Highway 401/Holt Road Interchange – Roundabout Solution and Microsimulation Assessment

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Upcoming increased activity at the Darlington Nuclear Generating Station made improving transportation capacity a primary objective for the Province. The transportation system needed to be upgraded and in place; ready in advance of the anticipated growth. Given that much of the existing infrastructure is aging , there is limited access to Highway 401 and the interchange does not lend itself to upgrading, significant changes to the Holt Road Interchange were proposed including road and ramp realignments with three roundabout intersections, new access to/from Highway 401 to the east as well as improved and safer access to/from Highway 401 to the west. The design also had to accommodate the access requirements of an operating nuclear power plant throughout the duration of the project and, as such, only minimal disruption during construction could be tolerated.

The AECOM Team produced a design to accommodate the immediate needs of OPG while allowing for future widening of Highway 401 and future connections to the East Durham Link (freeway connection to the future 407 extension). Maintaining smooth traffic flow and plant operations during construction works, improving traffic flow after construction, environmental concerns and addressing the unique challenges of an operating nuclear plant were key factors in the project's success.

AECOM undertook complex traffic analyses to understand the anticipated traffic operations through the three closely spaced roundabouts, and refinements to the design were made based on the results of the analysis. From a traffic operations standpoint, one of the challenges included managing unique demand from and to the Darlington Nuclear Generating Station, resulting in somewhat unbalanced traffic flows through the closely spaced roundabouts. As a first step, AECOM undertook a series of static analysis using Arcady software to obtain preliminary results for anticipated traffic operations at each of the three roundabouts, and to confirm the feasibility of roundabouts as an alternative solution to traffic signals. Once confirmed, further analysis was required due to certain limitations of the static analysis approach, and in order to better understand how the three roundabouts would operate as a system. A comprehensive microsimulation model was developed using VISSIM software to assess the proposed configuration, and to further "fine-tune" the design. The outcome of the microsimulation analysis played an instrumental role in the development of final recommendations for the entire interchange configuration.

Introduction

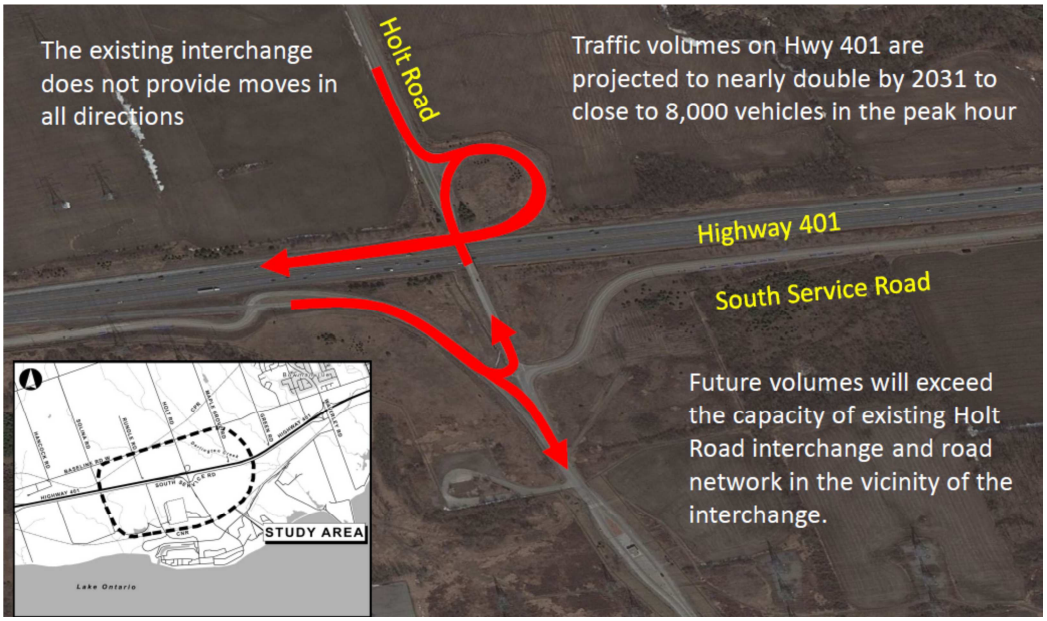
The upcoming changes to the Darlington Nuclear Generating Station (DNGS) will result in a significant increase in traffic volumes in the area triggering a need for improvements to the existing road infrastructure. The DNGS is located immediately to the south of a major freeway corridor (Highway 401) with access provided via an existing partial interchange at Holt Road. The freeway corridor itself is being planned for a major widening in the near future to accommodate anticipated traffic demand through this area. It was apparent that the existing interchange is in need of a significant reconfiguration with its partial

access to and from the freeway in its current state. The fact that the Holt Road interchange provides access to a nuclear generation station, and is part of an emergency evacuation route increases the complexity of the undertaking. Other challenges include close proximity of ramp terminal intersections to a service road on south side, and an arterial corridor on the north side.

