civil

CANADIAN CIVIL ENGINEER
L'INGÉNIEUR CIVIL CANADIEN

2013 | FALL/AUTOMNE

- Replacing hinge anchors on the Red River Floodway
- How will automated vehicles change cities?
- Framework for bridge sustainability
- Urban railway grade separation

Connected Vehicles

Les véhicules branchés

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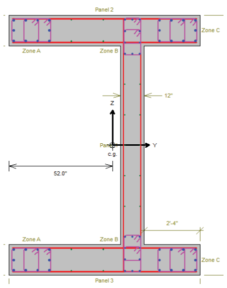

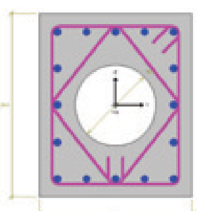

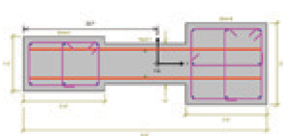

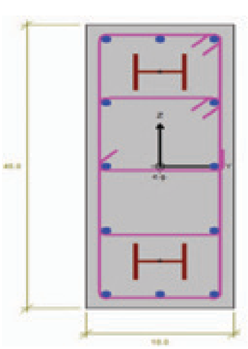

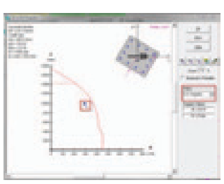

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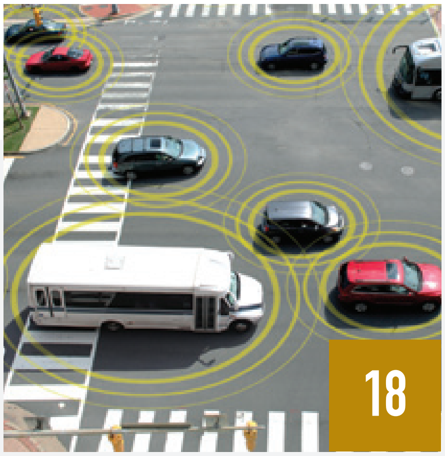
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CANADIAN CIVIL ENGINEER
L'INGÉNIEUR CIVIL CANADIEN

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Sustainability Measurement of Infrastructure

What is sustainable infrastructure? Is it infrastructure we can afford, not only to build but also to ultimately replace when it has reached the end of its useful life? Is it infrastructure that supports the lifestyle and social needs (i.e. provision of services) of Canadians adequately and equitably? Is it infrastructure that does not compromise the natural environment it terms of materials, natural resources and energy? It is a combination of all of these and more.

How then do we know if the infrastructure we are planning, designing, building and operating is sustainable? Is it good enough to add as many affordable "green" initiatives into an engineering project as possible? Is this fulfilling our obligations as civil engineers and stewards of the environment in developing infrastructure? The answer to these last two questions is "No."

The first step in developing a sustainability rating for infrastructure is to recognize that the lowest common denominator for infrastructure is the community. At the community level infrastructure systems come together, providing services that are required for living and working. A measure for sustainable infrastructure, therefore, is sustainable communities. How then is the sustainability of a community measured?

The United Nations uses a Human Development Index (HDI) as a measure of standard of living and development. HDI is an index combining normalized measures of life expectancy, literacy, educational attainment, and GDP per capita for countries worldwide. The threshold for acceptable human development is defined as a HDI of 0.8.

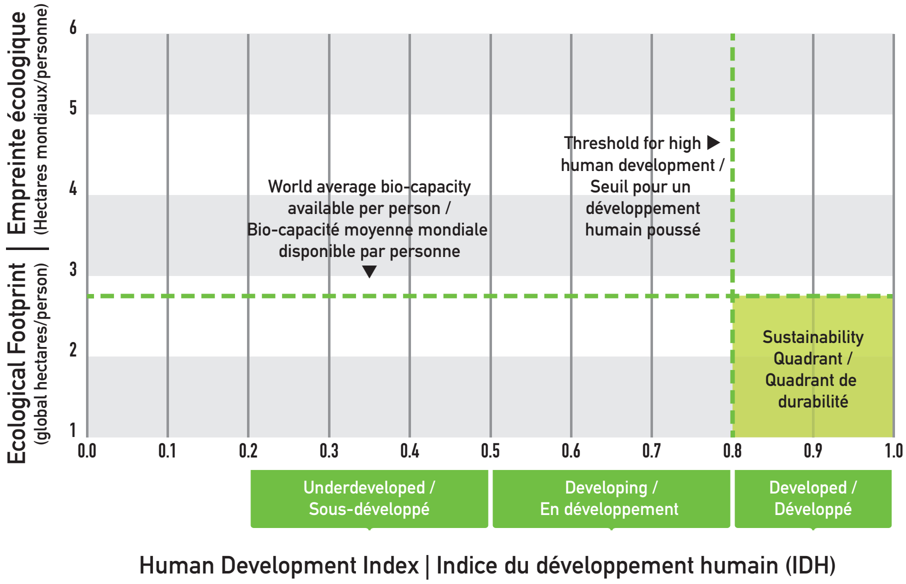
The World Wildlife Fund publishes a biennial report (Living Planet Report) that identifies the ecological footprint of countries around the world. The ecological footprint is a comparison of human consumption of natural resources with planet Earth's ecological capacity to regenerate them. The current sustainable ecological footprint for earth is identified as 1.8 global hectares per person. In terms of global ecological footprint ratings Canada ranks 8th at just over 6 global hectares per person.

The HDI vs. Ecological Footprint graph (next page) demonstrates how combining these two measurements provides a perspective for a potential measurement of the sustainability of communities. This includes the infrastructure systems that support a community.

In this context a national sustainability target is to gravitate to the sustainability quadrant as we develop our community-sustaining lifestyle while reducing our ecological footprint. For underdeveloped countries the challenge is to improve the HDI without increasing their ecological footprint. The challenge for developed countries, like Canada, is to reduce their ecological footprint while sustaining their HDI.

Herein is the challenge: a sustainability measurement for infrastructure that embraces the concept of moving communities towards the sustainability quadrant. This is a complex issue with multiple national stakeholders and is an opportunity for CSCE to respond within the context of its strategic direction for leadership in sustainable infrastructure. ■

HDI vs. ECOLOGICAL FOOTPRINT /
IDH vs. L'EMPREINTE ÉCOLOGIQUE



Comment mesurer la durabilité des infrastructures

Qu'est-ce qu'une infrastructure durable ? Est-ce une infrastructure que nous pouvons nous payer, non seulement en la construisant mais aussi en la remplaçant lorsqu'elle aura atteint la fin de sa vie utile ? Est-ce une infrastructure qui soutient le mode de vie et les besoins sociaux (i.e. la fourniture de services) des Canadiens adéquatement et équitablement ? Est-ce une infrastructure qui ne met pas en danger l'environnement naturel, soit en termes de matériaux, de richesses naturelles et d'énergie ? Est-ce un agencement de ces trois éléments, et plus ?

Comment savoir si l'infrastructure que nous planifions, concevons, construisons et exploitons est durable ? Est-ce assez d'ajouter autant « d'initiatives vertes » que possible dans un projet ? Est-ce que cela respecte nos obligations d'ingénieurs civil et de gardien de l'environnement dans le développement des infrastructures ? La réponse à ces deux dernières questions est « Non ».

La première étape dans l'élaboration d'un barème de durabilité des infrastructures est de reconnaître que le plus petit dénominateur commun en matière d'infrastructures est la collectivité. Au niveau des communautés, les systèmes d'infrastructures se rejoignent, offrant les services nécessaires à la vie et au travail. Toute mesure d'infrastructure durable est donc la mesure d'une collectivité durable. Comment alors doit-on mesurer la durabilité d'une collectivité ?

Les Nations unies utilisent un index ou un indice du développement humain (IDH) comme mesure du niveau de vie et du développement. L'IDH est un indice qui comporte des mesures normalisées d'espérance de vie, d'alphabétisation, de niveau d'éducation, et de PNB per capita pour les pays du monde entier. Le seuil pour un développement humain acceptable se définit par un IDH de 0,8.

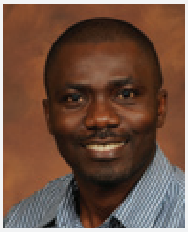
Le WWF-Fonds mondial pour la nature publie un rapport biennal (Living Planet Report) qui identifie l'empreinte écologique des pays du monde entier. L'empreinte écologique est une comparaison entre la consommation humaine de ressources naturelles et la capacité écologique de la terre de les remplacer. L'empreinte écologique durable actuelle pour la terre s'établit à 1.8 hectares globaux par personne. En termes d'empreinte écologique globale, le Canada se situe au 8e rang, avec un peu plus de 6 hectares globaux par personne.

Le graphique IDH vs. Empreinte écologique démontre comment l'intégration de ces deux mesures fournit une possibilité de mesurer la durabilité des collectivités. Ceci inclut les infrastructures qui supportent une collectivité.

Dans ce contexte, un objectif de durabilité consiste à graviter vers le quadrant de durabilité au fur et à mesure que nous développons notre mode de vie durable, tout en diminuant notre empreinte. Pour les pays sous-développés, le défi consiste à améliorer l'IDH sans accroître leur empreinte écologique. Pour les pays développés, comme le Canada, le défi consiste à diminuer l'empreinte écologique tout en conservant l'IDH.

Voilà le défi : une mesure de durabilité des infrastructures qui intègre la notion de pousser les communautés vers le quadrant de durabilité. C'est une question complexe, qui intéresse beaucoup de forces nationales, et c'est une occasion pour la SCGC de répondre, dans le contexte de son orientation stratégique en faveur du leadership en matière d'infrastructures durables. ■

Welcome from the Chair, CSCE Student Affairs



Charles-Darwin Annan, Ph.D, P.Eng., M.CSCE
CHAIR, CSCE STUDENT AFFAIRS COMMITTEE

A new academic year is here once again and I would like to extend a heartfelt welcome to you all. I hope that everyone enjoyed a relaxing summer with loved ones. I would also like to take this opportunity to introduce myself to you as the new Chair of CSCE Student Affairs. Nothing gives me greater pleasure than working with our passionate students.

I am very excited about this academic year as we develop programs to complement students' academic development. Professional and personal development will continue to be our hallmarks; we will continue to offer programs and opportunities that will help our students develop in key areas such as ethical behaviour, goal setting, decision-making, self-reliance, interpersonal relations, and a "can-do" attitude. These traits lend themselves to CSCE student chapter programs.

I am also excited about the progress we are making to increase student chapter participation in the various civil engineering competitions across the nation. The maiden edition of the CSCE Student Capstone Competition which took place in June 2013 during the annual conference in Montreal was very well represented by civil engineering departments across the country.

There is exciting news this year. We are looking to initiate stimulating interaction between student chapters. A national student leaders committee is being created as part of the student affairs committee. Social media, organized site visits and social nights with motivational speakers will be used throughout the year to facilitate interaction. An annual gathering of student leaders will be held during the CSCE annual conferences. We are also appointing practitioner advisors for each student chapter to assist faculty advisors. Our goal is to build a strong sense of civil engineering community and make better civil engineers right from our campuses.

Know that you are not alone! Once again, welcome to an exciting year. ■

Charles-Darwin Annan is assistant professor, Civil Engineering Department, Laval University, Quebec, Que.

Le mot de bienvenue du président du comité des affaires étudiantes de la SCGC

Charles-Darwin Annan, Ph.D, ing., MSCGC
PRÉSIDENT, COMITÉ DES AFFAIRES ÉTUDIANTES DE LA SCGC

En ce début d'année, je vous souhaite la bienvenue. J'espère que vous avez passé de belles vacances, en compagnie des vôtres. Je profite également de l'occasion pour me présenter en ma qualité de nouveau président du comité des affaires étudiantes de la SCGC. Rien ne me fait plus plaisir que de travailler avec nos étudiants.

Je suis ravi de cette nouvelle année puisque nous élaborons des programmes susceptibles de parfaire la formation de nos étudiants. Le perfectionnement demeure notre priorité, et nous continuerons d'offrir des programmes et des occasions qui aideront nos étudiants à se perfectionner dans des domaines comme l'éthique, l'établissement d'objectifs, la pris de décision, l'autonomie, les relations interpersonnelles, la confiance. Ces sujets se prêtent bien aux programmes des chapitres étudiants de la SCGC.

Je suis également ravi des progrès réalisés dans l'augmentation de la participation des chapitres étudiants aux divers concours de génie à travers le pays. La première édition du concours Capstone pour les étudiants s'est déroulée en juin 2013, dans le cadre du congrès annuel tenu à Montréal, et a attiré plusieurs départements de génie civil de tout le pays.

