THE UNIVERSITY OF TEXAS AT AUSTIN
CENTER FOR TRANSPORTATION RESEARCH

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Decision-Support Tools: Development and Tutorial

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TxDOT Project 0-6859: Operational Analysis of Active Traffic Management Strategies

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1. Development and Use of Spreadsheet Analysis Tools

This document describes the spreadsheet tools implementing the regression models developed in the main report (0-6859-1). The tools offer a user-friendly interface to evaluate the effectiveness of active traffic management (ATM) strategies for a given network. Three ATM strategies are considered: ramp metering, variable speed limit (VSL), and dynamic lane use control (DLUC). For each ATM strategy, the spreadsheet tool provides three cases based on the level of data availability:

- The **no-data case** assumes that the agency has no data available to build or calibrate either a microsimulation or a dynamic traffic assignment (DTA) model.
- The **microsimulation-only case** assumes that the agency has real-time data available to build and calibrate the microsimulation model but has no data available to develop a DTA model.
- The **DTA-only case** assumes that the agency has access to strategic data to build a DTA model but only limited access to real-time data to build a microsimulation model.

The framework used in developing the tools provides an approximate analysis and is useful in answering initial, planning level-questions. For example, a potential use of the tool could be in determining whether installing ramp metering on a particular on-ramp on IH 35 can help relieve congestion over the corridor in the long term. However, for assessing the precise impacts of an ATM strategy before its deployment, it is recommended that the agency develop a more detailed microsimulation model of the corridor if the tools developed in this project indicate potential benefits.

1.1 Inputs and Outputs to the Spreadsheet Tool

The inputs and outputs to the spreadsheet tool depend on the case being analyzed:

1. **No-data case (scenario 4 and 6 in the main report)**: This case requires the input of mainline demand, ramp demand (if applicable), and the downstream bottleneck discharge speed. It predicts the percentage improvement in the corridor travel time based on those inputs. If the percentage improvement is significant, this tool requires the input of the artificial link parameters and the total demand using the abstract network between nodes O and D. This input then predicts the shift in the mainline demand and the ramp demand possible from the predicted improvements. For non-recurring congestion (scenario 6), only the first set of input and output is used.
2. **Microsimulation-alone case (scenario 2 in the main report)**: This case requires two steps. First, the known demand from the microsimulation model is used to determine the artificial link parameters and the average green ratio for the ramp meter (obtained after the microsimulation run). Second, these values of artificial link parameters and average green ratio are used as inputs to the regression model, which predicts the updated demand for the microsimulation corridor as the output.

This modified demand reflects the changes in route patterns of the travelers due to the reduced capacity of the on-ramp with ramp meter or due to improved capacity of the corridor with VSL.

3. **DTA-alone case:** Similar to the no-data case, this case requires the input of mainline demand, ramp demand (if applicable), and the downstream bottleneck discharge speed and predicts the average green ratio on the on-ramp with ramp meter installed. This green ratio can then be used in the DTA model as a signal to approximate the microscopic impact of the ramp meter.

Table 1.1 shows the table of inputs for different scenarios coded in the spreadsheet tool for ramp metering. The inputs for VSLs follow the same format except that there is no ramp demand and the average green ratio is replaced by the capacity improvement predicted by the VSL on the mainline corridor.

