Risk Analysis Workshop

Session 2: An Approach to Better Understanding Forecasting Risk – Exploratory Modeling and Analysis

Moderator: Brian Gardner
Outline

• Overview of Travel Model Improvement Program (TMIP) Exploratory Modeling and Simulation projects – Sarah Sun

• Phase 1 and 2: Adapting existing models to evaluate disruptive technologies – Ben Stabler

• Phase 3: Developing a tool (TMIP-EMAT) to support exploratory modeling and analysis – Marty Milkovits
  • Example case study
  • Work flow review with breakout and group discussions

• Discussion facilitators: Tom Rossi, Rachel Copperman, Jason Lemp, Jeff Newman, Jay Evans, Mark Bradley
TMIP Exploratory Modeling and Simulation Project Background
TRAVEL MODEL IMPROVEMENT PROGRAM (TMIP)

• TMIP Vision - The TMIP provides technical support and promotes knowledge and information exchange in the transportation planning and modeling community.

• TMIP Mission - The TMIP helps transportation planners and analysts provide better information through effective use of quantitative methods and tools.

• TMIP Goals
  • Outreach: Get transportation planning research into practice and promote good practices in travel data analyses and quantitative methods application.
  • Agency Support: Build transportation planning agencies institutional capacity to effectively apply analytical tools in the transportation planning decision-making process.
  • Tool Enhancement: Develop a dynamic desk reference for applying travel analysis tools to support data-driven, performance-based transportation planning incorporating principles of risk management.
MOTIVATION FOR EXPLORATORY MODELING AND SIMULATION STUDY

“The committee finds that there is no single approach to travel forecasting or set of procedures that is “correct” for all applications or all MPOs. Travel forecasting tools developed and used by an MPO should be appropriate for the nature of the questions being posed by its constituent jurisdictions and the types of analysis being conducted.”

-- TRB Special Report 288 METROPOLITAN TRAVEL FORECASTING Current Practice and Future Direction, Page 3
THE GOAL OF TMIP EXPLORATORY MODELING AND SIMULATION PROJECT

• Provide an additional tool for planning agencies to manage the uncertainties in transportation planning
• Encourage agencies to continuously improve their current travel modeling methods and practices
BACKGROUND OF TMIP EXPLORATORY MODELING AND SIMULATION PROJECT

The project is inspired by and modeled after RAND’S EMA and Robust Decision Making (RDM) work.

• 2016 – 2017 (Phases 1 & 2): Using Exploratory Modeling and Analysis (EMA) framework to Evaluate Impacts of Disruptive Technology on Regional Surface Transportation System

• 2017 – 2020 (Phase 3): Conducting full Exploratory Modeling and Simulation Study
EXPLORATORY MODELING AND SIMULATION STUDY (PHASE 3) OBJECTIVES

• Focus on exploring (rather than predicting) future transportation system impact (due to technological revolutions);

• Develop a tool that helps agencies to manage uncertainties by creating an EMA tool with a comprehensive framework that will
  • illuminate interactions between transportation supply and demand on urban surface transportation system (especially at the corridor level) through exploratory modeling and simulation;
  • provide insights of potential, possible, plausible, probable or preferred futures;
  • support robust regional transportation planning decision-making incorporating principles of risk management.
FOUR TASKS IN EXPLORATORY MODELING AND SIMULATION STUDY

• Creating a TMIP Exploratory Modeling and Analysis Tool (TMIP EMAT) with a Comprehensive Framework
  • Develop detailed implementation plan for the project
  • Conduct proof of concept of the proposed Exploratory Modeling and Analysis (EMA) tool and its framework

• Building upon previous task
  • Make further improvement to the tool, focusing on theoretical soundness
  • Investigate uncertainties associated with origin and destination flows

• Assessing previous two tasks and complete the tool development
  • Continue to focus on theoretical soundness
  • Improve further on the tool with an emphasis on regional corridor level flows

• Developing a Robust Decision Making Framework (RDMF)
  • Demonstrate how the TMIP EMAT can be used in long range regional transportation planning
Phase 1 and 2 of Project
Use **Exploratory Modeling and Analysis (EMA)**

