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Linking demand from a regional travel demand forecasting model to a new DTA model: the Montreal Experience

by

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The development of a practical and computationally efficient dynamic traffic assignment (DTA) method, implemented in the Dynameq DTA software package, has enabled the modelling of much larger networks in considerable detail, compared to those that can be successfully modeled with conventional micro-simulation tools. In Montreal, a major corridor study prompted the City to commit itself to this new tool as the crucial congestion indicators would have been lacking in the existing regional travel demand forecasting model, which is based on static assignment. Micro-simulation of a 15 km by 3 km corridor would not have been feasible within the time constraints of this highly political and thus time-sensitive project. The Modernization of Notre-Dame Street Project[1] became the catalyst for the development of a modelling group at the City, revolving around Dynameq equilibrium DTA software[2]. The original 50 km^2 network has been expanded twice since delivering the first results in 2005, and now covers 120 km^2 (**Figure 1)**.

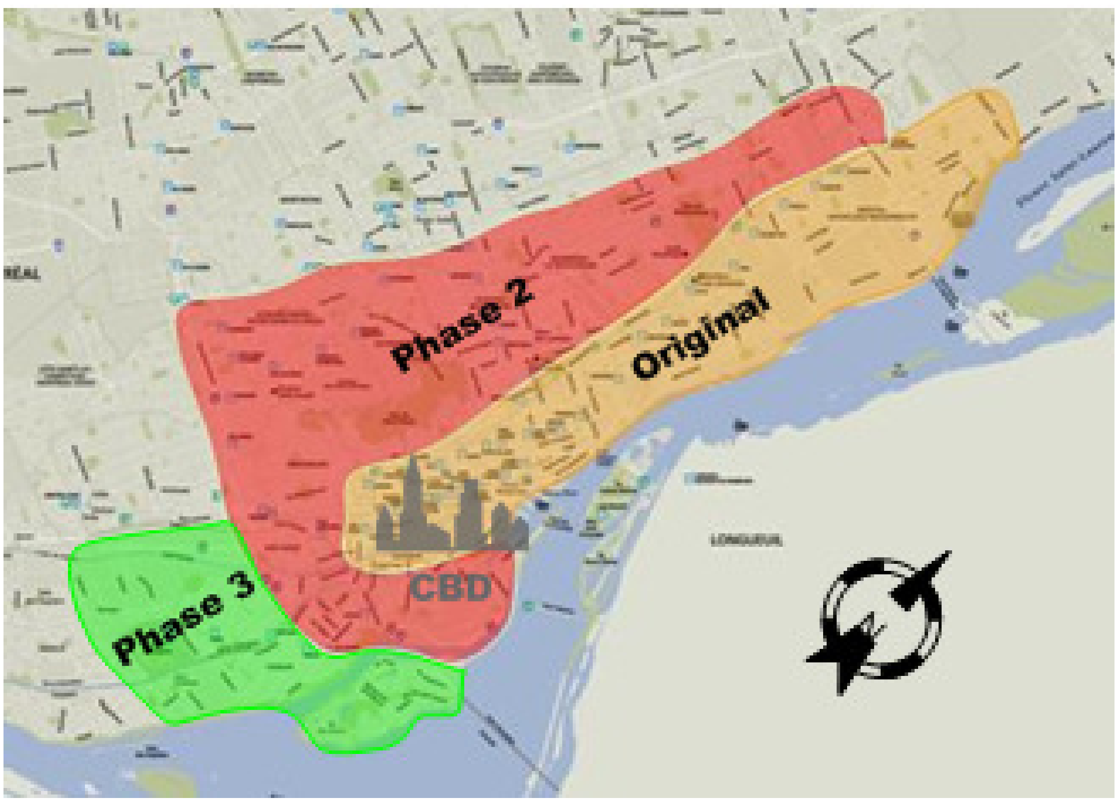

Figure 1 – Expansion Phases of the DTA Modelling Area

The boundary of the Notre-Dame Street study area was defined to include the area of influence of the Notre-Dame redevelopment plan. The initial concern was that added capacity on Notre-Dame Street would attract demand for parallel routes up to 2 km away. The DTA model demonstrated that the area of influence is even larger than expected. Volumes that were drawn from parallel streets to Notre-Dame Street should have been replaced, somewhat, by traffic coming from farther away. This domino effect could be modelled with the regional planning model, but the successes with Dynameq thus far led the project team to expand the DTA model to include a larger area of influence, double the size of the original study area.

Another phenomenon that motivates expansion of the study area is the presence of downstream congestion spilling into the study area from outside the boundary. In the newly expanded study area the boundary of the study area bisects two major north-south freeways. Two interchanges to the north, as well as merging on-ramp traffic in between these interchanges and the DTA northern boundary, create congestion which spills into the modelled area. The workaround was to gradually code the links exiting the network with reduced capacities. The need for this workaround will be alleviated as the study area grows to include these congested areas. The City plans to triple the study area over the next few years to cover 350 km^2.