Il y a d'autres bonnes nouvelles. Nous cherchons à créer des interactions stimulantes entre les chapitres étudiants. Un comité national des leaders étudiants est en voie de création par le comité des affaires étudiantes. Des médias sociaux, des visites de chantiers, et activités sociales en soirée, avec des conférenciers-motivateurs, seront organisées pour faciliter ces interactions. Une réunion annuelle des leaders étudiants aura lieu dans le cadre du congrès annuel de la SCGC. Nous créerons également des postes de conseillers-praticiens pour aider les conseillers de faculté de chaque chapitre étudiant. Notre but est de créer une communauté professionnelle forte et de former de meilleurs ingénieurs civils sur nos campus.

Sachez que vous n'êtes pas seuls et que nous sommes là pour vous aider ! ■

Charles-Darwin Annan est chargé de cours au département de génie civil de l'Université Laval, à Québec.

By Nigel Parker, EIT, M.Eng, LEED AP BD+C, AMCSCE
CHAIR, CSCE YOUNG PROFESSIONALS COMMITTEE

Young Professionals Across Canada: Western Region

In the first of a series of articles featuring highlights of Young Professional (YP) events held, or to be held, in your region, we start in the Western region.

UBC CSCE Industry Night, January 24, 2013. / Soirée industrielle UBC SCGC, le 24 janvier 2013. *Photo : Stanley Chan*

Vancouver Island

This year, the Vancouver Island Section has been working with the University of Victoria (UVic) to establish a CSCE student chapter for the new civil and environmental engineering program that started in the fall of 2012. UVic students who were enrolled in first year (general) engineering will be able to pursue the program's second year studies in September 2013.

The Section is also looking for opportunities to reach out to students in the local Camosun College that offers a civil engineering diploma program.

For more information about our activities, please visit www.cscebc.ca.
— Carl Wong, P.Eng., MCSCE

Vancouver

The Vancouver Section hosted several events geared to young professionals over the past few months, and continues to support the growing student chapters of University of British Columbia (UBC) and British Columbia Institute of Technology (BCIT).

The CSCE Vancouver Section hosted a bowling social night in January 2013 as a thank-you to the supportive members of the section. Members of the Vancouver executive were eager to hear suggestions and concerns, and the event provided a good venue for members to bring their comments and thoughts for the section.

In March 2013, the Vancouver Section hosted a bus tour of the 40-km long South Fraser Perimeter Road (SFPR) Project that was well attended by young professionals. ■

— Stanley Chan, EIT, AMCSCE

If you are interested in getting involved or want more information about any of the events above, please get in touch. nparker@rjc.ca.

Recipient of the CSCE Vancouver Section student chapter scholarship at the UBC CSCE Industry Night. / Gagnant de la bourse du chapitre étudiant de la section de Vancouver de la SCGC attribuée lors de la soirée industrielle UBC-CGC. ***Photo : Stanley Chan***

Les jeunes professionnels à travers le pays : Région de l'Ouest

Dans la premier d'une série d'articles portant sur les activités passées ou à venir des jeunes professionnels, nous parlons dans ce numéro de la région de l'Ouest.

BCIT students navigating their way through the rope maze at the first Annual Welcome BBQ. / Des étudiants de la « BCIT » cherchant leur chemin à travers les câbles mêlés lors du premier BBQ annuel d'accueil. ***Photo : Stanley Chan***

L'île de Vancouver

Cette année, la section de l'île de Vancouver Island a collaboré avec l'Université de Victoria (UVic) pour créer un chapitre étudiant de la SCGC pour le nouveau programme de génie civil et environnemental qui a démarré à l'automne 2012. Les étudiants de l'UVic inscrits en première année (général) de génie pourront poursuivre le programme de 2e année en septembre 2013.

La section cherche également des occasions de rejoindre les étudiants

de « Camosun College », qui offre un programme menant à un diplôme en génie civil.

Pour plus de renseignements sur nos activités, visitez le site www.cscebc.ca.

— Carl Wong, ing., MSCGC

Vancouver

La section de Vancouver a organisé plusieurs activités pour les jeunes professionnels au cours des derniers mois, et continue d'appuyer les chapitres étudiants en progression à l'Université de Colombie-Britannique (UBC) et à la « British Columbia Institute of Technology (BCIT) ».

La section de Vancouver de la SCGC a organisé une soirée de quilles en janvier 2013 pour remercier les membres supporteurs de la section. Les membres de l'exécutif de Vancouver avaient hâte d'entendre les suggestions et les préoccupations de chacun, et cette activité a permis aux membres d'exprimer leurs commentaires et leurs réflexions.

En mars 2013, la section de Vancouver a organisé une visite en autobus sur les 40 kilomètres de route de la « South Fraser Perimeter Road (SFPR) ». Cette activité bon nombre de jeunes professionnels. ■

— Stanley Chan, EIT, AMSCGC

Si vous désirez participer ou en savoir plus sur les activités ci-dessus, adressez-vous à nparker@rjc.ca.

IN MEMORIAM

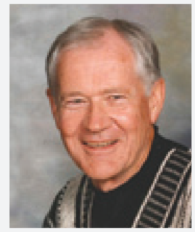
By Peter Wright, Jim Kells and Mel Hosain

It was with great regret that the Society learned of the passing of H. Keith Bowers on May 16, 2013, in Saskatoon, Saskatchewan, with his family at his side.

Keith, who was born in 1932 in Manville, Alta., grew up and was educated in Edmonton. After completing his high school diploma he attended the University of Alberta where he obtained his B.Sc. in Civil Engineering in 1955. Following graduation Keith worked for R. M. Hardy and Associates Ltd. until 1958.

He and his wife, Lynne, moved to Saskatchewan when he accepted a position with the Saskatoon architectural firm Webster and Forrester. The family moved to Saskatoon in 1960 after he completed a work assignment in North Battleford, Sask. Keith was named a partner in 1967 and was an active member of the firm, Forrester, Scott, Bowers, Walls, Architects and Engineer, until his retirement in 1991. Many of the most prominent buildings in Saskatoon and in other parts of the province were designed by this firm or one of its predecessors.

The Society is particularly appreciative of the many contributions that Keith made to it and to the profession in general. Keith was a longtime member of the Association of Professional Engineers of Saskatchewan and served as its president in 1975. In 1981 he became the vice-chair of the new Saskatoon Chapter of the CSCE and in 1982 was elected a Fellow of the Society in the first year of that honour. In 1989 Keith was the recipient of the Society's James A. Vance Award for his leadership in organizing the successful 1985 Annual Conference held in Saskatoon, and for his work as the vice-president for the Prairie Region from 1987 to 1989. Subsequently Keith was elected president of the Society for 1990/91. At the annual conference in 1991 Keith identified the important achievements during his term as president, especially the renewal of the agreement with the American Society of Civil Engineers.



Keith Bowers
CSCE PRESIDENT 1990/91

Keith Bowers loved being a civil engineer. He was proud of his profession and passionate in his beliefs. Keith, as one past-president has noted, didn't mince his words but one knew that he cared deeply for the Society and his profession, and made sure that he contributed to making them the best they could be. ■

Inlet Control Structure (at centre of photograph) on the floodway east of Winnipeg.

Inlet Control Structure Trunnion Anchoring Replacement

A team of engineers and construction firms had a complicated job to replace hinge anchors on the Red River Floodway Inlet Control Structure near Winnipeg.

By Dave MacMillan, P.Eng. and Gordon McPhail, P.Eng.
KGS GROUP

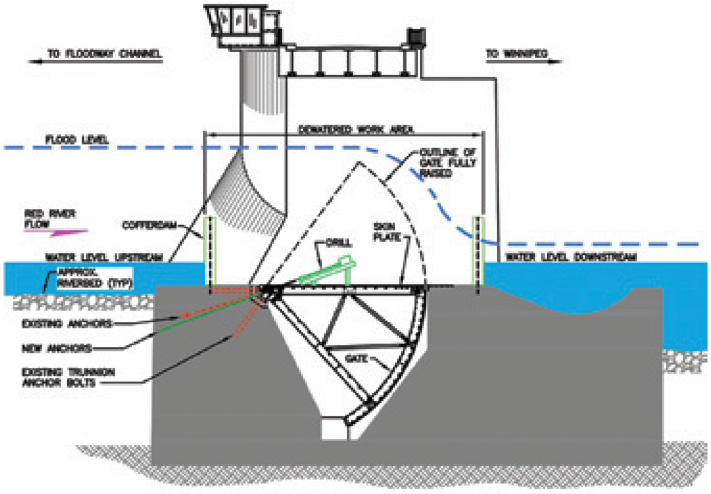
The Red River Floodway was constructed between 1962 and 1968 to protect the City of Winnipeg, East St. Paul, and West St. Paul from flooding by diverting flows from the Red River around the city. The original floodway, constructed at a cost of $63 million, has prevented more than $32 billion in potential flood damage to Manitoba.

A critical component of the floodway is the Inlet Control Structure (ICS), which controls the flows and water levels within the city and the amount of flow directed through the floodway channel during flood events. The ICS consists of a concrete structure with two 34-metre wide by 12-metre high submersible gates. The two gates are normally lowered, but in flood conditions they are raised to restrict flows into the Red River through Winnipeg.

In 2003, the Government of Manitoba established the Manitoba Floodway Authority, a provincial crown agency responsible for increasing the flood capacity of the floodway. KGS Group and subconsultants SNC-Lavalin and Hatch designed the floodway capacity upgrades and life extension measures. The total cost of this program, which was jointly funded by the governments of Canada and Manitoba, was estimated at $665 million.

While the major capacity changes to the floodway were completed in 2010, upgrades to some components are still being carried out. One of these is the Trunnion Anchoring Replacement Project. This project involved the careful detensioning and then replacement of existing post-tensioned strand anchors that provided in excess of 49,000 KN (11 million lbs.) of tension to secure the hinges (trunnions) of the floodway inlet gates to the concrete crest.

The trunnions allow for transferring the large hydrostatic wa-



Section of Floodway Inlet Control Structure showing orientation and location of the existing and new trunnion anchors, as well as required location for drill and tensioning jack on top of gate during construction.

Tensioning jack on top of gate applying 250,000 lbs. of tension to the new grouted DCP post-tensioned trunnion anchors which are located about 8 ft. below.

ter forces on the gate (as it holds the upstream water back) to the concrete structure. Site investigations performed by KGS in 2010 confirmed that the anchors were corroding and required replacement to ensure the continued reliable operation of the ICS gates.

The anchor installation system collaboratively developed by the design and construction team (Geo-Foundations Contractors and The Pritchard Group) advanced the state-of-the-art for anchoring in small confined spaces. The design required using various numerical models, including finite element method analysis (using ANSYS) and visualization tools to define the complex 3D spatial orientations.

Since there is very little room inside the gate, the drilling of the anchor holes and the tensioning of the anchors could only be done by cutting access holes in the gate and then performing the work from outside on the top of the lowered gate. The new strand anchors had to be drilled and located to precise coordinates, using a custom designed lightweight track-mounted drill rig and a downhole hammer to minimize the potential for the drill hole to wander as it passed through the concrete and reinforcing. The new anchors required precise in situ machining of the existing beams to allow the new anchor base plates to then be welded into position in the correct 3D orientation. The tensioning of the anchors required the development of pipe jack stands to allow the anchors to be jacked from outside the gate while the jack loaded the concrete within the gate.

Among the many challenges of the project was the fact that the Inlet Control Structure was required to be "flood ready" every spring, meaning that construction could only occur during the winter months between November and March. As a result, all the construction works had to be staged to ensure the Inlet's flood readiness each and every year that construction was undertaken.

Cooperation and an efficient means of design updates and communication was ensured throughout the design and construction phases by having KGS Group staff on site or available 24 hours per day to assist in the resolving construction and design issues as they occurred. Their availability proved of key importance in maintaining the challenging schedule.

Despite the many site constraints and challenges, along with the numerous design modifications required throughout the course of construction, the project was completed in the spring of 2013, one year ahead of the originally planned date, and under budget.

This was a rewarding project that presented KGS Group and its sub-consultants with new challenges, a high level of complexity, and an opportunity to develop and implement leading-edge engineering technology. The collaborative relationship and close communication used between MFA and the design and field staff proved critical to the project's schedule and budget success. The benefits from the life extension of these components will assure continued good performance of the trunnions and the gates for the next 50 years and more.

The KGS Group design team was presented with an Association of Consulting Engineers of Canada-Manitoba Award of Excellence in Engineering in 2013. ■

PROJECT: Inlet Control Structure Trunnion Anchoring Replacement, Red River Floodway
CLIENT: Manitoba Floodway Authority
PRIME CONSULTANT: KGS Group (Dave MacMillan, P.Eng., Gord McPhail, P.Eng., Scott Larson, P.Eng.)
SUB-CONSULTANTS/CONTRACTORS: SNC-Lavalin, Hatch, The Pritchard Group, Geo-Foundations Contractors

Georgetown South – Strachan Avenue Grade Separation

A complex project to create a grade separation between a busy railway line and a roadway is under way on a tight urban site in Toronto.

By EllisDon

As the population of the Greater Toronto and Hamilton Area increases, the area's roads are becoming more congested. The GO Transit Kitchener line, which runs to Union Station in Toronto, is expected to have daily ridership growth from 9,000 to 21,900 by 2031.