Phase 1 and 2 Objectives

- **with**
  - detailed simulation models (ABM + DTA)
- **to help**
  - transportation planning agencies
- **understand**
  - the impacts of CAV and ride-hailing (TNC) technologies
EMA is a systematic approach to perform sensitivity analysis using models when many of the model inputs cannot be asserted with confidence, so that a wide range of different input assumptions can be tested simultaneously, looking for patterns in the results to guide robust decision-making (RDM).
EMA Definition

• Define the scope of the system to be analyzed.
• Define the key system relationships and sources of uncertainty.
• Define a method for modeling the system (interactions and inputs).
• Define a method for simultaneously varying the input assumptions to cover a wide range of futures along the defined dimensions of uncertainty.
• Define the method for investigating and communicating the results of applying the model(s) across the wide range of scenarios.

Example Exercise

Define a Method for Modeling the System

• Adapted existing models for the Jacksonville, Florida area:
  • DaySim activity-based travel demand simulation
  • TransModeler dynamic traffic simulation
  • Feedback between the simulation models

• Assumptions
  • Detailed simulation models will facilitate a realistic representation of new aspects of CAV demand and supply for EMA
  • Relevant findings from these detailed models can be adapted for use with simpler (trip-based and static) models
Key Sources of Uncertainty Investigated

Travel Demand

• Market penetration and use of AVs
• Disutility of in-vehicle time in AVs
• Level of use of carsharing and ride-hailing as a substitute for private vehicle use

Network Supply

• Different vehicle headway and speed characteristics for CAVs
• Provision of CAV-only lanes
• Paid ride-hailing (TNC) operator characteristics* (partially explored)
### Experimental Design for the 16 Scenarios Run

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Private AV Adoption</th>
<th>Shared AV Adoption</th>
<th>Reserved AV Capacity</th>
<th>Automation Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>BB–N0</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>MM–L3</td>
<td>Medium</td>
<td>Medium</td>
<td>Interstate left lanes</td>
<td>Level 3</td>
</tr>
<tr>
<td>MM–AC</td>
<td>Medium</td>
<td>Medium</td>
<td>None</td>
<td>Level 3 + ACC</td>
</tr>
<tr>
<td>MM–LC</td>
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<td>Interstate left lanes</td>
<td>Level 3 + ACC</td>
</tr>
<tr>
<td>MM–IC</td>
<td>Medium</td>
<td>Medium</td>
<td>Interstate all lanes (only inside the I 295 ring road)</td>
<td>Level 3 + ACC</td>
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<tr>
<td>LH–L3</td>
<td>Low</td>
<td>High</td>
<td>Interstate left lanes</td>
<td>Level 3</td>
</tr>
<tr>
<td>LH–AC</td>
<td>Low</td>
<td>High</td>
<td>None</td>
<td>Level 3 + ACC</td>
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<td>Level 3 + ACC</td>
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<td>Level 3</td>
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<td>HH–AC</td>
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<td>High</td>
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<td>HH–IC</td>
<td>High</td>
<td>High</td>
<td>Interstate all lanes (only inside the I 295 ring road)</td>
<td>Level 3 + ACC</td>
</tr>
</tbody>
</table>
ABM + DTA Interface

ABM to DTA

- The ABM outputs a list of trips (over 6 million daily trips), parcel-to-parcel, minute-to-minute.

- The DTA model aggregates the parcel-level trips to traffic analysis zones (TAZs) and then builds several zone connectors to simulate the diversity of real-world loading points.

- The non-ABM demand for freight, externals, etc. are passed to the DTA as aggregate trip matrices. These trips are processed into individual trip lists with more detailed simulated times and locations.
The DTA outputs dynamic TAZ-to-TAZ travel time skims, in 30-minute periods, by user class (e.g., conventional vehicles and AVs).

The dynamic travel time skims are created by first running the simulation and then calculating a shortest-path travel time for each origin, destination, and departure time period. The skimmed paths include average simulated turn movement delay.

