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# The Development of a Mesoscopic Melbourne Model

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## Abstract

The development of infrastructure delivery is a well-trodden path from concept to business case to detailed design and opening. Processes exist at both state and national levels to outline justification for value of an investment. Many of these concept solutions are larger scale and require development from government bodies, while design elements sit with the local delivery teams. These two arms produce a dichotomy of challenges – the delivery for the city and state against the requirements for a well-defined project scope. The end result can produce for a project with focus on the new infrastructure but understated holistic network view to plan and deliver complementing projects for access and unloading to the new investment. VicRoads as part of Department of Transport required a model to explore wide range of questions of short term to midterm delivery needs of this includes how and to what extent the proposed projects influence traffic movements and journey patterns in terms of various tier of impact. The organization also needs traffic management solutions that requires to be implemented that can strategize to mitigate the impact of disruption as an indispensable part of construction of new projects. This ensures that projects can be delivered.

The Domino model was developed as an innovative new approach to estimate and predict the response of network to various projects ranging from change in signal plans to construction of new infrastructures such as highways or bridges. This instrument assists VicRoads in immediate delivery of network projects.

## 1 Introduction

The existing approach has left roads agencies such as VicRoads with a scaled comprehension to be assured of operational requirements in the road network with a major enhancement to the system. Exploring the extent of new schemes to the road network in a strategic scale provides little direction for complementing network refinements. Such details may not be a focus by a project team with a limited scope of exploration.

VITM, Victorian Integrated Transport Model, is a strategic model developed to demonstrate current travel demand and existing travel pattern and changes as a result of varied in land use and major infrastructure projects. This model evaluates traffic demand responses to changes in supply as well as change in land use. This instrument allows for understanding of global performance of network as well as introduction of long-term strategies. The model remains as a static assignment solution and this does not allow for practice of dynamic traffic assignment by which propagation traffic congestion across the network and interactions between transport network and travelers can be estimated.

In terms of this detailed model fit, as illustrated in Fig 1, this solution has been developed to investigate network operations as a primary focus. The model holds connection to strategic models demand matrices as well as connections to microsimulation models intersection designs. This concept is further explored in Fig 2 which exhibits the strategic model-Domino relation as well as Domino-microsimulation models relation. As illustrated in Fig 1, Melbourne network demand matrices derived from the strategic travel demand model, VITM, feeds into Domino model for a static. Without having this detailed model, even for application in a micro-simulation setting, the required subareas which are extracted directly from VITM model for the purposes of adaptive traffic and transport operations for localized deliveries are not sufficiently accurate and reliable.

The model allows us to perform network related investigations within the following context:

- Operational performance for new or existing infrastructure
- Capacity analysis to delivery of schemes
- Journey time estimation
- Revision to traffic signal plans
- Local area network planning
- Network Management Strategies
- Congestion Mitigation Strategies
- Signal time and offset optimisation solutions
- Traffic Impact Assessments
- Incident Response Planning
- Temporary lane or road closures in disruption space
- Development to Meso/Micro-simulation

The Domino model has been developed to answer the key question at hand which is what are the impacts of a proposed scheme given the manner that VicRoads can/does operate the network and the surrounding constraints? Tis provides a means to explore how VicRoads can refine traffic operations to enhance journeys (either by revised signal plans, or revisions to geometric design). This may pertain to managing existing and/or future infrastructure projects across the metropolitan network. The model has also been developed as a platform to explore operational questions at the “80%+ level” to determine if detailed investigations (ie micro-simulation) can be shortlisted.