In order to accommodate this growth Metrolinx has embarked on the ambitious $1.2-billion Georgetown South (GTS) project, which is one of the key elements of "The Big Move" program. Through track sharing with the GO Transit Kitchener line, the GTS project allows for the new Union Pearson Express from Union Station to Toronto Pearson International Airport.

As part of the GTS project, a series of at-grade railway crossings are being replaced with grade separations. One of the most complicated of these is the $165-million Strachan Avenue Grade Separation and Overpass project. EllisDon, as the general contractor, is responsible for its construction.

Sequencing 1.8-km of retaining walls

The rail corridor west of downtown Toronto from Bathurst Street to King Street West is being lowered by up to 8 metres. The new 40-metre Strachan Avenue overpass will be constructed 2 metres above the existing grade and will consist of four traffic lanes, two bike lanes and sidewalks to allow for safe movement over the rail corridor. With detailed scheduling and stakeholder coordination, EllisDon has maintained the high frequency of rail service along the corridor and ensured the safety of workers, pedestrians and motorists.

The work is sequenced so that the north and south halves of the corridor are excavated in stages:

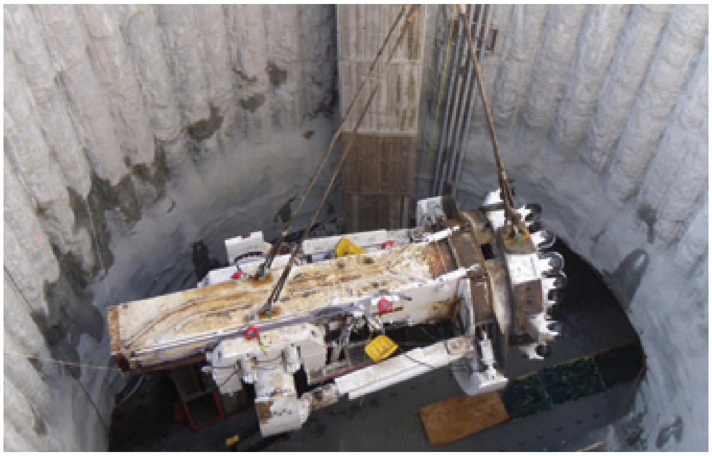
- shift existing rail operations to the south side of the corridor and install piles for the north and middle retaining walls;
- complete the north secant wall and pile and lagging wall, the centre pile and lagging wall, and install the permanent and temporary struts to provide lateral support to the retaining walls;
- replace the previously at-grade Strachan Avenue with a temporary bridge over the north excavation while remaining at-grade on the south;
- excavate the north half of the corridor;
- install new rails and shift rail operations into the new depressed north side of the corridor;

(Left) Approximately half-way through the project with the retaining walls and struts on the north side of the corridor complete.

- complete the south secant pile wall and install the permanent struts in the south corridor;
- excavate the south half of the corridor and remove all remaining temporary struts; and
- complete the Strachan Avenue overpass over the new eight-track corridor.

Tunnelling under rail corridor for utility relocations

The lowering of the rail corridor in a densely populated, urban environment required a number of complex utility relocations. To complete the relocation of a large storm sewer, EllisDon managed the construction of two vertical shafts, approximately 25 metres deep, and a 530-metre long siphon tunnel (4.2 metres in diameter) bored through shale under the rail corridor and Gardiner Expressway. The tunnel boring and the support and stabilization systems (including the use of a poly-fibre additive to the tunnel concrete) were engineered and constructed by EllisDon's subcontractor, C&M McNally Engineering. Taking into account available geotechnical information, the geomorphologic properties of the rock and soil and groundwater pressures, there was a concern that fresh water could displace the existing saline water in the shale, causing swelling and ultimately crushing the proposed tunnel. EllisDon and C&M McNally identified that the polymeric core membrane specified in the original design would become compromised by the infiltration of water, and successfully proposed an alternate waterproofing additive in the tunnel concrete to prevent water from passing through the tunnel liner into the shale.



Tunnel boring machine in tunnel access shaft.

Permanent painted struts will appear as tear drops when seen from above. Temporary unpainted struts provide further lateral support to the centre pile and lagging wall.

Connection detail for strutted retaining walls

Attention to detail with respect to the shoring systems that were subjected to high levels of soil pressure found on this site was paramount to ensure a safe, structurally sound installation. Sections of the retaining wall are strutted, rather than cantilevered, with 20-metre long hollow steel sections. The struts transfer the external soil pressures, developed as a result of the deep excavation (up to 8 metres), and the even greater soil pressures, developed as a result of the adjacent railway traffic. Additional temporary struts are also required in the interim stage to account for the railway loading from the south corridor applied on the centre pile and lagging wall.

To allow for a more efficient and safer installation of the struts, EllisDon worked with subcontractor Walters Inc. to propose a modification to the connection detail. Rather than fully welding the struts in the field, an end connection plate was welded to each strut in the shop during fabrication, and metal brackets were cast into the cap beam, allowing for the strut to be placed and bolted in the field.

Completing detailed constructability reviews and maintaining positive working relationships with Metrolinx, the consultants and subcontractors, allowed the EllisDon project team to initiate and implement positive changes throughout the project. ■

NAME OF PROJECT: Georgetown South – Strachan Avenue Grade Separation and Overpass
OWNER: Metrolinx / GO Transit
GENERAL CONTRACTOR: EllisDon Corporation
KEY SUBCONTRACTORS: Walters Inc., C&M McNally Engineering Corp.
PRIME CONSULTANT: AECOM Canada Inc.

A Bridge Sustainability Assessment Framework

How sustainable are Montreal's Victoria and Champlain bridges?

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Canada's severely deteriorated infrastructure requires hundreds of billions of dollars to be upgraded to an acceptable level; however, consideration of sustainability and asset durability over its service life is seriously lacking. To increase awareness and to establish a dialogue amongst engineers, politicians and the public, a holistic sustainability assessment framework for new and existing bridges was developed. While some commercial systems are available for the sustainability assessment of building systems, they are not directly applicable to bridges, which are different in their structural details and life-cycle performance and needs. Most of the existing bridge sustainability assessment programs focus mainly on structural aspects, with little or no attention paid to economic, social and environmental aspects of sustainability.

An overall framework (Table 1) was developed to incorporate all aspects of sustainability, with a pre-assigned maximum weight to each criterion. New or existing structures can be assessed by assigning an appropriate grade to each criterion and then adding the score. The structure is considered "sustainable" if the total score is 50% or higher. This framework was used to assess the sustainability of the Victoria and Champlain bridges, in Montreal. Because these are existing structures, only limited information was available for some sub-categories. Details are presented by Ali et al. (2013).

The Victoria bridge was the first permanent crossing between the island of Montreal and the south shore at the time of its completion in1859, and it had a significant impact on the region's economy. The initial tubular version was constructed using wrought iron members manufactured in England and shipped to Canada for assembly. The piers were built using limestone from two local quarries in Pointe-Claire, Que., and Isle-LaMotte, Vermont.

By 1898, the inadequate capacity of the single-track tubular bridge led to its replacement by the present rivet-connected, steel Pratt truss structure, which can accommodate two tracks and supports a cantilever structure on each side for carriageways and sidewalks. The structural steel was imported from the United States. The pier caps were extended to support the new, wider superstructure. A major rehabilitation of the piers

Table 1: Categories, sub-categories, weights and criteria for assessment of bridge sustainability

50	TECHNICAL ISSUES					
	10	T1			FEASIBILITY STUDIES	
			5	T1a	Life-cycle performance	Life-cycle performance, design, and costing
			5	T1b	Holistic approach	Economic, environmental, and social impacts
	25	T2			DESIGN AND CONSTRUCTION PHASE	
			5	T2a	Strength and serviceability over service life	Bridge location, pier placement, settlement, impact on marine environment, drainage, renovation
			15	T2b	Material selection	By order of preference: re-use of existing structure, use of local material (extraction and production), and recycled materials. Deterioration due to aggressive environment. Impact of climate change
					Piers and foundations	
					Superstructure	
					Bridge deck	
			5	T2c	Construction processes	Water and energy consumption. Use of local labour. Quality control and assurance
	10	T3			OPERATIONS	
			4	T3a	Planned monitoring, inspection and maintenance	Regular, planned inspections and maintenance
			3	T3b	Structural integrity audit	Mid-life audit, detailed inspection after significant deterioration, or a major natural and/or man-made disaster
			3	T3c	Planned rehabilitation	Replacement of deck after 50 years of service, etc.
	5	T4			END OF LIFE STAGE	
					Deconstruction, demolition and waste processing	Recycle and reuse of undamaged elements. Transportation of debris and disposal. Generation of energy from waste, etc.
20	ECONOMIC ISSUES (E)					
	10	E1			FINANCING	Source of sustainable funds from public and private sectors, and revenue from users. Consideration of depreciation of all elements.
			5	E1a	Construction, operation	
			5	E1b	Rehabilitation, decommissioning, disposal	
	10	E2			Impact on local economy	New investments in local and regional industries. Creation of jobs. Improvement of quality of life.
20	ENVIRONMENTAL ISSUES (Ev)					
	10	Ev1			Public Transportation	Public transit and/or buses with reserved lanes; reserved car-sharing and taxi lanes.
	5	Ev2			Active transportation	Protected bicycle lanes and/or sidewalks.
	2	Ev3			Energy source	Local energy and renewable energy generation.
	3	Ev4			Impact of climate change on structure	Impact of changing weather patterns, floods, storms, droughts on structural integrity and performance.
10	SOCIAL ISSUES (S)					
	3	S1			Negative impact of construction	Noise, vibrations, expropriation, etc.
	3	S2			Negative impact of operations	Traffic, closure for maintenance or repair, impact of closure.
	2	S3			Iconic structure	Visibility, renown, tourist attraction
	2	S4			Recreational access	Accessibility to river bank and local recreational areas

was undertaken in the 1940s; however, the same piers are still in use. In 1958, a diversion with lift spans for the St-Lambert Lock was constructed to accommodate the St-Lawrence Seaway (Triggs, et al., 1992). The tolls were eliminated in 1963 and the most recent rehabilitation was undertaken in 1988.

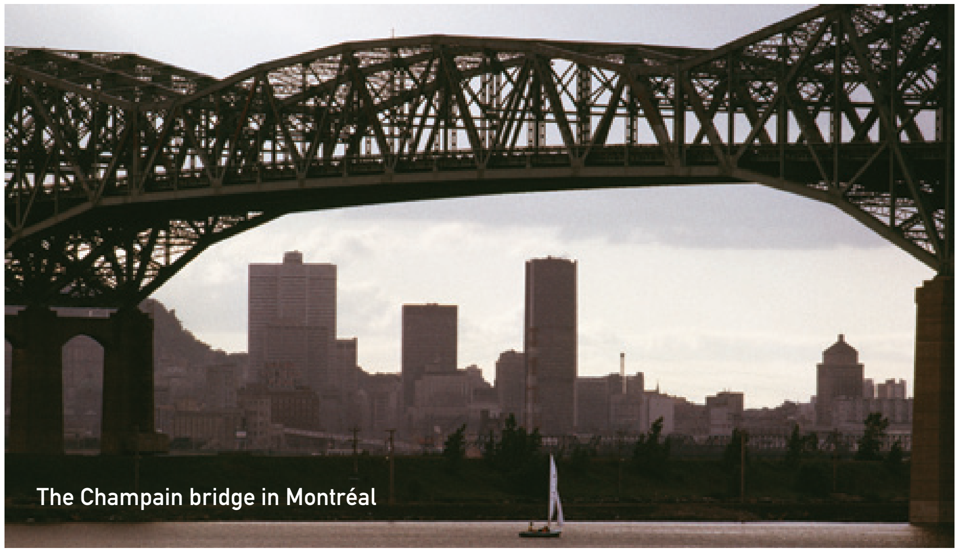
Presently, the Victoria bridge is open to trains and cars only. Using the sustainability assessment criteria (Table 1), all three bridge incarnations were deemed sustainable (Ali, et al., 2013) (Scores: tubular bridge 50/100; initial truss bridge 69/100; present version 63/100). Its longevity, the use of local materials for piers and their re-use with the new superstructure increased the sustainability score, although elimination of trams and public transportation on the bridge, as well as the removal of tolls somewhat decreased it.

The six-kilometer long, six-lane Champlain bridge, a Montreal lifeline structure, was constructed from 1958 to 1962 at a cost of $35 million. It is the busiest bridge in Canada. The bridge deck and piers became severely deteriorated after only 30 years of service, due to several factors, such as the unusual bridge design, poor deck drainage and corrosion from unplanned use of de-icing salts, high traffic volume, and inadequate and deferred maintenance in the earlier years (Carlin and Mirza, 1996).

In the early 1990s, a major rehabilitation of the severely deteriorated concrete deck over the St. Lawrence Seaway was undertaken (cost about $40 million). Recently, the bridge was found to be significantly deteriorated and functionally deficient. There is also a considerable risk of partial or complete failure during a major earthquake (Anderson, 2011).

