October 13, 2022

Integrating Exploratory and Simulation Modeling into Regional Transportation Planning

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RTC

U.S. Department of Transportation
Federal Highway Administration

Map Background Source: Google Maps

Disclaimer

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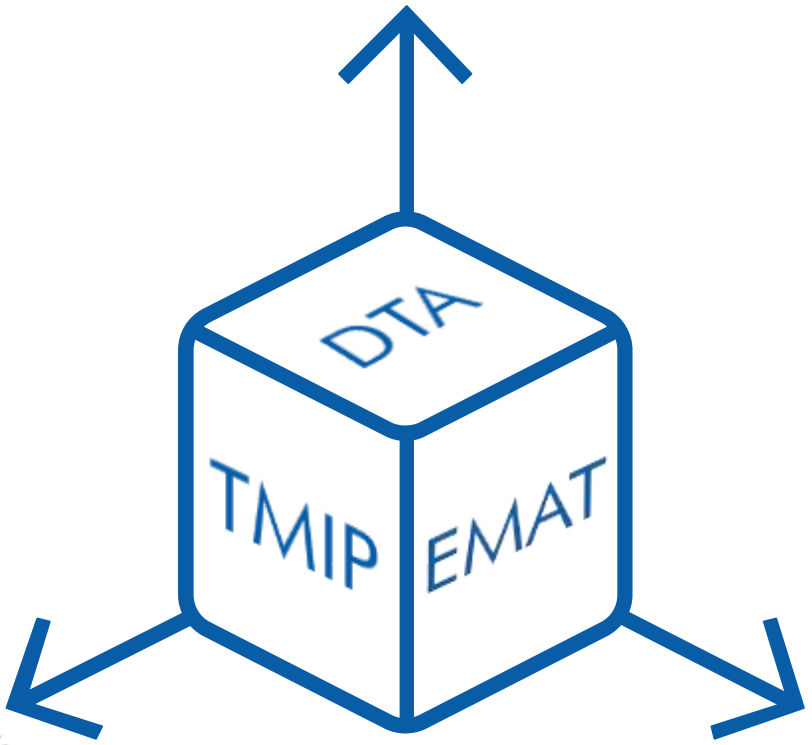
U.S. Department of Transportation
Federal Highway Administration



RTC

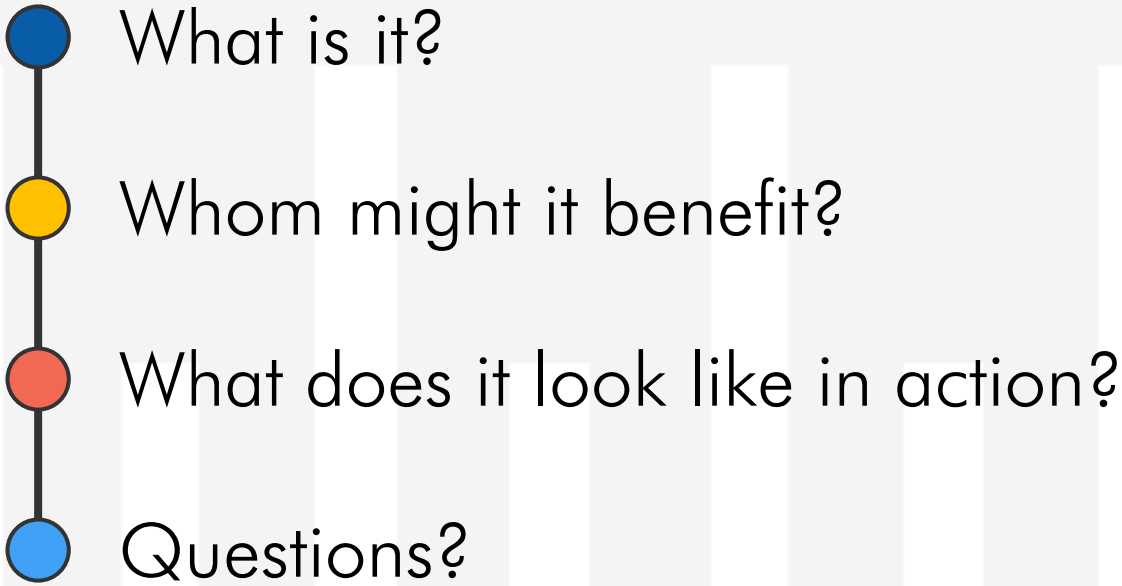
Caliper Corporation

Premise:

Formally Introduce EMAT+DTA

- Research spearheaded by FHWA/TMIP
- Project managed and Models supplied by RTCSNV
- Software development and applications research by Caliper

Exploratory & Simulation Modeling



Exploratory & Simulation Modeling

What is Exploratory & Simulation Modeling?

EXPLORATORY MODELING AND ANALYSIS (EMA)

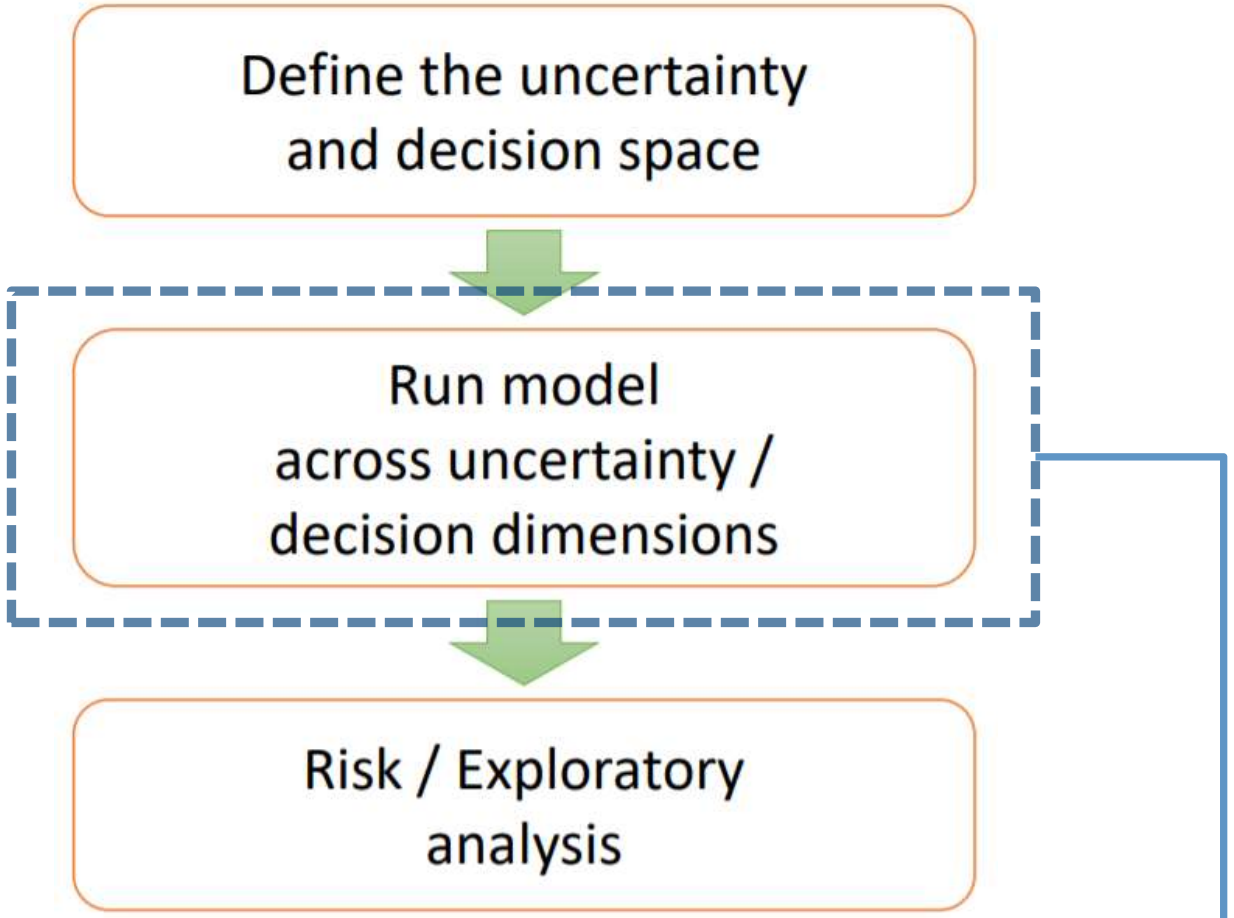
- An analytic framework
- A way to manage assumptions when they are subjects of deep uncertainty
- A decision-making tool that leverages existing models in new, different ways
- An alternative to traditional scenario analysis when number of possible outcomes is too high for that approach

RTC SIMULATION MODELS for REGIONAL TRANSPORTATION PLANNING (RTP)

- Travel demand forecasting
- Project prioritization
- Project evaluation
- Alternatives analysis

What is EMA?

