Multi-Resolution Model Integration

Project performed by
Center for International Intelligent Transportation Research

In cooperation with
PTV America, Inc.
The University of Arizona

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DISCLAIMER AND ACKNOWLEDGMENTS

This research was performed by the Center for International Intelligent Transportation Research, a part of the Texas Transportation Institute, in cooperation with The University of Arizona and PTV America, Inc. The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein.

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CHAPTER 1: BACKGROUND

MULTI-RESOLUTION MODELING

Advances in traffic assignment methodologies are fundamentally changing how researchers and practitioners model both regional and localized networks simultaneously. Transportation researchers are beginning to realize the limitations of using specific model resolutions for multiple project applications. While current macroscopic, mesoscopic and microscopic approaches have proven their value in analyzing and planning traffic infrastructure and control, they have also shown limitations in their applicability, most of which are inherent in the nature of the models. Microscopic models have proven to be difficult and time consuming to calibrate and difficult to apply because of their richness in parameters and their dependency on large sets of fine grained, accurate input data. Macroscopic models are more geared to long-term planning but do not capture the temporal and spatial distribution of traffic during peak hours including daily operational traffic management strategies. Mesoscopic models on the other hand have shown their ability to accurately model dynamics in traffic demand, but still lack the fidelity to analyze individual vehicles or corridors on a lane by lane basis. Multi-Resolution Modeling (MRM) is the integration of macroscopic, mesoscopic and microscopic models for the purpose of achieving a specific goal by enabling data to be shared across modeling platforms to analyze transportation projects at different levels of detail. The benefit of MRM is twofold. First, it can save time and resources, and consequently, expedite the process to answer transportation questions raised by decision makers. Second, the MRM concept is a more robust methodology than traditional modeling methods simply because it links the Dynamic Traffic Assignment (DTA) capability embedded with the mesoscopic model to both regional travel demand models (macroscopic) and localized high-detailed models (microscopic). The MRM data transfer process allows for a more accurate depiction of traffic conditions both temporally and spatially.

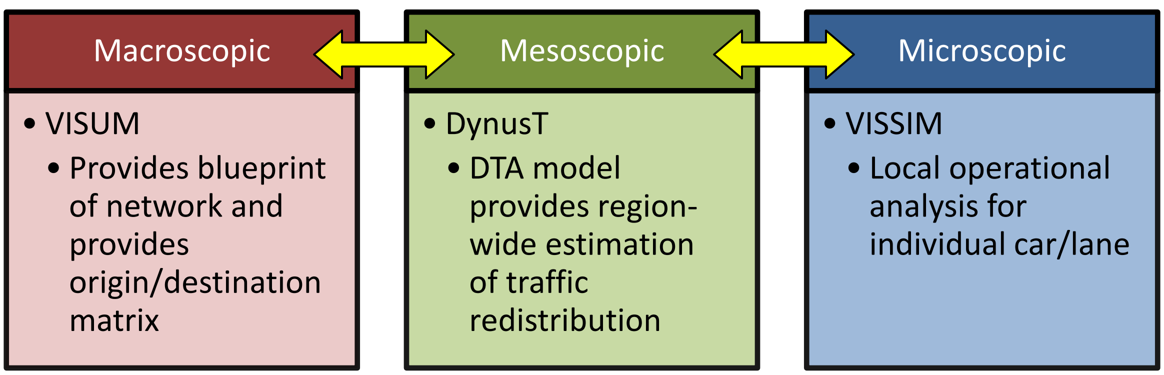

Figure 1: Multi-Resolution Model Integration

Macroscopic Traffic Models

Macroscopic traffic simulation models are mainly used for transport planning. A macroscopic model describes entities and their activities and interactions at a low level of detail.

For example, the traffic stream may be represented in some aggregate manner such as a statistical histogram or by scalar values of flow rate, density, or speed. Lane change maneuvers would not be possible or be represented at all; the model might assert that the traffic stream is properly allocated to lanes or employ an approximation [1]. A macroscopic simulation model is suitable when it is designated for freeways characterized by limited merging and weaving and lane-change interactions are not of great importance. Macro models deal with vehicle platoons rather than individual vehicles. This level of aggregation can usually be found in static planning models of typically large areas. These types of models usually display outputs as 24-hour MOE's. Therefore, they cannot give an accurate description of traffic flow during specific periods of the day and therefore are usually limited to transportation planning.

Microscopic Traffic Models

A microscopic simulation model describes both the system entities and their high level of detail. The details of microscopic models yield the flexibility to add many more modeling contexts and options than mesoscopic and macroscopic models [2]. Microscopic models, though requiring more computing time and resources to run, can represent vehicles more realistically than models at lower levels of resolution. These types of simulation models theoretically are more responsive to different traffic control strategies and can produce more accurate Measures-of-Effectiveness (MOEs) and provide enough flexibility to test various combinations of supply and demand for roadway management strategies [3]. Microscopic traffic simulation models are usually time-step and behavior based which replicate vehicular traffic, pedestrians, bicyclists and even public transit in the form of buses and rail. These models can analyze traffic and transit operations under constraints such as lane configuration, various vehicle compositions, traffic control strategies and transit terminals thus making it a useful tool for the evaluation of assorted alternatives based on Transportation Planning and Traffic Operations (TPTO) [4]. However, there exist some limitations with these high fidelity models. Even though these types of models can differentiate vehicle class compositions and can even use Dynamic Traffic Assignment (DTA), these models are unable to update shortest path search in the middle of simulation.

