characteristics, strategic models can examine equity effects and the impacts of fuel prices, pricing policies, service prices, and other factors on mode choice and travel behavior.

Strategic models are like integrated models in that they can account for the interplay between

continued on page 5

FIGURE 1. STRATEGIC MODEL NICHE



Source: Oregon DOT, 2019 (adapted by RSG)

Strategic Models in Action

AUTOMATED, CONNECTED, ELECTRIC, AND SHARED MOBILITY

Strategic models can help practitioners explore the uncertainty around disruptive technologies. These tools excel at modeling the rapid technological changes underway in the personal mobility space. Strategic models can help forecast how the increased availability of automated, connected, electric, and shared (ACES) mobility technologies could reduce personal vehicle ownership. They do this by modeling the competitiveness of various modes chosen by users.

Strategic models can also evaluate various futures related to automation. Will the future transportation system be built around fewer private vehicles? What percentage of vehicles will be electric and how will this reduce operational costs/emissions? Will more users opt for shared, automated vehicles or public transit and active modes, such as e-scooters and bikes? Will congestion be less of a concern from the road user's perspective since automated vehicle occupants can maximize their in-vehicle travel time? Strategic models can help practitioners answer questions like these by accounting for specific geography, transportation network, land-use, and socioeconomic profiles.

Ride-Hailing
Carsharing
Robotaxis

Electric Passenger Vehicles
Electric Commercial Vehicles
Electric Vehicle Supply Equipment

Work From Home
Telemedicine
Contactless Delivery

POTENTIAL CHANGES BROUGHT ABOUT BY COVID-19

Strategic models can quickly and efficiently evaluate many future scenarios, which makes them ideal to help evaluate system-wide change. The spread of COVID-19 has resulted in widespread global uncertainty that has roiled markets and challenged policy makers. In response, governments have raced to contain the disease by enacting a combination of social distancing guidelines and travel restrictions.

The result of all these rapid changes has been an immediate and dramatic shift in how and where people travel, which strategic models can help plan for. A sizeable percentage of workers and their employers may decide to negotiate varying degrees of work-from-home flexibility going forward. This could result in far fewer people commuting to work in some regions. Working from home may also increase home delivery options and demand for active travel. The associated risks of crowding are also affecting demand for high-capacity transit options. Strategic models can help assess the short- and long-term effects of these changes over several time frames and across multiple scenarios.

transportation and socioeconomic factors, such as mode choice, household budget, and neighborhood density. However, the components of strategic models have less interaction, or are more loosely coupled, than in an integrated model. In addition, strategic models require much less precise data and more easily accommodate new policies and features. This makes them faster and more effective than integrated models at covering a broader range of factors to explore a larger decision space.

Strategic Models

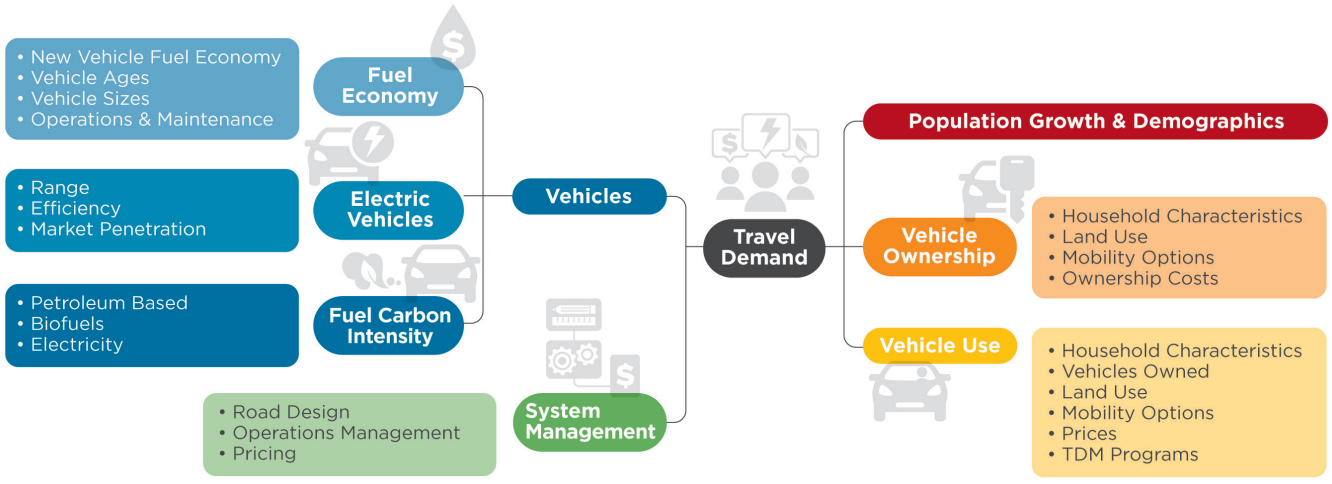
EVOLUTION OF STRATEGIC MODELS

Strategic models were originally developed by the Oregon Department of Transportation (ODOT). Their development was prompted by the realization among practitioners that existing models did not sufficiently address the diverse set of factors that impacted emissions (Figure 2), such as future vehicle types and fuels. Previous models were also primarily designed to examine system performance during peak periods. Strategic models closed this capability gap.