The expansion of the model area solves consistency issues, but it also creates large data requirements and calibration pressures. The supply-side data (network coding and traffic control) carries little risk, since the topology and signal timings are known or observable. However, extracting the demand from the regional travel demand forecasting model for use in the DTA model carries it's own set of challenges. The Montreal regional travel demand forecasting model (MOTREM) is based on static assignment for morning and afternoon peak periods, rendering the creation of time-slices a little more complicated. Recent advances in travel simulation and forecasting with the more widespread use of tour or activity-based models allows for a more elegant way of feeding the DTA model, for instance in one hour time slices over a three or four hour peak period.

The modelling methodology in the Montreal area, which is also applied by the Ministry of Transportation of Quebec (MTQ) in Quebec City, Trois-Rivières, and Sherbrooke is based on very detailed origin-destination (OD) surveys, taken every 5 years. The data is then transformed into demand matrices, thus by-passing the first three steps of the traditional four-step Urban Transportation Planning (UTP) process. Forecasts are obtained by applying expansion factors to each OD record of the survey, which has a 5% household sampling rate. The low to non-existing growth rate (in fact, a slight decline of the population is forecasted in ten to fifteen years) allows for this type of methodology to yield satisfactory results at the primary network level (major arterials and above). Post-processing of the demand is applied in the specific cases of modification of the transit networks, and mode shifting is recalculated at the OD record level. Destination and time-of-day choices are fixed for all cases. More details are available (in French only) on the MTQ's modelling group website[3].

The brief overview of the regional methodology presented above is necessary in order to grasp the difficulties in feeding demand to the DTA model. There are several constraints that have to be respected; the main ones are the following:

- A Consistent TAZ definitions;
- B Time slicing of the demand over the peak periods;
- C Presence of "non-OD surveyable" traffic on the network.

Constraint A is not as bad as it may seem, as the TAZ definition in the CBD is very fine, approximately four to six blocks per TAZ. Given that the regional model is not land-use based, the demand is tied to the zonal definitions of the output matrix. At the OD record level, aggregation to a finer TAZ level is always possible, but that would involve complicated database manipulations that could only be performed by the MTQ (the provincial ministry responsible for the regional travel demand forecasting model), creating an inter-agency dependency that would complicate project execution.

Constraint B is handled elegantly by a macro command in the Emme travel demand forecasting model that calculates the travel time during the period between OD pairs, adds it to each individual OD record's departure time and calculates the time it would hit the traversal cordon[4]. In this way, three one-hour time slices are generated for each peak period, from 6AM to 9PM and from 3:30PM to 6:30PM. The drawback of this method is that the first hour is under represented, as the trips departing before the peak periods (but are on the network during these periods) are not taken into account. In this regard, a tour based model that could generate hourly (or even quarter or half hourly) volumes from the early morning peak through the evening peak would be a much more robust way of feeding demand to a DTA. It should be noted that it has been the City's experience that using either quarter-hourly sliced demand matrices or hourly demand matrices gives more or less the same results in the DTA model, as long as the paths are recalculated at least every 15 minutes. The benefit of hourly matrices is that they are much less demanding in terms of adjustment, which leads us to constraint C.

The traversal demand data that is extracted from the demand model consists of three one-hour auto matrices per peak period, plus three other modes: heavy truck, light truck and commercial auto, which are only available in one three-hour period. These last three modes are calculated based on a somewhat outdated truck survey (circa 1993) that has since been adjusted on traffic counts and other more focused surveys (in particular a trucking survey of the Port of Montreal in 1997), as well as the 2003 OD survey. It is recognized that the commercial side of the MOTREM is its weak point, which has prompted the MTQ to use mostly the AM peak period (when trucking is less prevalent) for its analyses. The AM only modelling is less than ideal: the Montreal is an island, which means that most of the congestion modelled in the AM peak period is throttled onto the island by the bridges, whereas during the evening peak these same bridges are among the major bottlenecks which create the congestion on the island and for which the DTA model is required.

To compound the fact that the PM peak period is not as well calibrated in the MOTREM, the OD survey is also lacking during that particular time period, when many trips are either commercial or not reported. When analyzing the demand slices along a half dozen major screen lines in the expanded DTA network, it quickly became apparent that there was a need for demand adjustment, if only to be able to feed the more detailed road network required when simulating synchronized or non-synchronized arterial traffic signal plans.