The federal government has agreed to replace the bridge in about 10 years, in addition to committing $20 million per year over the next decade for bridge maintenance. The Champlain bridge was assessed using the framework and deemed unsustainable (Score: 33/100). Serious flaws in design, construction and maintenance of the bridge resulted in very low grades in several categories (Carlin and Mirza, 1996). The use of locally manufactured materials and local labour helped the sustainability score. The positive impact on the local economy of Montreal, Brossard, Longueil and the region also assisted in augmenting the sustainability score.

The authors would like to use this framework to assess sustainability of some selected bridges in Canada and seek assistance from the local engineers. ■



The Champain bridge in Montréal

Photo: Thinkstock

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Canada must be involved with connected vehicle development

By Ming Zhong, Ph.D, P.Eng, MCSCE
CHAIR, CSCE TRANSPORTATION DIVISION

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Modern technology is rapidly reshaping the landscape of global trade and transportation. For the transportation industry, connected vehicle (CV) technology is the next major advancement toward optimized planning, operations, and safety. CV technology facilitates an environment in which vehicles communicate wirelessly with one another and surrounding infrastructure via cellular and Internet networks that connect accompanying applications, sensors and devices. It greatly improves safety, mobility and efficiency for not only the agencies and engineers that design and operate the transportation network, but also for the drivers who use it.

CV systems fall into three data-exchange categories:

Vehicle-to-Vehicle: these applications rely on specialized in-vehicle equipment and sensors.

Vehicle-to-Infrastructure: these applications require connected roadside equipment or operations centres.

Vehicle-to-Device: these handheld devices may be stand-alone units, or may connect to operations centres.

This issue of *CIVIL* magazine provides insight into the work of moving Canada into the next generation of technology. The first and second articles describe the work underway in Western Canada to facilitate and test a CV environment through a test bed network. The third article describes the work underway at the University of Toronto to leverage CV technology into adaptive traffic signal controllers, while the fourth article describes the rollout of autonomous vehicles.

Canada must be involved in CV research, development and engineering. This technology will have a great impact on transportation performance and safety. Our geography and proximity to the U.S., combined with the latter's support for CV technology, means that Canada must have CV interoperability with its closest and largest trading partner. ■

Le Canada doit être présent dans le développement des véhicules branchés

par Ming Zhong, PH.D., ing, MSCGC
CHAIR, DIVISION TRANSPORT DE LA SCGC

Zhi-Jun (Tony) Qiu, Ph.D.,
SECRETARY, DIVISION TRANSPORT DE LA SCGC

La technologie moderne transforme rapidement le domaine du commerce et du transport global.

Dans l'industrie du transport, la technologie des véhicules branchés constitue le prochain grand pas vers l'optimisation de la planification, de l'exploitation et de la sécurité. La technologie des véhicules branchés facilite un environnement où les véhicules communiquent sans fil entre eux et avec l'infrastructure environnante par des réseaux de cellulaire et d'Internet qui relient les applications, les senseurs et les divers appareils. Tout ceci améliore beaucoup la sécurité, la mobilité et l'efficacité, non seulement pour les organismes et les ingénieurs qui créent et exploitent le réseau de transport, mais aussi pour les conducteurs qui les utilisent.

Les systèmes branchés appartiennent à trois catégories d'échanges de données :

De véhicule à véhicule : ces applications reposent sur du matériel et des senseurs spécialisés dans les véhicules.

De véhicule à infrastructure : ces applications exigent du matériel branché le long des routes ou des centres d'exploitation.

De véhicule à appareil : ces appareils tenus dans la main peuvent être des unités autonomes ou peuvent être branchés à des centres d'exploitation.

Ce numéro de la revue CIVIL traite de l'avenir du transport au Canada à la lumière de la prochaine génération de technologies. Le premier et le deuxième article font état des travaux en cours dans l'Ouest canadien pour faciliter et tester un environnement branché. Le troisième article décrit le travail en cours à l'Université de Toronto pour adapter la technologie branchée à des contrôleurs de circulation, tandis que le quatrième article décrit l'apparition des véhicules autonomes.

Le Canada doit être présent dans la recherche, le développement et l'ingénierie des véhicules branchés. Notre géographie et notre proximité par rapport aux États-Unis, ajoutées à l'appui de ce dernier pays pour cette technologie, signifie que le Canada doit jouir d'un interfonctionnalité avec son principal partenaire commercial dans le domaine des véhicules branchés. ■

ACTIVE-AURORA Test Bed

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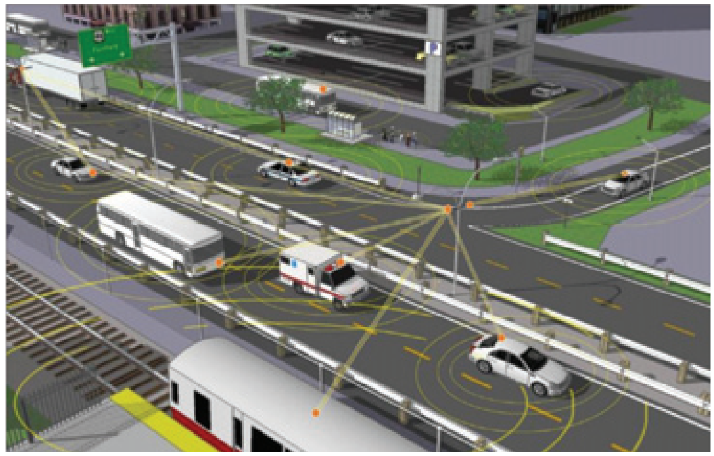

Figure 1. A fully connected transportation system.

Photo courtesy: USDOT

Canada's prosperity and economic growth depend on intercontinental trade, international commerce, and the effective, safe and efficient transportation of our people and resources. The competitive supply chains that underpin the Canadian economy are in large part enabled by the rapid, seamless and secure movements of goods and people across the globe. Our nation's success in this domain is long established, but the dynamics of global trade are changing rapidly and the global economy is becoming increasingly competitive.

No longer just science fiction, connectivity is being deployed to transform transportation around the world. The United States (U.S.), the European Union, Japan, China, Korea and South America are each wholly engaged in testing and deploying variations of connected vehicle (CV) technology.

As the latest development of intelligent transportation systems (ITS), CV technology represents a major effort by researchers, policymakers, and transportation professionals to enable vehicles to wirelessly communicate relevant data, such as location, trajectory, speed, and environmental warnings, with one another and surrounding infrastructure, producing a comprehensive picture of the traffic network for use by agencies, engineers, researchers and drivers (U.S. Department of Transportation, 2013).

In August 2012, the U.S. launched a significant multi-million dollar CV testing program in Ann Arbor, Michigan, that will possibly lead to the establishment of regulatory standards for new vehicles in the U.S. starting in 2013. In 2012, the National Highway Traffic Safety Administration (NHTSA) agency proposed a regulation requiring manufacturers to include CV equipment in new light-weight vehicles by 2013, and in new heavy-weight vehicles by 2014 (RITA, 2013). This regulation is not yet approved; however, it is foreseeable that CV technology will be a mandatory part in vehicles, comparable to seatbelts and airbags. The NHTSA also developed a Vehicle Safety and Fuel Economy Rulemaking and Research Priority Plan for 2011-2013, which includes three CV-related initiatives: (1) safety assessments, benefit estimates and cost analyses of CV equipment; (2) performance measures of CV applications, interfaces, security systems and standards; and (3) compliance with objective procedures (U.S. Department of Transportation, 2013).

Of particular significance to Canada's development and prosperity is our active and ongoing engagement with the Asia-Pacific region. Facilitating Canadian trade across the Asia-Pacific Gateway (APG) in the 21st century requires improvements in the capacity, efficiency, safety, sustainability and modal connectivity of the transportation system. It is expected that CV technology will aid these improvements. In 2006, the Government of Canada launched the Asia-Pacific Gateway and Corridor Initiative (APGCI) as an integrated set of infrastructure, policy and research actions focused on trade facilitation between Canada and the Asia-Pacific region. The government committed funding and support for new technology and infrastructure projects, policies, outreach and regulatory initiatives aimed at improving transportation efficiency in Western Canada. Provincial government programs, such as B.C.'s Pacific Gateway Transportation Strategy and the Alberta Transportation Business Plan (2012-2015) also support the priorities of the APGCI.

Commercial vehicle initiatives in Western Canada

Research teams at the University of Alberta (U of A) and the University of British Columbia (UBC) are working together to achieve and support the goals of the APGCI by fostering the development and deployment of CV technologies and solutions. An innovative infrastructure, called the ACTIVE-AURORA test bed, which is a network of five vehicular test beds equipped and linked together with CV technology, is being built and will operate in Edmonton and Vancouver, under the direction of transportation engineers and researchers at the U of A, UBC, the City of Edmonton, Alberta Transportation and the British Columbia Ministry of Transportation and Infrastructure.

Edmonton and Metro Vancouver are major nodes in Canada's APG, extending shipping routes between Asia and Canada into the heartland of the North American continent, ensuring that goods move swiftly and dependably from source to destination. The ACTIVE-AURORA test bed network has four key functions:

(1) characterize the issues and factors that limit the performance of existing technologies;

(2) develop models, simulation methods and experimental techniques that allow CV technology solutions to be systematically evaluated and assessed according to actual roadway environments;

(3) identify, demonstrate, adopt, commercialize and produce the best transportation and CV technology solutions; and

(4) support government agencies in establishing standards and protocols related to CV technology by exploring related policy and institutional issues.

As a major resource for knowledge transfer and commercialization, the ACTIVE-AURORA infrastructure provides a fruitful and multidisciplinary site for promoting collaborative approaches to research, education and training. Such collaborations between institutions (U of A, UBC, provincial and federal governments, etc.) strengthen Canada's economic advantage, building a critical mass of knowledge and supporting the integration of high-quality researchers and engineers into the labour market by providing a training ground for testing and evaluating new technology solutions. The ACTIVE-AURORA test bed network provides a unique opportunity to address capacity constraints and bottlenecks in support of international trade flows; foster improved mobility safety, security and reliability; support provincial and regional priorities and corresponding initiatives by other levels of government, including U.S. governments; advance knowledge and understanding of the multimodal transportation systems that contribute to improving the movement of international trade (e.g., through data collection, feasibility studies); and enhance the capacity, safety, security, efficiency and environmental performance of Canada's transportation network.

The five test beds each have distinct focuses, which derive partly from each one's geographical situation and partly from the expertise of the researchers involved. One ACTIVE (Alberta Cooperative Transportation Infrastructure and Vehicular Environment) on-road test bed is installed along a provincial highway under Alberta's jurisdiction; the other ACTIVE on-road test bed runs along two municipally governed roadways in Edmonton. The AURORA (Automotive Test Bed for Reconfigurable and Optimized Radio Access) on-road test bed is a shorter, on-campus roadway. The ACTIVE Laboratory test bed focuses on data collection related to active transportation and demand management. Finally, the AURORA Laboratory test bed emphasizes wireless communication technology evaluation, especially concerning freight security and efficiency. As Figure 2 illustrates, the combined strengths of these test beds can help to usher CV technology initiatives more swiftly and efficiently from the research stage into the market.

The remainder of this article discusses in detail the ACTIVE test bed, while a second article discusses in detail the AURORA test bed (page 22).

ACTIVE On-Road Test Beds—Edmonton, Alberta

The ACTIVE on-road test bed is comprises three road sections in the greater Edmonton area:

1. Anthony Henday Drive: This road is part of the NAFTA (North American Free Trade Agreement) north-south corridor and plays an important role in road transportation along the APG. As a ring road with a rural geometry, it provides service to more than 60,000 average annual daily traffic (AADT). One specific characteristic of this facility is that several Road Weather Information Systems (RWIS), traffic loop detectors and video cameras will be installed along the length of this highway. It will be possible to relate traffic characteristics, such as volume and trajectories, to specific environmental and seasonal parameters, such as air and pavement temperatures and precipitation, which are important factors in traffic operations and winter road maintenance. This test bed is used to explore and assess weather-related CV applications. The road is under the jurisdiction of Alberta Transportation, who will benefit from their participation as a knowledge-user of this study.

2. Whitemud Drive: This is the main east-

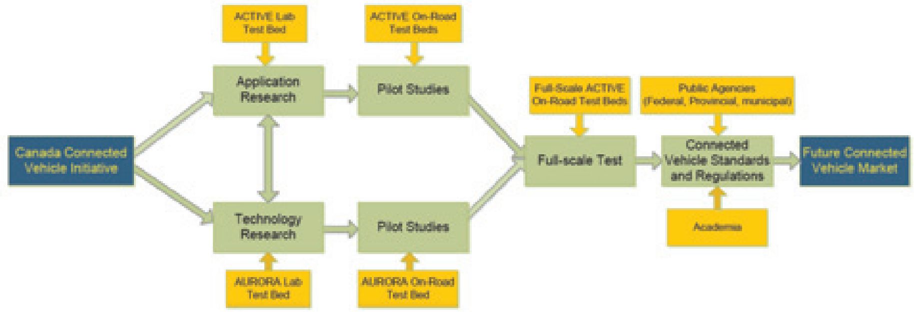

Figure 2. ACTIVE-AURORA test bed network interactions.