Mesoscopic Traffic Models

Mesoscopic simulation models fill the gaps between the aggregate level approach of macroscopic models and the individual interactions of the microscopic ones. Mesoscopic models normally describe the traffic entities at a high level of detail, but their behavior and interactions are described at a lower level of detail. These models can take varying forms. Vehicles are grouped into packets, which are routed through the network [5]. The packet of vehicles act as one entity and its speed on each link is derived from a speed-density function defined for that link, and the density on that link at the moment of entry. The density on a link is defined as the number of vehicles per mile per lane. The speed-density function relates to the speed of the vehicles on the link to the density. If there is a lot of traffic on the link, the speed-density function will give a low speed to the vehicles, whereas a low density will result in high speeds. Another mesoscopic paradigm is that of individual vehicles that are grouped into cells which control their behavior. A cell is simply a platoon of vehicles grouped together. The cells traverse the link and vehicles can enter and leave cells when needed, but not overtake. The speed of the vehicle is determined by the cell, not the individual driver's decisions [6].

Alternatively, a queue-server approach is used in some models, where the roadway is modeled as a queuing and a running part. Although the vehicles are not represented individually and maintain their individual speeds, their behavior is not modeled in detail. Vehicles traverse the running part of the roadway with a speed that is determined using a macroscopic speed-density function, and at the downstream end a queue server is transferring the vehicles to connecting roads. This model combines the advantages of dynamic disaggregated traffic stream modeling, with the ease of calibration and the use of macroscopic speed/density relationships [7].

Dynamic Traffic Assignment

The Federal Highway Administration (FHWA) has recently formulated the Traffic Analysis Tools Program in an attempt to improve and develop tools in support of traffic operations analysis. Under this program, FHWA has established two tracks under the Traffic Analysis Tools Program including the development track and the deployment track. Within the development track, FHWA focuses on methodologies that are more reliable in their applications and results. One such methodology capable of analyzing the effects of route alterations is DTA. The DTA program falls within the development track which uses expert computer processing to develop Traffic Estimation and Prediction Systems (TrEPS) that predict where and when vehicles travel on the roadway network [8].

DTA is a time-dependent methodology which captures traveler's route choice behavior as they traverse from origin to destination. The objective function known as Dynamic User Equilibrium (DUE) is based on the idea of drivers choosing their routes through the network according to their generalized travel cost experienced during the simulation. A generalized cost includes both travel time and any monetary costs (e.g. tolls) or other relevant attributes associated (preference) with a roadway. An iterative algorithmic procedure attempts to establish the DUE conditions by assignment of vehicles departing at the same time between the same OD pair using different paths. At any given point and after much iteration, travelers learn and adapt to the transportation network conditions.

In literature, there are two major DTA model categories – analytical and simulation-based DTA. Most of the existing commercially available models are simulation-based approach because simulation-based DTA models are generally more flexible than analytical DTA models in accounting for various network traffic conditions such as traffic signals, incidents, or driver routing behaviors. Characteristics of DTA include vehicles departing at different times are assigned different routes, vehicles departing at the same time departure time between the same origin/destination (OD) pair but taking different routes should have the same experienced travel time and experienced travel time cannot be realized at departure, but only at the end of the trip [9].

WHY IS MULTI-RESOLUTION MODELING IMPORTANT

Most model integration or model conversions are done directly from macroscopic to microscopic. Many software platforms on the market today have this capability. However, there is an inherent downfall when converting from macro to micro models. Macroscopic models are static and usually give outputs as overall daily averages. A travel demand model will tell a modeler the total amount of vehicles that have traveled on a specific link over the course of the entire day. They cannot show the hourly volume on a certain section of roadway at any given time. In addition, static macroscopic models typically show a volume-to-capacity (v/c) ratio >1 which means that the demand on that specific link has exceeded the capacity and subsequently oversaturation on the roadway. In reality, volume cannot exceed capacity and therefore must be represented with roadway capacity constraints. When a model is converted from macroscopic directly to microscopic, the loading pattern of vehicles remains constant for the duration of the simulation. This would reflect overloading before and after peak hours, and under loading during the peak hour. Figure 2 reflects the difference when a microscopic model loads vehicles based upon static and dynamic traffic assignment.

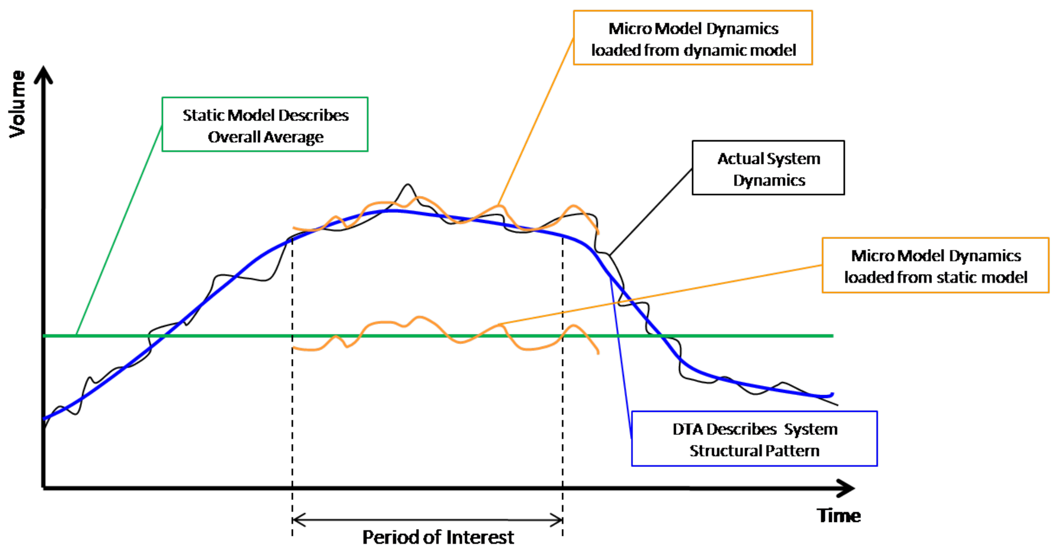

Figure 2: Static vs. Dynamic Vehicle Loading

Travel Time

In addition to vehicle loading pattern differences using MRM, the estimation of travel times between various network models is of great importance as this is the governing force in the DTA algorithm. The difference lies in whether the simulation models use a predictive or reactive assignment to estimate travel time. The predictive travel time is often referred to as an "instantaneous" travel time and is typically applied in the context of static assignment as well as in the micro-simulation context for one-shot assignment-simulation modeling. The reactive travel time, as referred to as "experienced" travel time, plays a critical role in establishing a dynamic equilibrium condition that is consistent with a traveler's route choice decision. The main difference between these two travel time estimations is in how the vehicles account for the time needed to transverse through links based upon departure time and congestion conditions [10]. In the example illustrated in Figure 3, there are four nodes and three links representing a simple roadway network.