Table 1.1: Spreadsheet inputs for the ramp metering case analysis

<table>
<tr><th colspan="6">Ramp Metering</th></tr>
<tr><th colspan="2">No-Data (Scenario 4)</th><th colspan="2">Microsimulation Alone (Scenario 2)</th><th colspan="2">DTA alone (Scenario 3)</th></tr>
<tr><th>Inputs</th><th>Output</th><th>Input</th><th>Output</th><th>Input</th><th>Output</th></tr>
<tr><td>Mainline demand, ramp demand, downstream bottleneck discharge rate</td><td>% improvement in travel time on main corridor</td><td>Overall corridor demand, artificial link parameters, average green ratio</td><td>Updated mainline and ramp demand using the corridor</td><td>Mainline demand, ramp demand, downstream bottleneck discharge rate</td><td>Average green ratio</td></tr>
<tr><td colspan="2">If the improvement is significant</td><th colspan="4">No-Data (Scenario 6)</th></tr>
<tr><td>2) Overall corridor demand, artificial link parameters</td><td>2) Updated mainline and ramp demand using the corridor</td><td></td><td>Input
Mainline demand, ramp demand, downstream bottleneck discharge rate</td><td>Output
% improvement in travel time on main corridor</td><td></td></tr>
</table>

1.2 Preparation of Inputs

After selecting the candidate freeway segment where the effectiveness of an ATM strategy is to be analyzed, the following steps need to be followed to prepare the input for regression models requiring overall corridor demand and artificial link parameters as inputs:

1. **Locating origin and destination:** This step requires the selection of origin and destination nodes for the selected segment. The location of origin and destination nodes captures the scale of the network where the impact of long-term route choice of the travelers is considered. For example, the farther the location of the nodes from the actual segment, the larger the scale of the network where route choices take place. The choice of the locations can be determined based on the experience. As a general guideline, the origin node can be considered two to three miles upstream of the segment, while the destination node can be considered two to three miles downstream.
2. **Estimating artificial link parameters:** Conceptually, an artificial link represents all possible routes existing between two nodes. Thus, at first all possible alternate routes between the endpoints of the artificial link should be enumerated. Only major arterials, collector-distributor roads, or other freeways should be considered as alternate routes. The free-flow travel time on the artificial link can then be approximated as the average travel time on all identified alternate routes. The capacity of the artificial link can be approximated as the sum of capacities on all alternate routes.
3. **Determining overall corridor demand:** The input origin-destination (OD) demand represents an approximate value of the number of travelers that will be traversing the freeway in addition to the travelers that will be using the alternative routes adjacent to the freeway. This number can be estimated by adding the observed peak-hour flows on the corridor and all alternate routes to the corridor or from the results of static traffic assignment model of the complete network.

For models requiring the inputs of mainline demand, ramp demand, and bottleneck speed discharge, and with no other model available to provide this data, an approximate value of input parameters can be determined using Google maps or by observing the traffic in the desired region for a particular day.

1.3 Spreadsheet Interface

This section presents some screenshots of the spreadsheet interface. Figure 1.1 shows the welcome screen of the spreadsheet tool, which prompts the user to choose among ramp metering, VSL, and DLUC for the analyses.