Photo courtesy: City of Edmonton

Figure 3. Edmonton's Whitemud Drive.

west arterial through Edmonton and features an urban geometry. Some sections of Whitemud Drive experience AADTs of 100,000, which are the highest in Edmonton. Edmonton has been installing a comprehensive traffic data collection system, including high-resolution cameras and embedded loop detectors, at different sections of this road. Hence, significant traffic data is available for this study. This test bed is used to explore and assess traffic data collection and CV applications related to proactive freeway traffic control.

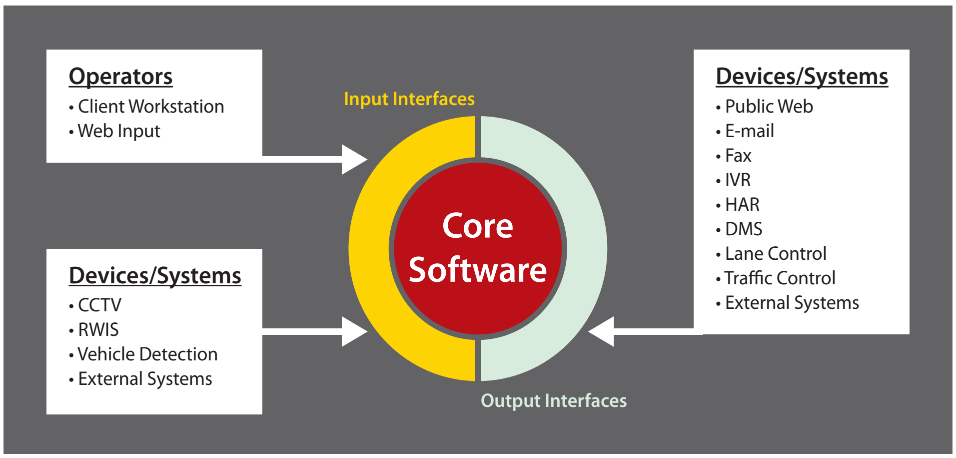

Figure 4. A typical traffic management system.

3. Yellowhead Trail: This road is part of Highway 16 or the Yellowhead Trail, which connects Canada's east coast to the west coast, making it an important road for the APG. The selected section of the Yellowhead Trail in Edmonton has several traffic signals and carries approximately 75,000 AADT. This road has a high percentage of trucks and includes two intersections with extremely high crash rates, making it a compelling location to study commercial vehicle operations, traffic signal timing, and traffic safety issues. This test bed is used to explore and assess traffic data collection and CV applications related to proactive arterial traffic control.

The first test bed is called ACTIVE AHD (Anthony Henday Drive), the second test bed (consisting of the two roadways) is called ACTIVE WMD-YHT (Whitemud Drive-Yellowhead Trail).

These road sections encompass a variety of traffic volumes, patterns and geometric characteristics, ensuring that most road jurisdictions in Alberta, as well as in Canada, are well represented. In addition to facilitating traditional equipment, the test bed holds 17 road-side equipment (RSE) units that quickly establish a connection with proprietary on-board equipment (OBE) located in passing study vehicles. These units exchange data using 5.9 GHz dedicated short-range communication (DSRC) protocols. The RSE can retrieve much information from OBE, such as second-by-second location data and other wireless communication solutions, and can send the OBE multiple formats of messages, such as alert messages. The RSE directly connects to either the Internet or an adjacent network access point.

ACTIVE Laboratory Test Bed—University of Alberta

ACTIVE Lab, the transportation research laboratory test bed at the U of A, will include a state-of-the-art traffic simulation platform, portable traffic data capturing equipment and hardware traffic control units. The portable traffic data capturing equipment is intended to collect supplemental traffic data so as to meet different research needs. The state-of-the-art traffic simulation platform will be connected with real, fully functional traffic control units and will keep this control hardware in the loop while traffic simulation models are running. The traffic simulation platform will design and evaluate innovative ITS using the evolving wireless communications infrastructure, and will fill the gap between simulation models and the reality.

One of the chief outputs of the ACTIVE Lab is that actual on-road data will be made available in real-time for use in traffic operational decisions. The laboratory test bed at the U of A will also be connected with the backhaul networks of multiple transportation agencies within and around the city of Edmonton to retrieve traffic data and monitor the traffic conditions. These network connections will also enable researchers using the ACTIVE Lab to obtain the latest comprehensive traffic data from the real world to conduct a wide range of traffic research.

To succeed, grow and thrive, the Canadian ITS and transportation sectors must continue to collaborate and innovate as they promote and prepare Canada's industries, businesses, governments, schools and workforce for the next wave of growth in Canada's new digital economy. To compete successfully, Canada must find new ways and opportunities to advance both the commercialization of leading-edge research and the creation of high-quality job opportunities through training and entrepreneurship. ■

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Canadian Asia–Pacific Gateway Wireless ITS Test Beds: The AURORA Test Bed

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UNIVERSITY OF BRITISH COLUMBIA, VANCOUVER

AURORA is a strategic asset for the Asia-Pacific Gateway. The Automotive test bed for Reconfigurable and Optimized Radio Access (AURORA) is an on-road test bed located at the Point Grey campus of the University of British Columbia in Vancouver. A strategic hub in the Asia-Pacific Gateway, Vancouver is home to Port Metro Vancouver, the largest handler of foreign export tonnage and the fourth-largest handler of overall tonnage in North America. The majority of loaded inbound and outbound containers bound for or originating from Canadian locations utilize terminal facilities, railroad connections, extensive transloading and distribution facilities, and the highway network in Metro Vancouver. The Vancouver International Airport (YVR) is Western Canada's largest airport and an international gateway for air cargo. In addition, Metro Vancouver is the most important highway gateway between the U.S. and Canada in Western Canada.

The test bed at UBC is in close proximity to operators and transport activity involving every mode of transport (rail, sea, truck and air), intermodal operations between these modes, and security processes at the air and sea ports and land crossings.

A priority for Asia-Pacific Gateway (APG) decision-makers is to identify pivotal connected-vehicle (CV) technologies and applications for facilitating information movement and coordination between the diverse participants or stakeholders in the supply chains utilizing the gateway. The ACTIVE-AURORA test bed network (see page 19 for description of the ACTIVE test bed) represents a major investment that will provide Canada and the APG with the capability to support this priority by enhancing new and existing engagements among industry members, universities, colleges, and governments at all levels. Not only does this essential resource act as a catalyst for the widespread development and penetration of intelligent transportation systems (ITS) and, especially, CV technology in Canada, it would also provide the foundation for industry personnel, government agencies, and academic researchers to advance their shared mandate of developing our knowledge about, and solutions to, the urgent problems facing the travelers, transport companies, and other users of the APG and its corridors.

Photo courtesy: Port Metro Vancouver

Figure 1. Vancouver's Port Metro

AURORA test bed configuration

The test bed will be comprised of up to 25 roadside equipment units (RSEs) deployed at 400-m intervals along 10 km of roadway around and leading to the campus. This includes both four-lane routes along Wesbrook Mall, West 16th Ave., East Mall, and SW Marine Drive and two-lane routes along NW Marine Drive (Figure 2). Some sections of the route experience more than 7,000 AADT. Wireless network architectures that are implemented by AURORA will fall into three major categories: point-to-multipoint networks, mesh networks, and heterogeneous networks that combine elements of both. A key aspect of AURORA is the ease with which the test bed can be reconfigured to realize these options.

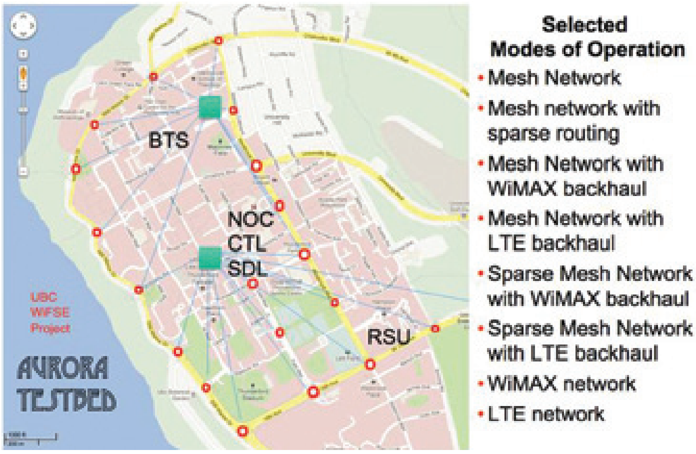

Figure 2. The AURORA test bed at UBC.

The roadside equipment units that are mounted on light and traffic standards along the route, and the on-board electronics (OBEs) that are carried by test vehicles will both incorporate a range of wireless technologies and standards, including LTE-TDD (Long-Term Evolution – Time Division Duplex), WiMAX , and Dedicated Short-Range Communications (DSRC). While the pair of LTE-TDD base transceiver stations (BTS) will provide backhaul for the RSEs, or, in some cases, directly to the test vehicles, there is ongoing discussion with a major communications provider to provide alternative backhaul using LTE or LTE-Advanced.

The wide range of available wireless connectivity options will permit a variety of radio access and backhaul network configurations to be set up and evaluated. These include direct-access networks based upon WiMAX or LTE standards, heterogeneous networks that involve access links from the OBE to the RSE using DSRC and backhaul from the RSE to the Internet via WiMAX or LTE, and mesh networks involving OBE and/or RSE nodes that have only DSRC capability. The RSEs will be deployed in four stages over one year as depicted in Figure 2.

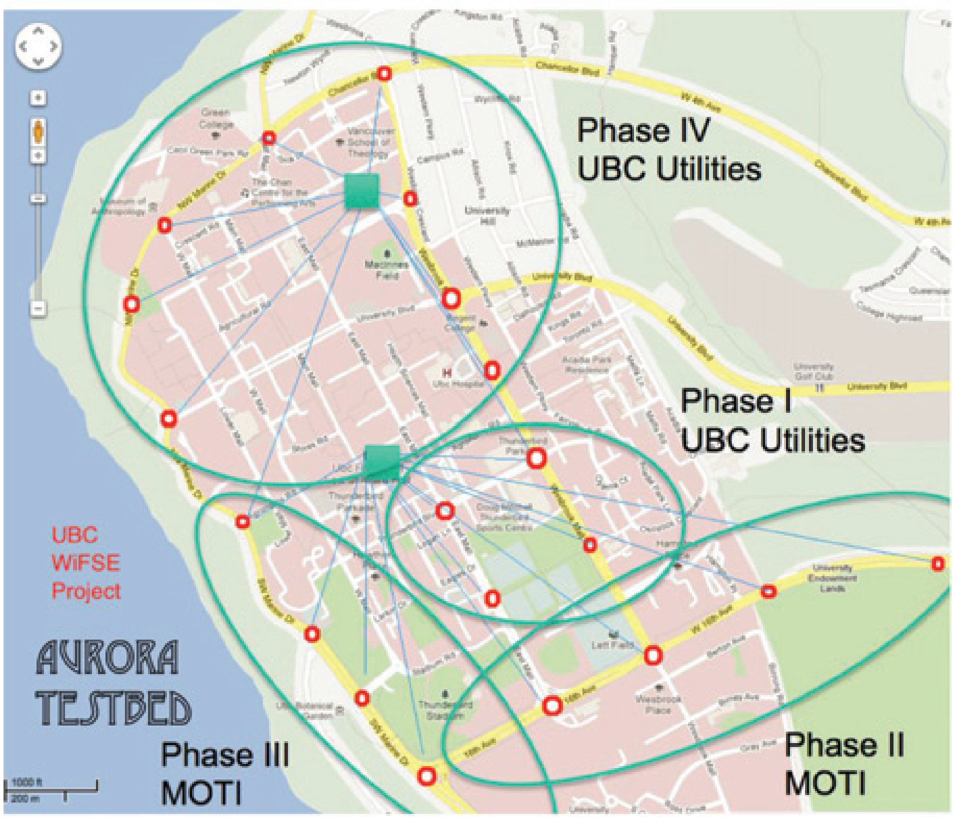

Figure 3. Stages of the AURORA test bed implementation.

As with ACTIVE, on-campus learning and commercialization facilities will support the AURORA on-road test bed and serve as a virtual test bed in its own right. The AURORA laboratory test bed facility at UBC includes state-of-the-art software and development facilities that will support the development of wireless applications for freight security and efficiency, running on the AURORA on-road test bed. The on-road test bed will be monitored and controlled through an operations centre (OPS) located in the Radio Science Lab (Penthouse of the MacLeod building, 2356 Main Mall). The base stations will connect to OPS via a MPLS-based (multiprotocol label switching) virtual network. Database servers that support the operations of the test bed will be hosted in the UBC ECE Department's server room.