Big picture

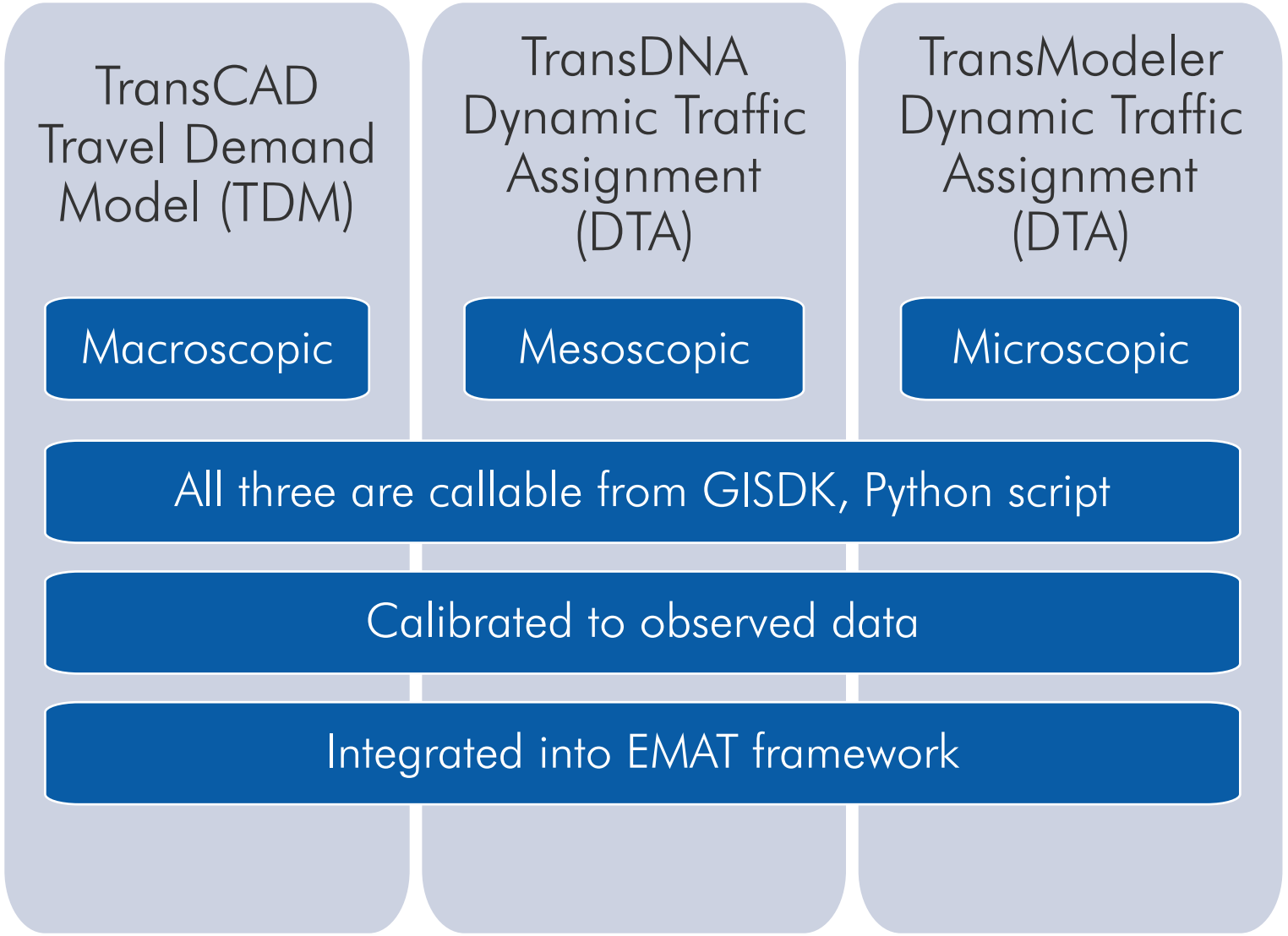


@ Oregon DOT presentation, May 28, 2020

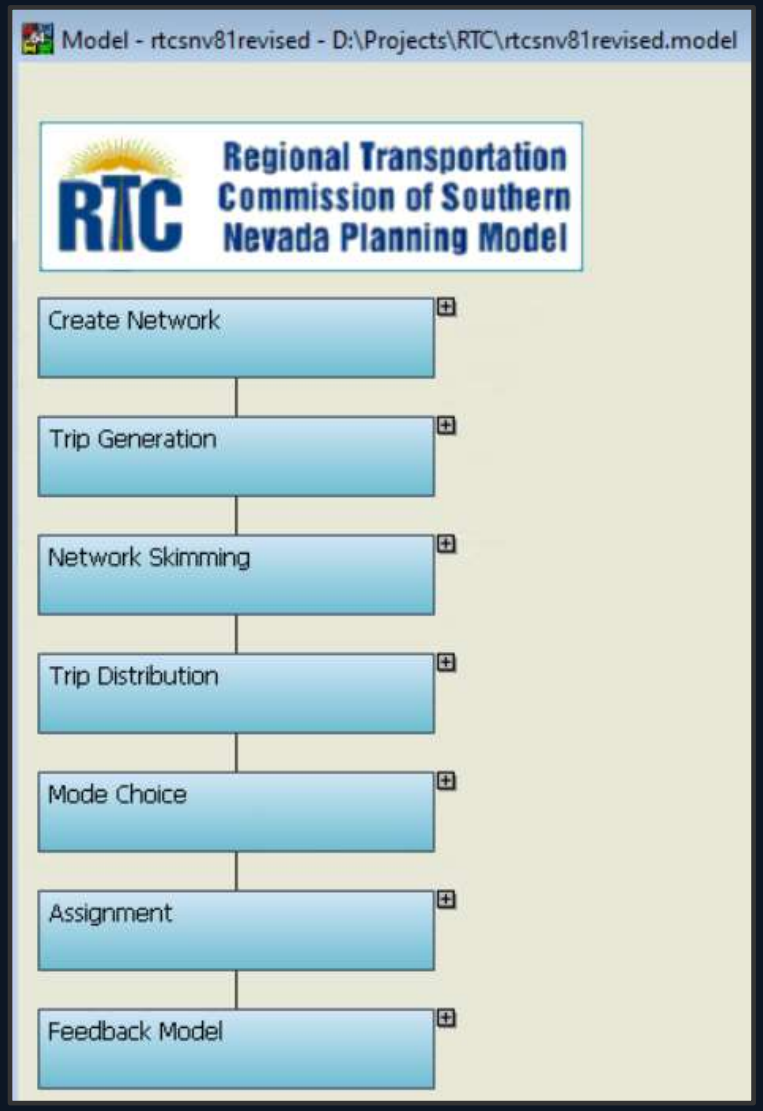
Requires a core model to evaluate pre-selected performance metrics

What are the Core Models?

Three regional models developed previously by and for the RTC



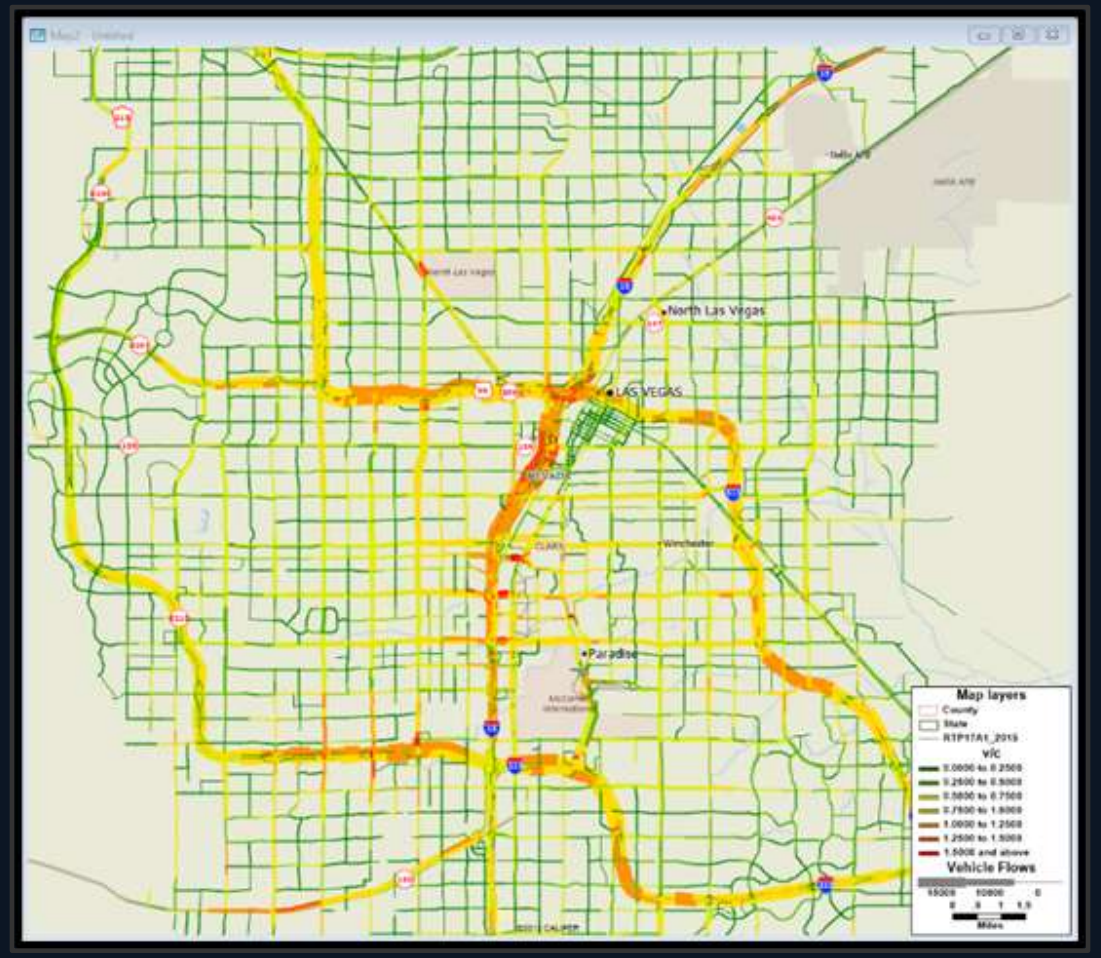
TransCAD Travel Demand Model



Key Features

- Base year and long-range forecasting
- Four-step and advanced paradigms
- Easy-to-use flowchart interface
- Cutting-edge public transit, traffic assignment methods
- Native Geographic Information System (GIS) for data analysis, visualization
- High computational efficiency

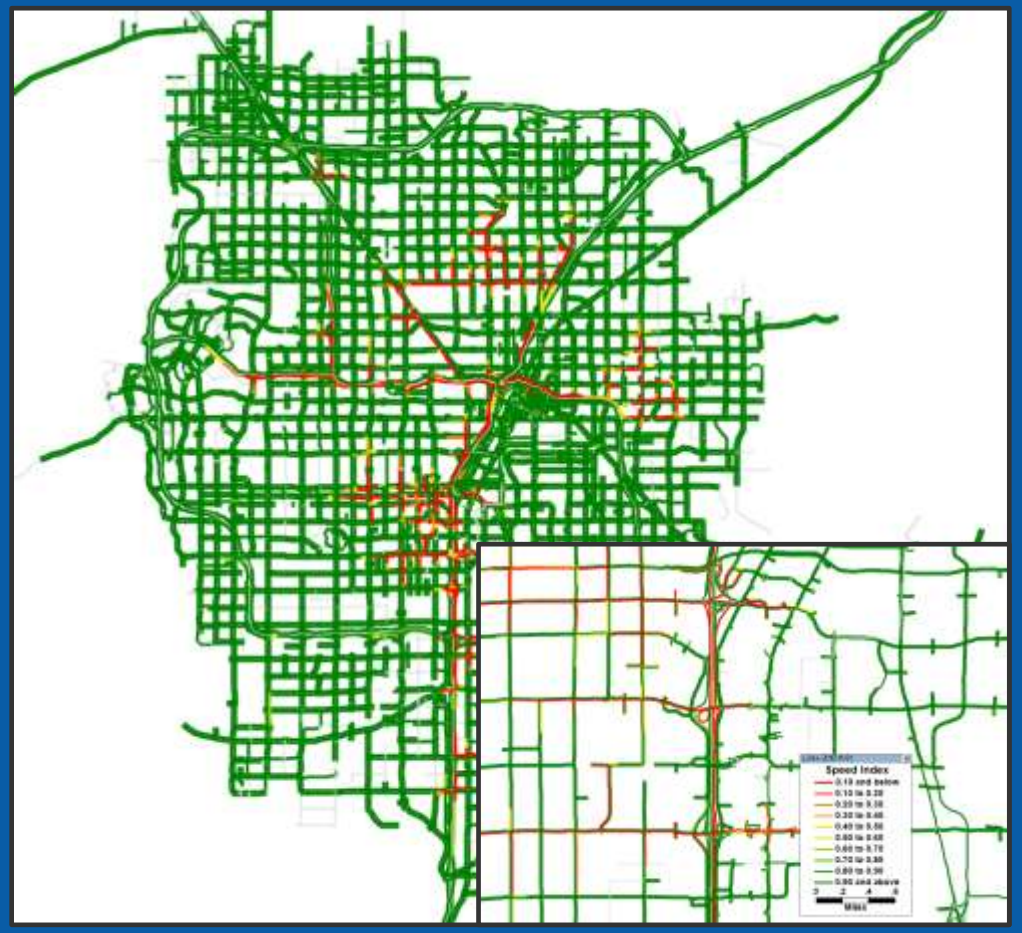
TransCAD Travel Demand Model



Potential Scenario Applications

- Demand changes due to demographic, employment shifts
- Mode shifts due to new modes, operations changes
- Tolls, fares, service parameters (e.g. headways)
- Impacts of proposed highway projects
- Capacity increases, speed limit changes
- New facilities/connections