The Greenhouse gas Statewide Transportation Emissions Planning (GreenSTEP) model was the first strategic model for statewide use; this model was later adapted for metropolitan applications. The Federal Highway Administration (FHWA) altered the GreenSTEP model to make the tool available and more accessible for other states across the country to use. The resulting Energy and Emissions Reduction Policy Analysis Tool (EERPAT) is largely identical to GreenSTEP; however, some revisions were made to the model to add estimated submodules for state-specific components. FHWA also added a GUI to make the tool accessible to practitioners without any R experience.

FHWA periodically updates EERPAT (version 4.0 in 2017), which now includes a freight model built on FHWA Freight Analysis Framework commodity flow data. Upgrades in the latest version also include improved life-cycle capabilities to analyze wheels-to-well emissions and updates to enhance the model interface with Environmental Protection Agency tool MOVES (MOtor Vehicle Emission Simulator).

FIGURE 2. FACTORS CONSIDERED IN OREGON STRATEGIC MODELS



Source: Oregon DOT, 2020 (adapted by RSG)

The latter enhancement allows users to employ the two conjointly in scenario planning. Practitioners can use EERPAT to screen multiple policy scenarios, while MOVES can perform more detailed modeling for a small subset.

FHWA also developed the Rapid Policy Assessment Tool (RPAT) using the GreenSTEP codebase, although more substantial revisions were made than with EERPAT. RPAT functions at the regional level and was designed to help practitioners evaluate the effects of smart growth policies on regional travel demand. Compared to ODOT's regional model of GreenSTEP (Regional Strategic Planning Model, or RSPM), RPAT uses the distinction between types of land use and calculates household travel based on the place type (Table 2) in which the household is located rather than calculating individual household vehicle ownership.

VISIONEVAL STRATEGIC MODELING SYSTEM

The GreenSTEP family of models evolved on an ad-hoc basis. FHWA and ODOT codeveloped the VisionEval framework, which formalized a common structure for all GreenSTEP-related models and created a software system to support implementing that structure. VisionEval is the open-source platform that now includes RSPM and RPAT, as well as an expanded statewide RSPM version, VEState. VisionEval is maintained and available on GitHub. Each model is briefly summarized in Table 3 and as follows:

- **VisionEval Rapid Policy Assessment Tool (VERPAT)**. The RPAT model was merged into the VisionEval framework as VERPAT. This model operates at a regional level using place types to distinguish between different development types and land uses within the region. Operating at the place-type level allows VERPAT to capture detailed interactions between transportation and land use while simplifying the input data requirements and minimizing run times.
- **VisionEval Regional Strategic Planning Model (VERSPM)**. RSPM was brought into the common software framework as VERSPM. VERSPM models the region in zones, similar to traditional travel analysis zones. By using inputs at the zonal level, VERSPM outputs more detailed results in terms of spatial resolution compared to VERPAT, but it also requires more effort to develop the input data.
- **VEState**. The VEState model is the most recent addition to the suite of VisionEval models and the only one that functions at the state level. It uses zones, often at the county level, for subarea analysis.

The selection of the right tool depends on the spatial level of analysis, the types of policies and investment decisions requiring evaluation, and the desired level of input and output detail.

TABLE 2. PLACE TYPES USED IN RPAT

		REGIONAL ROLE (AREA TYPES)			
		URBAN CORE	CLOSE-IN COMMUNITY	SUBURBAN	RURAL
Neighborhood Character (Development)	Residential	✓	✓	✓	–
	Commercial	✓	✓	✓	–
	Mixed-Use	✓	✓	✓	–
	Transit-Oriented Development	✓	✓	✓	–
	Rural/Greenfield	–	–	–	✓

Source: Oregon DOT/Oregon Department of Land Conservation and Development, 2020 (adapted by RSG)

Integrating Strategic Models Into the Planning Process

Strategic models can quickly and efficiently evaluate many future scenarios. This allows practitioners to explore futures based on changed circumstances and behaviors—including behaviors that *might* happen but have not yet been observed. Such hypothetical behavior shifts could include changes in vehicle ownership due to the accessibility and affordability of ride-hailing services. Changes could also include a rise in the percentage of employees who work from home and no longer commute on all or most days.