An extensive demand adjustment exercise was first done for the original network, and had to be repeated at each network expansion. Fortunately, through a clever use of Emme's triple index matrix calculator, the calibration and adjustment of the matrices for the original sub-area (Notre-Dame corridor) were maintained in the process of adding new demand when the network was expanded[5]. The creation of these adjusted matrices, for which a smoothing exercise had to be performed in the PM peak in order to ensure that all trips would get loaded onto the network, worked very well for creating a baseline (present day) model. This model is well-suited for a number of applications, such as modelling the effect of road and overpass closures. Creating the demand for modelling future scenarios, however, is another matter.

As stated above, forecasting is done after each survey, based on census data, several socio-economic factors and planned developments. These forecasts are then translated into trips by mode and corresponding OD record expansion factors for every five year interval 20 years after the most recent census. Iin this case, the last survey was in 2003 and the most recent census was in 2006, so the expansion factors are for 2011, 2016, 2021 and 2026. The problem lies in the fact that a traversal extraction of 2021 data, for example, still carries the same demand shortfalls as the existing OD survey. The auto mode will yield three hourly slices, with known PM underestimations, whereas the commercial traffic matrices are simplistically expanded by a uniform multiplier based on historical increases by mode. There is not much that can be done with the commercial traffic matrices, except apply the same multipliers directly in the Dynameq matrix calculator.

A specific methodology for the expansion of the calibrated demand to future conditions was developed for the auto demand.The methodology consists of applying expansion factors to the production and attraction vectors of the calibrated and adjusted actual matrix, based on the increases observed in the MOTREM traversal matrices. In order to do that, traversals are extracted for the present situation (for the MOTREM this means year 2003) and for the future conditions. For the Notre-Dame project, for example, the future year was 2021, for which two traversals were created: with and without the Modernization project. Since the TAZ systems are equivalent, the relative increases or decreases of each zone are applied directly to each production and attraction, and then using the matrix balancing tools in Emme, a future Dynameq adjusted matrix is generated for each time slice. It should be noted that a certain damping of the expansion factors was applied, by aggregating the TAZ into 75 homogeneous super-zones, from roughly 430 zones. This ensures that there are no overly large or small expansion factors. The demand increase from the 2003 to 2021 is approximately in the order of 15% in the MOTREM for each peak period, with values ranging from 10% to 20% for individual time slices.

The results of this future expansion in the original network for the Notre-Dame project showed a 100% traffic increase on the new facility, which satisfied both the MTQ and the City. The MTQ wanted enough capacity on Notre-Dame Streetavailable for future growth. The City was content that traffic would be diverted away from its local and collector road network. The expanded network is presently being tested with the Notre-Dame redevelopments to evaluate and quantify relief of cut-through traffic on the parallel streets in the adjacent residential neighborhood. This expanded network, with a recent addition, is also being used to evaluate the impact of removing a portion of an elevated freeway into the downtown core in favor of office development and wider arterials that would replace that facility, which is currently due for a major structural overhaul.

There are many more projects within the expanded study area for which the DTA model will be put to use, and which will also hopefully use new upcoming features of Dynameq software. In particular, an eagerly awaited generalized cost assignment would allow evaluation of a "London style" tolling of the CBD, a measure which has been announced in the latest City of Montreal Transportation Plan[6].

Conclusion

In having to feed a large DTA model from the existing static regional model, several methodologies for adjusting the demands extracted from the regional travel demand forecasting model had to be developed and adapted in order to make sure that the DTA would capture the temporal congestion effects for which it is best suited. Many demand adjustments accommodated shortfalls in the data precision for minor arterials and collectors. , and creative methods were required to forecast future demand and congestion. Tour and activity-based models should solve both the issue of slicing demand and feeding continuous slices, allowing congestion to build up and clear itself before and after the peak periods. The precision of the regional travel demand forecasting model in terms of its representation, or rather abstraction, of many collectors and local streets also becomes an important issue, as these facilities play an important role in the DTA model to feed demand to the rest of the network.

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French only website: http://www.projetnotredame.qc.ca/accueil/
More information in English http://www.canada.com/montrealgazette/news/story.html?id=fe62ef67-49f1-49ef-9462-7052bf0e4ae0&k=54943

2 http://www.inro.ca/dynameq

3 French only website
http://www.mtq.gouv.qc.ca/portal/page/portal/ministere/ministere/recherche_innovation/modelisation_systemes_transport

4 MMTRAV2 macro, André Babin, SMST (modelling group of the MTQ), Montreal, 2007

[5] Expansion of a Dynamic Model Within a Larger Static Model Network in Montreal. Pascal Volet, Christian Letarte. 20th International Emme Users' Conference. October 2006

[6] https://servicesenligne2.ville.montreal.qc.ca/sel/publications/PorteAccesTelechargement?lng=En&systemName=9455581&client=Serv_corp