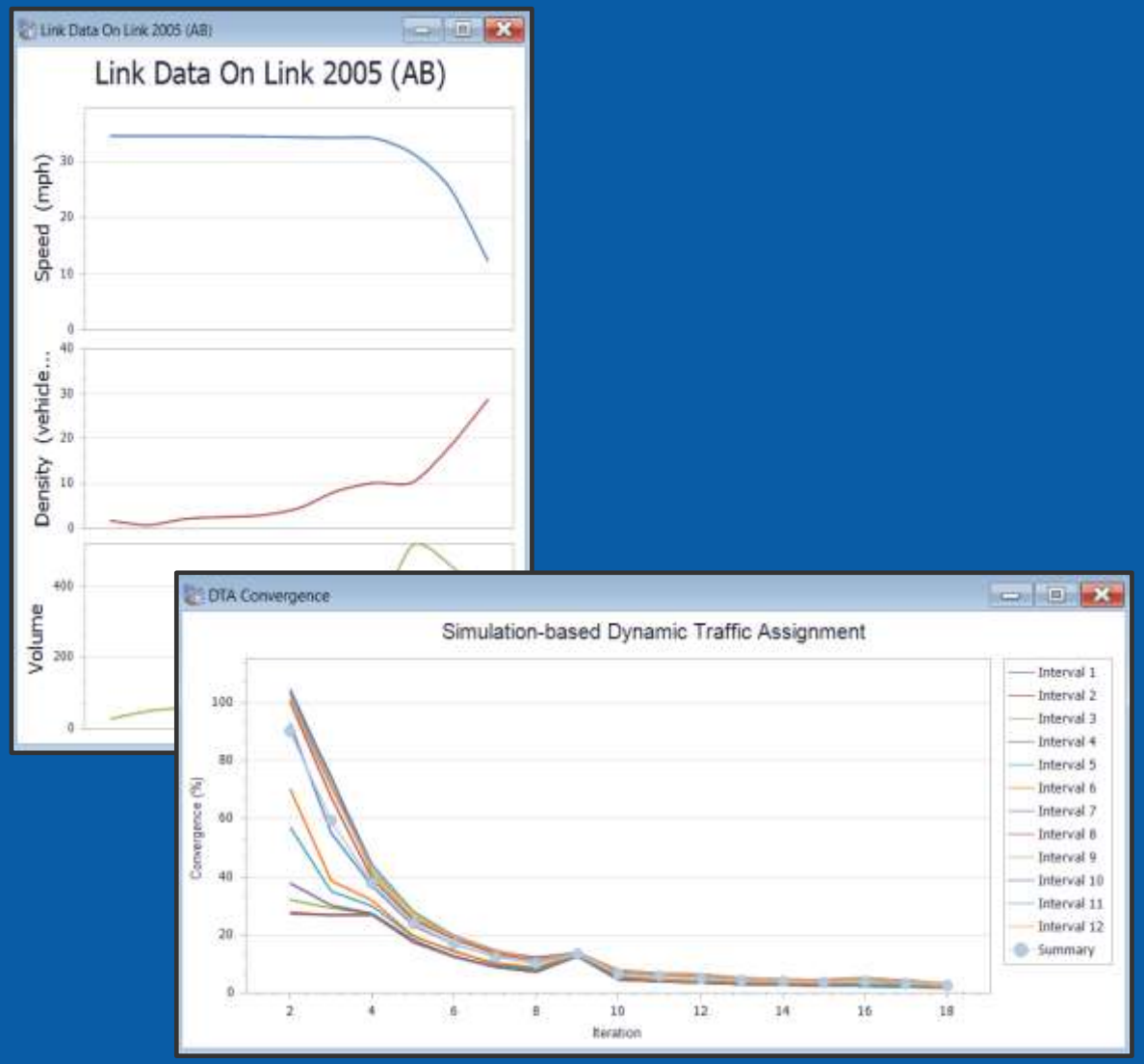
TransDNA Mesoscopic DTA



Key Features

- Mesoscopic Simulation
- Respects capacity constraints
- Captures traffic dynamics
- Runs on TransCAD line layers
- Faster setup times than other DTA solutions
- Fast running times

TransDNA Mesoscopic DTA



Potential Scenario Applications

- Reliability analysis → Variability of traffic metrics
- Impact of demand pattern changes → Special events, severe weather, etc.
- Re-routing due to capacity reductions → Work zones, incidents, etc.
- Route choice due to tolls
- Effects of increased bus traffic

TransModeler Microscopic DTA

Key Features

- Lane-level geometrics and operations
- Accurate modeling of signals
- Detailed reporting of delays, levels of service (LOS)
- Simulates range of ITS solutions/strategies
- Simulates managed lanes, connected and Autonomous Vehicles (CAV), and more

TransModeler Microscopic DTA

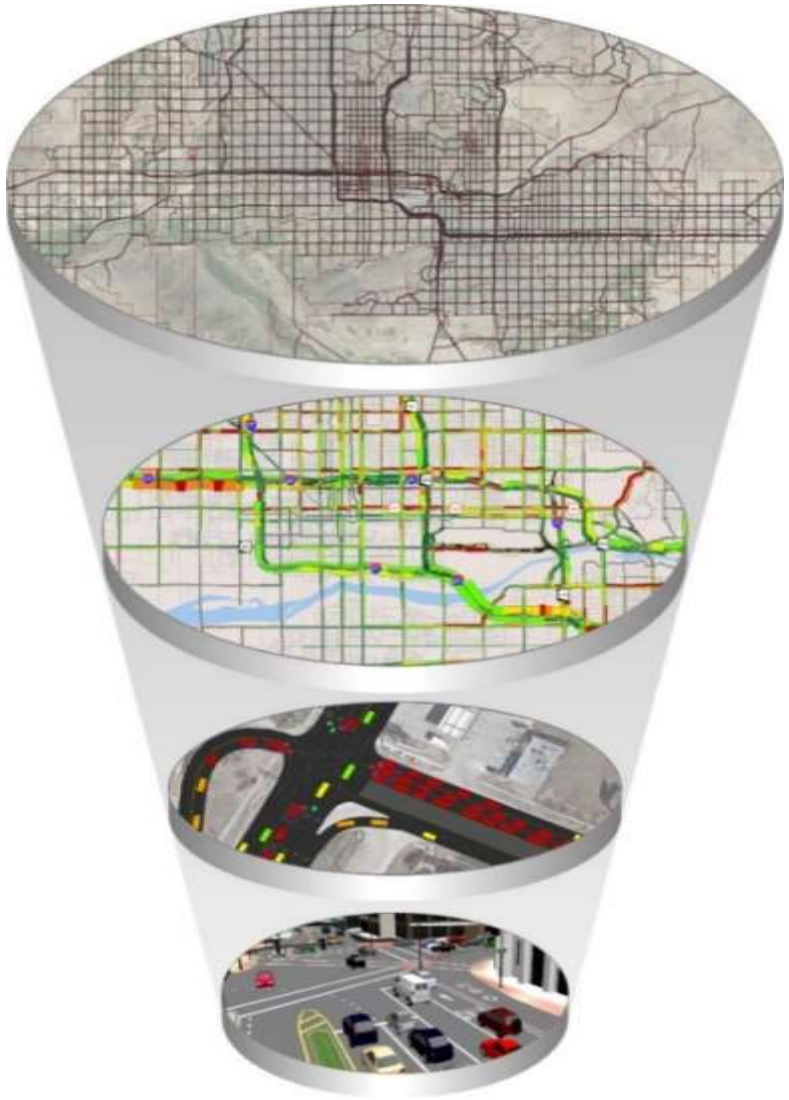
Background Imagery: Google Maps/Google Earth API

Potential Scenario Applications

- Effect of work zones, maintenance of traffic
- LOS, revenue impacts of congestion tolling
- Traffic control optimization
- Incident response planning
- Efficiencies from market penetration of CAV

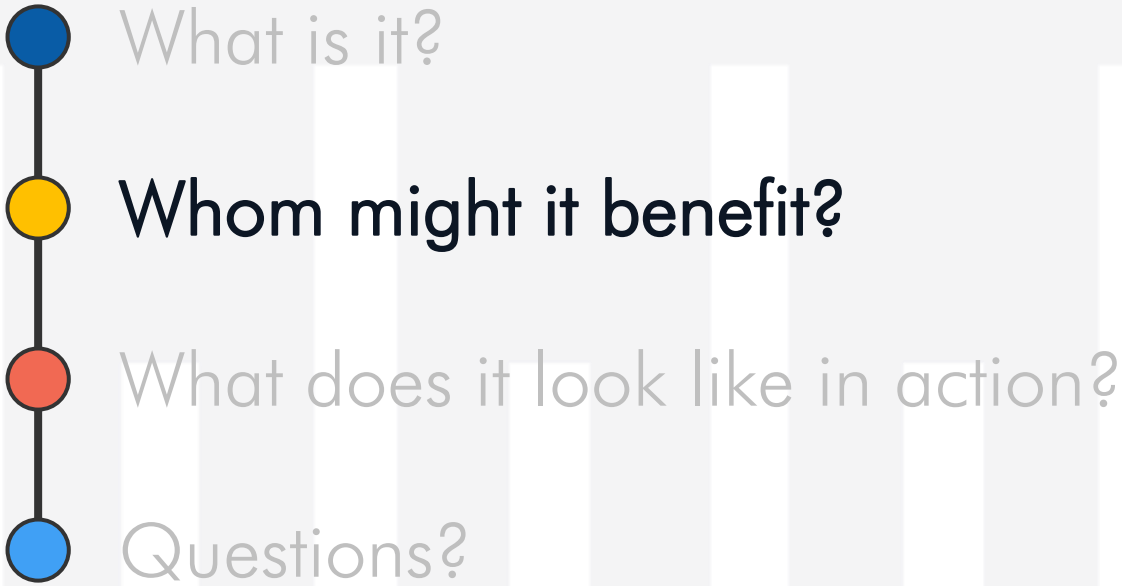
Summary of Core Models

A multi-resolution RTP toolbox



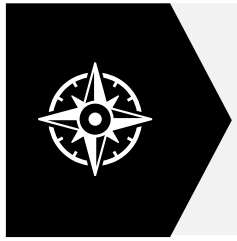
- Travel Demand Model
- Mesoscopic DTA
- Microscopic DTA

Exploratory & Simulation Modeling



Whom might benefit?

