CUTRIC · CRITUC

2019-2020

ANNUAL REPORT

CANADIAN URBAN TRANSIT
RESEARCH & INNOVATION CONSORTIUM (CUTRIC) -
CONSORTIUM DE RECHERCHE ET D'INNOVATION EN
TRANSPORT URBAIN AU CANADA (CRITUC)

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CUTRIC-CRITUC
Annual Report 2019 - 2020
Rapport annuel 2019 - 2020

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LETTER FROM THE CEO

A message from CUTRIC CRITUC
Dr. Josipa Petrunić
President & CEO
Canadian Urban Transit Research and Innovation Consortium (CUTRIC)

Dear CUTRIC Members & Supporters,

This year has had its challenges, to say the least.

As 2019 closed out, the North American economy was already showing signs of lethargy. As a new decade dawned, the first quarter of 2020 was struck with world-wide pandemic and concomitant economic contractions unlike any seen by most generations living today. The geo-political mayhem that emerged in jurisdictions around the world created social calamities that have coloured transit and mobility landscapes indelibly. The result? Our industry is now faced with an obligation to think smarter about the kinds of transit solutions we provide to our communities because the future century ahead will--no doubt--contain other challenges from climate change to pandemic outbreaks worse than COVID-19 that we must mobilize around and overcome.

Despite the ominous start to a new decade, hope and expectation prevail. It will get better and transit will thrive more than ever before. We have the brains to make it happen and a strong reputation to build upon.

For CUTRIC, the past year has been one of growth, strength, resilience and community-building. We have launched the Pan-Canadian Electric Bus Demonstration and Integration Trial with TransLink, York Region Transit, Brampton Transit, Newmarket-Tay Power Distribution Ltd., NFI Group, Nova Bus, ABB and Siemens. A world first, this demonstration deployment is proving to the world that 18 electric buses and seven high-powered opportunity chargers spread across three cities and designed by competitive manufacturers can operate inter-operably, enabling transit agencies to buy and operate cheaper standardized electrification systems in the immediate near-term future. The project faced every manner of challenge during the multi-year planning process -- technical, financial, political, and operational opposition from as many corners as you could imagine. However, it has succeeded, and Canadians are reaping the benefits.

Meanwhile, our team has launched national joint procurement efforts and innovative financing solutions for equally challenging technical deployments around hydrogen fuel cell electric buses, and automated smart shuttles that help to overcome first kilometre/last kilometre gaps in transit systems.

Over the past year, we have also fully commercialized our RoutΣ.i™ electric and hydrogen electric bus simulation and predictive modelling which helps transit agencies see how battery electric buses (BEBs) and hydrogen fuel cell electric buses (FCEBs) will operate in their communities, when they will run out of power, how many electrons or hydrogen molecules they will need, and where chargers or fuelling systems should be located to optimally benefit the transit systems' energy needs for full-fleet service.

In the COVID-19 era, we have also launched a new initiative--one focused on a "Return to Transit" cluster of immediate research. CUTRIC is harnessing the prowess of dozens of our university and college members to forge a national cluster of research projects helping get riders and clients of transit back into safer, more sanitized, and more convenient transit systems this year and onwards. Technical project proposals already include new seat angular design, materials design and air flow design. These projects will be matched with social science research into the cultural attitudes of riders, their triggers for returning to transit and their views about what benefits transit needs to provide to convince them that transit is where they should be bringing their mobility needs.

The nineteenth century developed transatlantic shipping. The twentieth century developed cross-continental automotive transportation. The twenty-first century will be defined by its nationally integrated transit-led mass mobility systems.

Cheaper, faster, greener transit for all. That's what we believe in. And with the right ideas, we'll get there. We must..

Mobility is becoming a twenty-first century right--not far off from the essential service definition of electricity and clean water. Transit and shared mobility set people free--free to go to work, free to raise families and free to support this country's return to economic viability.

We look forward to getting transit back up and running better than ever by making it the number one choice for cheaper, greener and safer mobility for Canadians in 2020 and beyond.

Sincerely,

Josipa Petrunić

JOSIPA PETRUNIĆ

President & CEO

BOARD OF DIRECTORS

Outgoing 2018 - 2020

Anna Murray
HYDROGENICS

Bem Case
TORONTO TRANSIT COMMISSION

Carolina Gallo
ABB

Janice Mady
QUEEN'S UNIVERSITY

Jennifer McNeill
NFI GROUP

Marc Secanell Gallart
UNIVERSITY OF ALBERTA

Michael Ledgett
DENTONS CANADA LLP (HONOURARY COUNSEL)

Sarah Buckle
TRANSLINK

Shanna Knights
BALLARD POWER SYSTEMS

Steve Kay
ENBRIDGE GAS DISTRIBUTION INC.