Strategic models are best used after policy goals have been identified by the planning agency involved, though they can also be used to inform decision makers in the policy development process. They can help practitioners prioritize strategies and identify those that are most effective at meeting planning goals. These models are a fitting tool for early work in the long-range transportation planning process since they are designed to evaluate several possible future conditions, identify high-return policies, and investigate the effects of various investment options. The permutations of all these options are numerous, which can make detailed network modeling expensive and time consuming.

Inputs vary across the VisionEval modeling platform (Table 4). VERPAT has about half the required input files as VERSPM. While they all require development of some region-specific inputs, other inputs are optional and can be run as defaults. The inputs can be grouped by changes in demographics and land use, policy and pricing, and changes in supply.

TABLE 3. SUMMARY OF STRATEGIC MODEL CHARACTERISTICS

	VERPAT	VERSPM	VESTATE
Geography Level	Regional	Regional	Statewide
Zonal Structure	Activity allocated to place types	Zones (TAZs) & aggregate zones (typically cities or counties) & M areas (metropolitan areas)	Simulated zones by area type & aggregate zones (typically cities or counties) & M areas (metropolitan areas)
	VERPAT	**VERSPM/VESTATE**	
Automated & Connected Modes	Fewer ITS improvements to reduce nonrecurrent congestion	Automated ride-hailing; number of ITS investments that can smooth traffic flow and reduce nonrecurrent congestion	
Electric Modes	PEV types and characteristics are applied globally per model year	User-specified powertrains for all vehicles except household vehicles; household PEVs are simulated based on cost, availability, daily VMT range, and charging infrastructure availability	
Shared Modes	TDM programs (carpooling, vanpooling, carshare), define proportion of SOV trips suitable to active modes (micromobility, bikes); used globally in model area	Ride-hailing, carsharing, personal lightweight vehicles, define proportion of SOV trips suitable to active modes; defined per A zone	
Output Granularity	Results by place type	Results by zones and metropolitan areas	
	VERPAT/VERSPM/VESTATE		
Policies	Pricing, modal availability, land use, and demand management, among others		

Notes: ITS – Intelligent Transportation System
TAZ – Traffic Analysis Zone
PEV – Plug-in Electric Vehicle
TDM – Travel Demand Management
SOV – Single-Occupancy Vehicle
Source: RSG, 2020

Strategic models produce several performance measure outputs that practitioners can use to identify high-return policies and the effects of various infrastructure and land-use changes. Key outputs include vehicle miles traveled, travel costs per household, and energy consumed and greenhouse gas emissions. Table 5 shows one of many possible sets of VERSPM standard output metrics summarized at the regional level.

Users can evaluate the effects of specific policies or investment decisions by reviewing tabular model outputs and the scenario viewer tool. This tool within VisionEval groups various input files into categories and can visually identify which input variables may be responsible for the output desired.

The future land-use and demographic conditions, policies, and investments that best align with the regional goals are then refined and fed into the planning process as shown in Figure 3. Incorporating strategic models can streamline the scenario planning process by identifying the highest-return policies and investments that practitioners can further model

TABLE 4. VISIONEVAL INPUTS

CHANGES IN DEMOGRAPHICS AND LAND USE	LOCAL POLICY ACTIONS AND PRICING	CHANGES IN TRANSPORTATION SUPPLY
• Changes in population & demographics • Changes in average income per capita • Changes in employment • Changes in the proportion of houses located in mixed-use and unprotected areas available for development • Residential & workplace PEV charging infrastructure	• Parking pricing programs • Demand management policies • Suitability for active transportation • Diversion of SOV trips by bikes, e-scooters, or other personal modes • Road cost recovery • Congestion fees • Pay-as-you-go insurance & other road fees • VMT fee	• Changes in freeway & arterial lane miles • Powertrain proportions for light-duty, transit, & heavy-duty vehicles (by ICE, HEV, & PEV) • Ride-hailing & carsharing availability, substitutability, & access time • Amount of regional transit service • ITS strategies for freeways & arterials

Notes: HEV – Hybrid-Electric Vehicle; ICE – Internal Combustion Engine; ITS – Intelligent Transportation Systems; PEV Plug-in Electric Vehicle; SOV – Single-Occupancy Vehicle; VMT – Vehicle Miles Traveled
Source: VisionEval Project, 2019