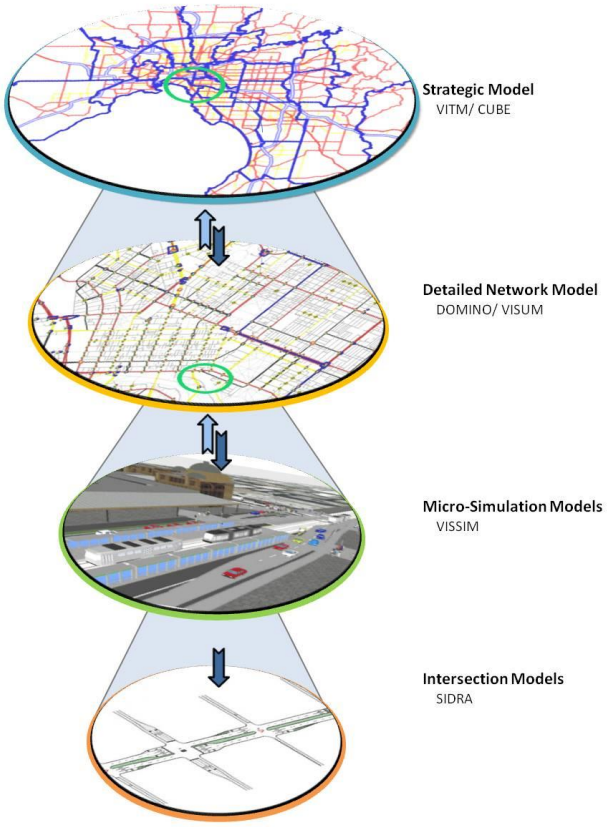


Fig 1 Software hierarchy in terms of captured details

For these reasons, VicRoads has invested in the development and application of a detailed network. This approach allows for a comparison to alternative models as the full network typology makes it an appropriate instrument for exploring the journeys across the metropolitan network of Melbourne. The model enables VicRoads to estimate a prospective response of the network to a wide range of possible network modifications and local changes including road infrastructure, signal plans and demand changes. The instrument is required to assist the organization in immediate delivery of tasks related to short term planning, network focus, operational pursuits and formation/propagation of bottlenecks without the need to consider individual vehicles in a micro-simulation landscape.

# 2 Methodology

The DOMINO model, illustrated in figure 2, is a detailed network solution that has been developed for the Melbourne metropolitan area. The solution provides VicRoads with the means to evaluate intersection capacity and turn delays using the HCM methodology and explore for smaller spaces with dynamic assignment abilities. These calculations provide a stopline capacity which pivots to form an approach capacity on each link upstream from the controller. The end solution covers for

- Approximately 650,000 links with more than 90% of links held as less than 200m
- 250,000 nodes
- 2,500 signalized intersections
- 4,500 Roundabouts