Sue Connor
BURLINGTON TRANSIT

Tim Dickson
BOMBARDIER TRANSPORTATION

Elisabeth-Victoria Walsh
NOVA BUS

Mark Shorey
THALES GROUP

INCOMING NOMINATION SLATE 2020 - 2022

Anna Murray
HYDROGENICS

Bem Case
TORONTO TRANSIT COMMISSION

Carolina Gallo
ABB

Heather Pratt
UNIVERSITY OF WINDSOR

Jennifer McNeill
NFI GROUP

Kymm Girgulis
BC HYDRO

Martin Lapointe
RÉSEAU DE TRANSPORT DE LA CAPITALE

Michael Ledgett
DENTONS CANADA LLP (HONOURARY COUNSEL)

Sarah Buckle
TRANSLINK

Nicolas Pocard
BALLARD POWER SYSTEMS

Steve Kay
ENBRIDGE GAS DISTRIBUTION INC.

Sue Connor
BURLINGTON TRANSIT

Theresa Cooke
BURLINGTON TRANSIT

Tim Dickson
BOMBARDIER TRANSPORTATION

Elisabeth-Victoria Walsh
NOVA BUS

Mark Shorey
THALES GROUP

ORGANIZATIONAL STRUCTURE

Josipa Petrunić, President & CEO

PhD - Science and Technology Studies (Economics and Mathematics Stream), University of Edinburgh
M.Sc. - Science and Technology Studies (Economics and Mathematics Stream), University of Edinburgh
M.Sc. - Political Science and Public Policy, London School of Economics and Political Science
BJ - Political Science and Journalism, Carleton University

Josipa Petrunic is the President and CEO of *CUTRIC*. She is leading the formulation of several national transportation technology trials related to zero-emissions transportation and "smart vehicles" innovation including the Pan-Canadian Electric Bus Demonstration & Integration Trial, the Pan-Canadian Hydrogen Fuel Cell Demonstration & Integration Trial and the National Smart Vehicle Demonstration Project. Dr. Petrunic has built up *CUTRIC*'s consortium to include more than 100 private and public sector companies and organizations across Canada.

Previously, she served as the lead researcher in electric vehicle policy studies at McMaster University and as a senior research fellow in the history and philosophy of mathematics at University College London (UCL) in the United Kingdom in Science and Technology Studies. Dr. Petrunic continues to lecture in Globalization Studies at McMaster University. She currently sits on the Board of the Women's Transportation Seminar (WTS) Foundation and Women's Transportation Seminar – Toronto (WTS Toronto). In 2018, she was named one of Canada's Top 40 Under 40 by Bloomberg News and Canada's Top Clean 50. In 2019, she was named Aspioneer Top 10 Influential Women Leaders.

Research Team

Parvathy Pillai

Parvathy Pillai (Toronto office) works as Project Manager: ZEB Simulation & Commercialization at CUTRIC. In this role, Parvathy manages a diverse portfolio of zero-emission bus simulation projects and research studies that CUTRIC leads in Canada and the U.S. Parvathy also supports the organizational project management of CUTRIC.

Parvathy is a certified project management professional (PMP) ® and holds the Certified Associate in Project Management (CAPM) ® designation from PMI. Prior to CUTRIC, Parvathy worked in project management, environmental consulting, quality control, research, teaching and knowledge translation at various organizations. Parvathy earned her Master of Science from McMaster University following her undergraduate studies in Chemistry and Life Sciences.

Elnaz Abotalebi

Elnaz Abotalebi (Toronto office) is a Research Scientist at CUTRIC. In this role, she examines automated and connected smart vehicle performance for first mile-last mile to promote transit ridership across Canada. She also explores the total cost of ownership models for electric and hydrogen fuel cell buses and develops prediction models for CUTRIC's transit agency clients. Her general expertise lies in the areas of sustainable and active transportation, emerging technologies, data analysis, discrete choice modelling, survey design, travel demand forecasting and policy recommendation for transportation and transit projects.

Prior to CUTRIC, Elnaz was a researcher at McMaster University with a focus on understanding the preferences and suitability of households for electric vehicle adoption using statistical modelling. Elnaz came up with decision-making results to accelerate the adoption rate of electric vehicles in Canada. She received her PhD degree in Transportation Planning & Modelling from McMaster University and her Master's degree in Urban Planning with a specialization in GIS and Spatial Modelling from the University at Buffalo, United States.

Mahmood Nesheli

Mahmood Nesheli (Toronto office) is the Smart Vehicle Researcher at CUTRIC. He is responsible for the research on automated and connected smart vehicles for first kilometre-last kilometre solution to promote transit ridership across Canada. He provides technical support for the National Smart Vehicle project and automated transit technology deployment. Mahmood is a member of Professional Engineers Ontario, and holds a P.Eng certificate. He is also a postdoctoral fellow of transportation engineering at the University of Toronto.

Prior to CUTRIC, Mahmood previously worked as a Senior Public Transport Analyst at Auckland Transport. Mahmood received his PhD in Transportation Engineering from the Department of Civil and Environmental Engineering, University of Auckland, New Zealand focusing on Public Transit systems.

Roberto Sardenberg

Roberto Sardenberg (Toronto office) is the Electric Bus Modeller & Data Science Researcher with CUTRIC. In this role, Roberto is responsible for fleet modeling, generation of duty cycles, energy consumption calculations and analysis.