The AURORA lab also provides sophisticated network access to the on-road test beds at both UBC and the U of A, as well as facilities for creating software applications, collecting data and analyzing results obtained using the test beds. Through CAnet, Canada's broadband academic data network, the AURORA Lab will interconnect with ACTIVE Lab and other transportation research laboratories around Canada to enable the exchange of traffic data. This connectivity will enable the test beds at UBC and the U of A to be utilized by researchers across the country. The facilities will also serve as a video conferencing, industry training, and virtual workshop space. The labs will be linked via a state-of-the-art communication framework that will allow not only for the real-time transfer of data, but also for sophisticated interprovincial collaborative ventures beyond the two universities. They will also enhance both universities' ability to attract, educate and train skilled labour and highly qualified personnel (HQP).

The test bed aligns with UBC's "Campus as a Living Lab," an initiative that encourages researchers and developers to deploy, monitor and test new technologies in real-life settings within the UBC campus community. This initiative combines the talent of UBC researchers and the knowledge of the operators and maintainers of UBC's infrastructure with the expertise of some of the world's most innovative companies. In doing so, it provides new research and educational opportunities for UBC students and faculty to work with industry partners to develop and test solutions in a real-world environment.

AURORA provides the entry point for engaging partners and internal/external university stakeholders that would like to develop, test, commercialize, and productize mobile communications technology for transportation infrastructure, applications and services with a particular emphasis on wireless freight security and efficiency. A linkage to the Wavefront Wireless Commercialization Centre will increase the network's exposure to start-ups, small and medium enterprises, large corporations and international organizations in the wireless sector and spur the development of innovative products and services relevant to active traffic management and freight security/efficiency from Canadian industry.

Short-range vehicular networking test beds

During the past decade, many large-scale short-range vehicular networking test beds have been established to develop, assess and resolve issues associated with relevant CV technologies and techniques. Examples include the C-Vet test bed at UCLA, the CarTel project at MIT, the DieselNet vehicular test bed at the University of Massachusetts - Amherst, the Virginia Smart Road test bed research facility managed by Virginia Tech Transportation Institute (VTTI), the Advanced Traffic Technology test bed at the University of California - Berkeley and the NCTU VANET test bed at National Chiao-Tung University (NCTU), Taiwan. The proposed AURORA test bed is unique in its emphasis on developing the best practices and strategies for realizing the freight security and efficiency goals of the national ITS architecture.

AURORA and ACTIVE – a single network working collaboratively

Each of the five test beds in ACTIVE and AURORA has a distinct focus which derives partly from each one's geographical situation and partly from the expertise of the researchers involved. The ACTIVE Lab laboratory test bed focuses on data collection related to active transportation and demand management. The AURORA Lab laboratory test bed emphasizes technology evaluation, especially those concerning freight security and efficiency. These distinct focuses support the overall life-cycle of the projects that will be undertaken after the infrastructure is in place. The combined strengths of these test beds can help to usher CV technology initiatives more swiftly and efficiently from the research stage into the market.

Together, the five on-road and laboratory test beds will build upon existing research programs, collaboration and partnerships at the U of A and UBC to support research, education, and training in the transportation and ICT sectors at these institutions. They will also provide industry, public sector and university partners and stakeholders with the facilities that are required to showcase, demonstrate and operationally evaluate new and innovative transportation applications, commercial products and services related to the requirements of the APG in a real-world environment. The development of these applications and technologies will also lead to commercialization and productization opportunities for innovators and small-business entrepreneurs. The ACTIVE-AURORA network will play a key role in a much larger strategy of developing a CV market in Canada. Figure 4 illustrates the process by which public and private sector organizations and universities ally with one another to support fundamental and applied forms of research leading to the development and demonstration of CV technology. This process is intended to lead to CV commercialization and market fostering. The ACTIVE-AURORA network takes the first enormous step towards realizing this goal and the great real-world benefits that it will make possible. ■

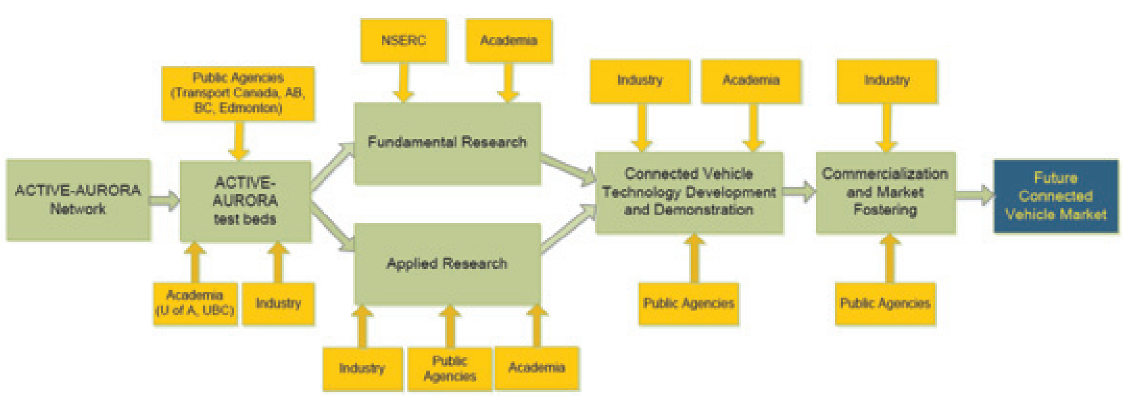

Figure 4. Stages of technology development for the ACTIVE-AURORA network.

Can Connected Vehicles Help Self-Learning Traffic Lights Adapt?

Baher Abdulhai, Ph.D., P.Eng, and Samah El-Tantawy, Ph.D.,
UNIVERSITY OF TORONTO, TORONTO

Population is steadily increasing worldwide and the Greater Toronto Area is no exception. Consequently the demand for mobility is rapidly increasing and congestion is turning into a household daily chore, hampering not only our quality of life but also our economic competitiveness. When the growth in social and economic activities outpaces the cash-strapped growth of transportation infrastructure, congestion is inevitable. Among the myriad demand and supply management possibilities to combat congestion, Adaptive Traffic Signal Control (ATSC) is a promising category of solutions. ATSC enhances infrastructure efficiency by adjusting the timings of traffic lights in real time in response to traffic fluctuations to achieve a chosen objective (e.g. minimize delay). ATSC, in general, has a great potential to outperform older pre-timed and actuated control methods (McShane et al. 1998). In Toronto, for instance, almost one quarter of the traffic lights are controlled by an ATSC system of British origin named SCOOT.

Another rapidly emerging stream of innovations that can help mitigate congestion is related to connected vehicles. Connected vehicles are vehicles equipped with variations of wireless communication technologies, either short range or long range, that allow the vehicle to be a node in a vast wirelessly connected network of devices. Connected vehicles can communicate with each other (V2V), with the infrastructure (V2I) or any other Internet-linked device (V2X). Connected vehicles have the potential to improve safety by reducing crashes, to enhance mobility by allowing better control and utilization of the infrastructure, as well as to enhance drivers' convenience and productivity while travelling.

In this article we pose and examine the specific question that, when connected vehicles become mainstream, can they talk to the traffic light and help the traffic light optimize its timing actions knowing the location and speeds of approaching vehicles?

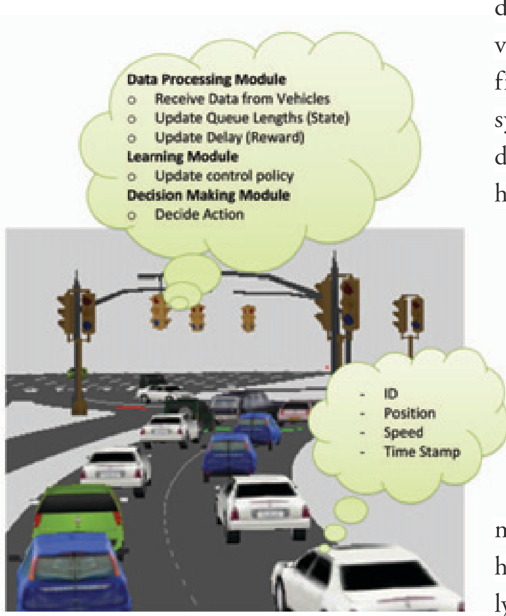

Figure 1. V2I communication for self-learning traffic lights.

Existing ATSC systems face challenges that make them relatively inefficient, expensive and difficult to maintain, ultimately limiting their potential benefits. Current ATSC systems rely heavily on traffic modeling and predictions (e.g. anticipated flows and turning percentages) to generate control strategies. However, the prediction models used in ATSC systems do not precisely capture the stochastic nature of vehicles' movements. Nevertheless, such predictions are utilized because existing sensing technologies used to provide inputs to the traffic signal control system, including inductive loops or video cameras, are incapable of directly measuring individual vehicles' driving information, such as position, speed and delay, well in advance of reaching the traffic light. This is where Vehicle-to-Infrastructure (V2I) communication can greatly help. V2I can link vehicles directly to the traffic light at the individual vehicle level as vehicles approach the traffic light location. The traffic signal control system, can in turn, use this information to decide which direction to serve green and for how long, in an agile manner in real time.

Another challenge in ATSC is the fact that treating intersections as isolated nodes which are independent of neighboring intersections limits the efficiency gains of such technology. Therefore, optimally controlling the operation of multiple intersections simultaneously can be synergetic and beneficial. Such integration certainly adds more complexity to the system which science has not been able to resolve until very recently. Multi-intersection coordination has been typically approached in a centralized way (e.g., SCOOT [Hunt et al., 1981], TUC [Diakaki et al., 2002]) which is only feasible if communication channels amongst all intersections and the central control location are available, which is demanding on resources and prone to communication failure. SCATS is another example of an adaptive signal control system that is a hierarchical and distributed system in which an area is divided into smaller subsystems (in the range of 1–10 intersections) that perform independently (Sims and Dobinson, 1979). PRODYN (Farges et al., 1983), OPAC (Gartner, 1983), RHODES (Head et al., 1992) are also examples of adaptive systems that are decentralized but their relatively complex computation schemes make their implementation costly (Bazzan, 2009).

The coordination mechanism in the systems above is employed along an arterial (where the major demand is). Although it is important to efficiently operate traffic signals along arterials where the major demand is (e.g. progression), it is also important to consider the network-wide effect of such operations, especially when major east-west arterials pour traffic demand onto north-south arterials, as is the case in downtown Toronto. In a signalized urban network setting, considering a two-dimensional network-wide objective has the potential to improve overall network performance and mobility, and to reduce emissions.

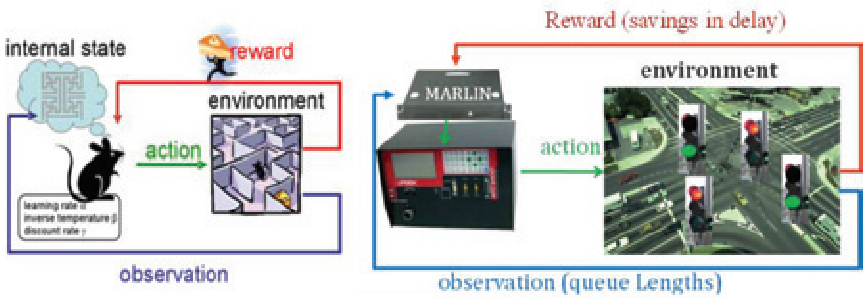

Figure 2. Agent-environment interaction architecture.

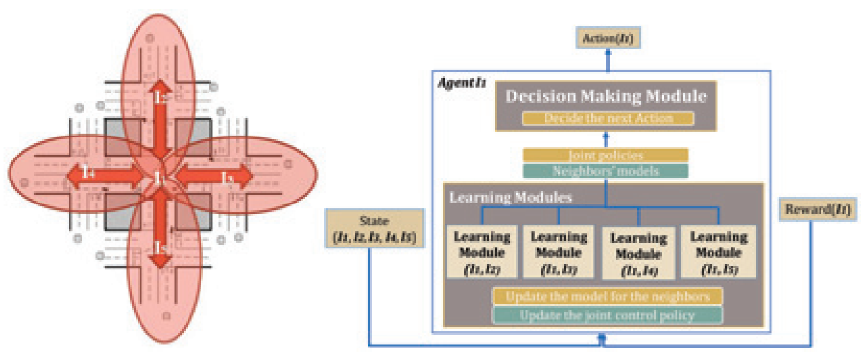

Figure 3. Illustrative example of collaboration between agents in MARLIN.

With the above in mind, the University of Toronto developed a Multi-Agent Reinforcement Learning for Integrated Network of Adaptive Traffic Signal Controller (MARLIN-ATSC) which learns to adapt to vehicle arrivals as connected vehicles announce themselves in the vicinity of the traffic light. In addition to vehicles communicating to the traffic light controller, controllers at adjacent intersections also communicate and collaborate on a global set of control actions (El-Tantawy et al., 2013).