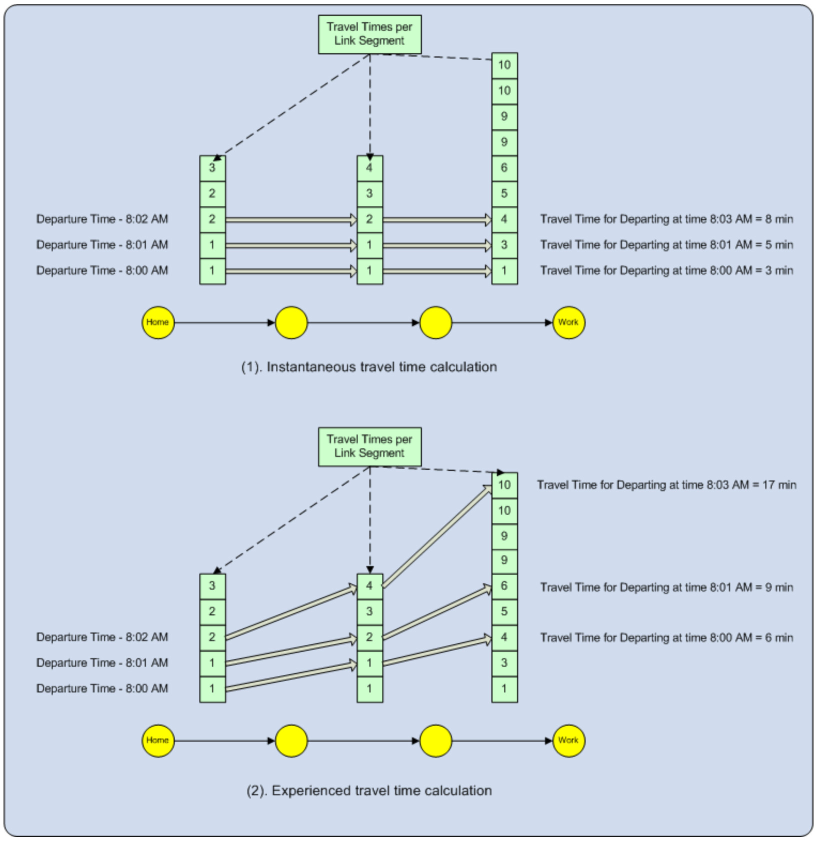

Figure 3: Instantaneous vs Experienced Travel Time Calculation [9]

Applications

The use of the MRM platform allows researchers and practitioners the ability to create large scale microscopic models for various operational planning scenarios. Normally, large scale micro-models take tremendous time and resources to calibrate. For example, a large network can be coded into microscopic simulation software relatively quickly – but developing the OD pairs within the network requires substantial time and efforts. However, using a conversion tool that is capable of translating not only the network geometry (link, nodes zones) from one level of resolution to another, but also transfer over the time-dependent paths and flows for each OD pair is a great achievement. In addition, regional travel demand models can now utilize the DTA algorithm embedded within the mesoscopic framework and in turn analyze regional traffic conditions both spatially and temporally. These capabilities open up a wider spectrum of applications that would normally be constrained by the limits of any one individual model resolution.

GOALS AND OBJECTIVES OF THE PROJECT

The proposed project was aimed at the continued development of two conversion tools that integrate DynusT[1] (mesoscopic) with VISSIM/VISUM[2] (microscopic/macroscopic) traffic simulation and assignment models to achieve optimum modeling capabilities. DynusT-VISSIM Converter (DVC) converts sub-area cuts from DynusT to VISSIM format while the VISUM-DynusT Converter (VDC) transforms travel demand models to mesoscopic format. Researchers enhanced the DVC tool by incorporating additional features including the addition of traffic control, improving the graphical user interface (GUI) and incorporate the new abstract network model (ANM) feature currently in the VISSIM/VISUM software. Researchers also continued the development of the VDC tool by creating a direct conversion from VISUM to DynusT where network geometry, zonal structure, traffic control, traffic flow models and demand matrices are converted from macroscopic to mesoscopic format where DTA can be utilized. The ultimate goal was to make the tools commercially viable by either incorporating them into the PTV software as "AddIn" modules or sold as standalone products. Figure 4 below depicts the entire MRM process.

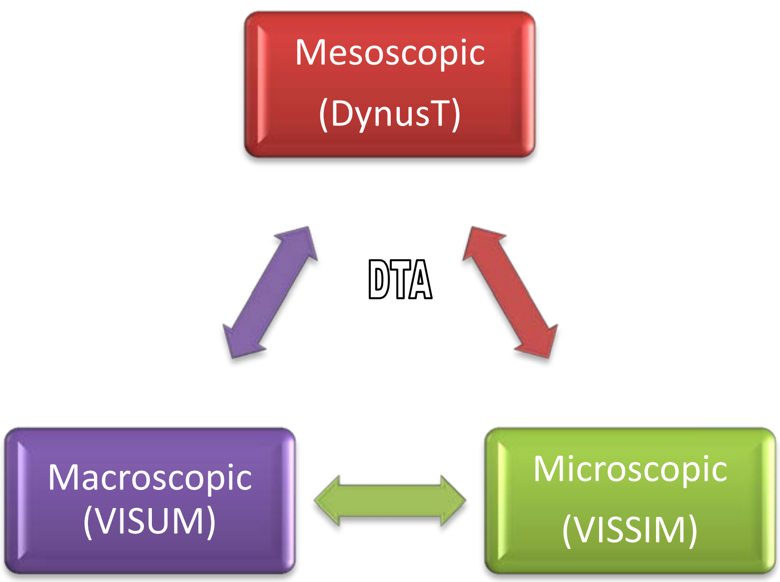

Figure 4: VISUM-DynusT-VISSIM Integration

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[1] DynusT is the dynamic traffic assignment model developed by Yi-Chang Chiu, PhD., University of Arizona
[2] VISSIM/VISUM is developed by PTV AG and distributed by PTV America, Inc.