Prior to CUTRIC, Roberto previously worked with electrical measurement techniques in order to retrieve microscopic information on electrochemical cells and nano-structured samples. His research interests include the electrical characterization, modelling and simulation of electrical devices, sensors, and electrochemical cells. He contributed with the development of the measurement theory of Impedances by investigating constraints imposed on measured data by physical principles such as causality relations. Roberto received his PhD in Physics, Electromagnetism and Measurement Theory and M.Sc. in Electrochemistry, Impedance Spectroscopy from the Federal University of Minas Gerais (UFMG).

Shervin Bakhtiari

Shervin Bakhtiari (Montreal Office) is the GIS Analyst and Outreach Officer at CUTRIC. As a member of the modelling team, he is responsible for geospatial data analysis to assess the potentials of bus network electrification. He also examines the development of RoutΣ.i ™ modelling tool for potential opportunities regarding the automatization and optimization of the modelling process.

His greatest interests lie in transportation planning and network analyses with the aim to bring sustainability and GHG emission reduction to public transportation. Shervin holds a Bachelor's degree in Urban Planning from Concordia University and an Advanced Diploma in Architecture from Box Hill Institute, (where?).

Yutian Zhao

Yutian Zhao (Toronto office) is the Modeling and Data Science Researcher at CUTRIC. In this role, Yutian is responsible for managing tasks for CUTRIC's research team, developing electric bus powertrain models (e.g. RoutΣ.i) and performing data analysis. Yutian has nine years of experience in developing mathematical models for a wide range of systems including buses, duty cycles and polymerization. He has implemented Monte Carlo methods, method of moments, energy balances and machine learning models in Python, MATLAB and Visual Basic.

Prior to CUTRIC, Yutian worked for two years as a postdoctoral researcher at Queen's University where he also received his Ph.D from the department of Chemical Engineering. Yutian obtained his Bachelor's degree in Chemical Engineering from Zhejiang University (China).

Commercialization Team

Aditya Ramesh

Aditya Ramesh (Toronto Office) is the Project Manager: Electric Bus and Coach at CUTRIC. In this role, Adi manages CUTRIC's commercialization projects, showcasing the technology of our members and demonstrating the means to move people faster, smarter and greener.

Prior to CUTRIC, Adi spent many years working as a design engineer in the automotive sector and has a keen interest and love for all things transportation. Adi received his Master's in Business Administration from the University of Illinois at Urbana-Champaign where he trained as a project manager and worked on sustainable marketplace projects. Adi received his Master's in Mechanical Engineering from the University of Nottingham and spent a number of years living in Europe and Southeast Asia where he developed a fascination for public transport systems and how they could drive the future of sustainable mobility.

Dr. Abhishek Raj

Abhishek Raj (Toronto office) is the National Project Lead for CUTRIC's Pan-Canadian Electric Bus Demonstration and Integration Trial. He is responsible for the project-management of the Phase I and Phase II of CUTRIC's Electric Bus Project, which strives to deploy multi-manufacture-built standardized electric buses and chargers across various jurisdictions in Canada. This involves participating in strategic planning, resource sourcing, operational evaluation and coordination among internal and external project stakeholders with regards to time bound project delivery within prescribed budgetary limits. He also oversees the program management of the National Academic Advisory Committee associated with the E-Bus project.

Abhishek completed his Doctorate of Philosophy in Mechanical Engineering from the University of Waterloo. He previously worked as a Researcher at the University of Waterloo and at Masdar Institute of Science and Technology, Abu Dhabi in the field of Sustainable Energy and Clean Combustion. His interests lie in the interdisciplinary domains of Policy, Energy, Engineering and Environment.

Membership Team

Adriana Shu-Yin

Adriana Shu-Yin (Toronto office) is the Membership Success Officer & Contracts Administrator at CUTRIC. In this role, Adriana is responsible for leading Membership outreach and delivering value to Members. She also administers all research and funding contracts including those associated with CUTRIC's R&D funding program.

Prior to CUTRIC, Adriana worked on municipal climate change and sustainability projects with ICLEI – Local Governments for Sustainability as well as waste management projects with the University of Toronto Sustainability Office. Adriana holds a Bachelor of Science degree in Environmental Science and Environment and Health.

Carla Guillaume

Carla Guillaume (Montreal office) is the executive assistant and Quebec liaison officer at CUTRIC. In this role, Carla is responsible for creating and maintaining relationships with key stakeholders. In addition, she assists in the daily planning and coordination of administrative procedures and activities in the Montreal office.

Carla completed an undergraduate degree in Political Science from Concordia University and a graduate diploma in International Relations from the University of Montreal. She is currently pursuing a Master's degree in Public Administration at the École Nationale d'administration publique du Québec (ENAP). Carla received an Emerging Talent Award from the Bar of Montreal and continues to be dedicated to social issues like representation and gender equality.

Grace Reilly

Grace Reilly (Toronto office) is the Operations Coordinator to the CEO at CUTRIC. In this role, Grace is responsible for managing and coordinating the schedule of the CEO as well as CUTRIC's governance. Grace also assists with government lobbying commitments and CUTRIC's contracts administration.

Prior to CUTRIC, Grace worked as an Executive Assistant and Office Manager in Toronto and was previously an ESL Teacher in Austria, Scotland and Spain. Grace received her Master of Arts Degree in Spanish and German from the University of Glasgow and is currently enrolled in the Paralegal Program at George Brown College.