Exploratory Modeling and Simulation helps RTCSNV and its stakeholders:



Better navigate uncertainty

Identify trends and patterns in otherwise complex systems

Extract new value from prior investments

Engagement of Stakeholders

1 Invited Stakeholders to a Workshop

2 Posed a Problem/Scenario

3 Asked Questions

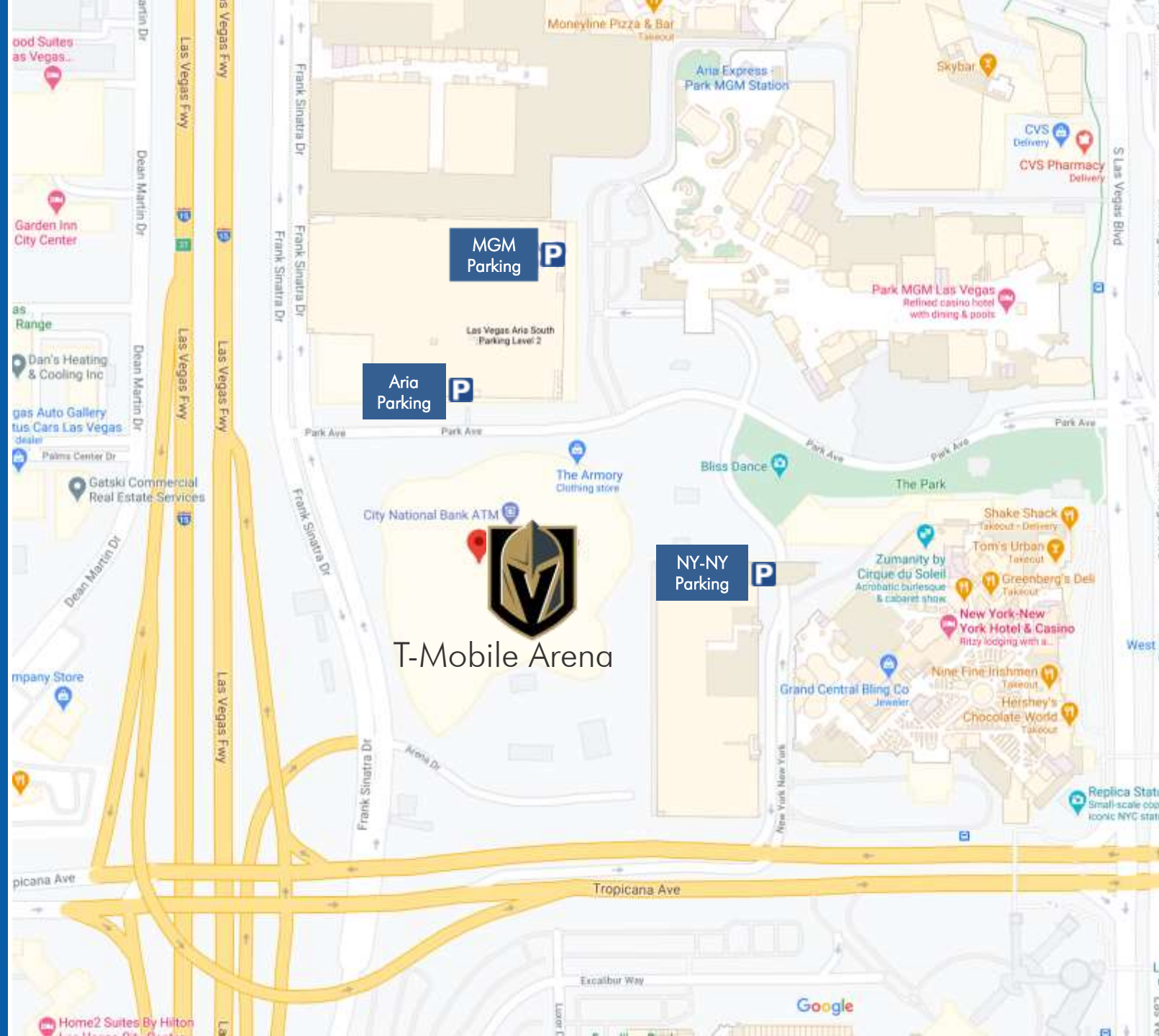
Stakeholder Workshop

Participants

RTC of Southern Nevada	FHWA
Clark County	Nevada DOT
City of North Las Vegas	City of Las Vegas
The City of Henderson	Nellis Air Force Base

The Scenario

Event traffic during the PM peak attending a Golden Knights home game at T-Mobile Arena



What are Variables of Uncertainty?

Fuel Cost

Technology:

Connected and

Autonomous Vehicles

Land Use

Economic Factors:

Unemployment,

Recessions,

Pandemics

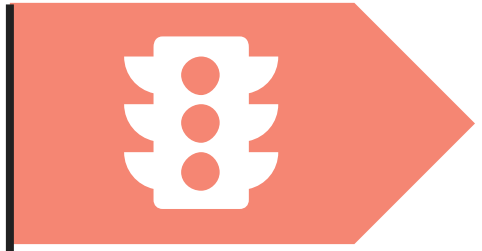
What are Practical Policy Levers?

Parking Policies

- Pricing
- Regulations and Restrictions

Traffic Management

- HOV lanes
- Dynamic pricing
- Contraflow lanes



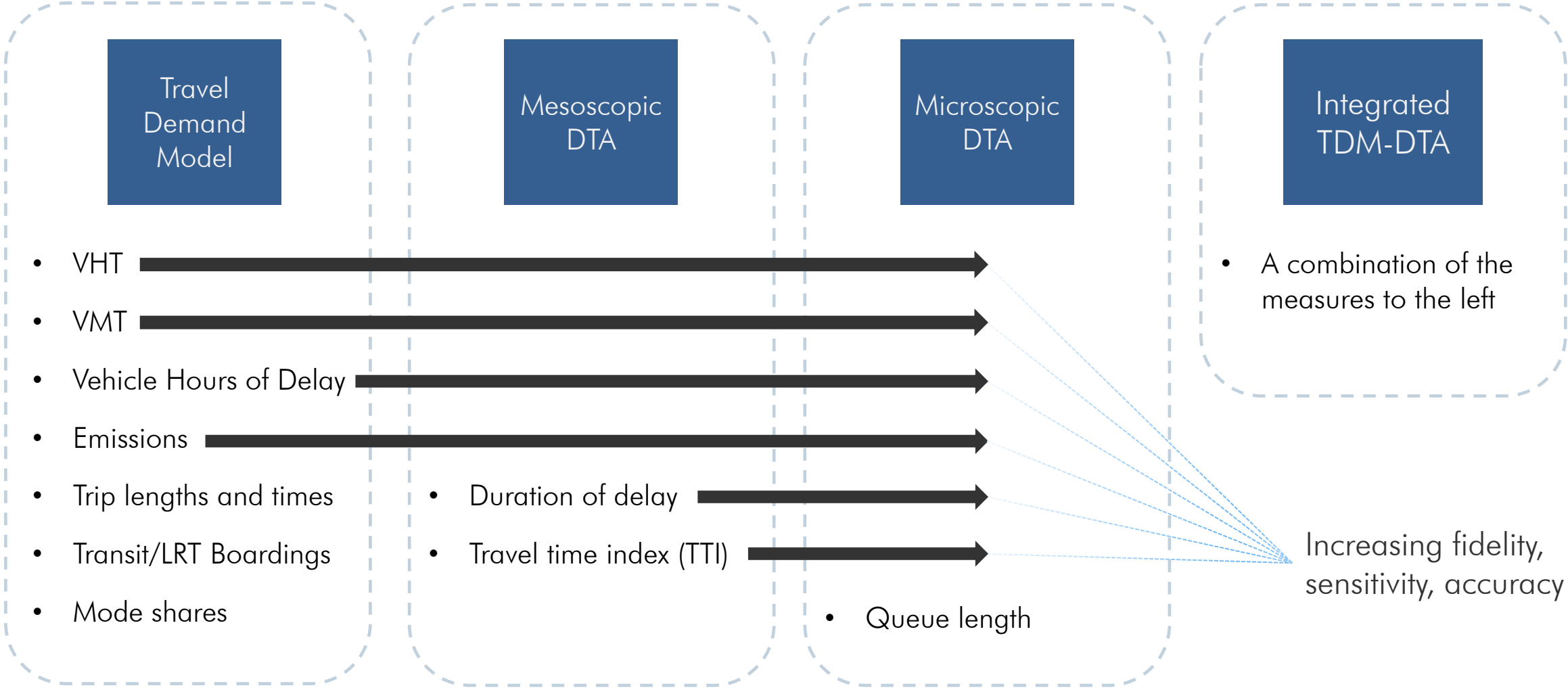
Traffic Control

- Signal timing optimization
- Transit signal priority
- Ramp metering

Transit Service

- Service frequency
- Bus lanes
- Fares

What Performance Measures are of Interest?