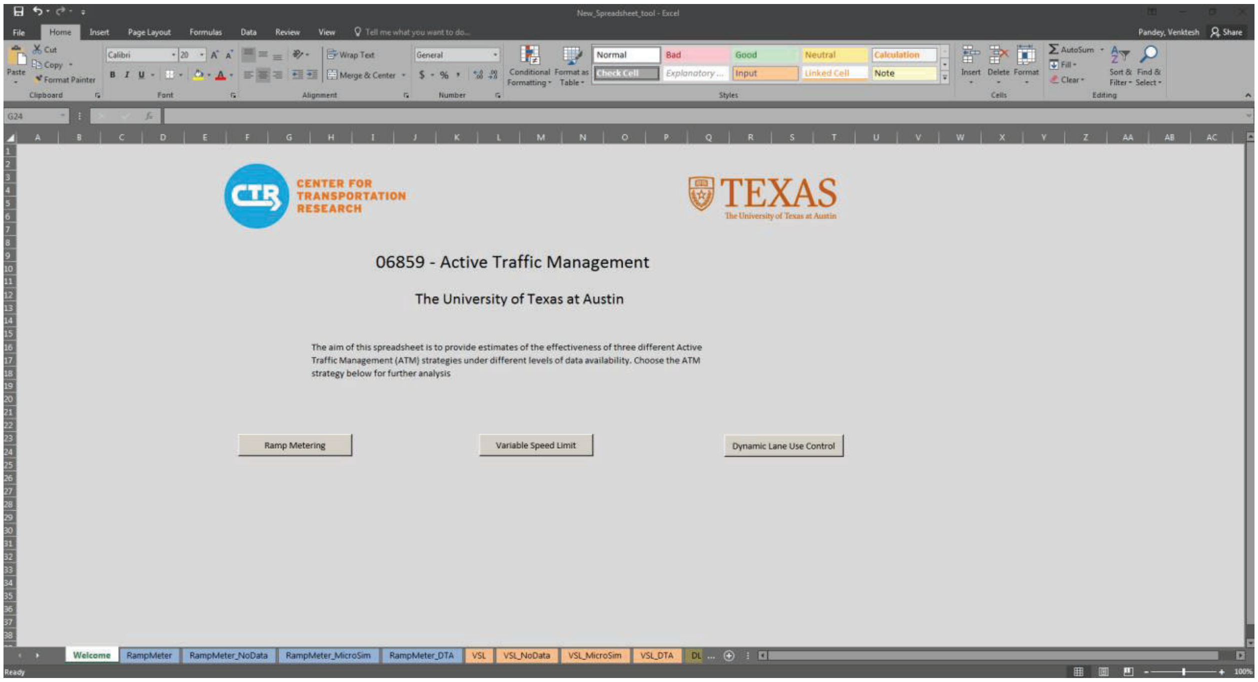

Figure 1.1 Welcome screen of the spreadsheet tool

Figure 1.2 shows the screen after selecting the ramp metering option at the welcome screen. This screen provides the user with a background of the ramp metering analysis and prompts the user to select one among the three cases: "no data," "microsimulation-alone," or "DTA-alone."

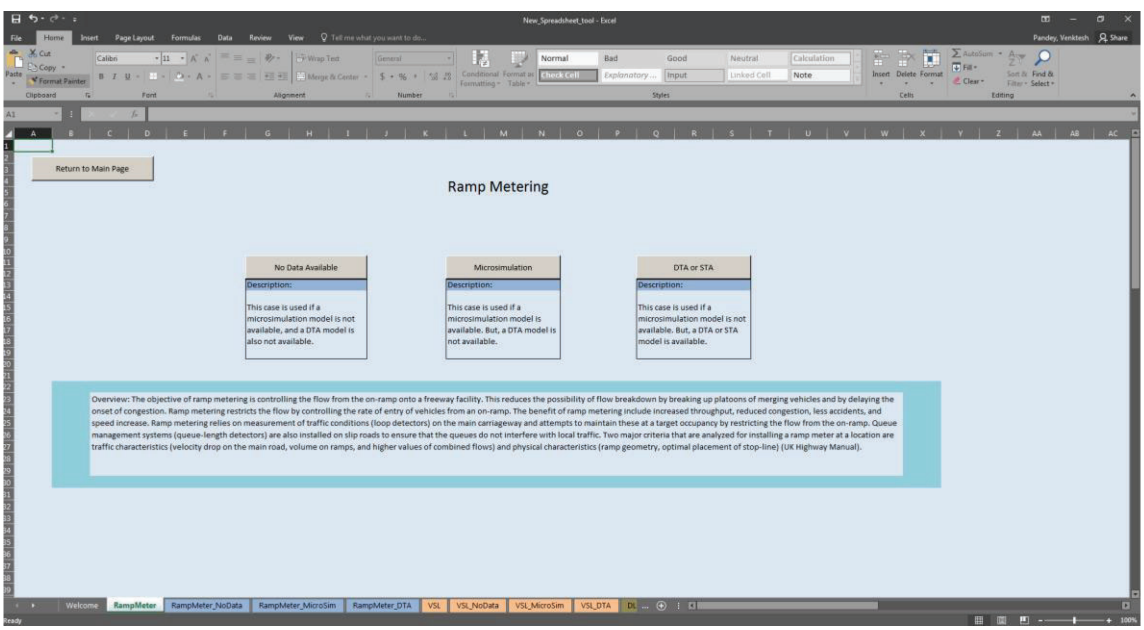

Figure 1.2 The screen prompting the user to choose one among three cases under the ramp metering strategy