Jason Lesage

Jason Lesage (Vancouver office) is the British Columbia Liaison Officer with CUTRIC. In this role, he is responsible for stakeholder relations with companies, business associations, academic institutions, research organizations and government in B.C. as well as in the prairie provinces.

Prior to CUTRIC, Jason worked in marketing and communications in the corporate, governmental and non-profit sectors including LifeSciences BC, Mitacs, the British Columbia Lottery Corporation, the Queen's Park Healthcare Foundation, the B.C. Legislature and the Mayor's Office at Vancouver City Hall. He received his Bachelor of Science Degree from the University of Victoria, a Certificate in Public Relations from Langara College and he will receive a Certificate in Dialogue and Civic Engagement from Simon Fraser University later this year. Jason is also certified by the International Association for Public Participation in Planning, Techniques and Foundations in Public Participation.

Coordination & Logistics

Lana Sanderson

Lana Sanderson (Lethbridge office) is the Managing Coordinator at CUTRIC. In this role, Lana Sanderson is responsible for the coordination of projects, proposals, events, contracts, third party subcontractor purchasing and assisting with daily operations. She received her Bachelor of Business Operations from DeVry University and received a certificate in Global Village for Future Leaders of Business and Industry Interns from Lehigh University. Prior to CUTRIC, Lana worked in various positions in construction operations, real estate, planning, engineering, water resources and environment.

ABOUT CUTRIC

The Canadian Urban Transit Research & Innovation Consortium (CUTRIC) supports projects that develop the next-generation of mobility and transportation technologies for Canadians. These advancements help grow the low-carbon and "smart" technology eco-system in the country, leading to job growth and economic development over the long-term.

CUTRIC's work generates solutions that decrease fuel consumption, reduce emissions, eliminate redundancies, reduce congestion, improve the quality of life for Canadians, advance the digital integration of low-cost mobility solutions for communities across Canada, increase road safety and reduce road accidents. CUTRIC supports the technologies required for a 21st century low-carbon economy.

Vision

To make Canada a global leader in low-carbon smart mobility technologies across heavy-duty and light-duty platforms, including advanced transit, transportation, and integrated mobility applications.

Mission

To support the commercialization of technologies through industry-led collaborative research, development, demonstration and integration (RDD&I) projects that bring innovative design to Canada’s low-carbon smart mobility eco-system.

PILLARS OF INNOVATION

1. Zero- and low-emissions propulsion technologies and systems integration

Including battery electric and hybrid electric propulsion technologies, hydrogen fuel cell electric propulsion technologies as well as grid-based smart management tools that balance electric fleet charging and/or hydrogen refuelling.

3. Big Data for mobility analytics and Mobility as a Service applications

Including initiatives to optimize public and private fleets through the use of descriptive, analytic and predictive data assessment and the integration of artificially intelligent decision-making systems that guide fleet managers in real-time.

2. Smart vehicles and smart infrastructure

Technologies for automated and connected vehicles on road and on rail, including standardized and interoperable fleet management systems, vehicle-to-vehicle and vehicle-to-infrastructure communications systems, as well as intelligent transportation systems and smart mobility solutions.

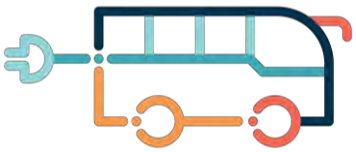
4. Cybersecurity in advanced mobility applications

Securitization of low-carbon smart mobility systems including secure communications for autonomous and connected vehicles given the susceptibility of new vehicle systems to malicious attack.

MAJOR RESEARCH OUTPUTS & CUTRIC-CRITUC LOW-CARBON SMART MOBILITY KNOWLEDGE SERIES

Rail Innovation in Canada: Top 10 Technology Areas for Passenger and Freight Rail Report

With the support of Transport Canada, CUTRIC's report documents the top 10 most feasible areas of technology innovation aimed at building Canada's future rail systems. Based on focus group sessions carried out over a 24-month period, CUTRIC consulted more than 220 participants representing dozens of companies and organizations active in the rail sector, including manufacturers, rail operators, industry experts, academics and government officials. The report includes recommendations and considerations for industry, government and the Canadian public.



Best Practices and Key Considerations for Transit Electrification and Charging Infrastructure Deployment to Deliver Predictable, Reliable, and Cost-Effective Fleet Systems

CUTRIC's report provides recommendations to Natural Resources Canada in its pursuit of best practices for transit electrification and charging infrastructure deployment to deliver predictable, reliable and cost-effective electrified fleet systems to Canadians.

This report provides full results of a comprehensive review of the Canadian landscape in fleet electrification, charging deployments and utility strategies. Included are results from interviews and focus groups held with transit agencies across North America.

Autonomous Shuttle Simulation for First-Kilometre/Last Kilometre Transit Solutions in Canada

CUTRIC was awarded a research contract through Transport Canada's Advance Connectivity and Automation in the Transportation System (ACATS) program to help prepare the country for connected and automated vehicle (CAV) deployments on Canadian roads. This report reviews five areas that are allied to CUTRIC's first-kilometre/last-kilometre electric low-speed automated shuttle (e-LSA) deployment efforts within the National Smart Vehicle Demonstration and Integration Trial.