Existing and Future Deficiencies

The Holt Road interchange in its current state is a partial interchange with access to and from the west only. Both ramp terminals are currently unsignalized with Holt Road being two-lanes wide across the structure. Highway 401, which is a major freeway corridor through the Greater Toronto Area spanning between Windsor and the Province of Quebec has a six lane cross-section, and is projected to double its existing traffic demand to approximately 8,000 vehicles per hour in the peak direction by 2031. The existing interchange itself will not be able to handle the amount of traffic that is projected within the next ten years. **Exhibit 1** below illustrates the existing Holt Road interchange and summarizes existing and future deficiencies.

Exhibit 1. Highway 401/Holt Road Interchange – Existing and Future Deficiencies

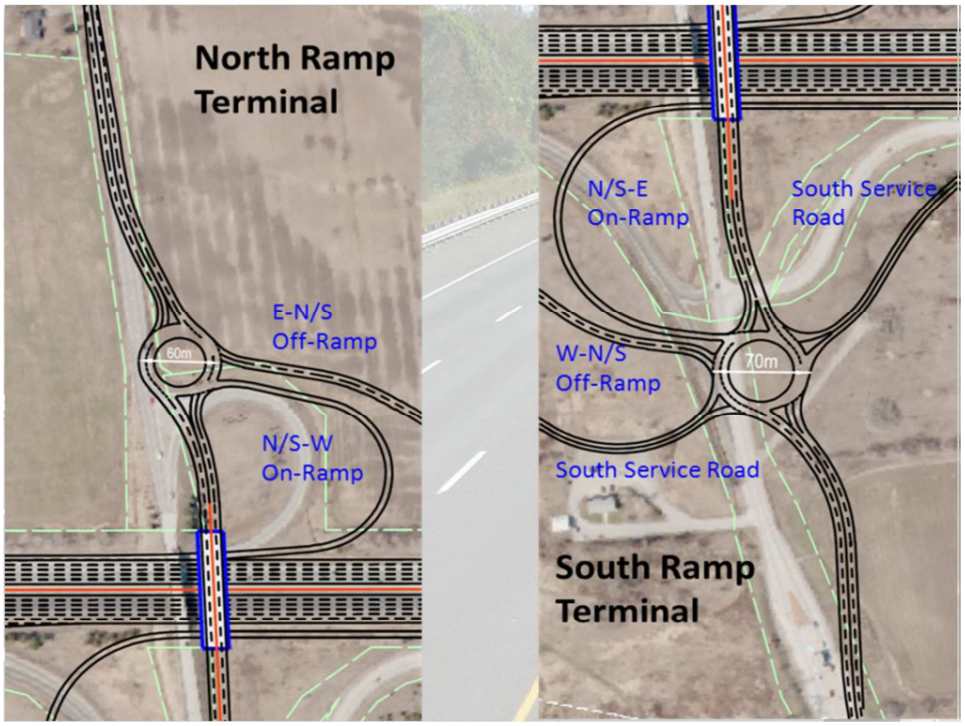


Alternatives Selection and Analysis

A number of alternatives was generated and assessed using various criteria, including traffic operations and safety. Although the Parclo A4 type interchange is the interchange of choice for the Ministry of Transportation of Ontario, given the characteristics of the area, including close proximity to the future freeway link (East Durham Link) that would connect Highway 401 with Highway 407, an interchange with roundabouts was selected as the Recommended Alternative. **Exhibit 2** illustrates the initial

recommended alternative, which comprises a three-legged roundabout at the north ramp terminal and a five-legged roundabout at the south ramp terminal that also incorporates the intersection with South Service Road.

Exhibit 2. Initial Recommended Alternative



The main advantages of this alternative included reduced environmental impacts, reduced property impacts, cost savings; and operational benefits along both Highway 401 and at the Holt Road interchange. Potential disadvantages included the fact that five-legged Roundabout creates challenges with signage, as well as lack of drivers' familiarity with roundabouts.

