Traffic Disruption Evaluation with a Large-Scale Dynamic Traffic Assignment Model: A Case Study

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1. Introduction

A traffic simulation model is an essential tool to support evidence-based decision-making for transportation planning and design projects. While traffic microsimulation models provide detailed traffic operational insights at an individual vehicle level for a set of intersections or a corridor, it is quite challenging to use the tool for network-wide traffic operational assessments. To bridge this gap, transportation practitioners are getting more interested in mesoscopic simulation models based on Dynamic Traffic Assignment (DTA) methodology. As an evolving technique, DTA modeling is sensitive to time-dependent network congestion and able to capture queue spillback delay. Therefore, prediction of traffic performance measures and flow diversion impacts due to network capacity and/or land-use changes appear more credible in DTA. Literature review and current industry practice suggest that operational planning projects are one of the major application areas of DTA. Such operational planning projects could include but not be limited to construction detour planning, LRT design and construction, road/bridge widening or closure, freeway/arterial corridor analysis due to significant network changes [1-4].

Capital roadway construction projects can cause major disruptions in the city, as lane closures and decreased speed limits significantly reduce the capacity. Moreover, hazardous conditions, decreased visibility, and dangerous construction equipment increase driver anxiety and cause more traffic incidents. It is necessary to use dynamic traffic models to assess the level of impact to the road network and develop traffic management plans during construction to minimize traffic delays and maintain traffic safety [5-7]. In Edmonton, there are typically more than 270 road construction projects yearly, and the constructions mainly happen from May to October. The City of Edmonton (COE) had developed a city-wide mesoscopic model which has been extensively used for a wide variety of projects ranging from construction detour programs to planning and designing transportation infrastructure projects at short-term and long-term horizons.

The objective of this study is to demonstrate the capabilities and required efforts of using a large-scale DTA model to evaluate network-wide traffic disruptions. The case study used the city-wide DTA model to analyze both the network-wide and localized traffic impacts along with the greenhouse gas emissions for all major construction projects in the city. Additionally, the study provides transportation practitioners with practical guidance by sharing insights gained and lessons learned from the development and practical application of the city-wide DTA model.

2. Mesoscopic Model Overview

COE uses DYNAMEQ for the city DTA model development. DYNAMEQ provides mesoscopic traffic simulation and DTA procedures that make it an ideal choice for a range of model applications and evaluations. To better understand DTA model structure and forecasting methodology as well as gradually increase the team capacity, a staged development, from a small-scale corridor level pilot study to a middle size sub-area model and to a large-scale city-wide DTA model, was adopted.

As shown in Figure 1, the study area of the DTA models follows the City of Edmonton's corporate boundary line. A model network, which includes all collectors and above roads as well as most local roads, is properly geo-referenced and guided by online maps and aerial imagery. In addition, all intersection controls, detailed intersections, truck routes, parking restrictions, public transport priority facilities, public transport stops, and other relevant features/facilities are included. The Edmonton DTA travel demand is obtained from the corresponding planning horizons of Edmonton's Region Travel Models (RTM), which is used for travel demand estimation and travel pattern analysis for the entire Edmonton region.