Rout∑.i™ modelling

Milestone projects since 2018:

Burlington Transit · ETS Edmonton Transit System · GRT Grand River Transit · Guelph Transit On Your Way · London Transit · OCTA · RTC Réseau de transport de la Capitale · RTA Riverside Transit Agency · TTC

STRATEGIC GOALS: PROJECTS

Commercialization Projects

1. Pan-Canadian Battery Electric Bus Demonstration and Integration Trial, Phase I

This project is the first in the world to design, develop and integrate battery electric buses (BEBs) with charging systems that can operate interactively despite being made by different manufacturers.

Mutual and standardized operations

The manufacturers will support the operation and maintenance of these innovative technologies helping municipalities and transit agencies to develop standard systems across Canada. High-powered charging systems that can operate interactively are essential to increase the electrification of trucks and other medium- to heavy-duty vehicles beyond buses too.

Core goals for the trial

- Show how standards operate in real-time for high-power overhead chargers and battery-electric buses that are remotely controlled and monitored;
- Put 18 electric-battery buses and seven overhead chargers in Vancouver, Brampton and York Region to demonstrate interactive operability;
- Develop CloudTransit™ for cloud-based data storage and analysis of real-time data from electric buses and chargers to enable city-to-city data sharing; and
- Expand the project to include more than 200 battery-electric buses across seven cities by 2021 in a national joint procurement using an innovative funding and financing solution with the Infrastructure Bank of Canada.

CUTRIC aims to launch an *Innovation P3(C)* (i.e., an innovative public-private partnership) to supply, finance, maintain, operate and track the data associated with:

- Battery-electric buses
- Electricity "fuel" energy supply chain, including storage
- Necessary infrastructure (like new garage components and upgrades)
- Lifecycle bus and charging system tracking and performance monitoring

Innovative aspects of the trial

- Expand to more locations in Phase 2 from 2020 to 2023;
- Innovate a type of joint venture involving public and private financing;
- Help transit agencies to work with outside experts in their areas of expertise to finance, design, build, and maintain;
- Reduce charging times on routes and at depots using high-powered, overhead chargers with integrated energy storage;
- Make routes more efficient by using connective technology to automate convoys of electric-battery buses; and
- Automate charging events to reduce the time to return to service.

Intellectual property and research outcomes

We recruited seven universities and colleges for our *National Advisory Committee for Zero-Emissions Buses* for research related to battery bus systems performance, transit systems operation, bus cybersecurity, design and consumer acceptance.

CUTRIC has led developments in intellectual property as follows:

- Standards for operating high-powered overhead chargers integrated with energy storage;
- CUTRIC's RoutΣ.i™ tool to simulate the energy consumption and operational performance of electric-battery buses across full fleets;
- Performance reports for battery- and flywheel-based energy storage devices connecting with high-powered overhead chargers;

- Reports on cybersecurity and networking in automated charging of electric-battery buses;
- Procurement best practices provided to the Government of Canada and others;
- Data visualization tools to show data to cities to support buying electric-battery buses and utilities; and
- Measures of performance to guide transit and utility agencies.

Leading consortium

CUTRIC has built a consortium of organizations to develop and bulk buy technologies for battery-electric buses.

Industry Partners

- ABB Group
- BC Hydro
- CIMA+
- eCamion
- IBI Group
- Inverted Power
- New Flyer Bus
- Nova Bus
- Newmarket-Tay Power Distribution Limited
- Proterra
- Siemens
- Stantec
- Tok Transit

Transit Partners

- Brampton Transit
- Burlington Transit
- Durham Region Transit
- Guelph Transit
- TransLink
- Winnipeg Transit
- York Region Transit

Post-Secondary Partners

- Ontario Tech University
- Ontario College of Art & Design
- Queen's University
- University of Windsor

Project Manager: Aditya Ramesh (aditya.ramesh@cutric-crituc.org)

2. Pan-Canadian Hydrogen Fuel Cell Electric Bus Demonstration and Integration Trial

Phase 1 of this national, multi-year project will put into use hydrogen-fuel-cell electric buses. In this trial, three to four cities will work with Canada's manufacturers and academic researchers to achieve the following:

- Launch and monitor 30 hydrogen-fuel-cell electric buses for a full life cycle (up to 18 years); and
- Design and use low-emissions hydrogen fueling stations and fueling networks based on the green model of Enbridge-Hydrogenics in Markham, Ontario.

Hydrogen-fuel-cell technology can reduce greenhouse gas emissions. Hydrogen generation (using rapid-response electrolysis) could be an effective solution for storing and balancing surplus power on the grid.

CUTRIC aims to launch an *Innovation P3(C)* (i.e., an innovative public-private partnership) to supply, finance, maintain and operate:

- Hydrogen-fuel-cell electric buses
- Hydrogen supply chain
- Necessary infrastructure (like new garage components)
- Lifecycle fuel supply
- Lifecycle bus and charging system tracking and performance monitoring

Intellectual Property and Research Outcomes

We recruited seven universities and colleges for our *National Advisory Committee for Zero-Emissions Buses* for research related to alternate transit systems, including cybersecurity, performance, design and consumer acceptance. We expect outcomes that:

- Show how hydrogen fuel cell electric buses operate on roads and along routes, including how much hydrogen they consume;

- Assess the cybersecurity of the buses;
- Show how hydrogen buses can be made to operate more cheaply than diesel buses; and
- Design standards for harmonized hydrogen fueling systems operations for heavy-duty vehicles.