Stakeholder Input

Variables of Uncertainty

- Urban Growth Boundary
- E-commerce Impacts
- Transit-Oriented Development
- Special Land Uses
- Population Growth Forecasts
- Telecommuting/WFH Trends
- Connected and Autonomous Vehicles
- Visitor Demand
- Funding

Stakeholder Input

Policy Levers and Operational Strategies

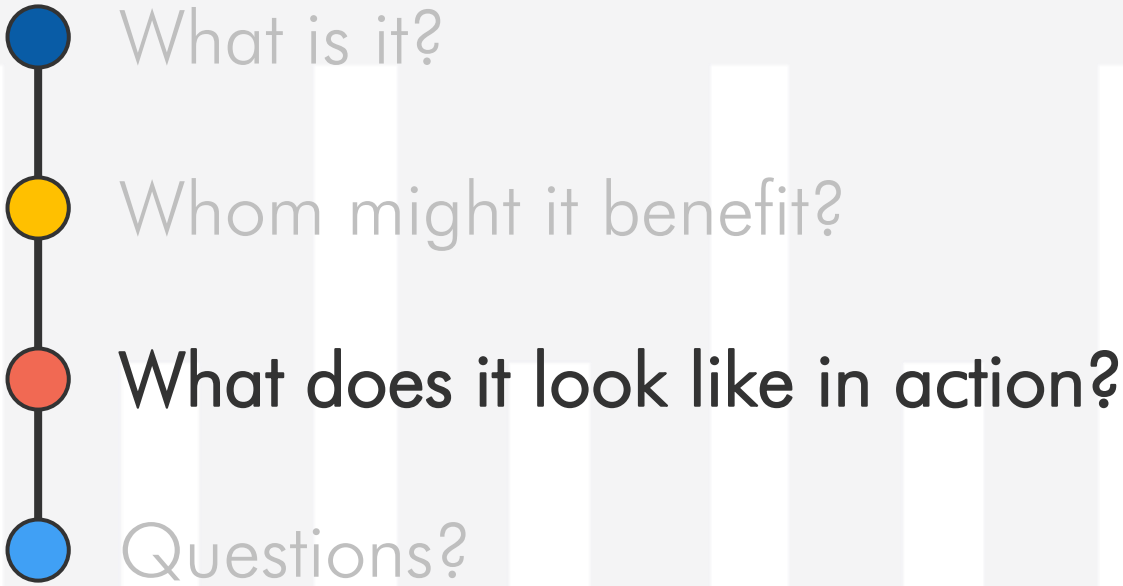
- Road Diets
- Pedestrian Enhancements
- Transit Service Improvements
- Event Traffic Management
- Ramp Metering
- Signal Timing
- Dynamic Message Signs
- Parking
- Complete Streets
- Protected Bike Lanes/Paths

Stakeholder Input

Performance Measures

- Travel Times
- Traffic Delay
- VMT & VHT
- MAP-21 Performance Measures
- Equity
- Accessibility
- Cost-effectiveness of Different Implementation Horizons
- Safety
- Emissions

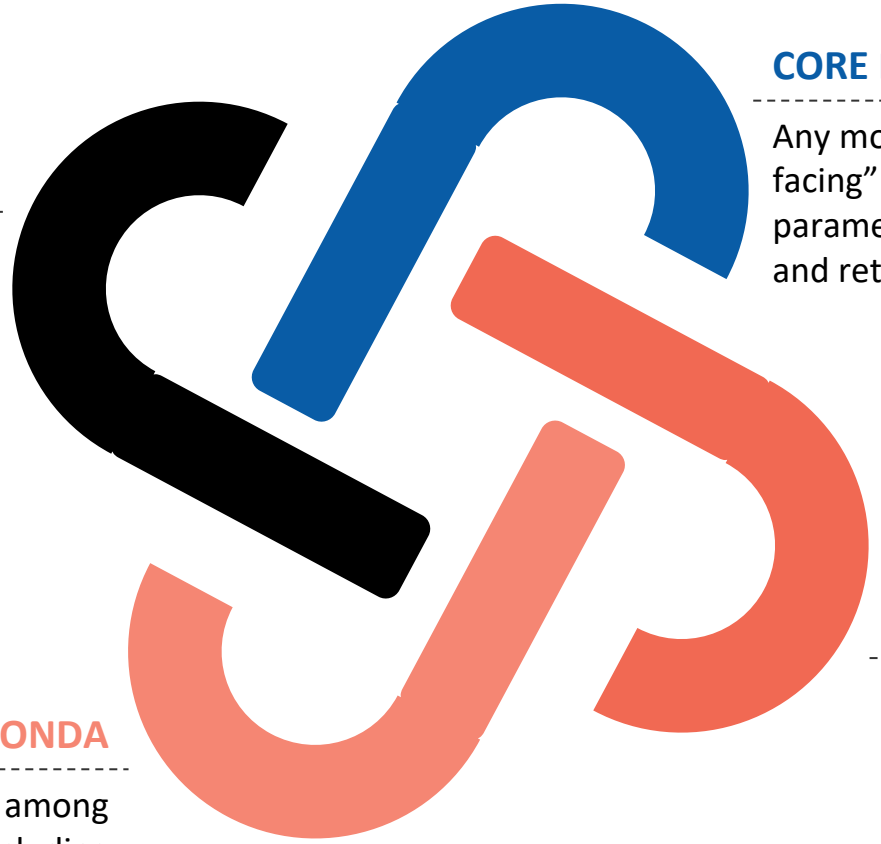
Exploratory & Simulation Modeling



The Tool

A Practical Application integrating EMAT with the RTC Core Models

The EMAT Framework BEFORE Integration



TMIP-EMAT

A Python "environment" that hosts a set of software libraries, methods, tools that facilitate the exploratory analysis

CORE MODELS

Any modeling software that has a "Python-facing" interface for receipt of input and parameter adjustments from TMIP-EMAT and return of performance measures

PYTHON/ANACONDA

Python: A scripting language popular among data science communities, including transportation planners

VISUALIZATION

Jupyter Notebook, which is Python command-driven and JupyterLab, which runs in a web browser, enable interactive exploratory visualizations

The EMAT Framework AFTER Integration

TMIP-EMAT

A Python "environment" that hosts a set of software libraries, methods, tools that facilitate the exploratory analysis

CORE MODELS

Developed a Python-facing interface in TransCAD and TransModeler, including a GUI from which the entire process can be driven

VISUALIZATION

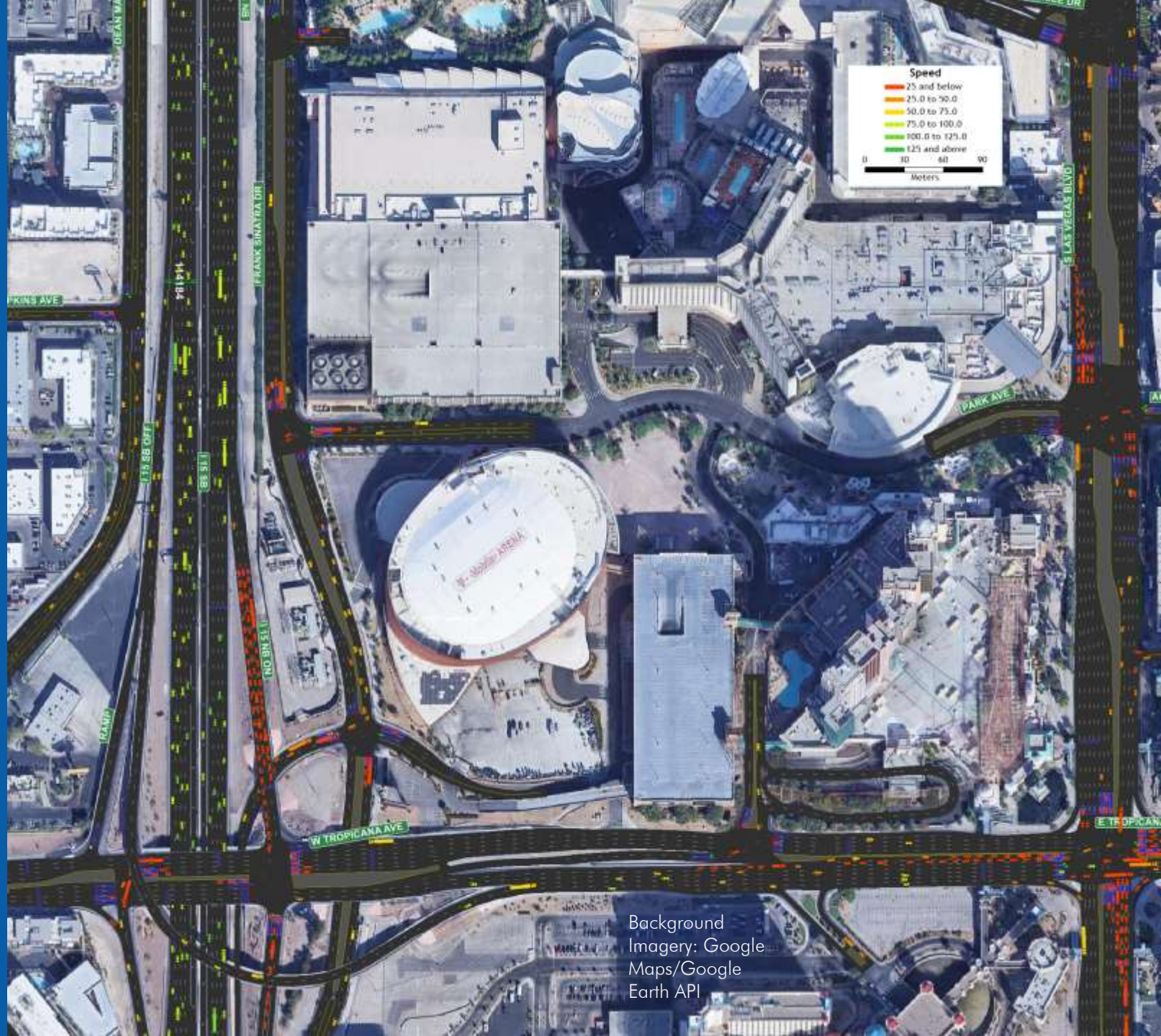
Developed a GUI for creating many of the standard TMIP-EMAT visualizations (e.g., Feature Scores) from within TransCAD and TransModeler

PYTHON/ANACONDA

Python: A scripting language popular among data science communities, including transportation planners

The Scenario

Event traffic during the PM peak attending a Golden Knights home game at T-Mobile Arena



Background Imagery: Google Maps/Google Earth API

Exploratory Scoping

Parameters

- Represent variables about which we are uncertain
- May have representation in core model parameters (e.g., % CAVs)
- Or in core model inputs (e.g., demand)
- May be parameters of models built in to TransCAD or TransModeler (e.g., % CAVs)
- Or to unique features of a specific model (e.g., MIAPass)

Policy Levers

- Represent mitigation strategies under our control
- Will typically have representation in core model inputs (e.g., signal timings)

