CANADIAN CONSULTING engineer

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CCE AWARDS 2020

ION Stage 1 Light Rail Transit (Waterloo LRT)

Summary

The ION Stage 1 Light Rail Transit (LRT), also known as the Waterloo LRT Project, encompassed the design of approximately 19 km of LRT track connecting the Conestoga Mall transit terminal to the Fairview Mall transit terminal. The project is a mix of on-street, line-of-sight operation and off-street components on a segregated right-of-way, sharing existing railway corridors and servicing daily ridership of 25,000 passengers. The project also included a new vehicular/rail grade separation at King Street.

The Waterloo LRT aims to increase overall transit ridership and reduce traffic congestion while striving to meet the long-term infrastructure and service needs and continued population and employment growth within the Region. All 19 LRT passenger stops are at-grade and integrated into the existing surrounding urban streetscape and existing infrastructure with LRT shelters and communication systems such as variable message displays, closed circuit television (CCTV) cameras, PA systems and passenger assistance intercoms. At the stops, embedded track sections are tied to the at-grade platform in order to maintain Accessibility for Ontarians with Disabilities Act (AODA) standards and level boarding compliance.

Innovation

AECOM implemented a number of innovative solutions, providing technical excellence on the Waterloo LRT project. The team provided solutions to technical and design challenges, including, electrification, shared track and signalling systems, and trackwork.

Electrification

The traction electrification system consists of a traction power system design with 13 traction power substations and an OCS consisting of a fixed termination trolley system in the OMSF areas and an auto-tensioned simple catenary system on the mainline. Connections with the regional power supplier were coordinated for the design and construction phases.

Shared Track and Signalling Systems

AECOM coordinated with the Contractor, stakeholders and AHJs, including Transport Canada and CN Rail to develop design and specification for the track and signalling systems that was required to support safe shared LRT and freight railway operations. A particular challenge posed by the project was having turnouts for mixed traffic (LRT and freight) with different wheel profiles and wheel set dimensions. Design considerations such as selection of high strength rail and installation of track lubricators were selected to extend the overall rail life cycle and reduce maintenance activities. Specific to the running rail, premium carbon steel in line head hardened rail was selected. This type of running rail was required to have a Brinell Hardness number between 370HB and 410HB (i.e., categorized as high strength rail as per AREMA). Other design considerations included placement of restraining rail in curves having tight radii to reduce the amount of rail wear caused by normal train operations and directly prolongs life of the outside running rail.

Additionally, since mixed use traffic was expected AECOM has designed gauntlet tracks for the Research and Technology Park LRT stop, the University of Waterloo LRT stop and the Seagram Drive LRT stop. These tracks allow freight trains to run on a discrete pair of rails to allow access through the platform limits, which would have been otherwise constrained. The constraint arises due to the clearance envelope requirements as freight movements require a much larger clearance envelope compared to LRT vehicle movements. The benefit of this design is that since there is only a minor increase in track bed width, compared to a single track, both tracks can be carried on the same crossties using different track material based on appropriate direction, track gauge or loading.

Trackwork

All trackwork elements were designed according to the technical/performance output specifications, TCRP, AREMA, CN standards and industry best practices. Both LRT and freight railroad standards were referenced throughout the design due to the mixed-use traffic expected throughout specific areas of the rail corridor. The goal of the trackwork design was to provide a robust uniform structure for each track type, while standardizing materials and sizes. This approach to the trackwork design was taken to minimize future maintenance and expedite long-term maintenance activities, by applying best practices and lessons learned on past projects.

Trackwork solutions considered the key environmental conditions, including resistance to the effects of heavy salt and deicing chemicals, cold temperatures, heavy snow falls, icing conditions, frost heaving conditions and snow plowing activities. The design also considers site specific constraints, such as rubber tire traffic loading and mixed rail traffic conditions. The detailed trackwork design controlled stray current, mitigated noise and vibration and achieved compatibility between the LRT and freight railroad equipment.

Generally, the types of track used for the Waterloo LRT are a flexible ballasted track and more rigid embedded or direct fixation track. Special trackwork accommodates 115RE tee rail, conforming to

AREMA standards. Efforts have been made to use a reduced disparity in terms of turnout sizes that will allow faster procurement and reduced volume of spare parts for maintenance.

All special trackwork is located on tangent, non-super elevated track. Direct-fixation special trackwork has incorporated elastomeric materials to dampen noise and vibration and to accommodate deflection under dynamic load. Special trackwork design for exclusive freight rail-road conforms to the specific railroad requirements and has been submitted and reviewed by the railroad authority for their acceptance. On direct fixation or ballasted track, frogs are Welded Boltless Manganese to better conform to the tread support criteria. For turnouts that are to undergo mixed LRT and freight traffic moveable point frogs are used.