The basic concept of MARLIN is that each controller is represented by an artificial-intelligence-based software agent (at each signalized intersection). Each agent interacts with its environment (traffic network) in a closed-loop measure-and-control fashion (Figure 2). The agent observes the state of the environment (e.g. status of vehicles approaching the light), takes an action accordingly (e.g. extend current green or switch to another phase), and receives a feedback reward (e.g. delay reduction) for the actions taken. The agent adjusts its control policy until it converges to the desired mapping from traffic states to optimal actions (optimal policy) that maximizes the cumulative reward (e.g. minimizes total delay for the traffic network). Each agent engages in collaboration (a.k.a. game, in game theory terminology) with all its adjacent intersections in its neighbourhood (Figure 3). Each agent not only learns the local optimal control policy but also considers the policies of its neighbours and acts accordingly. In turn, neighbours coordinate with their further neighbours in a cascading network-wide fashion. In lay language, the agents act as a team of players cooperating to win a game; much like players in a soccer match where each player endeavors to score, but at the same time considers the ultimate goal of the entire team which is winning the match.

In MARLIN, the agent's state is represented by the following: the current green phase; the elapsed time of the current phase; and the maximum queue lengths associated with each phase. As connected vehicles announce their position and speed to the traffic controller every time step (e.g. 1 sec), the controller is able to measure vehicles queues travelling below a threshold speed (e.g. 5 km/hr). For V2I communication, a suitable wireless communication is required that provides high availability and low latency. The DSRC (Dedicated Short Range Communication) protocol appears to be one option that provides the required functionality (Chen, 2005). DSRCs operate in a licensed frequency band (75 MHz of spectrum) and they support high speed, low latency wireless communications. In addition, DSRC is designed to be tolerant to multi-path transmissions typical with roadway environments. DSRC enables an exchange of information between the approaching vehicles and the controller within a reasonable range of a few hundred meters. Existing detection technologies cannot detect vehicles and queues that far without multiple detection stations and stitching the information from the multiple detectors. Connected vehicles, on the other hand, can periodically send information to the traffic signal controller via IEEE 802.11p standard. Each record consists of the vehicle's identification number (ID), and time-stamped position and speed data.

The messages that are received by the controller can be processed in order to update the queue length information through tracking each individual vehicle approaching the intersection. The vehicle is considered to be in a queue if its associated speed is less than a predefined threshold. Each Δt - interval the received position data are compared to the stored topography information of the intersection. Vehicles' presence is assigned to lanes and subsequently accumulated to queues for the corresponding phase. The controller calculates the cumulative delay for each vehicle and sums up the total intersection delay. The reward for the MARLIN-based agent is defined as the reduction (saving) in the total cumulative delay associated with that agent, i.e. the difference between the total cumulative delays of two successive decision points. If the reward has a positive value, this means that the delay is reduced by this value after executing the selected action, and vice versa. The reward signal helps the control agent to learn the optimal control policy.

It is worth noting that the agent learns off-line first through a simulation environment (such as the micro-simulation model employed in the experiments) before field implementation. After convergence to the optimal policy, the agent is ready to be deployed in the field – by mapping the measured state of the system to optimal control actions directly using the learned policy. The agent can also continue learning in the field by starting from the learned policy.

Connected vehicles and V2I are still emerging. It will be a few years before a reasonable market penetration is achieved. In the interim, and until V2I communication is mainstream, a method for queue lengthestimation (Priemer and Friedrich, 2008) or an advanced video detection technology (Citilog, 2009) can be used to get the queue length information.

The target user sector for MARLIN is municipal traffic departments in medium to large cities experiencing chronic congestion, while the ultimate indirect beneficiaries are drivers and commuters who are suffering in escalating congestion in major urban areas. MARLIN offers value to both municipal operators and motorists alike. Simulation tests in Toronto showed that MARLIN cuts down motorists' delay at intersections by an average of 40% and by up to 75% in some areas. It improves travel times on major corridors like Toronto's Lake Shore Blvd. by 25% and cuts down emissions by 30%. These values enables motorists to enjoy improved mobility, save time and money, lower unpredictable delay risk, and enhance their travel convenience and overall quality of life.

For municipal operators, in addition to enabling them to better serve the public and fulfill their mandates, MARLIN cuts down implementation and operation costs due to its decentralized design, putting intelligence right in the traffic light, and hence does not require second-by-second communication to a remote traffic management centre. MARLIN is also self-learning and hence relieves municipalities of the burden of maintaining highly skilled operators, which is a major challenge even for large cities like Toronto.

MARLIN is designed to use input from connected vehicles, but in the interim, it uses non-intrusive detection of queues and hence relieves municipalities of the burden of using the common pavement-embedded detectors that often break, fail and are hard to repair in heavy traffic corridors and in harsh winter weather. As the market penetration of connected vehicles increases over the next few years, MARLIN can use their messages to directly drive the traffic light. Overall, the value of MARLIN to motorists and municipal operators presents a new generation of intelligent traffic control, made in Canada. ■

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How Automated Vehicles Will Impact Civil Engineering

By Barrie Kirk, P.Eng.,
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Independent Transportation Specialist

Automated vehicles (AVs), also known as autonomous, self-driving or driverless cars, will be here much sooner than most people expect and will lead to major changes to the way that civil engineers design and construct infrastructure. They will result in the first paradigm shift in road transportation since the invention of the modern motor car. There is a strong argument that we should already be incorporating this change in the design of civil engineering projects.

Status of automated vehicles and the likely roll-out scenario

The expected AV rollout is shown in Table 1. At the recent Transportation Research Board (TRB) Workshop on Road Vehicle Automation at Stanford University, Google explicitly stated that they want to have fully-autonomous AVs in the public's hands by 2017; these will be capable of driving unmanned. It is not yet clear if it will be necessary to have a human behind the wheel. California will draft laws by January 1, 2015, that will hopefully clarify some of the many issues.

Safety

By removing the driver from behind the wheel, AVs are expected to eliminate most of the 93% of collisions that currently involve human error. In a 2007 study commissioned by Transport Canada, road collisions had a societal cost of $62 billion, or 4.9% of GDP that year.

Connected vehicles and automated vehicles

Connected vehicles (CVs) and AVs are on parallel paths but it is expected that they will converge in the near future. Each provides a distinct and separate capability and each can function and provide benefits without the other. AVs are being designed to operate safely with no changes to the existing infrastructure. AVs will not require CV functionality but will benefit from it.

Transportation and the road system

There are two key trends. First, there is a trend to Transportation-as-a-Service (TaaS), i.e. the use of cars on a short-term rental basis as an alternative to ownership. This will develop as the taxi, car-rental and car-share business models converge and as fleets of "automated taxis" become more competitive.

The other trend is that the younger demographics are showing far less interest in car ownership than earlier generations.

In the TaaS model, people will find it cheaper and more convenient to order a car using a smart device, and the car comes to you. This in turn will lead to fewer cars on the road, although the average number of vehicle miles travelled (VMT) will increase. Because many of shared fleet cars can be smaller, and because AVs have very rapid reaction times, the vehicle headways can be smaller and with increased average occupancy the highway capacity to transport people will increase. In addition, one- and two-seater cars will become available that will be significantly narrower; these will allow lane-sharing, or "doubling up" of vehicles in a lane the way motorcycles do.

Timeline	Details
2013	Semi-autonomous cars, such as the Mercedes Benz S-Class, will be commercially available in September 2013.
2017	Google expects to have its full self-driving car technology in the public's hands.
2020	GM, Volvo, Nissan, BMW, and others will launch their first fully-autonomous cars.
2021+	Increased number of AVs on the road and an increase in the choice of models and features.

Table 1. Expected AV rollout.

"Cars will soon drive themselves and ......it will all happen sooner than you might guess."
-Bill Ford, the Executive Chairman of Ford.

"Autonomous vehicles will trigger a burst of economic growth, transform transport around the world, free vast amounts of time, increase productivity, make us a lot wealthier and unleash drastic, unpredictable economic and cultural changes."
-A recent editorial in *The Telegraph* (a UK newspaper).

"I don't like hyperbolae, but this technology is a "game-changer."
-Bernard Soriano, California's Department of Motor Vehicles, in a presentation to the TRB Workshop on Road Vehicle Automation in July 2013.

"This is the hottest technology policy being discussed."
-A White House representative at the same TRB conference.

Figure 1. A sampling of expert opinions on automated vehicles.

The capacity of the existing road system will increase, and this will reduce the need to construct new roads and widen existing roads and intersections. A weakness is that current traffic forecast models do not recognize the impact of AVs.

Parking

Parking uses a huge amount of land in downtown areas. It is estimated that the U.S. has as many as eight parking spaces per car and this may be the same in some Canadian cit-

Author Barrie Kirk rides in an automated vehicle

ies. With AVs, the demand for parking will decrease substantially. In some cases, a commuter can send the car home for his/her spouse to use. In the TaaS model, the car simply drives itself to the next person who needs it. If a car must be parked downtown, it will be less expensive to establish parking lots/garages on the fringe of downtown and the car drives itself there and parks itself for the day.

Because electric vehicles (EVs) will be ideal for most urban trips, there will be a need for electric charging or battery swap stations. The increased demand for additional electricity generation and distribution infrastructure should be studied and planned for now.

In an era of AVs, the method of paying for parking will need to be automated. We will need to get away from the technology of taking a ticket from a machine and paying with a credit card. AVs will need a method that is wireless and fully automated – and includes paying for re-charging the batteries.

Finally, with a reduced need for parking, there is an opportunity to reclaim some of the space currently allocated for parking. Do we use it for development or green space? With a reduced need for on-street parking, we also have the option to create more bike lanes and/or wider sidewalks for pedestrians.

Transit

The introduction of AVs is expected to lead to a revolution in the transit sector. TaaS means that small, custom-designed, fuel-efficient, self-driving taxis will be developed and introduced. Users will be able to call a self-driving taxi which will pick them up, take them to their office, home or wherever they are going, drop them off at the front door, and then continue to other customers. The Earth Institute at Columbia University estimates this new mobility system will cost the average person 40% less than their current transportation costs occurred by private car ownership. There are several reasons for this low cost:

- Better capital utilization: far fewer shared AVs are needed to provide the same level of service as personally owned vehicles.
- Better capacity utilization: during peak travel times, the shared AVs are occupied more than 75% of the time, compared to a typical car which is in use less than 5% of the time.
- More efficient energy use: the one- to two-passenger, purpose-designed vehicle weighs 75% less than a conventional car, thereby using significantly less energy.

Professor Alain Kornhauser of Princeton University has analyzed 32 million daily trips in New Jersey and has found that shared AVs could result in an average vehicle occupancy during peak hours of 2.74, compared with the current average of around 1.1. This would remove the congestion problem in almost every Canadian city if implemented, even allowing for the release of suppressed demand. For users, these mini-taxis will be far more convenient and the cost will be significantly less than traditional transit, whilst providing a door-to-door level of service.The impact on our towns and cities is significant: these AVs will need no special infrastructure, no bus stops, and no park-and-ride facilities.However, there will still be a need for traditional buses and mass-transit systems for the high-volume, rush-hour inner-city conditions. The challenge will be to determine the optimum mix of traditional transit and self-driving taxis/micro-buses.

Greener towns and cities

The above trends will lead to greener municipalities for a number of reasons. The reclamation of excessively paved areas, such as parking lots and garages can lead to more green spaces. The synergies between AVs and electric propulsion will reduce air pollution levels in towns and cities.

The full advantages of AVs will only be realized once they can operate efficiently without having to make allowance for the weaknesses of human drivers. Paul Godsmark has proposed that this could artificially be achieved by creating AV zones (AVZs), where human drivers are only allowed by special permission. If urban centers create these AVZs, similar to the London Congestion Charging Zone, then the aspirations of many urban planners and city mayors for the most livable, sustainable, emission-free, active transportation-friendly and business-friendly cities with an improved quality of life, might be achievable.

Housing

One area of disagreement is whether the improvements in the livability of our urban areas will lead to more people living in the urban footprint, i.e. intensification, or whether the ease and reduced cost of transportation will lead to more suburban sprawl. We can actually foresee both scenarios occurring simultaneously.

In larger cities with transit stations, there is a tendency for land values to be higher in the vicinity of transit stations, especially where transit oriented development is being promoted. With the reduced emphasis on traditional transit, the importance of transit stations may diminish and therefore land values may not be as influenced by the proximity to transit stations.

Public services

There are many other areas where the arrival of AVs will impact our towns and cities. Probably none more so than in providing easily accessible transportation for those that are registered disabled (14% of the population), seniors (25% over 65 don't have a licence) and those that for whatever reason cannot drive – including children. The freedom and liberty for these groups could be transformational.

Conclusions

Many people believe that AVs are science fiction, that they are over-hyped, and that they are many years away from reality. The reality is that Google and the car manufacturers are all moving very quickly towards autonomous vehicles. They may start to appear in 2017 and the compelling business case for their use by fleet operators means that the rate of market penetration could be very rapid indeed.