Performance Measures

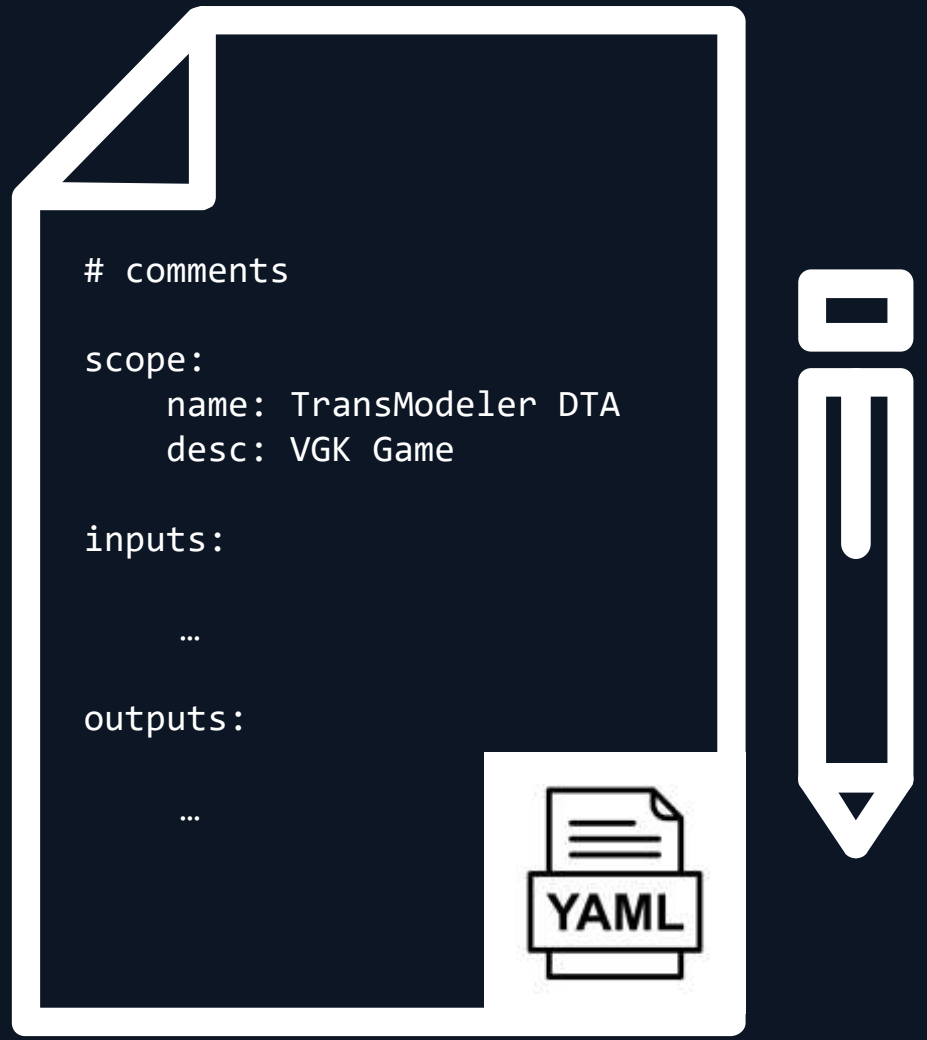
- Should relate to stakeholders' interests, priorities
- Should meaningfully describe the positive and negative consequences of parameters and policy levers
- May be standard outputs of the core model
- Or outputs unique to a feature (e.g., a bus route) or facility (e.g., express lane) in a specific model

WHAT IF

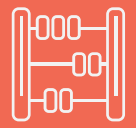
OUTCOMES

Exploratory Scoping – THE EMAT SCOPE FILE

- YAML File
- Describes experiment
- Defines inputs
- Defines outputs



Exploratory Scoping – inputs



Parameters

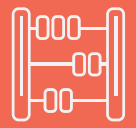
Policy Levers

Performance Measures

more info

```
ATTENDANCE:
        ptype: uncertainty
        desc: Vehicle trips to Aria and New York-New York parking
        shortname: Game Attendance
        dtype: integer
        default: 4800
        min: 3600
        max: 6000
        dist: uniform
        corr: []
```

Exploratory Scoping – inputs



Parameters

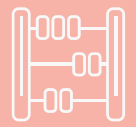
Policy Levers

Performance Measures

more info

```
CLOSURE:
        ptype: policy lever
        desc: Road Closure
        dtype: cat
        default: Do Nothing
        values:
            - Do Nothing
            - Park
            - Frank Sinatra
            - Park and Frank Sinatra
```

Exploratory Scoping – outputs



Parameters

Policy
Levers

Performance
Measures

more info

VMT:

```
shortname: Vehicle Miles Traveled
kind: maximize
metamodeltype: logxp-linear(-59)
```

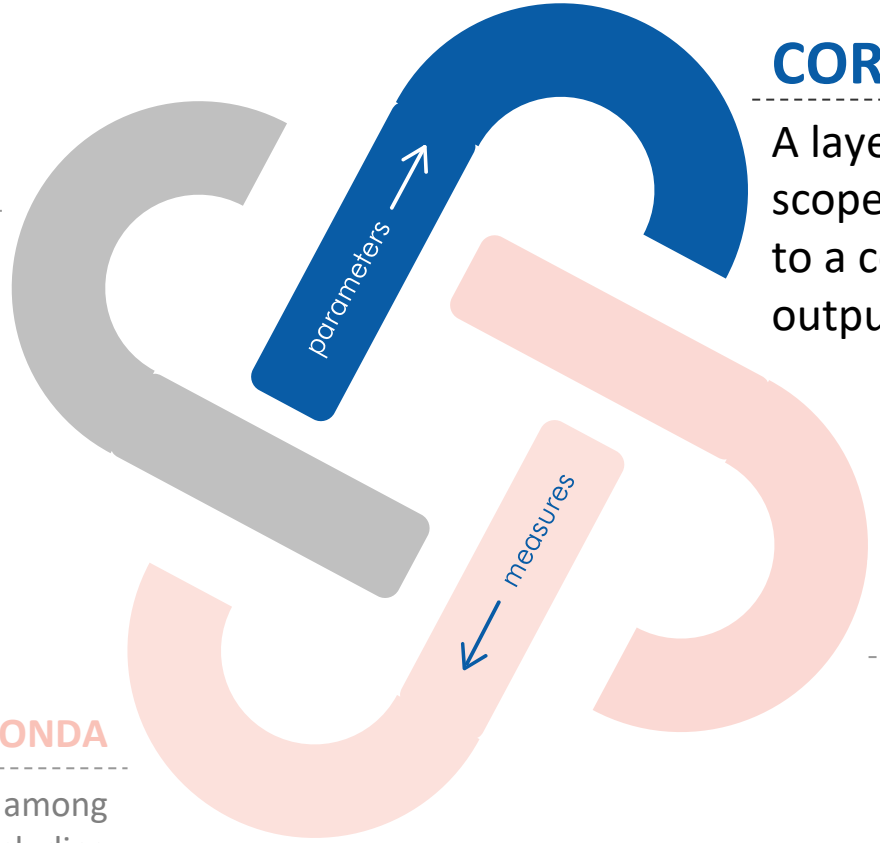
VHT:

```
shortname: Vehicle Hours Traveled
kind: minimize
metamodeltype: logxp-linear(-59)
```

The EMAT Framework Application Interface

TMIP-EMAT

A Python "environment" that hosts a set of software libraries, methods, tools that facilitate the exploratory analysis



CORE MODELS

A layer of GISDK script may translate a scope **`input`** parameter or policy measure to a core model input and a core model output to a scope **`output`** measure

PYTHON/ANACONDA

Python: A scripting language popular among data science communities, including transportation planners

VISUALIZATION

Developed a GUI for creating many of the standard TMIP-EMAT visualizations (e.g., Feature Scores) from within TransCAD and TransModeler

The Interface – Three APIs

EMAT Python

- design_experiments()
- run_experiments() (*not used*)
- calculate_feature_scores()
- More info

Core Model Python

- The "Python-facing" interface that EMAT requires
- Establishes the connection with EMAT through Python
- Manages the running of all experiments designed by EMAT (negating the need for run_experiments())
- Populates the measures database for analysis by EMAT

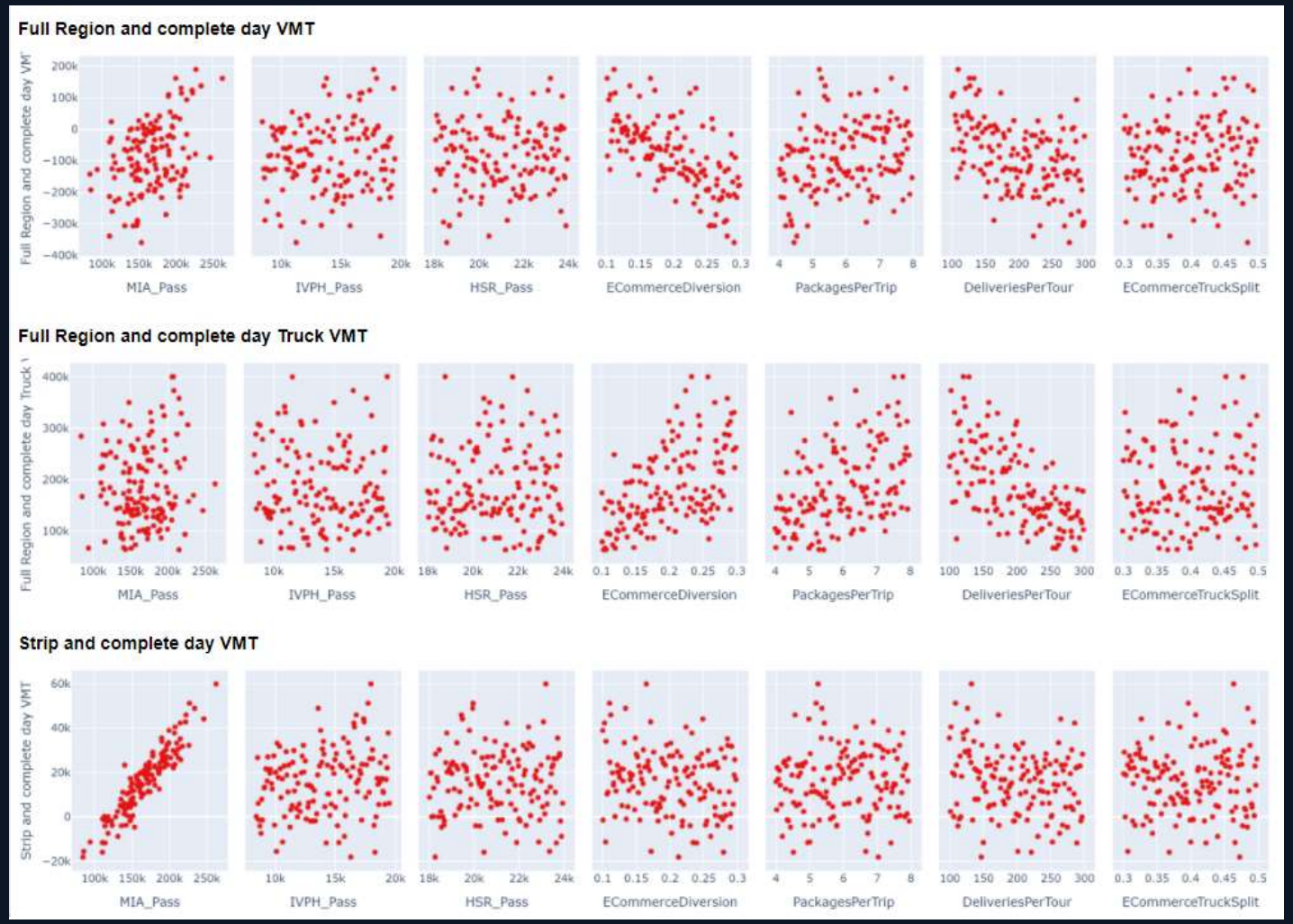
Core Model GISDK

- Customization
- TransCAD: The same GISDK used to develop the RTC travel demand model in TransCAD
- TransDNA: An API was developed to expose access to mesoscopic simulation parameters
- TransModeler: A RunManager class facilitates automation of run management and report production