Intellectual Property and Research Outcomes

CUTRIC has created an advisory committee composed of three research institutes that conduct research related to hydrogen-fuel-cell electric buses and fueling systems, including their operation, design and consumer acceptance.

The aims of the National Advisory Committee for Zero Emissions Buses are:

- To develop CloudTransit™ for cloud-based data storage and analysis to measure and assess real-time operations, improve specifications for buying and sharing data across cities;
- To compare actual performance with potential performance, nationally and regionally, for Canadian standards for heavy-duty fuel-cell vehicles, fueling and storage; and
- To reduce hydrogen costs for transit agencies and connect hydrogen production networks.

Industry Partners

- ABB Group
- Ballard Power Systems
- Enbridge Natural Gas
- Hydrogenics Corp. (Cummins)
- New Flyer Industries
- Siemens Canada

Transit Partners

- Brampton Transit
- MiWay
- Toronto Transit Commission (TTC)
- Winnipeg Transit
- York Region Transit

Post-Secondary Partners

- Canadian Nuclear Laboratories
- Centennial College
- York University

Project Manager: Aditya Ramesh (aditya.ramesh@cutric-crituc.org)

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3. National Smart Vehicle Demonstration and Integration Trial

The National Smart Vehicle Demonstration and Integration Trial aims to standardize technologies so that systems from different manufacturers can work together. We will find out how transit systems can make their operations autonomous but cooperative.

We addressed the challenge of high capital costs by developing an innovative model for joint ventures involving public and private financing.

We will develop standard technology which will:

- Coordinate short-range communication-Vehicle-to-vehicle and vehicle-to-base;
- Increase cybersecurity;
- Create common, automated charging systems; and
- Develop software to manage across fleets.

The driverless mini-shuttles required are automated and digitally controlled. We will also design new public-private partnerships to support advances in:

- Finance, supply, maintenance and operation of the smart vehicles
- Roadside infrastructure
- Long-term management of multi-manufacturer fleets

Intellectual Property and Research Outcomes

We recruited six universities and colleges for our *National Academic Committee for Smart Vehicles* for research related to alternate transit systems, including cybersecurity, performance, design and consumer acceptance. We expect outcomes that:

- Visualize how low-speed, electric shuttles work in public transit to provide service for travel between a person's home and a transit hub;

- Provide effective cybersecurity across vehicles and infrastructure;
- Design standards for harmonized charging systems and single-fleet operating systems across manufacturers; and
- Assess the hackability of these vehicles to ensure they are safe for Canadians to ride.

Industry Members

- 2getthere
- ABB Group
- Bombardier Transportation
- eCAMION
- ELIX Wireless
- Pacific Western Transportation
- NAVYA
- Nova Bus
- New Flyer Industries
- S2E Technologies
- Smartcone Technologies
- Thales Group
- Tok Transit

Transit Members

- Brampton Transit
- Durham Region Transit
- Le Réseau de transport de la Capitale
- Société de transport de Trois-Rivières
- York Region Transit

Post-Secondary Partners

- Carleton University
- Queen's University
- University of Calgary
- University of Toronto
- University of Windsor

Project Lead: Dr. Elnaz Abotalebi (elnaz.abotalebi@cutric-crituc.org)

INDUSTRY-ACADEMIC RESEARCH PROJECTS

CUTRIC-led projects with National Academic Committee modules:

1. Pan-Canadian electric vehicle energy consumption, state of charge, & vehicle simulation modelling for heavy duty powertrain systems and high-powered charging

A simulation tool was developed to support electric-bus deployment projects by predicting operational benefits, total CO2e savings and charging requirements. The model is based on the original code developed via collaborations through the Pan-Canadian Electric Bus demonstration & Integration Trial: Phase I. The main inputs of the model include physical characteristics of the bus, route topography, ridership, powertrain efficiencies, route scheduling, and driving speeds. The model can calculate e-bus energy consumption as well as battery state-of-charge, time required to charge, and total electricity consumed. Website overview

2. High-powered electric vehicle charging with energy storage integration: optimization analysis & techno-economic predictive analysis

This Project will gather analytical knowledge emanating from cyber-security protocol analysis for e-buses and e-chargers which may lead to improved technology standards for these systems. A 3D visualization tool that allows transit and fleet systems to design and develop urban informatics approaches to visualize dynamic, complex, multi-modal mobility with scalable data for future fleet electrification decision-making will be used. A prototype of an enhanced powertrain for the e-buses that would be of relevance will be created. Several new core technology outcomes associated with this project will emanate from the Project. Website overview

3. Automated and connected electric vehicle integration: optimization analysis & techno-economic predictive analysis

The objective of the project is to predictively assess optimization and techno-economic parameters of e-LSA operation along selected routes within municipal jurisdictions in Ontario, utilizing the TRiPSIM™ modelling tool. The outcomes of TRiPSIM™ modelling highlight the benefits of a long term implementation and monitoring of a series of national on-road demonstration trials using e-LSAs across a proposed set of municipal jurisdictions. Website overview