CHAPTER 2: DYNUS-T VISSIM CONVERTER (DVC)

TRAFFIC CONTROL

The main objective for task one was to develop a direct conversion of traffic control from DynusT to VISSIM. Two and four-way stop signs as well as signalized traffic signals in the form of pre-timed and actuated were developed. Stop sign conversion was completed by placing a stop sign on individual links approach which applies only to that intersection's approach, or placing a stop sign on every signal approach. For two-way stop signs, researcher's needed to identify the major and minor approaches to distinguish which approach would yield right-of-way. All minor approaches to the intersection were given a stop sign. For all-way stops, signs were placed at the node for all inbound approaches. After an extensive investigative effort to convert over signalized intersections through the component object model (COM) and several discussions with PTV America, it was determined that signalized intersections would be better suited if created from ANM. Researchers therefore abandoned the COM approach for signal conversion and pursued the ANM methodology. ANM is a XML based format for the representation of VISUM and VISSIM networks. It is easy to deal with ANM models because its text based and COM interface is not required to manipulate the network. Also, as we don't need to use the VISUM COM interface, users who wish to use the conversion tool will no longer need a VISUM license for the conversion of network from DynusT to VISSIM.

GRAPHICAL USER INTERFACE

The main objective of this task was to enhance the existing DVC GUI by added additional features. A new "error-log" file was developed with the GUI which creates a record of any errors that may occur during the conversion process. VISUM does not allow intra-zonal trips whereas DynusT can have vehicles originate and destined to the same zone. Therefore, a log track file was developed to identify how many vehicles are lost within each zone. The GUI has several new preference features imbedded including the "time interval, minimum length of links to be split, and the start time. The time interval allows users to define the interval at which the paths and flows are updated. For smaller networks, paths can be updated every 5 minutes. Larger networks are recommended to be updated in 15 minute intervals. Since DynusT generates vehicles directly on the links, it was necessary to split all generation links and add an additional intersecting link (perpendicular). This newly generated link represents a driveway or smaller localized streets which give a more realistic flow of vehicles that are loaded into the network. The minimum length of link that can be split is defaulted to 317 ft. but can be defined longer or shorter depending on the geometry of the network. A start time (hrs: mm) is now part of the GUI where users specify the time-of-day when the simulation starts. A new status bar now informs users when the conversion process has been completed. This was necessary to aid users in determining how long it takes for conversion. A help tab on the task bar now links to the user's manual. Figure 5 below is a display of the DVC GUI.

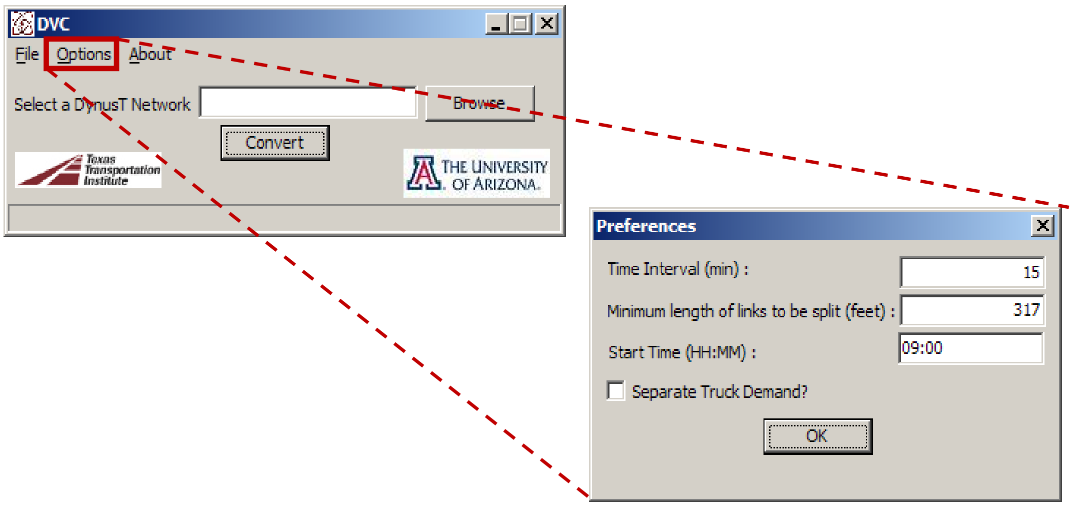
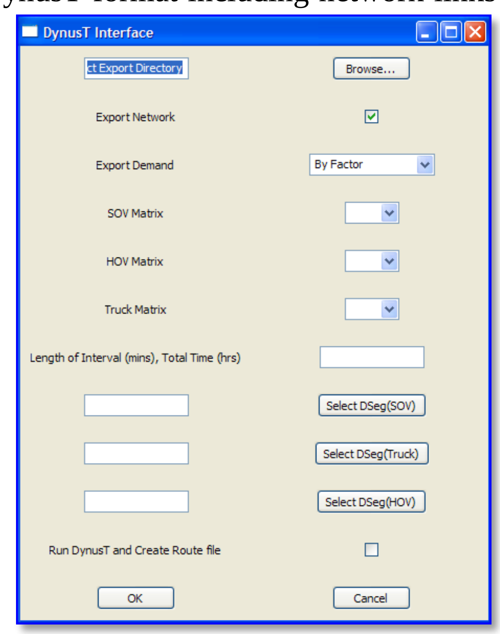