The nonauto network LOS skims (e.g., walk-to-transit) remained fixed from the existing model.
ABM + DTA Interface

• Windows machine with 12 cores
  • TransModeler DTA – AM period, 25 iterations → 24 hours
  • DaySim ABM → 1hr
  • DaySim using AM dynamic skims + transpose for PM and static assignment for other time periods
• Ran 3 to 5 feedback loops
• Transit skims held constant

• As expected, runtimes limited the scoped of the EMA
Verifying of Dynamic Skims

<table>
<thead>
<tr>
<th>OD Pair</th>
<th>Static</th>
<th>Dynamic (AM)</th>
<th>Google Maps (AM) (Monday April 2, 2018)</th>
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<tbody>
<tr>
<td></td>
<td>SOV</td>
<td>HOV2</td>
<td>HOV3</td>
</tr>
<tr>
<td>Origin</td>
<td>Destination</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>10</td>
<td>541</td>
<td>54</td>
<td>55</td>
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<td>410</td>
<td>2577</td>
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</tr>
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<td>382</td>
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<tr>
<td>2551</td>
<td>919</td>
<td>33</td>
<td>34</td>
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</table>

Verification of Dynamic Skims

Dynamic vs. Static

Outlier Review
ABM + DTA Integration Issues and Resolutions

- DTA runtimes $\rightarrow$ *simulate just AM period*
- Zone resolution and loading $\rightarrow$ *use more precise MAZ zone system and smarter connector choice methods*
- Quality dynamic skims $\rightarrow$ *use DTA for loading network and then use shortest paths skims for every OD pair*
- DTA TNC fleet characteristics (size, initial location, matching with requests, repositioning, etc.) $\rightarrow$ *still investigating*
AM VMT by Vehicle Type and EMA Scenario

- VMT goes up with more private AVs due to trip length increases
- VMT goes down with more shared AV (TNC) usage because the costs are higher
Regression Model of VMT based on ABM Output
Total VMT (millions) by scenario, time period, vehicle type

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Non-AV</th>
<th>Non-AV</th>
<th>Private AV</th>
<th>Private AV</th>
<th>Shared AV</th>
<th>Shared AV</th>
<th>All types</th>
<th>All types</th>
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<tr>
<td>Constant</td>
<td>0.262</td>
<td>11.1</td>
<td>0.443</td>
<td>10.6</td>
<td>0.226</td>
<td>12.9</td>
<td>0.931</td>
<td>117.6</td>
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<td>Demand - High Private, Low Shared</td>
<td>-0.174</td>
<td>-9.8</td>
<td>0.346</td>
<td>11.0</td>
<td>-0.103</td>
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<td>0.068</td>
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<td>Supply - Network scenario AC</td>
<td>0.000</td>
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<td>0.000</td>
<td>0.0</td>
<td>0.000</td>
<td>0.0</td>
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<tr>
<td>Demand - Low Private, High Shared</td>
<td>0.116</td>
<td>6.5</td>
<td>-0.281</td>
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<td>0.108</td>
<td>8.1</td>
<td>-0.057</td>
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<tr>
<td>Demand - High Private, High Shared</td>
<td>-0.190</td>
<td>-10.6</td>
<td>0.083</td>
<td>2.6</td>
<td>0.113</td>
<td>8.5</td>
<td>0.006</td>
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<td>-0.1</td>
<td>-0.002</td>
<td>-0.1</td>
<td>0.000</td>
<td>0.0</td>
<td>-0.004</td>
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<td>0.0</td>
<td>0.000</td>
<td>0.0</td>
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<td>0.0</td>
<td>0.000</td>
<td>0.1</td>
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<tr>
<td>Arrive Period - 5:00 to 5:29</td>
<td>-0.182</td>
<td>-7.2</td>
<td>-0.434</td>
<td>-9.7</td>
<td>-0.237</td>
<td>-12.7</td>
<td>-0.853</td>
<td>-100.7</td>
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<tr>
<td>Arrive Period - 5:30 to 5:59</td>
<td>-0.177</td>
<td>-7.0</td>
<td>-0.422</td>
<td>-9.5</td>
<td>-0.231</td>
<td>-12.3</td>
<td>-0.830</td>
<td>-98.1</td>
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<tr>
<td>Arrive Period - 6:00 to 6:29</td>
<td>-0.051</td>
<td>-2.0</td>
<td>-0.109</td>
<td>-2.5</td>
<td>-0.075</td>
<td>-4.0</td>
<td>-0.235</td>
<td>-27.8</td>
</tr>
<tr>
<td>Arrive Period - 6:30 to 6:59</td>
<td>-0.057</td>
<td>-2.3</td>
<td>-0.125</td>
<td>-2.8</td>
<td>-0.081</td>
<td>-4.3</td>
<td>-0.263</td>
<td>-31.1</td>
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<tr>
<td>Arrive Period - 7:00 to 7:29</td>
<td>0.035</td>
<td>1.4</td>
<td>0.107</td>
<td>2.4</td>
<td>0.051</td>
<td>2.7</td>
<td>0.192</td>
<td>22.7</td>
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<tr>
<td>Arrive Period - 7:30 to 7:59</td>
<td>0.008</td>
<td>0.3</td>
<td>0.042</td>
<td>0.9</td>
<td>0.026</td>
<td>1.4</td>
<td>0.076</td>
<td>9.0</td>
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<tr>
<td>Arrive Period - 8:30 to 8:59</td>
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<td>-0.7</td>
<td>-0.048</td>
<td>-1.1</td>
<td>-0.018</td>
<td>-1.0</td>
<td>-0.083</td>
<td>-9.8</td>
</tr>
</tbody>
</table>
Some Conclusions and Key Findings