4. Integrated hydrogen fuel cell electric vehicles systems analysis: route optimization, fuel consumption, powertrain performance, and economic feasibility analysis & techno-economic predictive analysis

In this project, an integrated vehicle system analyses of fuel cell electric vehicles (FCEVs) (transit buses) will be conducted. Module specific, independent, third party principal applicants involved in this project ensure neutrality of the research and accounting procedures. Key deliverables expected out of this project include: a fully developed Fuel Cell Electric Bus modelling algorithm; a comprehensive literature review of the global FCEB innovations and key findings from the consortium-led project development meetings; a federal or provincial funding application to fund a large-scale demonstration and deployment of FCEBs; training of multiple highly qualified personnel (HQPs); a report on analyses of data collected from on road vehicle deployments; a comparative analysis findings report on validated modelling outputs based on data collected; a detailed analyses-based report of women representation in STEM and technology innovation and transportation; and multiple course modules with embedded professional development units (PDU). Website overview

Stakeholder-led projects:

1. Development of low-cost, high performing and durable pem fuel cells (phase I)

This study focuses on zero-emission fuel cell technology that can be used in: fuel-cell power/propulsion systems; battery electric power/propulsion systems with fuel cell as ranger extenders; and electric power/propulsion systems with battery- fuel cell electric hybrids. The research focuses on proton-exchange membrane (PEM) fuel cell technology and the technical challenges involving cost and durability under variable load operations. Website overview

2. Social-semantic analysis of social media interactions to assess customer satisfaction in transit agencies

The aim of this proposed study is to advance the discipline of social media analytics and its application to public fleet decision makers. The project starts by integrating incoming social media

feeds vis-a-vis public fleets and merges all incoming data into one cloud-platform. This platform will enable (in the future) an artificially intelligent response mechanism for fleet action, including dispatching additional vehicles or communicating with consumers regarding their challenges on the street in hailing, riding or commuting by public vehicles in a public mobility system. The immediate outcome of this social media analytics tool is a better capture of customer views and opinion dynamics, customer satisfaction and operational support. Website overview

3. Electric vehicle enclave (EVE) autonomous vehicle infrastructure demonstration pilot

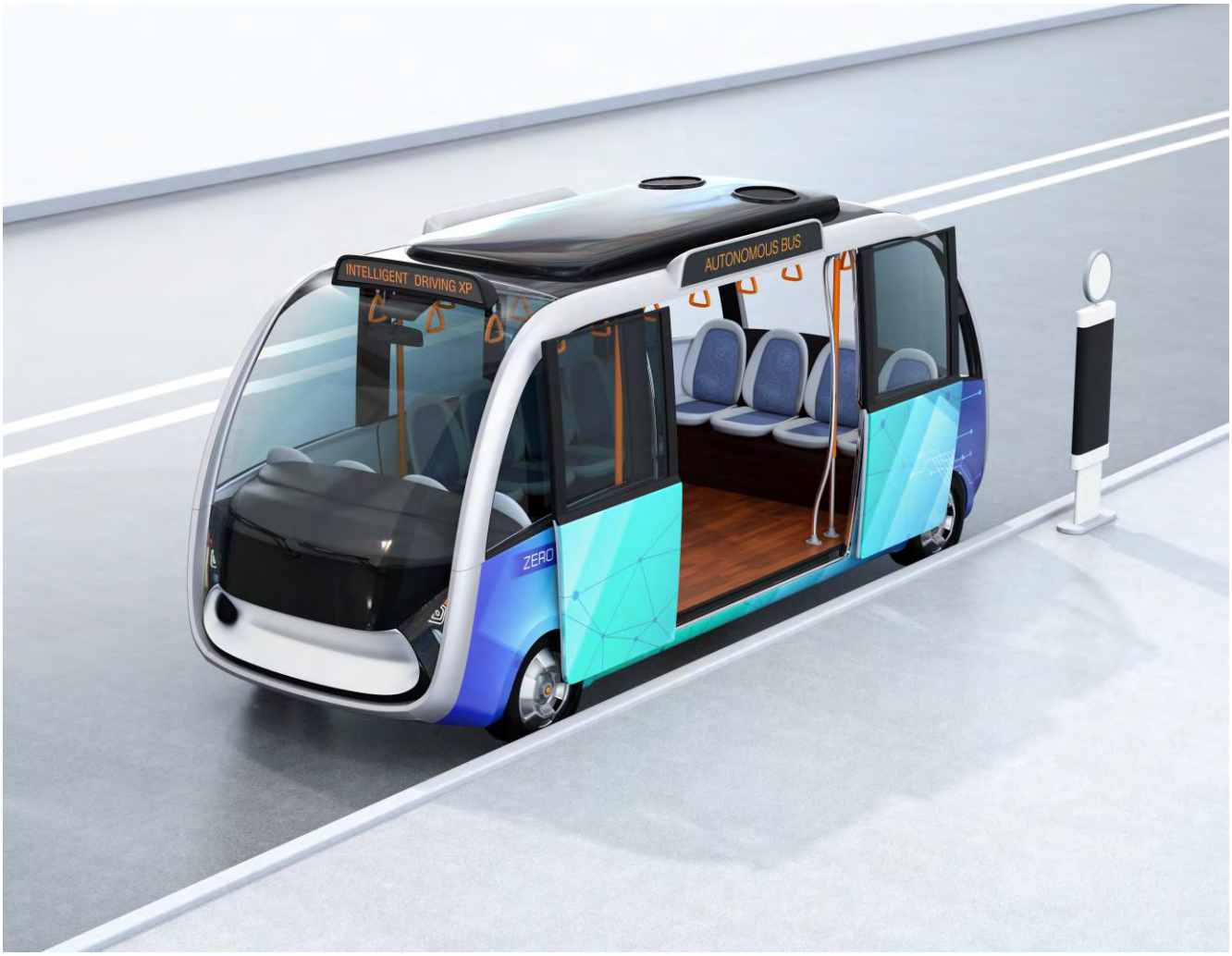
This project is designed to tackle some of the key challenges for autonomous vehicle penetration. S2E Technologies combines infrastructure-based controls and sensing with an optimized onboard unit assembly. S2E will minimize the need for hardware on the vehicles while at the same time gaining from the constant monitoring and robustness of sensors on the infrastructure. S2E will package the concept and commercially deploy it in school zones, urban road construction and other residential areas. Moreover, the same infrastructure will communicate with a possible community-wide autonomous shuttle and autonomous utility vehicles (for landscaping, snow removal, package delivery, and waste management). Website overview