Figure 5: DVC Graphical User Interface

CHAPTER 3: VISUM DYNUS-T CONVERTER (VDC)

The VDC conversion tool was developed to integrate travel demand models with the capabilities of DTA within the mesoscopic simulation and assignment model. A series of tasks were completed in order to convert a VISUM model to DynusT format including network links and nodes, zonal structure and matrix disaggregation in order to have a viable network conversion. DynusT required several additional input files before a network can be run using the DTA algorithm. Several of these additional files including traffic flow model.dat, parameter.dat, origin.dat, destination.dat, epoch.dat, etc. were hard-coded into the conversion process. TTI began the initial development of the VDC tool and passed on the source code to PTV America for continued development. PTV America continued the construction of the conversion tool and completed the process with the development of traffic control at nodes. In addition, PTV completed the development of the "AddIn" module which allows the VDC tool to be part of the VISUM software. The AddIn feature is now part of the VISUM software as a dropdown from the main menu task bar. The current state of the VDC tool allows VISUM roadway networks to be converted to DynusT format. The conversion process was tested using the Beaverton, Oregon network as shown in Figure 6. Links, nodes, zones and traffic control were converted from a macroscopic model to a simulation-based DTA mesoscopic model.



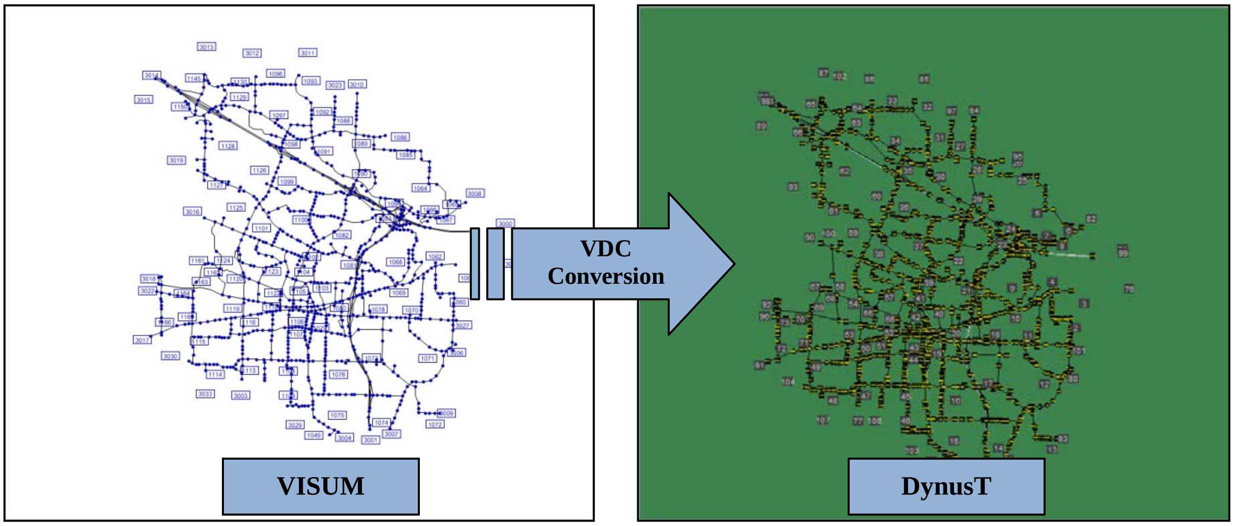


Figure 6: VDC Sample Conversion (Beaverton, Oregon)

LINKS AND NODES

Nodes were converted from VISUM to DynusT format by taking their X-Y coordinates and translating them to mesoscopic format. Nodes are point objects which indicate the spatial locations of intersections, junctions or switches in the road network [11]. They are the start and end points of links and all intermediate coordinates are referred to as feature points which define the curvature of roads. In addition, zones are connected to the network via nodes where vehicles are loaded into and out of the network. The nodes were categorized based upon the type of traffic control needed at each intersection (e.g. signalized, stop sign, uncontrolled). Link type was also needed to identify each link type's identification record. This is necessary as different link types have different properties. Table 1 below represents the various link types defined in DynusT that are converted from VISUM [12].

Table 1: DynusT Link Type Identification

Record Type	*Description*
1	Freeway
2	Freeway Segment with Detector (Ramp Metering)
3	On-Ramp
4	Off-Ramp
5	Arterial
6	HOT
7	Highway
8	HOV
9	Freeway HOT
10	Freeway HOV

ZONAL STRUCTURE

Zones were replicated from VISUM to DynusT in the same process as nodes. Zones are simply boundary areas which determine the origin and destination of vehicles. These zonal boundaries were converted by taking the X-Y coordinates and overlaying on the converted street network (nodes and links). Origin connectors in VISUM are equivalent to generation links in DynusT while destination connectors are considered destination nodes. Since VISUM generates vehicles from centroids located inside each zone as opposed to DynusT which generates vehicles directly on the links within each zone, it was necessary for researchers to remove all centroids in the conversion process. Since DynusT is simulation based, having centroids would replicate additional roadways which in turn will create additional travel time. Vehicle turning in VISUM were also converted to allowable movements in DynusT. Figure 7 shows a sample network conversion of nodes, links and zones from the travel demand model to a mesoscopic counterpart.