- The introduction of new types of network users like CAVs only becomes significant once they reach high market penetration.
- The relative use of private and shared CAVs and their occupancy levels greatly influence the scenario results (VMT, delays, etc.).
- A comprehensive and realistic investigation of the impacts of CAVs and TNCs requires an ABM+DTA model even though they require significant resources and runtime.

*These disaggregate models are better able to model the complex relationships between individual persons (including drivers and passengers), individual vehicles (CAV or not), and network vehicle communication (V2V, V2I, V2X).*
What Else Did We Learn?

• This project was an experiment in making assumptions (which applies to all modeling, but here it is more explicit).

• Our industry’s most advanced tools can only tell us a limited amount about a future with CAVs and TNCs because:
  • We have to make so many significant assumptions.
  • We have to design and estimate a detailed set of interactions (i.e., models) between components that are not yet well understood.
  • We have to develop and test complex software simulating all of this.
  • We have to do this within a reasonable time to be relevant.

• Yet, we cannot investigate how to prepare for an uncertain future if we do not even try to, and complex models can address more questions than simpler models.

Assumptions

- land use
- need and supply for parking
- level of vehicle automation
- in-vehicle experience
- stability of daily travel patterns
- TNC fleet operations
- future transit network structure
- policy futures
- etc.
For More Information

How-To Guide

How-To: Model Impacts of Connected and Autonomous/Automated Vehicles (CAVs) and Ride-Hailing with an Activity-Based Model (ABM) and Dynamic Traffic Assignment (DTA)—An Experiment

which includes lots of additional info

SAE automation levels

simulation results

Potential superstacked parking locations
Phase 3 Workshop: Introduction to TMIP-EMAT
Workshop outline

• Case Study Materials
  • Core Model
  • Strategies
  • Performance measures
  • Uncertainties

• Introduction to TMIP-EMAT
  • User work flow
  • Scoping
  • Experiment design
  • Meta-models
  • Analysis
Strategy 1: Decommissioning Kensington Expressway
Initial Consideration of Kensington Decommissioning Conditions
Performance Measures for Kensington Decommissioning

• **VMT and Trip Length**
  • Region-wide VMT
  • VMT by facility
  • Congested VMT by facility type in peak periods
  • Regional average trip length (miles)

• **Accessibility**
  • Households within 30 minutes of CBD

• **Corridor Level**
  • Kensington Expressway VMT / VHT
  • Travel time from downtown to airport
  • Targeted segment volumes
  • Change in Trips to/from Downtown
Strategy 2: Extending Amherst LRT
Performance Measures for Amherst LRT

• **VMT and Trip Length**
  • Region-wide VMT

• **Mode Share**
  • Share of transit
  • Share of non-motorized travel

• **Corridor Level**
  • Change in Trips to/from Downtown

• **Accessibility**
  • Number of HBW trips with <=45 minute transit travel time

• **Transit related**
  • Total Boardings (LRT + Bus)
  • LRT-only Boardings
Uncertainties (Risk Factors)

- **Economy**
  - Land use development patterns
  - Impact of a new large employer coming/goin
  - Growth/decline within or outside the region

- **Auto Environment**
  - AV/CV
  - Shared mobility
  - Energy mix
  - Fuel Cost

- **Highway network**
  - Tolls
  - Speed limits
  - Ramp metering

- **Transit network**
  - Fares
  - PnR location and availability
  - Frequency

- **Travel patterns**
  - Telecommuting/shopping
  - Flex time

- **Model parameters**
  - VOT
  - Rates
  - Capacities
Introduction to TMIP-EMAT

Travel Model Improvement Program – Exploratory Modeling and Analysis Tool
What is TMIP-EMAT?