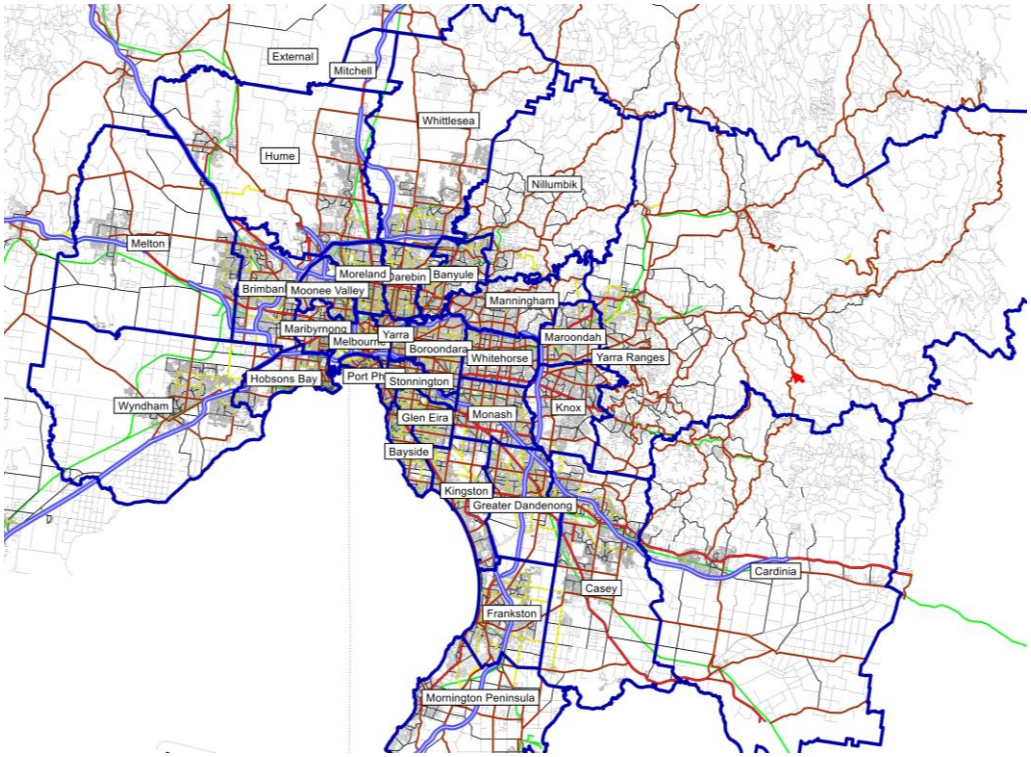


Fig 2 Network extent of the detailed model

The demand estimation is initially derived from the strategic travel demand model, developed by the Victorian Department of Transport and refined against the 24,000 detectors on 8,000 links. As the end solutions focus on network operations rather than demand estimation, we provide four separates one-hour time intervals when the network is at the most constrained: 7-8AM, 8-9AM, 4-5PM and 5-6PM.

This solution delivers a transport model that explores the inverse predicament of the strategic model – which by design provides a means to complement rather than compete for the strategic space. The Domino model provides an emphasis on calculation of bespoke link carrying capacities and a reduced focus on demand forecasting mechanisms. While both are important, the strategic downplays one

component to determine road utilization and journey times, while Domino focuses on these elements including a means to explore congestion across a broad network. The calculation of bespoke capacity also provides for a means to validate journey times on corridors and can also identify prospective bottlenecks from network conditions. The transport model not only aims to deliver a means to build demand estimations on routes, but also ensure that the journeys can be delivered.

Furthermore, it is important to note that because this model builds carrying capacity to be site specific (as a function of the downstream network objects). Any changes in network operations may also impact on the appeal of the location (potentially raised or lowered). Additional legs to a location may add signal complexity and prospectively reduce the capacity of individual movements at the intersection. Should there be changes to the downstream controller, a new operation can be implemented for this location. In other words, the approach capacity on the link allows for a measure of delay to be determined, for which the combination across prospective journeys allows for derivation of a preferred choice of route across the network. In this manner, changes to intersections and signal plans for operational pursuits can also further deter or attract journeys into the infrastructure. Application of this technique across the network means that journeys are explored as a function of the constraints within the system. Acceleration of a problem may build to a traffic reassignment issue with unexpected consequences from the initial perception. This transfers the challenge in a road management action, as the core function of VicRoads deliveries.

For better clarification of approach capacity captured in this detailed model, the modelling process is demonstrated in Fig 3. As can be seen, the approach capacity on the link then allows for a measure of delay to be determine, for which the combination delays across prospective journeys allow for derivation of a preferred choice of route across the network. Changes to intersection design and signal plans will then further deter or entice journeys in response to changes to the infrastructure or the operations over the shorter-term timeframe. For example, inclusion of new lanes may increase capacity and attracts more traffic into a space, whereas change from a T-junction ( three arms intersections) to a crossroads may have other effects to the established movements.

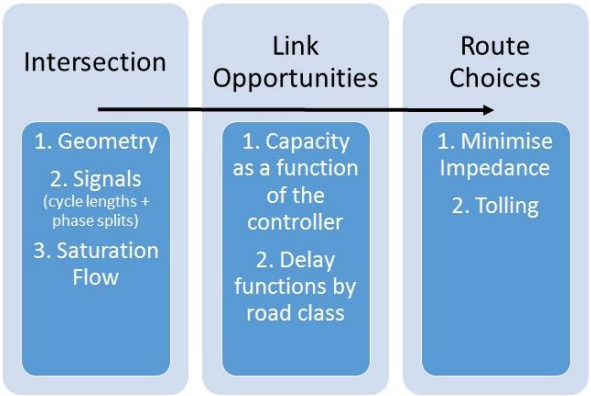


Fig 3 the connection between intersection geometry and signal program

The network provides VicRoads with a means to explore operational questions beyond the means of the strategic vision development or project delivery focus. As the model is built to explore traffic pursuits using VicRoads data and VicRoads delivery measures