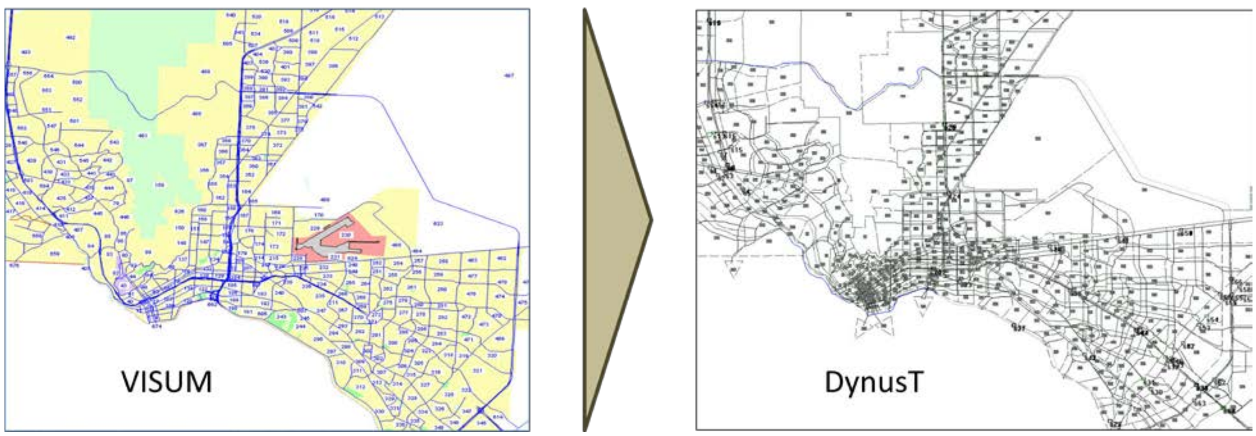


Figure 7: Initial Network Conversion (Nodes, Links, Zones)

DEMAND MATRICES

The VISUM model has one aggregated matrix that is based upon multiple trip purposes (e.g. home-work, work-home, home-private, private-home, through, external local, etc.). It was necessary to disaggregate the matrix into several matrices based upon trip purposes. The VDC tool then takes a table of hourly factors and multiplies each trip purpose factor to the corresponding matrix. Once the hourly factors have been multiplied to all corresponding trip purposes, the matrices are summed and a “one-hour” matrix is derived with directionality. The process is repeated for each hour of the day until a series of 24-hourly matrices are developed. It must be noted that the hourly factors were obtained from the El Paso Metropolitan Planning Organization and are specific to El Paso commuter departure times. The VDC tool will use these hourly factors as default values but will allow users to input hourly factors that correspond to the departure times of their network (region). Figure 3 below depicts the matrix conversion process.

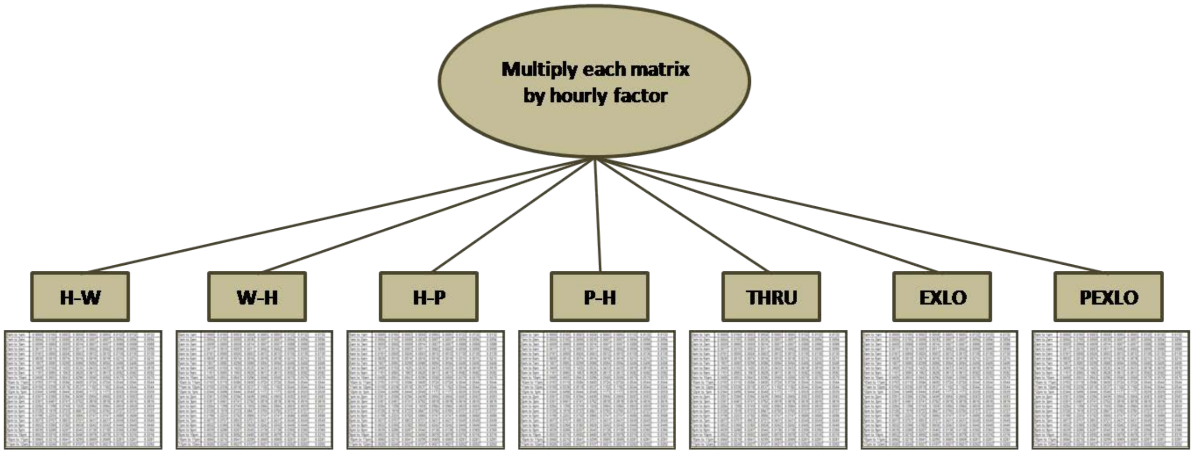


Figure 8: Matrix Conversion Process

CHAPTER 4: MODEL CALIBRATION

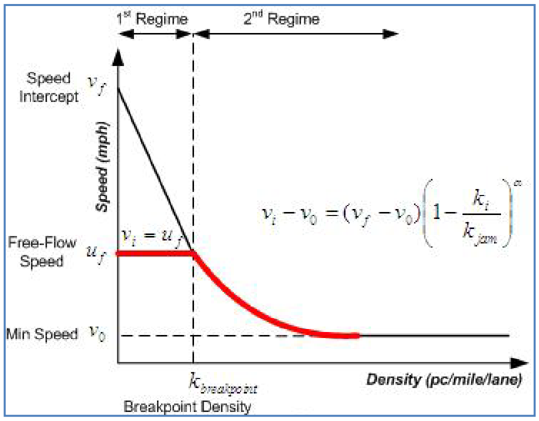
NETWORK CALIBRATION

Within the DynusT modeling framework, a series of calibration techniques is needed to achieve optimum modeling results before network conversions are conducted. Researchers performed "network" calibration in which the simulation procedure is fine-tuned to reflect network interactions between supply and demand. The traffic flow model was calibrated based upon data collected at several locations (freeway and arterial). The speed/density (v-k) relationship is calibrated using tube count data in which the average speed and volumes are calculated per defined interval. Counts are converted to flow rates and the density is calculated by taking k=q/v.