• Travel Model Improvement Program – Exploratory Modeling and Analysis Tool
• Tool to support a quantitative Robust Decision Making approach to transportation planning with deep uncertainty
• Complements and enhances (does not replace) existing models, visualizations, or planning tools
Available Tools

• Regional travel demand model
  • Trip-based
  • Activity-based

• Microsimulation
  • Corridor-level
  • Dynamic Traffic Assignment

• Hybrid

• Data driven

• Sketch (strategic)
What do we do?

• Point prediction – Best Guess on All Concerns
• Scenario planning – Several Best Guesses
• Why can’t we do it all?
Range of Uncertainty

TMIP-EMAT

Core Model
How does TMIP-EMAT work?

- Where necessary, leverages **Core Model** outputs to produce **Meta-Models** that can quickly explore the range of uncertainty

- **Key Steps**
  - Scoping (define uncertainty space)
  - Develop meta-models
    - Design experiments
    - Run core model
    - Estimate meta-models
  - Analysis
    - Simulate across range of uncertainty
    - Risk or exploratory

Meta-models are regression models of the Core Model outputs that run very fast
TMIP-EMAT Components

- Experiment Design
- Analysis Utilities
- Meta-Model Development
- Simulator

Core Model Manager

Core Model API

Configuration Data and Simulation Results

Developed through FHWA Project

Core Model

Risk Variables, Performance Measures, Strategies

Deployment Specific Requirements

Region/Application Specific Materials

Materials

Deployment Specific Requirements

Developed through FHWA Project

Core Model
1. **Initial Information**
   - Proposed Projects/Policies/Treatments
   - Risk Factors
   - Performance Measures

2. **EMA Scoping**
   - Determine Model Need
   - Strategies for Evaluation
   - Confirm Risk Variables
   - Risk Variable Ranges, Distributions, and Correlations

3. **Meta-Model Development**
   - Experiment Design
   - Core Model Execution
   - Results DB
   - Meta Model Derivation

---

**TMIP-EMAT Automated Process**
TMIP-EMAT Automated Process

- Performance Measure (Meta-) Model
- Risk Variable Ranges, Distributions, and Correlations

Monte Carlo Simulation

Performance Measure Estimate by Strategy and Risk Variables

Potentially Modify Risk Variable Ranges, Distributions and Correlations

4 Model Simulation

5a Risk Analysis
- Visualization of Performance Measure Distributions
- Performance measures statistical significance (build vs. no-build)

5b Exploratory Analysis
- Robust strategy support (minimize regret)
- Adaptive strategy support (identify signposts/correlated risk areas)
Step 1 and 2: Initial Information and Scoping

**Breakout Group Discussion**

- Choose a model (per group) to use as an example through the workshop
- What strategies would you test?
- Performance measures of interest
- Identify how risk factors could be represented in your model (a model)
  - What are the risk variables?
  - Ranges and distributions
<table>
<thead>
<tr>
<th>Risk Variable</th>
<th>Minimum</th>
<th>Most Likely</th>
<th>Maximum</th>
<th>Distribution</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households and Employment in downtown TAZs</td>
<td>-18%</td>
<td>0%</td>
<td>37%</td>
<td>PERT - Standard</td>
<td>Percent change from Base socio-economic dataset</td>
</tr>
<tr>
<td>Roadway Capacity</td>
<td>0%</td>
<td>50%</td>
<td>100%</td>
<td>Triangular</td>
<td>Percent increase in capacity on Interstates, Expressways, and on-ramps</td>
</tr>
<tr>
<td>Auto In-vehicle Time Coefficient</td>
<td>1- (0.25 / auto occupancy)</td>
<td>1- (0.15 / auto occupancy)</td>
<td>1.0</td>
<td>Triangular</td>
<td>Unit = Factor on coefficient</td>
</tr>
<tr>
<td>Vehicle Availability Alternative Specific Constants</td>
<td>0 Veh = 14.2%</td>
<td>0 Veh = 7.1%</td>
<td>0 Veh = 0%</td>
<td>PERT - Standard</td>
<td>Unit = percentage of vehicle sufficiency categories resulting from vehicle availability model</td>
</tr>
<tr>
<td></td>
<td>Veh &lt; Workers = 7.1%</td>
<td>Veh &lt; Workers = 3.6%</td>
<td>Veh &lt; Workers = 0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Veh &gt;= Workers = 78.7%</td>
<td>Veh &gt;= Workers = 89.3%</td>
<td>Veh &gt;= Workers = 100%</td>
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<td></td>
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Step 3: Experiment Design and Meta Model