Figure 1.3 shows the screen for the “no-data” case for VSLs. The screen offers an explanation for the input and output parameters and asks the user to provide inputs for the regression models based on the choice of control algorithm. The output of the regression models is presented in the adjacent cells.

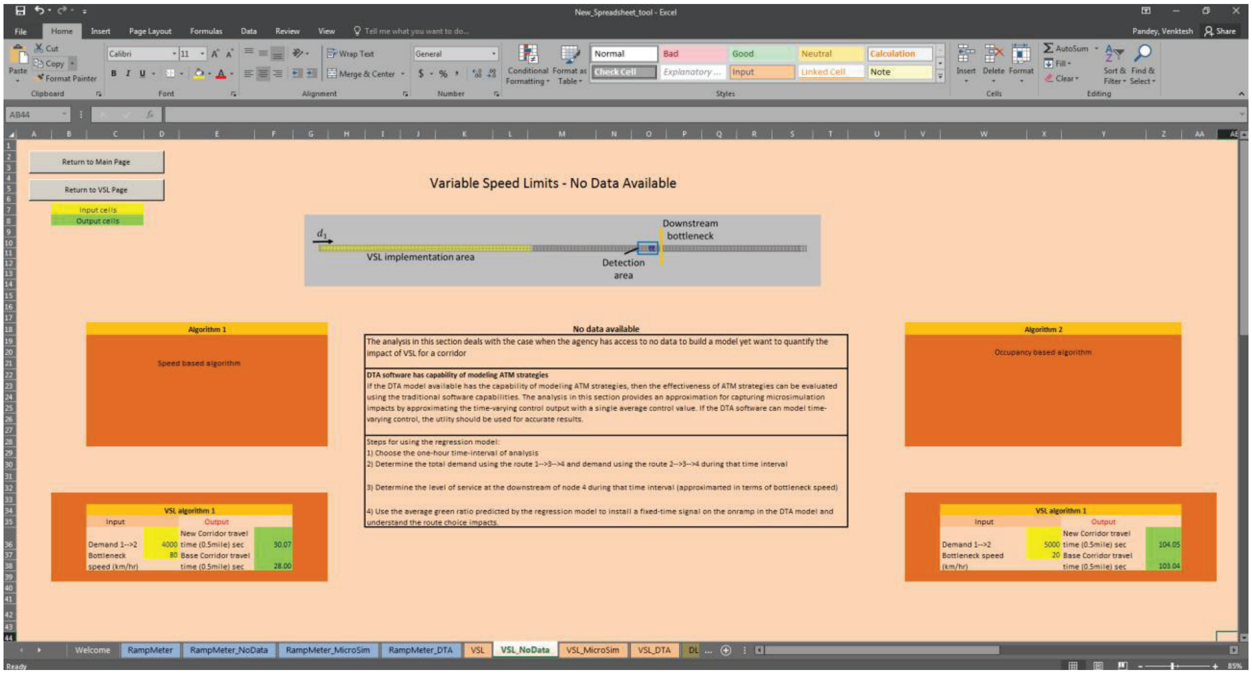

Figure 1.3 Screen showing the no-data case for VSLs with separate regression models for both control algorithms

1.4 Tutorial for the Spreadsheet Tool

This section outlines the systematic procedure for using the spreadsheet tool to evaluate the effectiveness of ramp metering or VSLs for a corridor.

1.4.1 Step 1: Identify location and time-period

This step requires the identification of the location where the effectiveness of an ATM strategy is being considered and the time-period of the analysis. The location can be an area within a city that has medium to high levels of congestion, since the effectiveness of ATM strategies is poor under extreme congestion levels. The availability of data is also a factor in selecting the location.