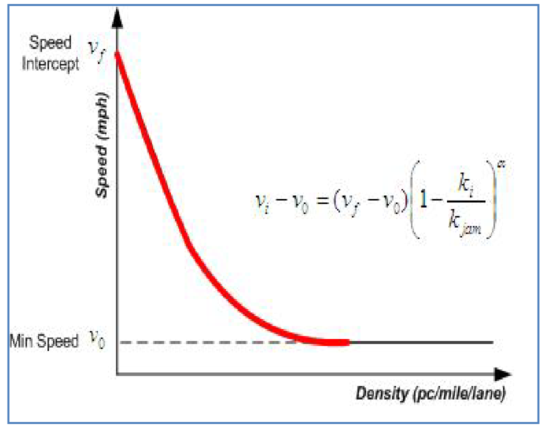
The flow model utilized in the simulation model is called the modified Greenshield's Model (Equation 1) which follows the basic traffic engineering principles and relationships of speed, density, and flow. There are two types of traffic flow models identified in the DynusT simulation model. Type 1 better dictates freeway traffic flow behavior because freeway links have greater capacity than arterials and can hold larger densities near free-flow speeds. Type 2 is more suited for arterial – type links (arterial, ramp) in which they are more sensitive to density changes due to interrupted flows (control signals) and less capacity. Both flow model types are shown in Figure 9.

$$v_i - v_0 = (v_f - v_0)\left(1 - \frac{k_i}{k_{jam}}\right)^{\alpha}$$

Equation 1: Modified Greenshield's Model



Type 1



Type 2

Figure 9: Modified Greenshield's Model

Free-flow speed v_f, minimum speed v_0, density breakpoint $k_{breakpoint}$, and jam density k_{jam} are estimated based on the collected data. The unknown variable α is the shape term which gives the curvature of the speed-density curve as the density increases. By taking the natural log (ln) of Equation 1, the α can be estimated by performing a linear regression analysis of what is now a linear equation:

$$\ln(v_i - v_0) = \ln(v_f - v_0) + \alpha\ln\left(1 - \frac{k_i}{k_{jam}}\right)$$

Equation 2: Modified Greenshield's Model as a Linear Equation

Equation 2 is the traffic flow model equation used to calibrate freeway traffic flow behavior. The free-flow speed v_f is estimated to be approximately 65mph, while the minimum speed v_0 was fixed at 5mph. The density breakpoint $k_{breakpoint}$ was approximated to be 20veh/mile/lane. Different values of the jam density k_{jam} were used to evaluate to calibrate the traffic flow model. v_i and k_i are the data points along the speed-density curve used to calibrate. The alpha α value is the unknown variable being solved.

For the example El Paso network, a k_{jam} of 180 veh/mile/lane proved to be the best value to determine the optimal α value of 3.33 with a R^2 value of 0.981129. Table 2 gives the final traffic flow model parameters. This calibrated traffic flow model was applied to all freeway links in the network.

Table 2: Freeway Traffic Flow Model Parameters

Parameter	Value
v_0	5 mph
v_f	65 mph
$k_{breakpoint}$	20 veh/mile/lane
k_{jam}	180 veh/mile/lane
α	3.33

The arterial traffic flow model variables were assumed based on available data from secondary sources. These past arterial flow models demonstrate to be quite stable and provide adequate estimation of arterial behavior. The final arterial traffic flow model parameters are given in Table 3.

Table 3: Arterial Traffic Flow Model Parameter Values

Parameter	Value
v_0	5 mph
v_f	n/a
$k_{breakpoint}$	n/a
k_{jam}	200 veh/mile/lane
α	3.55

OD CALIBRATION

The OD demand calibration methodology developed by The University of Arizona is a two-step approach, in which the first step is to systematically match the total link volumes/counts over the entire analysis period (extended peak hours) by adjusting the OD entries through the optimization model, while the second step is to properly represent the speed profile through the demand-supply concept based on the calibrated OD. There are several advantages for this approach. First, it reduces the problem to be in a manageable size; second, it has a satisfactory convergence behavior.

The calibration process attempts to match simulated time-varying link volumes with observed link traffic counts collected from the field such that the difference between the simulated link volumes and observed link volumes is minimal. The calibration procedure is a bi-level optimization problem. The upper level is the one-norm linear program optimization problem minimizing total link count deviation, and the lower level is the DUE problem solved by DynusT. Figure 10 displays the OD calibration procedure.

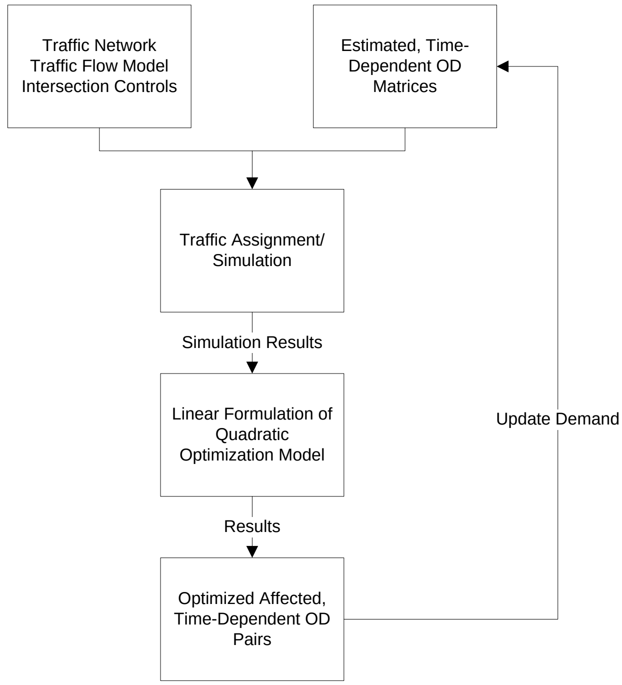


Figure 10: OD Demand Calibration Framework

The procedure is an iterative process which alternates between DynusT and the calibration program. DynusT is executed with the original demand and run to DUE. A post-processing program written in Python is called to evaluate vehicle-based output data and accumulate information of vehicles (and their associated OD pair) whose paths traversed through any link being evaluated. OD pairs that were found to have vehicles traveling through evaluated links are considered affected OD pairs. The ratio of vehicles from an OD pair that traveled an evaluated link and the total number of vehicles from that same OD pair is calculated. The linear optimization solver is then called to determine the optimal number of vehicles to adjust for each affected OD pair according to the weighted ratios of each affected OD pair. The time-dependent OD demand tables are then rebuilt to reflect the changes, and the demand is fed into DynusT is then re-run to DUE to evaluate the new demand. In this nested loop algorithmic process, each outer loop is called the OD iteration, within which each DynusT run include multiple DUE iterations.