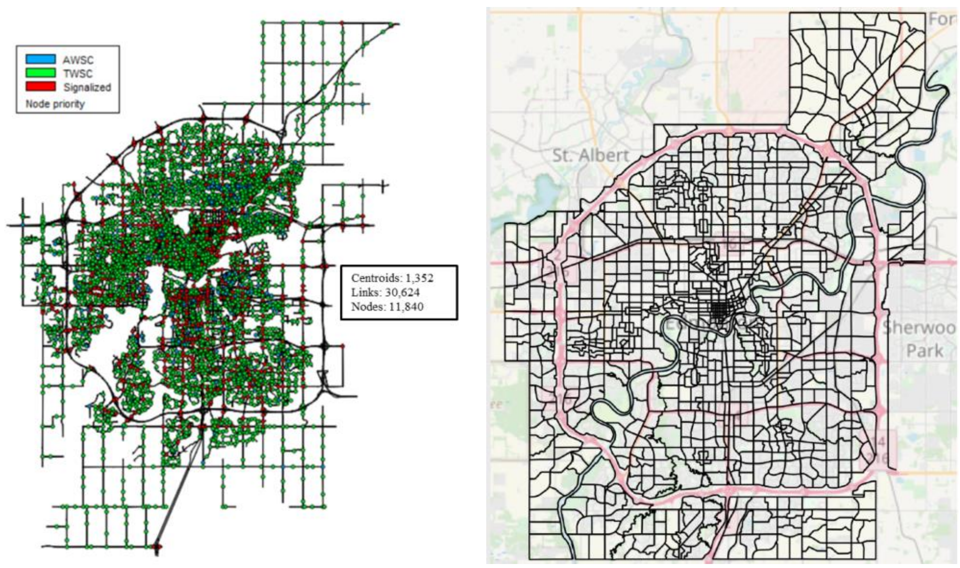

Figure 1 Edmonton DTA Model Road Network and Traffic Zone System

An iterative process was adopted to calibrate the base year model, which included adjustments on various model parameters and demand input and execution of the DTA model until traffic assignment was converged and the model output data matched reasonably well with observed field data. Table 1 shows the overall results from calibrated AM Peak models.

Table 1: Base Year Model AM Calibration Results

Objective	Vehicle Class	Time Period	Goodness-of-fit	Target	Results
Link Volumes	Auto	7:00-8:00	Linear regression statistics	R2>=0.90 Slope: [0.95,1.05]	R2=0.94, Slope=1.00
		8:00-9:00			R2=0.92, Slope=1.00
Link Volumes	Total Truck	7:00-8:00	Linear regression statistics	R2>=0.80 Slope: [0.85,1.15]	R2=0.81, Slope=1.01
		8:00-9:00			R2=0.83, Slope=0.94
Link Volumes	Heavy Truck	7:00-8:00	Linear regression statistics	R2>=0.80 Slope: [0.85,1.15]	R2=0.90, Slope=0.89
		8:00-9:00			R2=0.93, Slope=0.95
Screen Line	Auto	7:00-8:00 8:00-9:00	Percent error	Difference within 15%: > 80% cases	93% cases
Corridor Travel Time	Auto	7:00-8:00 8:00-9:00	Percent error	Difference within 15%: > 80% cases	94% Cases
Visual Audits Queuing Check	Auto	7:00-9:00	Bottlenecks from model	To analyst's satisfaction	Bottlenecks in the study area were checked and compared well with observed Google typical traffic condition

3 Case Study

As shown in Figure 2, the construction scenario represents the road network condition during the 2024 construction season. Only the projects with construction on weekdays and duration longer than 4 weeks are included in the simulation model.