Civil engineers and others are currently designing and constructing billions of dollars worth of infrastructure with no consideration of the fact that AVs will start to appear as soon as 2017. We have very few laws, and no standards, guidelines or codes of practice to guide us, but engineers of all disciplines need to provide their clients with appropriate designs and ensure that funds are spent wisely.

The arrival of AVs will produce changes to society as great as those that followed the introduction of the car more than 100 years ago. As civil engineers develop and implement projects for their public and private sector clients that will be in use later this decade and throughout the 2020s, they will be well-advised to consider the impacts of this disruptive but very exciting and overall beneficial technology. ■

Barrie Kirk, P.Eng., is a partner in Globis Consulting and the chair of ITS Canada's Autonomous Vehicle Task Force. Paul Godsmark is an independent transportation specialist.

SPOTLIGHT ON MEMBERS | MEMBRES EN VEDETTE

Welcome to new members

CSCE welcomes the following individuals who joined as new members in the last year:

Bienvenue aux nouveaux membres

La SCGC accueille les personnes suivantes qui sont devenues membres au cours de l'année :

Member	Section	Member	Section	Member	Section
Nizar Abboud	Montreal	Hafid Bouzaiène	Montreal	Patrick Delaney	Hamilton
Razek Abdelnour	Montreal	Anthony Bozzo	North Bay	Katherine Dennert	Vancouver
Nima Aghniaey	National Capital Section	Andrea Bradshaw	Newfoundland	Yves Denomme	Vancouver
Habib Ahmari	Manitoba	Seth Bryant	Edmonton	Matthew DiBerardino	Toronto
Kawsar Ahmed	Calgary	Marlen Buitelaar	Calgary	Karen Dow Ambtman	Edmonton
Akbar Ali	Edmonton	Jodi Burchenson	Toronto	Marc-Andre Ducharme	Montreal
Malika Ali	Edmonton	Geoff Cahill	Vancouver	Muhammad Durrani	Edmonton
Othman Alshamrani	Foreign	Julian Cajiao	Vancouver	Abdelhamid E Tahan	Foreign
Juliana Alves	Manitoba	Peter Calcetas	Vancouver	Greg Eitzen	Edmonton
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Warren Andersen	Saskatoon	Iain Cameron	Vancouver Island	Tayseer El Ramadi	Foreign
Fred Antunes	Vancouver	Frank Cattafi P. Eng.	Toronto	Mohammed Elenany	Edmonton
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Frank Au-Yueng	Edmonton	Manash K. Chatterjee	Toronto	Jeremy Enarson	Edmonton
Samantha Barnes	Vancouver	Devon Chaykowski	Edmonton	Kennard Failaban Esbieto	Toronto
John A. Baxter	Calgary	Bill Cheung	Vancouver	Abayomi Olukayode (Jim) Ewetade	Foreign
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CSCE National Honours and Awards – Call for Nominations

Nominations are invited at any time for the awards listed below; those nominations received by November 15, 2013 will be considered for 2014 awards to be presented at the CSCE Annual Conference in Halifax in May 2014. Additional information is available on the CSCE website http://csce.ca/committees/honours-and-fellowships/. Please submit nominations, clearly stating the award for which the nomination is made, by email to the Executive Director of CSCE at: doug.salloum@csce.ca.

W. Gordon Plewes Award

Recognizes particularly noteworthy contributions by an individual to the study and understanding of the history of civil engineering in Canada, or civil engineering achievements by Canadian engineers elsewhere. Normally, the recipient will be an individual, not necessarily an engineer, but in special circumstances the award can be given to an organization.

Sandford Fleming Award

Recognizes outstanding contributions by a civil engineer to transportation engineering research and/or practice in Canada.

Horst Leipholz Medal

Recognizes outstanding contributions by a civil engineer to engineering mechanics research and/or practice in Canada.

Albert E. Berry Medal

Recognizes significant contributions by a civil engineer to the field of environmental engineering in Canada.

E. Whitman Wright Award

Recognizes significant contributions by a civil engineer to the development of computer applications in civil engineering in Canada.

Camille A. Dagenais Award

Recognizes outstanding contributions by a civil engineer to the development and practice of hydrotechnical engineering in Canada.

A.B. Sanderson Award

Recognizes outstanding contributions by a civil engineer to the development and practice of structural engineering in Canada.

Walter Shanly Award

Recognizes outstanding contributions by a civil engineer to the development and practice of construction engineering in Canada.

Young Professional Award

Awarded annually to a CSCE Member or Associate Member who has demonstrated outstanding accomplishments as a young professional engineer. Normally, nominees must be no older than 35 as of December 31 of the year that the award is presented, although this limit may be extended for nominees who have taken extended leaves from professional practice.

James A. Vance Award

Recognizes a CSCE member whose dedicated service, other than as president, has furthered the advancement of the CSCE and who has completed or recently completed service in one or more sequential positions at the national level.

Excellence in Innovation in Civil Engineering Award

Recognizes excellence in innovation in civil engineering by an individual or a group of individuals practicing civil engineering in Canada, or a Canadian engineering firm, or a Canadian research organization. (Deadline for nominations is Jan. 15, 2014).

Award for Governmental Leadership in Sustainable Infrastructure

Recognizes those in the public sector who, through a project or program, are building for the future. Any municipal government or provincial or federal department that is planning, designing, building or delivering an infrastructure program or a project that significantly extends the life of these critical assets, makes better use of resources and reduces the environmental impact may apply. (Deadline for nominations is Jan. 15, 2014)

Appel – Distinctions Honorifiques Nationales SCGC

Les membres sont invités à soumettre en tout temps, des candidatures pour les prix ci-dessous; les candidatures soumises d'ici le 15 novembre 2013 seront considérées pour les prix 2014 qui seront décernés au congrès annuel de la SCGC à Halifax en mai 2014. Des informations complémentaires sont disponibles sur le site web de la SCGC : http://csce.ca/fr/committees/honours-and-fellowships/.

Veuillez soumettre les candidatures, en précisant le titre du prix, par courriel au directeur exécutif de la SCGC à : doug.salloum@csce.ca.

Le prix W. Gordon Plewes

Est décerné à une personne, pas nécessairement un ingénieur, qui s'est distinguée par sa contribution à l'étude de l'histoire du génie civil au Canada ou de l'histoire des réalisations canadiennes en matière de génie civil à travers le monde. Dans les circonstances exceptionnelles, le prix peut être décerné à une organisation.

Le prix Sandford Fleming

Est décerné à un ingénieur civil qui s'est distingué par son importante contribution à la recherche et/ou à la pratique du génie du transport au Canada.

La médaille Horst Leipholz

Est décernée à un ingénieur civil qui s'est distingué par son importante contribution à la recherche et/ou à la pratique de la mécanique appliquée au Canada.

La médaille Albert Berry

Est décernée à un ingénieur civil qui s'est distingué par son importante contribution au génie de l'environnement au Canada.

Le prix E. Whitman Wright

Est décerné à un ingénieur civil qui s'est distingué par son importante contribution au développement des applications de l'informatique au génie civil au Canada.

Le prix Camille A. Dagenais

Est décerné aux ingénieurs civils qui se sont signalés par leur contribution exceptionnelle au développement et à la pratique de l'hydrotechnique au Canada.

Le prix A.B. Sanderson

Est décerné aux ingénieurs civils qui se sont signalés par leur contribution exceptionnelle au développement et à la pratique du génie des structures au Canada.

Le prix Walter Shanly

Est décerné à un ingénieur civil qui s'est distingué par son importante contribution au développement et/où à la pratique du génie de la construction au Canada.

Le prix du jeune professionnel

Attribué annuellement à un membre ou à un membre associé de la SCGC ayant accompli des réalisations exceptionnelles en tant que jeune ingénieur professionnel. Les candidats doivent être âgés de 35 ans ou moins au 1er décembre de l'année de l'attribution du prix. Toutefois, cette limite peut être prorogée pour les candidats qui ont pris des congés prolongés.

Le prix James A. Vance

Est décerné à un membre de la SCGC dont le dévouement a favorisé l'avancement de la Société et qui termine, ou achève, récemment un mandat au sein de la Société, sauf comme président.

Le prix d'excellence en innovation dans le domaine du génie civil

Souligne l'excellence dans le domaine du génie civil dont a fait preuve une personne ou un groupe de personnes pratiquant le génie civil au Canada, ou une société canadienne d'ingénierie ou un organisme canadien de recherche. (Délai de soumission de candidats: le 15 janvier 2014.)

Le prix pour le leadership gouvernemental en infrastructures durables

Reconnait des entités du secteur public qui, de par un projet ou un programme, construisent pour le future. Tout gouvernement municipal, provincial ou département fédéral qui planifie, conçoit, construit ou livre un programme ou un projet d'infrastructures qui prolonge d'une manière significative la vie de ces actifs, fait un bon usage des ressources et réduit l'impact sur l'environnement peut postuler. (Délai de soumission de candidats:15 janvier 2014).

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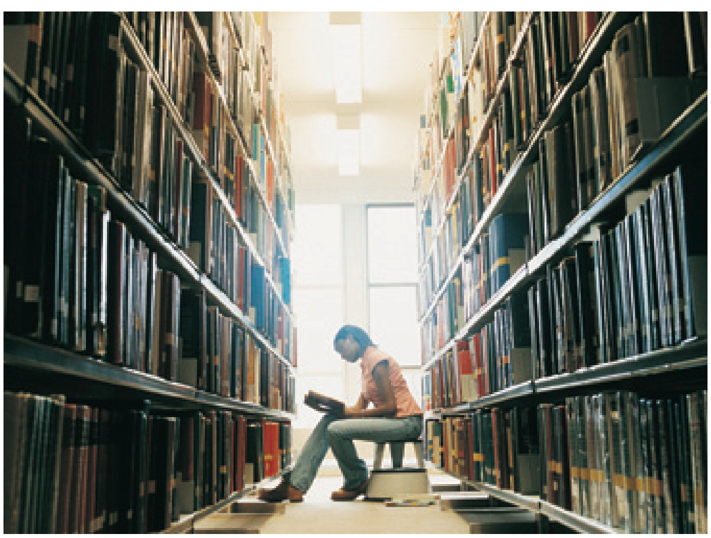

CAN / CSA-S6-06 - Design of Aluminum Bridges and Footbridges

Toronto – November 27, 2013
Ottawa – November 28, 2013

This course presents the contents of Section 17 – Aluminum Structures of CAN/CSA-S6-06 Canadian Highway Bridge Design Code, in force since October 2011. It covers all the recommendations of Section 17 and provides additional material, application examples and calculation samples. It is presented by Denis Beaulieu, Ph.D., ing., consultant and CSCE past-president.

HEC-RAS Modelling Including Advanced Applications

Winnipeg – December 4,2013
Edmonton – December 5, 2013

This course covers the following topics: theoretical background of 1D flow simulation with HEC-RAS, model calibration, bridges and weirs, flood simulations and inundation mapping, flow splits, and unsteady flow simulations. It is presented by Wolf Ploeger, Ph.D., P.Eng., project manager, Golder Associates.

Ces formations seront présentées en anglais.

Please visit www.csce.ca for full details.

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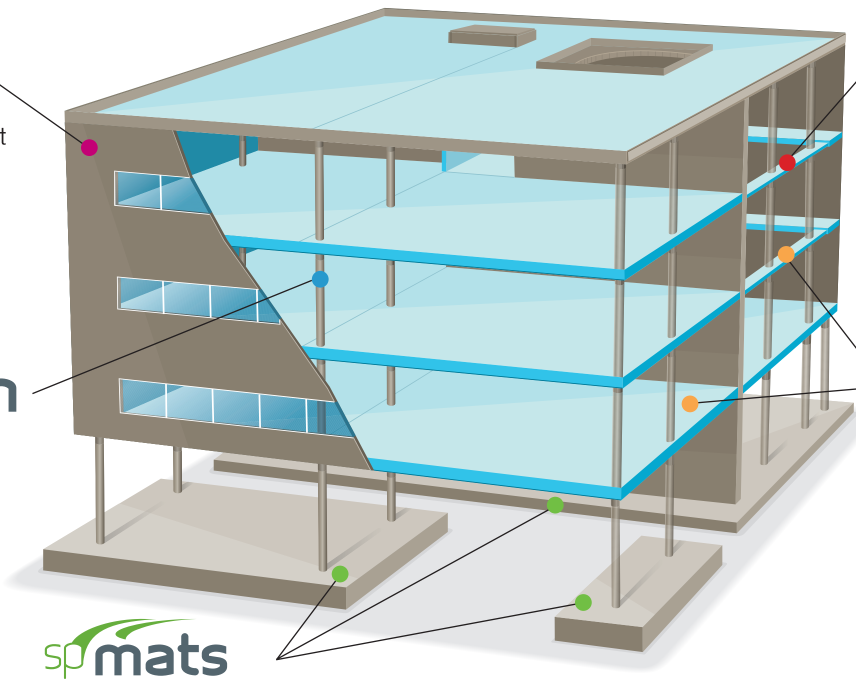

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