Utilizing a Multi-Tiered Modeling Approach to Conduct a Consolidated Traffic Impact Analysis in Fairfax County, VA

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INTRODUCTION

Parsons Brinckerhoff (PB) is assisting the Fairfax County (Virginia) Department of Transportation with performing multiple Consolidated Traffic Impact Analyses (CTIA) and Grid of Streets Analyses for the Tysons Corner area, west of the District of Columbia. The Tysons area has been identified as the center of growth for the region which will include a mix of residential, commercial, and professional land uses in combination of multimodal transportation options. This includes a 40 year plan to redevelop the area into a vital urban center with multimodal transportation options.

The Tysons area has been broken into smaller areas, specifically, East, West, and Central. There are numerous developers with large scale developments currently under review which are anticipated to generate thousands of trips each day in and out of the Tysons area. Each developer has developed and submitted their own traffic impact study and analysis. However, there are no traditional methods to evaluate the cumulative impact of each development. As a result, FCDOT requested that PB develop a modeling technique to analyze the impact of the developments in each region and Tysons as a whole. The request was to develop a robust tool that had the ability to analyze the results on a larger scale to evaluate diversion while also having the ability to look at microsimulation assessments.

The development of the models was conducted with close coordination of FCDOT which entails direct inputs from Tysons Partnership, developers and their traffic consultants. Multiple meetings were held throughout the course of project to facilitate the study process. This includes meetings between FCDOT and PB, stakeholders identified by FCDOT, including representatives from Tysons Partnership, developers and their traffic consultants.

OBJECTIVES

The objectives of the Tysons East CTIA and Grid of Streets Analysis were as follows:

- Develop and calibrate a set of modeling tools to be used to analyze growth in Tysons area.
- Determine a grid of streets network and road elements at gateways to Tysons which would provide the best possible traffic flow, be cost effective, and require the minimum right-of-way with the least negative impacts to adjacent properties and the environment and take into consideration the provisions of the TCP.
- Determine the phasing of the implementation of elements of the grid streets and of road requirements at gateways to Tysons.
- To perform detailed microsimulation analysis, which would assess the future traffic operations and address the complexity of Tysons.
- To help explain complex transportation situations to the stakeholders and also to facilitate the decision making process by utilizing animation features from the simulation output that would clearly indicate the visual impact of improvement alternatives.

METHODOLOGY

A multi-tiered modeling approach was used for this project, which includes the use of a macroscopic, mesoscopic, and microscopic model. Figure 1 on the following page shows the three tiers:
Figure 1: Three-Tiered Modeling Approach

More specifically:

- **Macroscopic:** The Fairfax County Travel Demand Model (build upon the Metro Washington Coalition of Governments regional travel demand model) was used as the *macroscopic model* for this project. Macroscopic models generally are developed for the purpose of conformity testing, public policy, and analyzing regionally significance projects.

- **Mesoscopic:** The middle diagram is the sub-regional model referred hereto as the *mesoscopic model*, an extraction of sub-area network links, nodes, and transportation analysis zones (TAZs) from the regional (macroscopic) demand model. Within the mesoscopic model, regional trips are linked in and can be categorized into trip purpose to conduct details of assignment and analysis of link volumes, travel time and demand to capacity ratio.

- **Microscopic:** Microscopic models (lower portion of the figure) are a further enhancement of the mesoscopic model for the purpose of performing detail simulation and analysis of corridor specific, intersections and driveways functional characteristics. Additionally, the microscopic model is used to provide visualization to help explain complex transportation scenarios to stakeholders.
SELECTION OF SOFTWARE

The key of the modeling process was a versatile mesoscopic model. VISUM was chosen as the preferred mesoscopic modeling tool for the purpose of this study. This software and modeling platform was developed by PTV Vision, a German company with satellite offices in North America. The VISUM software allows input of traffic volumes and origin-destination information to be modeled at the mesoscopic (local roadway system) level, and then be seamlessly translated into a VISSIM micro-simulation model for testing detailed operations evaluation of transportation network alternatives at the microscopic (roadway intersection) level. Additionally, VISUM has the ability to read in “geo text” files created by other developers or platforms, and as a result, has the ability to:

- Incorporate the Fairfax County Travel Demand Model O-D tables (base and future years)
- Split analysis zones (as requested by FCDOT) to allow for disaggregation of data.
- Run multiple iterations of transportation and land use scenarios quickly and efficiently.
- Refine trip matrices using the software’s matrix estimation utility.
- Be sensitive to transportation network changes including the number of lanes, intersection configurations, and trip paths.
- Provide a direct output to VISSIM for micro-simulation modeling purposes.

DEVELOPING THE VISUM MODEL (INCLUDING NETWORK)

The following analysis methodology was adopted to meet the project deliverables and schedule, which entails the full integration of regional demand model via Geographic Information System (GIS) interface with a meso/micro-simulation model. The integration of the regional model is both a top-town and a bottom-up approach. The process allows GIS to translate geographic information from the region model to VISUM/VISSIM, and improvements made to VISSIM/VISUM can be integrated back into the regional model for future use. This was an important component of the modeling process due to the complexity of the existing and future scenarios.

In short, the regional model was translated into GIS for further network refinement and enhancement by geo-coding additional network links to reflect detail roadway network of Tysons East. This process was conducted by superimposing the regional model with FCDOT 2008 aerial photography. Roadway distance and topography were checked, rectified and reasonably replicated. Additionally, travel direction, physical lane configuration, including lane assignment (such as turn bays) were added.