Signage issues proved to be a significant concern with the initially preferred five-legged roundabout alternative, and as a result, this scenario was further refined by splitting the south roundabout into two roundabouts in order to improve signage as well as operations, resulting in three roundabouts in close proximity to each other. This formed the Technically Preferred Alternative (TPA). **Exhibit 3** illustrates the TPA.

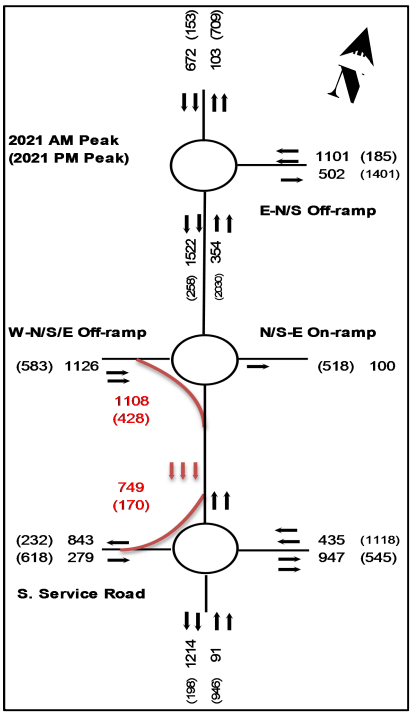
Exhibit 3. Technically Preferred Alternative

Arcady vs VISSIM Assessments

The initial assessment was undertaken using the Arcady software for roundabouts. It was quickly recognized that Arcady does not take into account channelized right turn lanes, as the software considers capacity within the roundabout, specifically at merges between traffic within the roundabout and traffic entering the roundabout from each approach. With the channelized right turn lane in place, traffic in such a lane bypasses the merge within the roundabout, and merges with vehicles exiting the roundabout in the same direction. This merge area is not assessed by Arcady, triggering additional consideration as operational concerns downstream from the roundabout may affect operations of the roundabout itself. These potential operational issues are not captured by Arcady, which may lead to overly optimistic results. In addition, given the close proximity between the roundabouts, the static type of operational assessment does not capture traffic interaction between the roundabouts, such as lane selection/utilization between adjacent sections. For these two reasons, the technically preferred

alternative was further assessed as one network system using VISSIM software. This microsimulation assessment helped to identify potential operational concerns not only within the roundabouts, but also along the sections between them, including possible weaving issues. The analysis revealed that significant volumes from the W-S off-ramp create potential for a weave between the ramp terminal and the roundabout at South Service Road (refer to Exhibit 4 for traffic volumes).

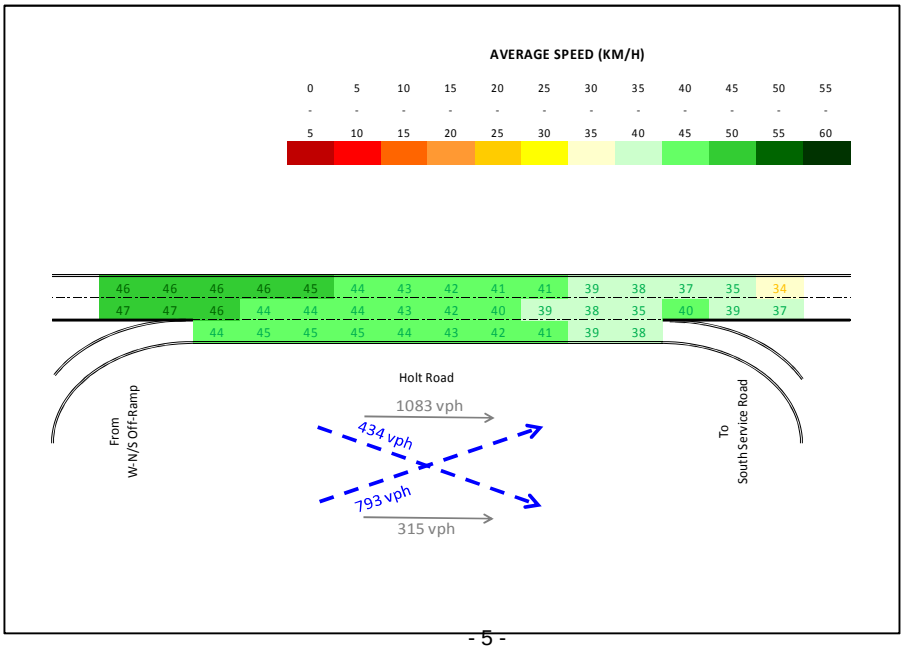
Exhibit 4. Holt Road Interchange Traffic Volumes



As can be seen from **Exhibit 4**, the majority of the off-ramp volume is destined to the south. The heavy demand for the right turn creates a weave between traffic entering Holt Road from the off-ramp and southbound traffic on Holt Road destined to the west on South Service Road. The VISSIM analysis revealed frequent speed reductions in the southbound direction between the two roundabouts. Although the channelized right turn improves operations at the south ramp terminal, it results in a relatively short weaving section between the two roundabouts.