The time-period selected can be the peak hour if the congestion level is not extreme during peak hours, or hours preceding the peak hour if mitigating congestion earlier than peak hour can prevent the extreme onset of congestion.

1.4.2 Step 2: Select the candidate ATM strategy

This step requires the selection of candidate ATM strategies. This selection is based on the usefulness of ATM strategy in particular congestion scenarios and on the available infrastructure.

The ramp metering is a suitable candidate ATM strategy under the conditions when the ramp length is suitable to accommodate the queue generated by the meter and when the congestion is observed primary at the locations immediately downstream of the merge.

VSL is a suitable candidate ATM strategy when the infrastructure to measure speed data is available for different lanes and when the congestion pattern follows the stop-and-go oscillation behavior.

DLUC strategy near ramp merge is suitable where there is heavy ramp demand that leads to a capacity drop downstream of the bottleneck, but the mainline demand is not very high. Dynamic lane use as hard shoulder running is suitable where enough width is available for the shoulder to function as an extra lane under congestion.

1.4.3 Step 3: Select the segment where ATM strategy will be installed

This step identifies the segment where ATM strategy will be installed. For ramp metering an appropriate on-ramp location is selected, and for VSL the segment where speed limit need to be changed with time is selected. This step can be worked in conjunction with the previous step.

After the segment has been identified, the appropriate location of the nodes must be identified to build the abstract network. The location of origin and destination nodes are considered by factors described in Section 1.2. Figure 1.4 shows the abstract network for the selected segment.

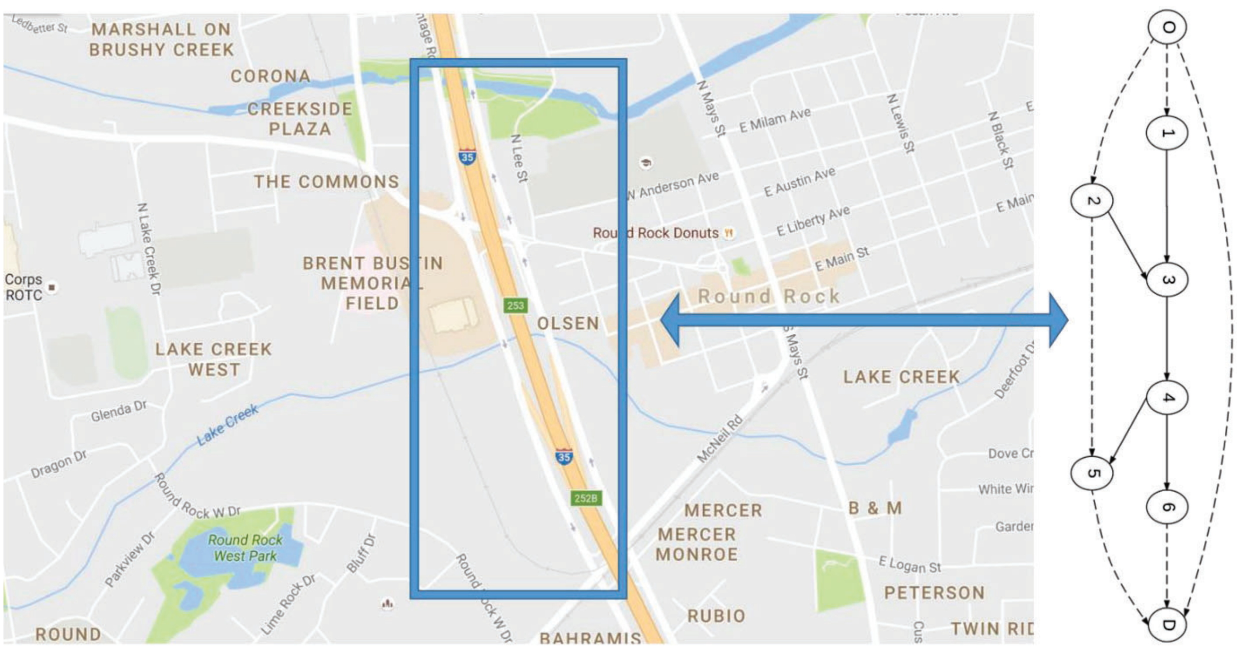

Figure 1.4 Abstraction of selected segment as a single entrance/exit pair ramp-metering network