In each DUE iteration, the mesoscopic simulation (network loading) is run to the end of the analysis period as depicted in Figure 10. The necessary information is first passed to the time-dependent shortest path and then the assignment algorithm to update the assignment of vehicles for each OD pair and departure time to the corresponding path set. This procedure is repeated for multiple iterations until the minimal gap value is reached.
At this point, the link volumes are known. They are then fed into the one-norm linear programming formulation to solve for the next updated OD matrices. The OD iterations continue until the maximum number of OD iteration is reached, or a pre-specified stopping criterion is met.

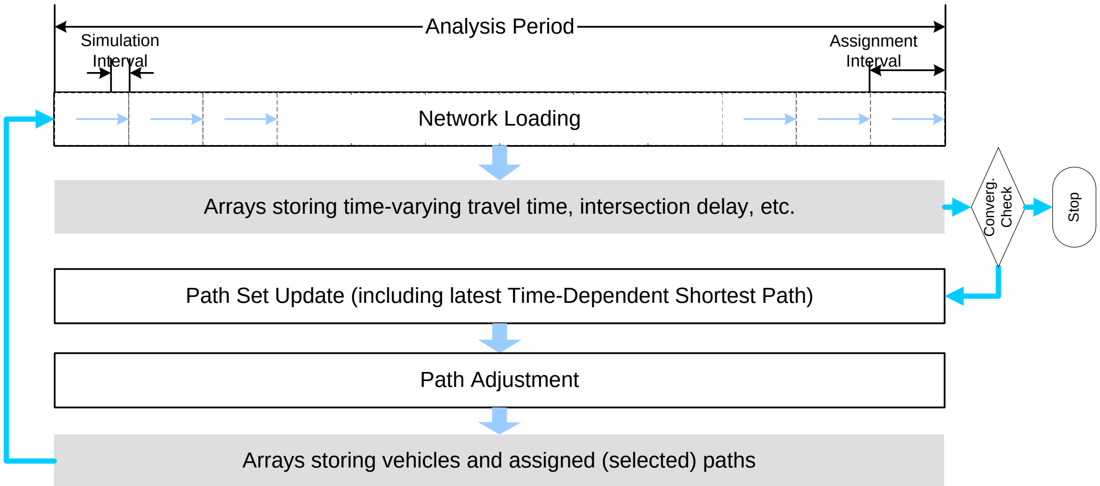


Figure 11: DynusT algorithmic procedure

As discussed above, the convergence is measured by the relative gap which is the sum of the difference between the experienced travel time for the used paths and the time-dependent shortest path for each origin, destination and departure time. The typical definition of the total relative gap is:

$$rel_{gap} = \frac{\sum_t \sum_{i \in I} \sum_{k \in K_i} f_k^t \tau_k^t - \sum_t \sum_{i \in I} d_i^t u_i^t}{\sum_t \sum_{i \in I} d_i^t u_i^t}$$

Equation 3: Relative Gap Percentage

where t is an index for an assignment interval or a departure time interval. Index i represents the set of origin destination pairs and K_i denotes the set of paths connecting the origin destination pair i. f_k^t represents the flow on path k departing at assignment interval t. τ_k^t is the travel time on path k for assignment interval t. d_i^t denotes the demand (total flow) for origin-destination pair i at time interval t and u_i^t is the shortest path travel time for OD pair i and departure time intervalt.

Note that at perfect equilibrium, the travel times on all used paths are equal to the time-dependent shortest path time and hence the value of relative gap is to zero. Since the travel time on all used paths will always be greater than or equal to the shortest path, the value of relative gap will never be negative. In most DTA applications, the solution is assumed to have converged to an equilibrium solution when the relative gap is less than a pre-specified tolerance level ($10e^{-2}$ is the mostly reported convergence level for existing DTA models).

CHAPTER 5: RETURN ON INVESTMENT

DVC

The DVC tool has been successfully used in several projects with the Texas Department of Transportation (TxDOT), Colorado Department of Transportation (CDOT), and the City of El Paso. These projects include:

- *"Analyzing the Effectiveness of Truck Lane Restrictions on Interstate 10"*
- *"Multi-Resolution Simulation Modeling of El Paso Transit Corridors"*
- *"Loop 375/SH 20 Alameda Interchange Safety Analysis"*
- *"I-70 Mountain Corridor Winter Traffic Management Scenario Analysis in Conjunction with Moveable Barriers"*

Each of these projects used a sub-area cut from a regional DynusT network and converted it to VISSIM format where the microscopic model was used for detailed analyses. TTI has applied and obtained a disclosure of invention (#3005) with the Texas A&M University System's Office of Technology and Commercialization. Researchers have established a Service Center for the DVC tool and have already seen a return-on-investment.TTI and the University of Arizona have joint ownership of the conversion tool.

VDC

The VDC tool is a collaborative effort between TTI and PTV America and therefore both parties have joint ownership. PTV and TTI have signed a memorandum of agreement (MOA) regarding future developmental work of VDC. The MOA grants PTV authorization to perform developmental work relating to the VDC tool with the goal of commercializing the "Final" software product for public benefit. PTV has fulfilled all obligations regarding the signed MOA and has given TTI the latest version "VDC ver 1.3" and user's manual. TTI has applied and obtained a disclosure of invention (#3059) with the Texas A&M University System's Office of Technology and Commercialization.

CHAPTER 5: REFERENCES

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