In addition, applicable freight and LRT standards were blended to incorporate the mixed running freight and LRT traffic. In cases of overlap between standards, a more conservative design approach was utilized, maximizing safety and accommodating the mixed-use traffic. For example, grade crossings are illustrative of the blending of standards as they are designed in accordance with Transport Canada's applicable regulations. The grade crossing standards referenced regulate freight trains and not LRT vehicles. However for the crossing safety assessments, the LRT vehicles were treated in the same manner as freight trains. This resulted in a more conservative grade crossing design for LRT exclusive crossings. All crossing equipment and design of both mixed traffic and exclusive traffic crossings are compliant to the requirements of Transport Canada Grade Crossing Standards, AREMA Signal Manual of Recommended Practices and Performance Output Specifications.

Complexity

AECOM worked with contractors, stakeholders and other project team members to provide solutions to project complexities, including, integration and management of existing infrastructure, working within an active freight rail corridor, freight and commuter shared railway corridor.

Integration with Existing Infrastructure

Introducing an LRT through the urban areas of Waterloo and Kitchener required integration with the existing traffic control system, traffic management during staged construction and operations and the integration of new LRT infrastructure, including stops/platforms, grade separation and electrification equipment into the existing urban landscape.

A multidiscipline design approach was adopted that involved the parallel development of design with all design disciplines and all relevant approval agencies. Where possible, infrastructure elements were combined to provide multiple uses (e.g., OCS poles combined with street lighting and traffic signals), which reduced clutter in the urban cores. Detailed traffic staging plans were developed for each phase of the construction and formed the basis of regular public communication.

Working within an Active Freight Rail Corridor

A portion of the line was converted from freight service (Waterloo Spur) and is utilized by freight during periods when transit is not operating. Another portion of the line was constructed and operates parallel to CN under the Conestoga Parkway. The project included integration challenges as the work had to meet both freight standards (CN and AREMA) and LRT standards (TCRP).

The project team developed a multi-staged approach which included the design and construction of temporary track bed widening **on** the final northbound alignment on the Waterloo Spur, and the design and construction of a diversion track on the CN Guelph Subdivision to facilitate the staged construction of the King Street grade separation. The design team developed track design solutions that achieved the LRT ride parameters and complied with CN standards for freight railways.

The project included a new vehicular/rail grade separation at King Street, which required a complex rail profile adjustment and track diversion/staging plan that allowed the grade separation to be constructed on an active rail corridor. The design of the King Street grade separation required a multidisciplinary design approach involving representatives from CN, GO Transit, the Region, City of Kitchener and other stakeholders.

Traction Power & Stray Current

An ungrounded and electrically segregated traction power distribution system was designed to manage stray current emissions from the LRT system. Electrical segregation was established between the mainline, OMSF yard and OMSF shop traction power systems. In addition, the mainline LRT tracks were electrically isolated from the nonelectrified freight tracks. A total of 12 traction power substations were designed and installed along the mainline for distribution of the traction power current.

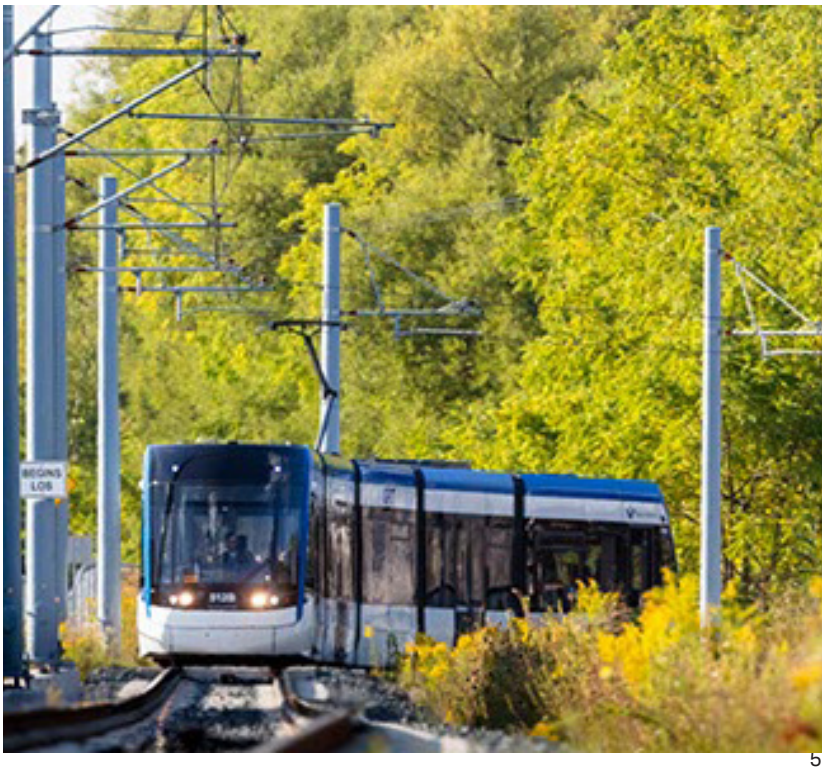
Traction power load flow modeling was also performed, which confirmed electrical continuity and cross-bonding of the negative return system and the OCS system design were adequate to properly operate the system and to keep the track-to-earth voltage at acceptable levels for stray current control and public safety. This included at-grade ballast track with wood or concrete cross ties (300 ohms); aerial ballast track with electrical isolation membrane (500 ohms); embedded track (200 ohms); and direct fixation track (500 ohms). Access for stray current mitigation and monitoring equipment was included in the design of the traction power substations. Stray current monitoring and mitigation was designed through interdisciplinary coordination to ensure the designs were mutually compatible. The unique challenges of stray current

mitigation design for construction of the LRT tracks on several existing structures were developed on an individual structure basis to address the risks associated with each structure.