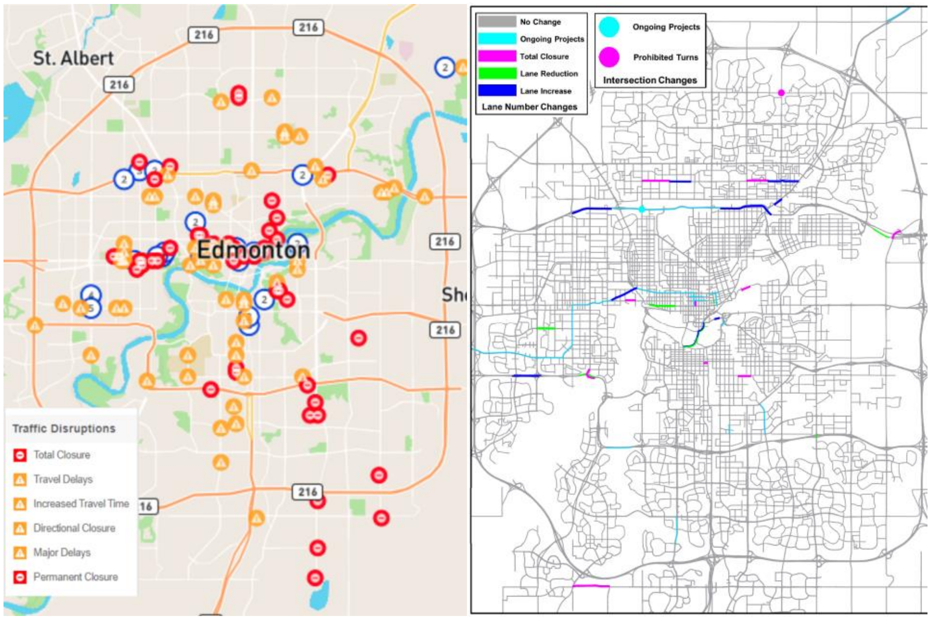

Figure 2 Traffic Construction Projects in 2024

The traffic impact of all major construction projects is evaluated from a system-wide perspective (e.g., vehicle hours of delay and greenhouse gas emissions) and a local site perspective (e.g., traffic detours, level of service, and speed contour). Based on the analysis results, projects in the areas that have the most impact on the network are then adjusted for timing and the level of roadway restriction allowed. Other aspects of traffic accommodation planning are also considered to identify and mitigate traffic disruptions for all modes of travel.

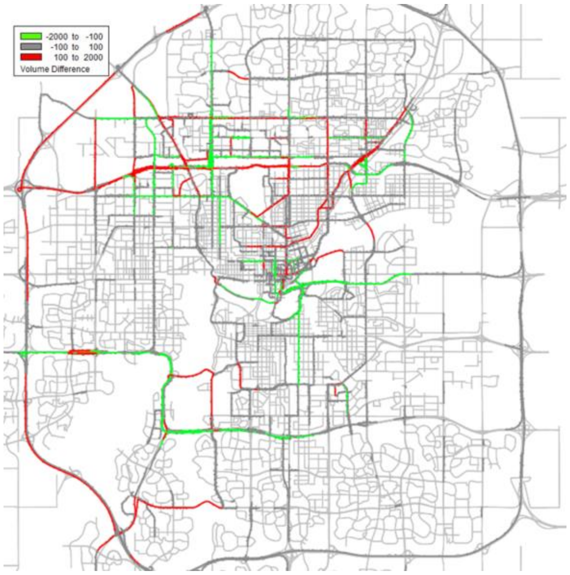

Figure 3 Traffic Detour Information

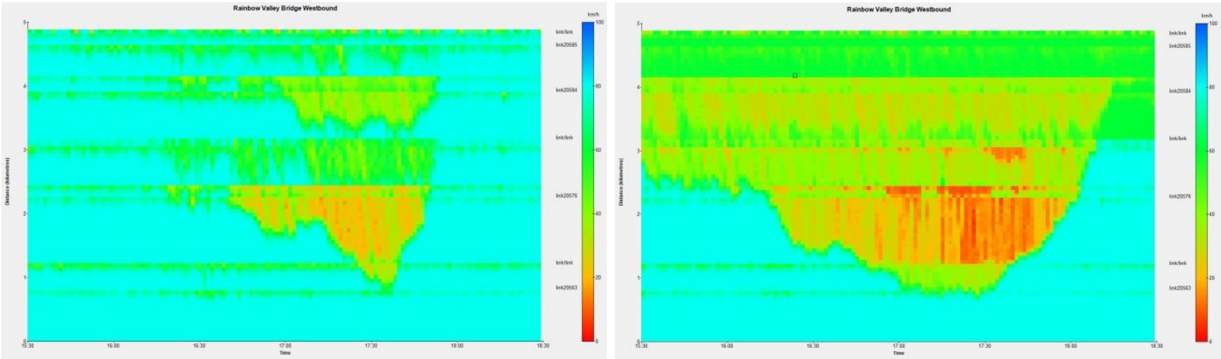

Figure 4 Speed Contour Comparisons

4 Conclusion

By conducting a case study of city-wide construction projects, we demonstrated the capabilities of using a large-scale DTA model to measure network-wide and localized traffic impacts. The mesoscopic simulation is effective in capturing the spatial and temporal interactions between travelers and the network. It can provide evidence-based decision-making for transportation planning, construction, and traffic operations. However, roadway capacity within a construction area may vary due to many factors, such as driver behaviors, pavement conditions, work intensity, work zone layout, and length. It is time-consuming to calibrate the model to reflect real traffic capacity perfectly, and sensitivity analysis may be necessary when resources and data allow.

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