Exploratory Analysis: The TDM Core Model

Uncertainty	Description
MIA_Pass	Number of passengers to McCarran International Airport
IVPH_Pass	Number of passengers to proposed Ivanpah Valley airport
HSR_Pass	Number of passengers using high-speed rail
EcommerceDiversion	The percentage of home-based shopping (HBS) productions that are replaced by e-commerce
PackagesPerTrip	The number of packages that result from dropping a HBS trip
DeliveriesPerTour	The number of package deliveries made by and e-commerce truck in a tour
EcommerceTruckSplit	The split of the e-commerce trips among light and medium trucks

Exploratory Analysis: The TDM Core Model



Bivariate Trends

- Airport Visitor Demand and Diversion to E-Commerce most highly correlated with regional VMT
- Airport Visitor Demand most highly correlated with VMT on the Strip
- Some trends are obvious but still useful for verifying model sensitivity

Exploratory Analysis: The TDM Core Model

	DeliveriesPerTour	ECommerceDiversion	ECommerceTruckSplit	HSR_Pass	IVPH_Pass	MIA_Pass	PackagesPerTrip
VMT_DAY_All	0.192747	0.333833	0.065039	0.068238	0.072731	0.160680	0.106732
VHT_DAY_All	0.176686	0.331917	0.078270	0.062522	0.067650	0.184644	0.098311
VDT_DAY_All	0.225291	0.173295	0.111820	0.064059	0.077088	0.248276	0.100172
VIS_Total_Trips_All	0.068252	0.067177	0.069749	0.064270	0.109698	0.557634	0.063220
VIS_Walk_Share_All	0.062288	0.066624	0.062424	0.068043	0.097387	0.575760	0.067474
VIS_Taxi_Share_All	0.053973	0.057422	0.059167	0.057822	0.539416	0.174840	0.057359
VIS_Public Bus_Share_All	0.057286	0.059861	0.057589	0.052932	0.432412	0.290461	0.049460
VIS_Private Auto_Share_All	0.063955	0.065704	0.068223	0.083321	0.388945	0.261093	0.068757
Reduced_Shop_Trips_All	0.061602	0.660705	0.053865	0.054167	0.056658	0.062607	0.050395
Increased_Truck_Trips_All	0.283466	0.263066	0.077239	0.062608	0.068491	0.081007	0.164121
Truck_VMT_DAY_All	0.305297	0.254019	0.066426	0.063991	0.062900	0.073961	0.173407
VMT_DAY_Strip	0.083988	0.094718	0.066514	0.077660	0.090354	0.517833	0.068934
VHT_DAY_Strip	0.100723	0.128983	0.077671	0.082991	0.093881	0.445431	0.070319
VDT_DAY_Strip	0.097334	0.152620	0.084560	0.072160	0.079284	0.442560	0.071482
VIS_Total_Trips_Strip	0.068558	0.068256	0.064974	0.072889	0.107922	0.554067	0.063334
VIS_Walk_Share_Strip	0.064304	0.058675	0.060078	0.069844	0.098067	0.589321	0.059712
VIS_Taxi_Share_Strip	0.061335	0.068309	0.060961	0.071384	0.089827	0.587699	0.060485
VIS_Public Bus_Share_Strip	0.060353	0.073641	0.062074	0.064699	0.097703	0.578519	0.063011
VIS_Private Auto_Share_Strip	0.056623	0.063443	0.059123	0.065292	0.094690	0.606758	0.054071

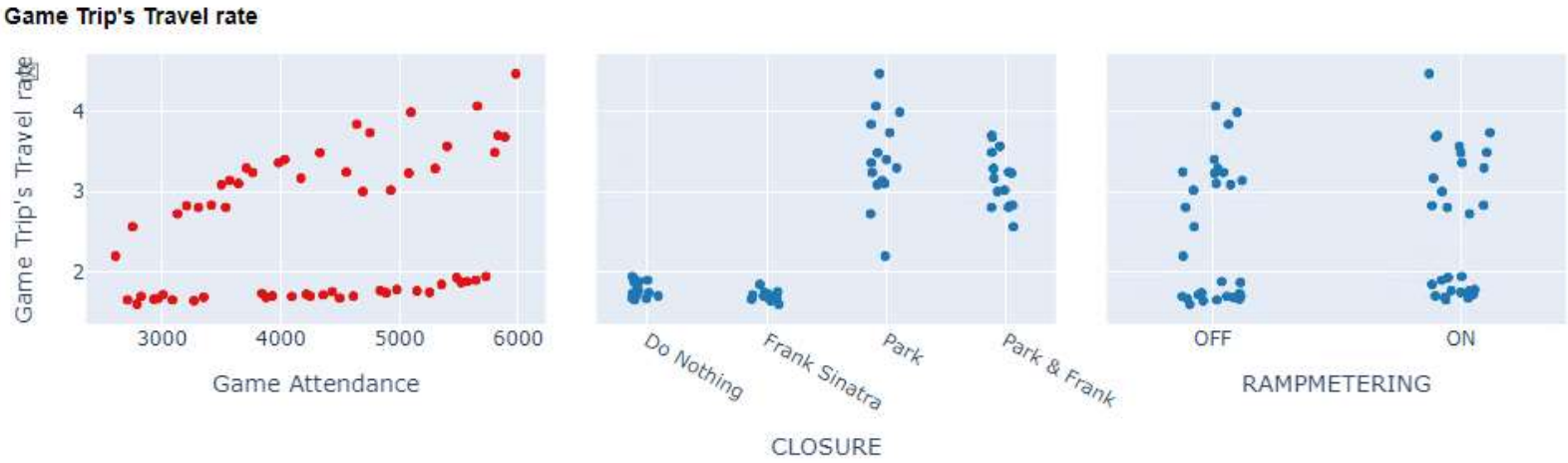
Dominant Variables

- VMT, VHT, VDT most influenced by Diversion to E-Commerce, Deliveries/Tour, and Airport Visitor Demand
- Daily Truck VMT is most influenced by Deliveries/Tour, followed by Diversion to E-Commerce, and is not very sensitive to Packages/Trip

Exploratory Analysis: The Meso DTA Core Model

Uncertainty	Description
Attendance	Number of driving trips to T-Mobile Arena for the game
Road Closure	Road closure policies: Do Nothing / Park / Frank Sinatra / Park and Frank Sinatra
Ramp Metering	Ramp metering strategy at Tropicana Ave interchange: ON / OFF

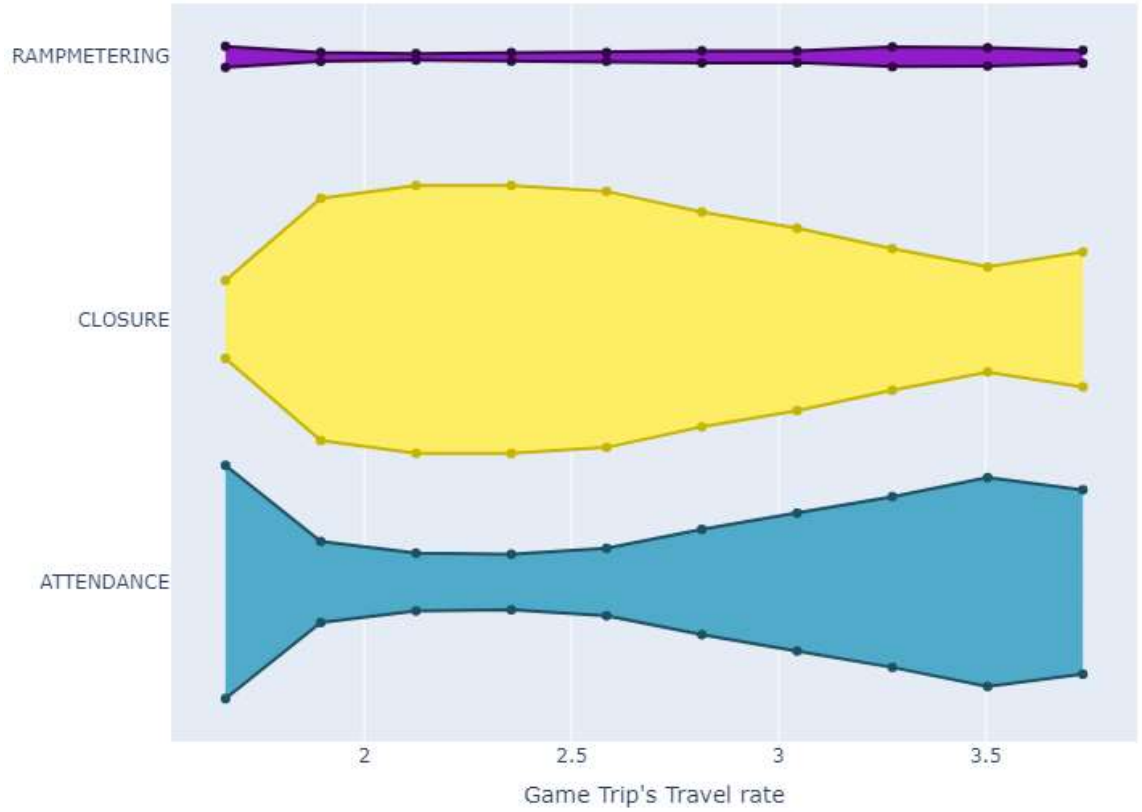
Exploratory Analysis: The Meso DTA Core Model



Bivariate Trends

- Travel Rates for Game Trips jumps with some road closure policies
- Ramp metering has little impact on Game Trips but as adverse impact on Background Trips
- Background Traffic largely unaffected by attendance or closure policy