Upon the completion of roadway network enhancement, the GIS database and accompanying geographic information were exported to VISUM for traffic assignment and calibration. Link volumes and travel time were calibrated in VISUM; the resultant was exported to VISSIM for further detailed analysis of critical corridors, intersections, and driveways.

Both Mesoscopic and Microscopic models have the flexibilities to assign and simulate individual vehicle trips at the driveway level. However, the microscopic model is more robust and has a built-in module to simulate / animate vehicles in motion. A typical TAZ within Tysons East study area covers multiple developments with more than one driveway and / or access road. To replicate the detailed operational characteristics of each driveway, certain parcels were split to provide adequate allocation for trips it produces and attracts.
Given the requirement of the VISUM/VISSIM modeling, certain zones within the immediate Tysons East vicinity needed to be subdivided. The division of zones took both existing land use data (base condition calibration) and future development patterns and conditions (testing of future scenarios) into consideration. The objective was to enhance the level of detail of the model so that trips produced by and attracted to each TAZ would be more accurate.

Once the existing zones were subdivided, trips were then required to redistributed among the enhanced zones. Knowing that different demographic elements affect different types of trips being produced and attracted, the demographic compositions were compared to determine how trips of existing zones are reassigned among subdivided zones. For example, a TAZ containing a place of employment would generally produce and attract trips at a high order of magnitude when compared with a TAZ containing a concentration of residential units or school enrollments.

REFINEMENTS TO VISUM MODEL

Enhancements made to the VISUM network was sufficed to conduct a mesoscopic assignment; however, additional detail coding was necessary to improve VISSIM simulation. The translation from VISUM to VISSIM included the use of shape points (inherited as part of network coding) to align center line of line layer with aerial photo. In cases where the number of lanes changed, shape points may overlap with adjacent links when exported to VISSIM. Representation of intersection layout in the mesoscopic model is a center node with minimum distinction of a physical stop line and signal heads; In contrast, VISSIM requires clear distinction of signal heads and physical stop line to properly align vehicles in the appropriate lane. Using high resolution aerial photography, further refinement was made to VISSIM network.

CALIBRATION

The primary focus of the base year calibration effort was to establish a base for future alternatives analyses. The calibration process was carried out two-fold:

1) The employment of VISUM to calibrate link volumes, travel time and speed at the mesoscopic (local roadway system) level; and
2) The employment of VISSIM to conduct microscopic simulation for the purpose of identifying any issues not apparent in VISUM (and to provide visual animation to help explain complex travel conditions to the community and its stakeholders).

ADJUSTMENTS OF TRIP GENERATION RATES

Typically, traffic impact analyses use Institute of Transportation Engineers (ITE) Trip Generation Manual to estimate trips generated / attracted to a proposed development. The trip generation produced by a travel demand model is based on other factors, such as household surveys, etc. Therefore, it was necessary to compare the two and resolve differences between the two methodologies. The regional model demand trip generation was developed at the district level, which were based on social economic data. To properly reflect the trip distribution at parcel level, TAZs within the primary study area were parsed into multiple zones in order to capture the true characteristics of trip generation and distribution based on actual development size. ITE trip generation rate methodology was employed to develop the trip rate for each proposed parcel development and further employed the 2000 Census for mode choice.
and trip distribution. The matrix manipulation and FRATAR were employed to update and balance the final trip tables.

EXPECTED MAJOR RESULTS

The results of the modeling effort is a tool that FCDOT can use in the future to analyze TIAs submitted as developers continue to submit development plans for the Tysons area. Therefore, instead of focusing, on the impacts of a single development, the County has the ability to compare results of a combination of developments to determine the compounded impact on the study area roadways.

IMPLICATIONS FOR THE SCIENCE AND/OR PRACTICE OF TRAVEL MODELING

The use of Mesoscopic models will increasingly become important as macroscopic models are often too coarse for obtain peak hour volumes on specific study area links and/or intersection. On the other hand, microsimulation models often are too detailed and require too many inputs to test multiple alternatives requiring regional diversion. Mesoscopic models provide that balance by using procedures similar to a travel demand model but can consider node delay and produce measures of effectiveness similar to a microscopic model.

Macroscopic models are generally developed for conformity study purpose and the calibration and validation process are generally conducted at regional level with zonal trip distribution grossly represented. By integrating Macroscopic model with Meso-Scopic models, sub-area network can be carved out for further network coding and enhancement to properly represent study area and collect useful performance data for decision making.

For the purpose of this study, a GIS tool kit was introduced to facilitate seamless integration from macroscopic model to mesoscopic model and further trigger down to microscopic simulation. The GIS interface functioned as a "bridge" to provide a two-way communication for easy of information transfer. Figure 2 displays this linkage. Therefore, as changes are made to the Fairfax County travel demand model, these changes (network, zonal attributes, and/or trip tables) can be incorporated into the VISUM model. Similarly, changes made at the Mesoscopic (VISUM) level can be incorporated into the County model through this linkage. This allows the County to test new trip tables at the macroscopic level if desired.

CONCLUSION

The use of a multi-tiered modeling approach provides many benefits to an agency needed a defendable way to test a variety of lane use scenarios. For instance, in Fairfax County, multiple development scenarios and subsequent mitigation measures can be achieved. If developed properly, the models can be streamlined so that the use can decide which tier is most applicable for a particular analysis.
Figure 2: Flowchart of Model Interactions