TABLE 5. STANDARD STRATEGIC MODEL OUTPUT METRICS

VERSPM PERFORMANCE METRICS	
Mobility	Daily VMT per capita
	Daily walk trips per capita
	Daily bike trips per capita
Economy	Annual all-vehicle delay per capita (hours)
	Annual household parking costs
	Annual household vehicle operating cost
	Annual household ownership costs
Land Use	Residents living in mixed-use areas
	Housing types
Environmental	Annual GHG emissions per capita
	Household vehicle GHG per mile
	Commercial vehicle GHG per mile
	Transit vehicle GHG per mile
Energy	Annual all-vehicle fuel consumption per capita (gallons)
	Average all-vehicle fuel efficiency (net MPG)

Notes: GHG – Greenhouse Gas; MPG – Miles per Gallon; VMT – Vehicle Miles Traveled
Source: VisionEval Project, 2019

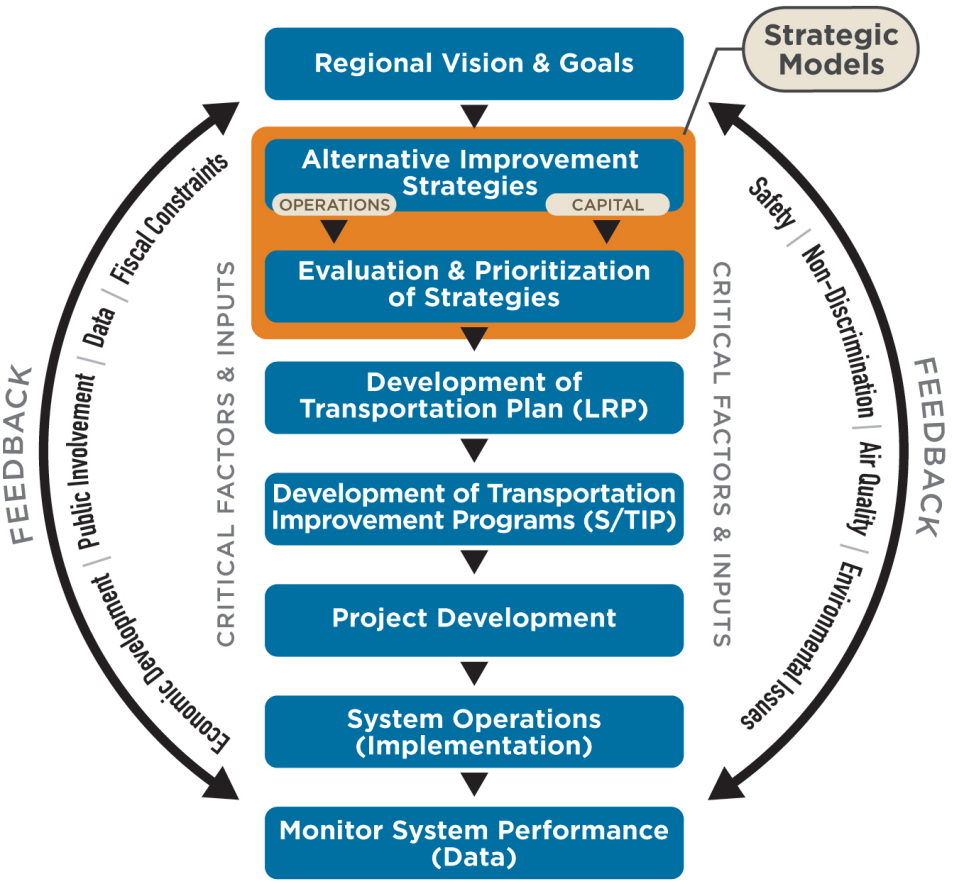
and assess in more robust assessment tools. This economical process reduces the number of model scenarios, network options, and runs in the regional or statewide travel demand model.

Strategic Models and Disruptive Technologies

Strategic models can explore the uncertainty around disruptive technologies. Several model input files define the implementation extent and efficiency of intelligent transportation systems. Some model inputs also define vehicle powertrain-type proportions for different fleets. For VERSPM and VEState, the user can also define the percentage of residences with electric vehicle charging availability (plus workplace electric vehicle charging for VEState).

In the VERSPM and VEState models, users can employ the car service mode to model diverse modes, including traditional carshare services, taxis, ride-hailing services, and automated "robotaxi" services. The model recognizes two levels of car service, low and high, and users can define characteristics of both. For example, users could employ the low level of car service to model carshare; the high level of car service could model ride-hailing or automated vehicle services.