Exhibit 5 summarizes the lane-by-lane speed assessment based on the VISSIM modelling outputs. As can be seen from the exhibit, operating speeds decrease on the approach to the southbound right turn channel onto South Service Road. The speed reductions are in the 10 km/h range.

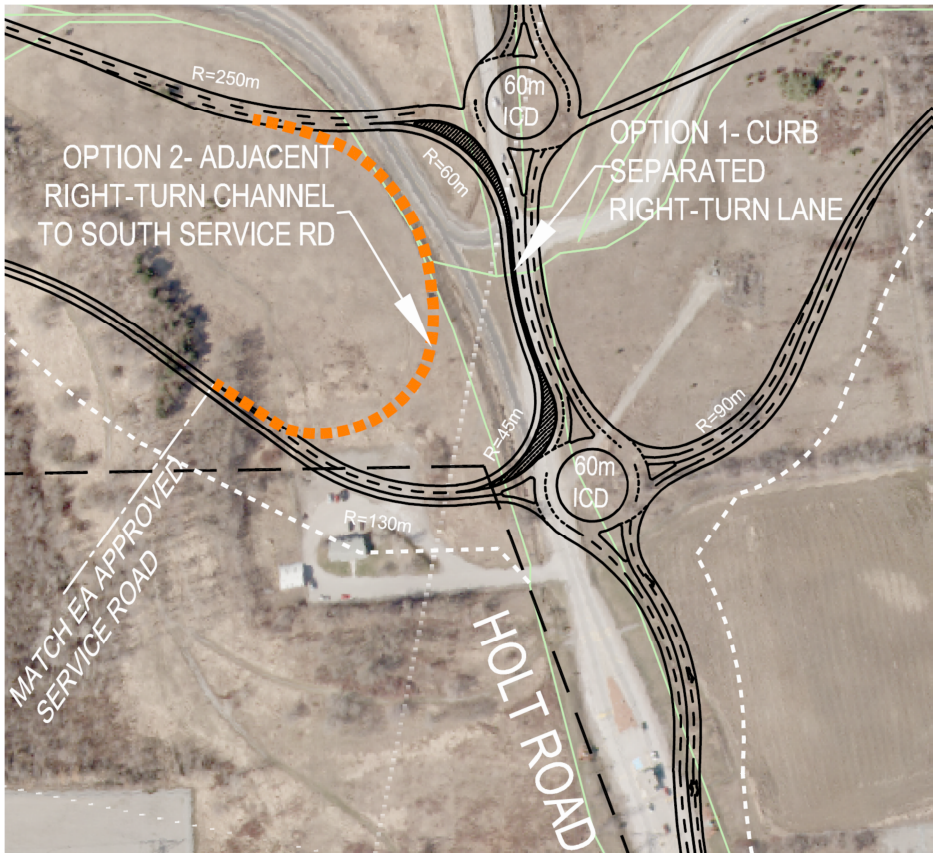
Exhibit 5. Weaving Analysis - Lane-by-Lane Speed Assessment