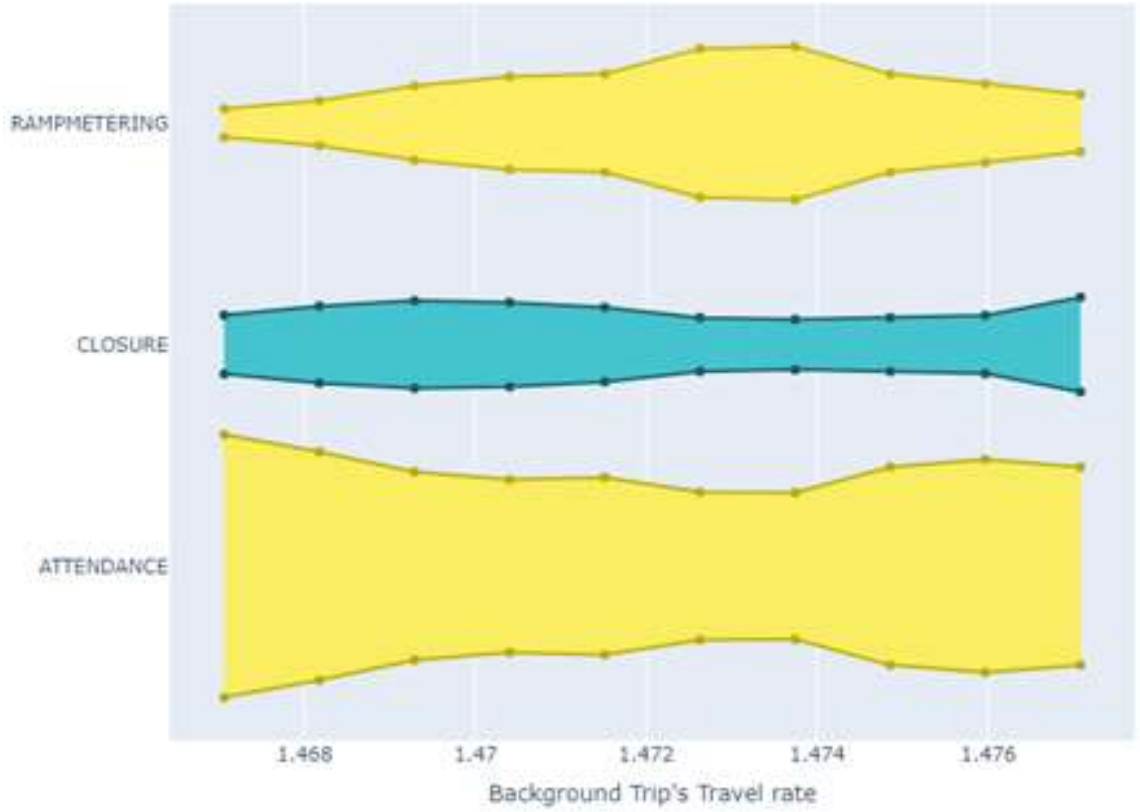
Exploratory Analysis: The Meso DTA Core Model



Game Trip Travel Rate

- Attendance influences travel rates when it is very low and very high
- Closure policy has greatest influence in intermediate attendance range

Exploratory Analysis: The Meso DTA Core Model



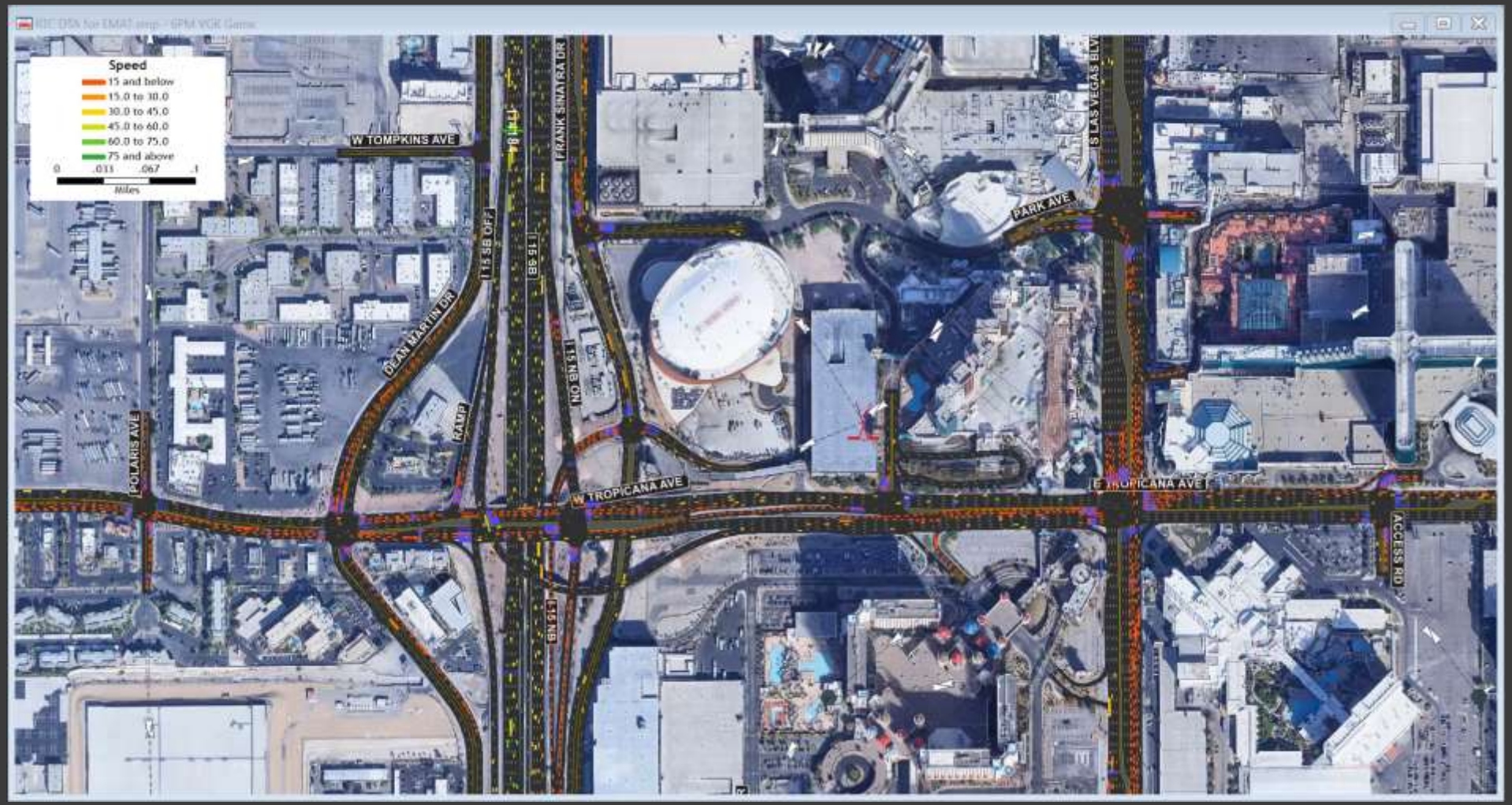
Background Trip Travel Rate

- Influence of ramp metering evident in threshold feature scores

Exploratory Analysis: The Micro DTA Core Model

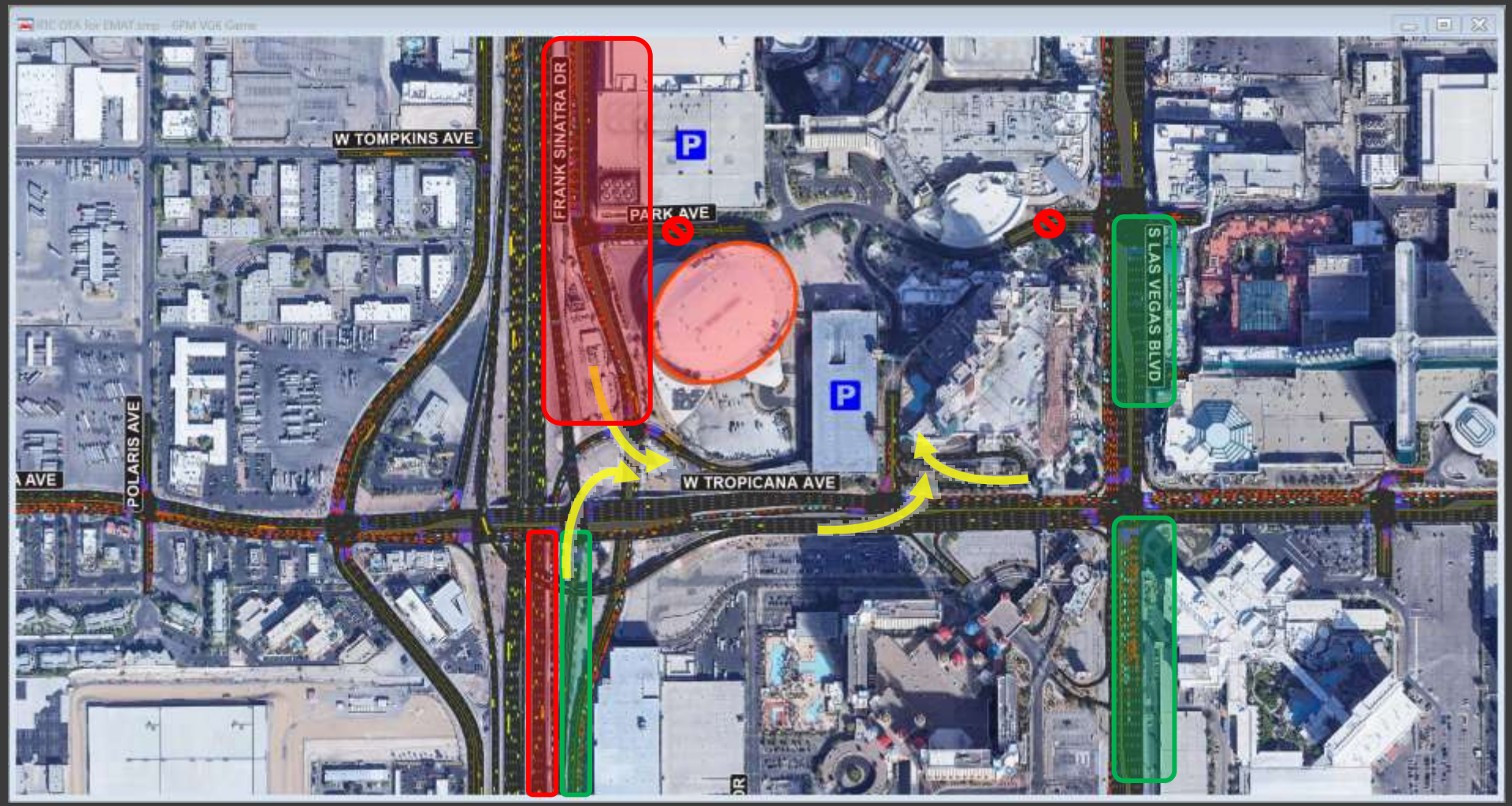
Uncertainty	Description
Attendance	The number of auto trips attracted to T-Mobile Arena for the VGK game
DMS Compliance	Percentage of drivers not attending the game that heed a DMS message on I-15 encouraging use of alternative interchanges to Tropicana
CAV Percentage	Percentage of the vehicle fleet that are connected/autonomous vehicles (CAV)
Road Closure	Road closure policies: Do Nothing / Park / Frank Sinatra / Park and Frank Sinatra
Ramp Metering	Ramp metering strategy at Tropicana Ave interchange: ON / OFF
Advisory DMS	DMS advisory messaging strategy: YES / NO

Exploratory Analysis: The Micro DTA Core Model



Background Imagery: Google Maps/Google Earth API

Exploratory Analysis: The Micro DTA Core Model



Background Imagery: Google Maps/Google Earth API

Lessons Learned

Keys to Successful Application

- Sound experimental design
- A measure of proficiency with core model APIs
- Accommodation for lengthy model running times

Conclusions

- EMAT with DTA core models is a technical reality
- Making it a practical one will require:
  - Commitment in time, resources, personnel
  - The right/suitable application
  - Subarea/windowing with a microscopic DTA core model

Exploratory & Simulation Modeling