FIGURE 3. STRATEGIC MODELS IN PLANNING PROCESS



Source: FHWA Office of Operations, 2020 (adapted by RSG)

By default, VERSPM and VEState both define the high level of car service as having costs and access times comparable to owning a private car. Users can define areas with car service availability, average cost per mile, average age of car service vehicles in years, and access times. Users can also select the proportion of both automobile and light-truck owners who would substitute a less-costly car service option with owning a vehicle. Adjusting these inputs can affect the competitiveness of car services and simulated household vehicle ownership.

VisionEval developers are pursuing more capabilities, including different levels of vehicle occupancy for car services and privately owned automated vehicles. The ability of VisionEval models to explore disruptive technologies, including but not limited to ACES, is a focus area for future development. The National Cooperative Research Program's Report 896, published in 2018, identified ways to improve strategic models to account for disruptive technologies. Other areas targeted for improvements include mobility, accessibility, connectivity, and equity.

Conclusion

Strategic models occupy a unique niche within the large array of modeling tools. These models offer practitioners at state, regional, or local levels planning capabilities that are normally inaccessible or only possible with significant effort, investment, and expertise. Strategic models can also quickly and cost-effectively cover multiple policy inputs and community outcomes.

The ability of strategic models to flexibly and quickly run hundreds of scenarios makes them ideal for exploring uncertainty in the planning process. They can help quantify the impacts of emerging and disruptive technologies, or unexpected shocks to the system such as the COVID-19 pandemic, that have short- and long-term travel implications. They are a good fit for metropolitan and statewide long-range plans.

Practitioners can employ strategic models as a stand-alone tool or as a complement to other types of modeling. They can help define areas of interest for further research and exploration. Moreover, integrating strategic models with existing tools and planning processes will enhance the ability of users to explore the effects of changes in pricing policies, new modes, investments in the supply of vehicular or transit infrastructure, and demographics for years to come.

Visit rsginc.com/strategicmodels to discover how strategic models can help your organization plan for change.

Sources

1. Börjeson, Lena & Höjer, Mattias & Dreborg, Karl-Henrik & Ekvall, Tomas & Finnveden, Göran. (2006). "Scenario Types and Techniques: Towards a User's Guide." Futures. 38. 723-739. 10.1016/j.futures.2005.12.002.

2. Car Service and Autonomous Vehicle Model. https://rawcdn.githack.com/gregorbj/RSPM/a5702f888f5670b6a34feb81a229c4395d46736e/Documentation/RSPM_V3.6_AV-Model_Code&Testing.html.

3. Development Roadmap (VisionEval). https://github.com/VisionEval/VisionEval/wiki/Development-Roadmap.

4. EERPAT – Energy and Emissions Reduction Policy Analysis Tool. https://web.archive.org/web/20170507074932/https://www.planning.dot.gov/FHWA_tool/Download.aspx.

5. Environmental Protection Agency. "MOVES (MOtor Vehicle Emission Simulator." https://www.epa.gov/moves.

6. Lee, Amy, Fang, Kevin, & Handy, Susan (2017). "Evaluation of Sketch-Level VMT Quantification Tools: A Strategic Growth Council Grant Programs Evaluation Support Project." UC Davis: National Center for Sustainable Transportation. Retrieved from https://escholarship.org/uc/item/08k3q8m5.

7. NCHRP Research Report 896: Updating Regional Transportation Planning and Modeling Tools to Address Impacts of Connected and Automated Vehicles, Volume 2: Guidance: http://www.trb.org/Main/Blurbs/178393.aspx.

8. Oregon Department of Transportation. "GreenSTEP Model Overview." https://www.oregon.gov/ODOT/Planning/Documents/GreenSTEP-Model-Overview.pdf.

9. Oregon Department of Transportation. "Place Types." https://planningtools.transportation.org/files/124.pdf.

10. R Project Website. https://www.r-project.org/.

11. RSG Open-Source Tools Website. https://rsginc.com/open-source/.

12. VE Concepts Primer. https://github.com/VisionEval/VisionEval/wiki/VE-Concepts-Primer.

13. VERSPM Scenario Viewer. https://htmlpreview.github.io/?https://github.com/VisionEval/VisionEval/blob/master/sources/VEScenarioViewer/verspm.html.

14. VE-RSPM Training Workshop. https://github.com/gregorbj/Archive-VisionEval/wiki/VERSPM-Training/VE-RSPM_Training_Draft_Slides_3-15-19.pdf.

15. VisionEval. https://github.com/visioneval/visioneval.

Contact Us

Maren Outwater, PE
VICE PRESIDENT
maren.outwater@rsginc.com

Jonathan Slason, PE
DIRECTOR
jonathan.slason@rsginc.com

RSG
the science of insight

rsginc.com