Group Discussion

• Is this step necessary for your model?
• Approaches to experiment design
• Factors to consider
• What makes a good meta model?
Latin Hypercube vs. Factorial Design

LHS vs. Factorial in 2 Dimensions

LHS vs. Factorial collapsed to 1 Dimension

- Full Factorial Experiment
- Latin Hypercube Experiment

Linear Regression and Gaussian Regression
De-trending

• Deterministic model results will have a clear trend that can be largely explained with linear terms

• Meta Model Process
  • Estimate a simple linear regression model
  • Apply a Gaussian Process Regression to the linear model residuals

• Linear regression parameters useful in checking and analysis
• Gaussian regression used to represent more complex interactions
<table>
<thead>
<tr>
<th>Performance Measures</th>
<th>Region-wide VMT</th>
<th>Total LRT Boardings</th>
<th>Downtown to Airport Travel Time</th>
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</thead>
<tbody>
<tr>
<td>Constant</td>
<td>16.316 (1259.66)</td>
<td>8.038 (90.5)</td>
<td>2.615 (141.5)</td>
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<tr>
<td>Households and Employment in downtown</td>
<td>0.717 (122.3)</td>
<td>2.236 (55.66)</td>
<td>0.2 (23.96)</td>
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<tr>
<td>Roadway Capacity</td>
<td>0.016 (5.45)</td>
<td>-0.013 (-0.64)</td>
<td>-0.099 (-23.47)</td>
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<td>Auto IVTT</td>
<td>-0.088 (-7.33)</td>
<td>-0.103 (-1.26)</td>
<td>-0.037 (-2.18)</td>
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<tr>
<td>Vehicle Availability</td>
<td>0.056 (17.94)</td>
<td>-0.456 (-21.2)</td>
<td>0.025 (5.49)</td>
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<tr>
<td>Kensington Decommissioning</td>
<td>-0.002 (-1.77)</td>
<td>-0.006 (-0.69)</td>
<td>0.009 (4.84)</td>
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<tr>
<td>LRT Extension</td>
<td>-0.004 (-3.06)</td>
<td>0.257 (30.84)</td>
<td>0.002 (0.93)</td>
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<td>R-Square</td>
<td>0.997</td>
<td>0.989</td>
<td>0.959</td>
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Step 4 - 5a: Simulation for Risk Analysis

• Simulation: scoped and updated
• Types of measures
Risk analysis visualization utility

**Group Discussion**

- Range and probability of occurrence
- Cumulative distribution of performance measures
- Relative importance of risk

- Launch Risk Visualization Utility
Step 4 - 5b: Simulation for Exploratory Analysis

• Simulation: distributions to use?
• Exploratory process
Exploratory Analysis – Selection Sets

**Group Discussion**

- Understand strategy impacts given risk variable ranges
- Understand strategies for a given range of performance measures
- Understand risk variable significance given strategies

- Launch Exploratory Visualization Utility
How does TMIP-EMAT change the practice?

Benefits
• Produce performance measure estimates across range of uncertainty
• Leverage region/application specific tools

Costs
• Deployment
• Core model validation: response to range of inputs
TMIP-EMAT Next Steps

• Improve the usability
• Explore the value of the approach
• Improve meta-model formulation
• Collect feedback from potential users
Requested Feedback

• Key challenges to using TMIP-EMAT with your models and planning applications

• Complementory software
  • Models
  • Visualizers

• Other helpful tests / demonstrations / reports / visualizations
## Contributors

<table>
<thead>
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<th>Person</th>
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<tbody>
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