The overall stray current mitigation design included electrically isolating rail fastening systems; rail boots; electrically isolating and waterproofing membranes; stray current monitoring and collection systems; selective bonding of concrete structure reinforcement; bonding, coating and cathodically protecting pressurized metallic pipelines crossing under the tracks; and testing facilities distributed system-wide for monitoring the effectiveness of the stray current mitigation.

Rehabilitated Infrastructure

The project included new and rehabilitated infrastructure requiring permits and approvals with different Authorities Having Jurisdiction, and also included impacts due to possible electromagnetic interference as well as noise. AECOM's discipline leads coordinated all related permits, mitigating impacts of permitting from a specific agency, and ensuring efficiency with agencies by address numerous permitting issues at once. This was effective as the lead most familiar with each of the different agencies were working to obtain the permits.



Social and/or Economic Benefits

The construction of the Waterloo LRT system and the public infrastructure elements have been designed to have a long-term, positive impact on the Region of Waterloo by providing a core transit artery as part of an integrated, expandable, multi-mode transit network. Light rail provides a fast, reliable way to travel around our urban areas for work, shopping and entertainment. It provides people with more choice about how they move around the Region and increases their ability to travel without always needing a personal vehicle.

The overall goal of the project was to provide a fast, convenient, safe, comfortable and appealing travel mode choice while also facilitating higher density urban development. The Waterloo LRT aims to increase overall transit ridership and reduce traffic congestion while striving to meet the long-term infrastructure and service needs and continued population and employment growth within the Region.

The project was designed as a completely integrated LRT system as the final goal, but was divided into twelve individual design sections to facilitate a construction staging approach that minimizes impact to existing traffic conditions and restrictions. Since the rail corridor is heavily integrated within the existing infrastructure, it was critical to develop design methodologies that focused on preserving public safety and minimizing disruption to the existing traffic conditions all while trying to maximize rail service capacity. Methodologies such as grade crossing safety assessments were used to address the challenges which come with designing and constructing in congested road intersections.

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Environmental Benefits

Construction of the WLRT was completed under an Environmental Management Plan (EMP) developed to meet the Region of Waterloo's commitments outlined in the project's Environmental Assessment. The EMP addressed environmental objectives and targets, and outlined compliance monitoring and management requirements for various significant environmental aspects including air quality, noise and vibration, contaminated materials, aquatic and terrestrial resources, stormwater and sediment control, archaeology and cultural heritage resources.

The OMSF achieved LEED Silver Certification on February 18th, 2018. The OMSF was designed to meet stringent green –building standards that included sustainable site development and materials selection and supports on-going water and energy efficiency and indoor air quality. This means that in the years to come its operation will place less strain on the environment and promote a healthy workplace. The maintenance and repair shop have a slopped roof to capture rainwater for re-use in washrooms, and other areas that can use grey water.

The WLRT Project was the result of decades of municipal planning geared towards directing growth of the city's core while preserving farmland and significant environmental areas. Maintaining an urban-rural balance was essential, especially given projections for population growth. With more than 200,000 new residents expected to move to Waterloo Region over the next 20 years, light rail is a sustainable solution to meet our community's future growth and transportation needs. Since the onset of construction, the Region has seen significant development at the Stations and along the corridor reflecting the success of their planning efforts.

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Meeting Client's Needs

The Waterloo LRT was a large, complex, integrated Multi-disciplinary program delivered under a Design-Build-Finance-Operate-Maintain (DBFOM) model sponsored by Infrastructure Ontario (IO). AECOM managed a multidisciplinary team (track, roads and drainage, architectural, structural, mechanical, electrical, bridges, utilities, lighting, traction power, LRV integration, traffic signals and ITS, train control, communications, traffic modelling, urban design, LRV integration, environmental and geotechnical), as well as managing subconsultants providing specialty services.

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AECOM implemented a number of innovative solutions, providing technical excellence on the Waterloo LRT project in order to achieve the Clients needs and goals for the project. The team provided solutions to technical and design challenges, including, electrification, shared track and signalling systems, and trackwork. AECOM worked with contractors, stakeholders and other project team members to provide solutions to project complexities, including, integration and management of existing infrastructure, working within an active freight rail corridor, freight and commuter shared railway corridor.

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About AECOM

AECOM is the world's premier infrastructure firm, delivering professional services throughout the project lifecycle – from planning, design and engineering to consulting and construction management. We partner with our clients in the public and private sectors to solve their most complex challenges and build legacies for generations to come. On projects spanning transportation, buildings, water, governments, energy and the environment, our teams are driven by a common purpose to deliver a better world. AECOM is a Fortune 500 firm with revenue of approximately $20.2 billion during fiscal year 2019. See how we deliver what others can only imagine at aecom.com and @AECOM.