Final Design Recommendations

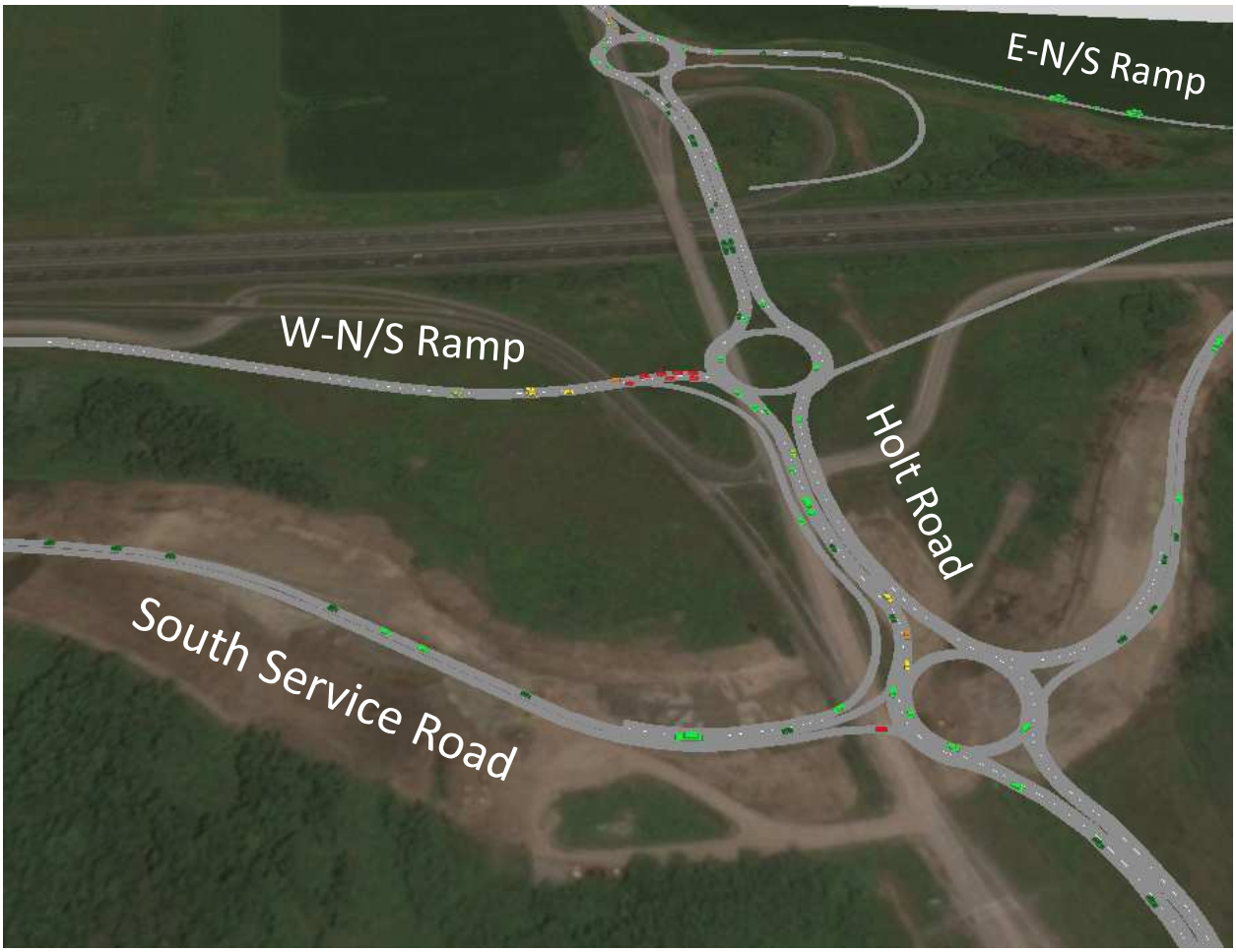
The microsimulation assessment results revealed numerous potential operational concerns in the preferred scenario triggering a need for additional reviews in search of optimum and cost effective improvements that would alleviate the identified concerns. First assessed was the split of the five-legged roundabout into two separate roundabouts. This improvement resulted in unacceptable operations on the approach to one of the roundabouts from the W-N/S off-ramp. The introduction of a channelized right turn at the south ramp terminal roundabout eliminated this operational deficiency, however, created a potential for a weave between the off-ramp and South Service Road in the southbound direction. As a result, a "bypass" lane was introduced that would separate the two flows of traffic, as illustrated in **Exhibit 6**.

Exhibit 6. Recommended Design (Final)



A VISSIM microsimulation run of the scenario with the "bypass" lane confirmed acceptable operations for this alternative, which formed a recommendation for the final design. **Exhibit 7** illustrates a snap shot from the VISSIM model of the final recommended design.

Exhibit 7. Final Recommendation – VISSIM Snap Shot



Conclusions

Due to proximity of the future East Durham Link/Highway 401 interchange to Holt Road (amongst other reasons), the alternative with roundabouts was selected as the Technically Preferred Alternative. A static analysis proved to have limitations in capturing traffic operations immediately downstream from the roundabout where channelized right turns are present. The VISSIM microsimulation analysis helped to detect potential operational issues not identified in the static analysis. The outcome of the microsimulation analysis played an instrumental role in the development of final recommendations for the entire interchange configuration.

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