there is now an established network solution to explore challenges of the metropolitan landscape. As referenced, this is not simply a matter of strategic vision development but of cumulative impact evaluation and operational deliveries. We utilize this for network challenges in the short-term disruption management (associated with construction and maintenance projects).

The structure of the Domino network model allows for users to explore conditions within an entire of partial metropolitan network for new or existing infrastructure capacity analysis, staging of schemes, journey time estimation, revision to traffic signal plans, local area network planning, network management strategies, congestion reduction strategies, signal optimization, corridor signal offset optimization, impact evaluations, incident response planning and permit and event conditions. These measures are not limited to traditional static assignments but hold flexibility for suitable approaches to the challenges including means for DTA, meso-simulation and formation of a micro-simulation as required. VicRoads and accompanying teams can then immediately step into a network solution and begin to explore challenges at hand. This includes development of communication strategies such as placement of messaging to entice drivers away from downstream works.

This model holds a wide range of datasets to supplement the network analysis investigations that complement transport modelling tasks including specifics of land uses such as schools, hospitals, religious and sporting venues, motorway details and crash data specifications (severity, time/date, interactions etc).

Within a given structure of simulation modelling, one would be able to produce vastly different patterns of movement and thereby varied predictions of journey time and traffic volumes. Simulating a process of vehicular movements using link-based model requires the modeler to specify set of parameter values to determine certain aspects of traffic behavior in order to enable the whole network model to represent traffic conditions with adequate accuracy. Here, the model has been calibrated four stage demand modelling process, subarea models should also be recalibrated to reflect the local traffic assignment elements. Therefore, volume delay functions, practical speeds and links capacity calculation, saturation flow and impedance have been considered as part of calibration process.

Validation has been undertaken using journey time metrics across 68 corridors defined within the network model.

The Domino network model is the most detailed exploration of transport conditions within metropolitan Melbourne which allows VicRoads to explore immediate changes and deliver results in a fast timeframe. This process builds upon existing solutions and delivers an application that has been adopted by teams for network evaluation and comprehension of journeys as network undergo a series of short-term changes.

The choice of software was intended to sit well with the experience and resources within VicRoads. Therefore, PTV VISUM software was chosen as a platform for development of this detailed model.

Each release of the Domino model is intended to hold a version name. The initial version of the model is referred to as the Ashburton release. Subsequent release versions will hold a different name. After this time, the more recent application of the network model should be pursued when commencing an investigation. For the update process, two full time people take care of changes happening in the network.

This detailed model provides an opportunity for various teams in VicRoads to investigate journeys as a function of characteristics of intersections and the impacts of changes to signal plans at intersections can then be examined in the context of the detail within the traffic engineering constraints and the route choice considerations. Additionally, this detailed model allows the Planned Disruptions team at VicRoads to explore the changes to the road network as a consequence of the proposed construction or proposed project scheme via plot of baseline traffic volume and its comparison with plot of project volume, difference plot of journey speeds, plot of new set of cumulative bottlenecks and more importantly map of potential messaging sign.

This model also enables VicRoads as part of Department of Transport to explore how and to what extent change in traffic operations can enhance journeys (either by revised signal plans, or revisions to geometric design). This may pertain to managing existing and/or future infrastructure projects across the metropolitan network.

This paper explores the development process behind the Domino model, including discussion around data sources, challenges explored and means to evaluate schemes so that a narrative can be developed for the delivery of construction projects and journeys across the metropolitan space. The paper is not limited to the formation of the base model, but also discusses steps forward in delivering experiences around the future year horizons.