1.4.4 Step 4: Determine data availability

This step requires collection of all available data and identifying the level of data availability to build either a microsimulation model, or a DTA model or both or none. The following four cases are possible:

1. The **no-data case** assumes that the agency has no data available to build or calibrate either a microsimulation or a DTA model.
2. The **microsimulation-only case** assumes that the agency has availability of real-time data to build and calibrate the microsimulation model but has no data available to develop a DTA model
3. The **DTA-only case** assumes that the agency only has access to strategic data to build a DTA model (or a static traffic assignment model) but has limited access to real-time data to build a microsimulation model
4. The **DTA-microsimulation case** assumes that the agency has enough data available to build both models.

1.4.5 Step 5: Prepare the inputs and use the spreadsheet tool

This section highlights the inputs required for the regression models for the first three cases of data availability.

No-Data Case

The artificial link parameters and the OD demand are determined by methods highlighted in Section 1.4. They are fed into the 'No-data' section of the spreadsheet tool under the particular ATM strategy.

Microsimulation Alone Case

The artificial link parameters are determined by the methods highlighted in Section 1.2. The OD demand is obtained as the accumulating the time-dependent demand for the three-hour period from the microsimulation model. The microsimulation model is then run for the generated demand and the average green ratio predicted by the installed ramp meter is used as an input to in the spreadsheet tool to predict the shift of demand for next iteration.

DTA (or STA) Alone Case

The artificial link parameters are determined by considering the travel time and capacity of the alternate routes in the DTA model. The OD demand is obtained by accumulating the time dependent demand from the DTA model.

DTA-Microsimulation Case

In this case, the spreadsheet tool is not used and the hybrid modeling procedure outlined earlier is followed. The procedure starts with running a base iteration in the DTA model to develop a time-dependent demand (OD matrix) for the microsimulation model. The ATM strategy is implemented in the microsimulation model and the control outputs are approximated in the DTA model to predict the shift in the demand patterns resulting in a new time OD matrix. This process is then repeated until a desired level of convergence is reached.

1.4.6 Step 6: Analyze the outputs and make conclusions

This step analyzes the output produced by the spreadsheet tool. The outputs can be studied based on the case of data availability:

1. The **no-data case** results predict the corridor travel time with and without installation of the ATM strategy. This is useful in the before-after analysis and can give a preliminary idea on the success of the ATM strategy. The maximum queue length predicted by the regression model is useful to check if the queue spills back into the arterials for the available ramp length.
2. The **microsimulation-only case** result predicts the new demand using the corridor under the obtained values of average green ratio or speed limit. This demand can then be simulated for the three-hour period in the microsimulation model using the initial demand distribution. This provides us an updated value for the green ratio. The process can be repeated until consistent average green ratios are obtained.
3. The **DTA-only case** results predict the average green ratio or speed limit which can then be modeled in the DTA model as a fixed-time signal or reduction in speed limit respectively.

Sensitivity analysis should also be performed for each of the case under different levels of demand and different locations of origin and destination nodes.

1.5 Concluding Remarks

This document described the spreadsheet tool developed to test effectiveness of ramp metering and VSL for a general network. Three cases indicating the different levels of data availability were considered for each ATM strategy. Regression models developed for each case were coded using Microsoft Excel macros and formulas. The detailed outline of the spreadsheet tool was presented in Section 1.4.