4. Design and real-life verification of light-weight solar anti-idling system in urban transit vehicles and service fleets for reduction of ghg emissions

This project focuses on the optimization of the system design. The main purpose is to accomplish commercialization of an “anti-idling” solution for public transit buses. Therefore, the project entails aspects of design, cost considerations and safety concerns. Two core technologies will be developed to achieve a light-weight anti-idling system with an adaptable and modular architecture. Website overview

5. Shared electric work fleets for universities and colleges with a system of resource and location optimization using machine learning

The project’s objective is to demonstrate the world’s first shared, electric work fleets with on- demand rides, tools, supplies and assets. The study aims to test shared work fleets with university and college partners that have field staff (i.e., plumbers, electricians) through several pilot projects. Post-secondary school staff who participate in the pilots will switch from driving their own work vehicles with their own equipment (i.e., ladders and shop vacuums) to an “Uber-like” model where pick-ups and drop-offs can be requested from smartphones. In addition to pick-ups and drop-offs of the technician, assets (ladders, shop vacuums) and supplies (nails, nuts and bolts, etc.) can also be picked up or dropped off and accessed via smart Bluetooth-enabled lockers in the vehicles that open by technicians pressing a button on their smartphone. Website overview



6. Pantonium intelligent on-demand transit

Since September 2018, Pantonium has provided newly developed technology to enable an intelligent on-demand bus service in Belleville, Ontario. Several new features and capabilities are slated to be added to the system based on feedback of the initial pilot as well as Belleville's future goals for public transit expansion. A third overall objective of this project is to deploy this technology to another municipal public transit agency that is similar to Belleville. This project will generate original research and validate data generated by Pantonium's On-Demand Transit (ODT) Software, further innovate and iterate on the technology platform to make a commercializable product and expand the project in Belleville to new service areas and deploy the technology to a new municipality. Website overview

7. Next-generation integrated battery-based electric bus charging system

In the proposed project, the consortium will develop a novel bus charging technology that is backed up by a battery energy storage system. The overall project query is to create a cheaper and more effective electric bus charging system, with reduced capital and operating costs. As part of the research query, eCAMION will design and develop an inverted pantograph bus charger backed up by a Li-Ion energy storage system. Website overview

CUTRIC INTELLECTUAL PROPERTY & TRADEMARKED CONSULTING TOOLS: SUMMARIES OF TRADEMARKED TOOLS

RoutΣ.i™

To serve our national consortium, CUTRIC developed RoutΣ.i™ – an industry-leading electric bus & transit simulation tool that allows transit agencies to accurately predict the performance of battery electric buses (BEBs) with various charging strategies (i.e., in-depot, on route, and combined solutions) as well as hydrogen fuel cell electric buses (FCEB) with H2 fueling time and delivery strategies.

- For Battery Electric Buses (BEBs), RoutΣ.i™ predicts vehicle and fleet range, charging needs, total energy and power needs, total energy costs, CO2e reductions, and scheduling challenges/optimization to support effective BEB charging requirements.
- For Hydrogen Fuel Cell Electric Buses (FCEBs), RoutΣ.i™ predicts vehicle and fleet range based on hydrogen fuel parameters, fueling time needs, total energy needs, total energy costs, CO2e reductions based on the source of H2, and scheduling challenges/optimization to support effective FCEB fueling requirements.
- For electric Low-Speed Autonomous Shuttles (e-LSAs), RoutΣ.i™ predicts vehicle and fleet range, charging needs, total energy and power needs, total energy costs, CO2e reductions, scheduling challenges/optimization to support effective e-LSA fleet deployments for first kilometre/last kilometre requirements.

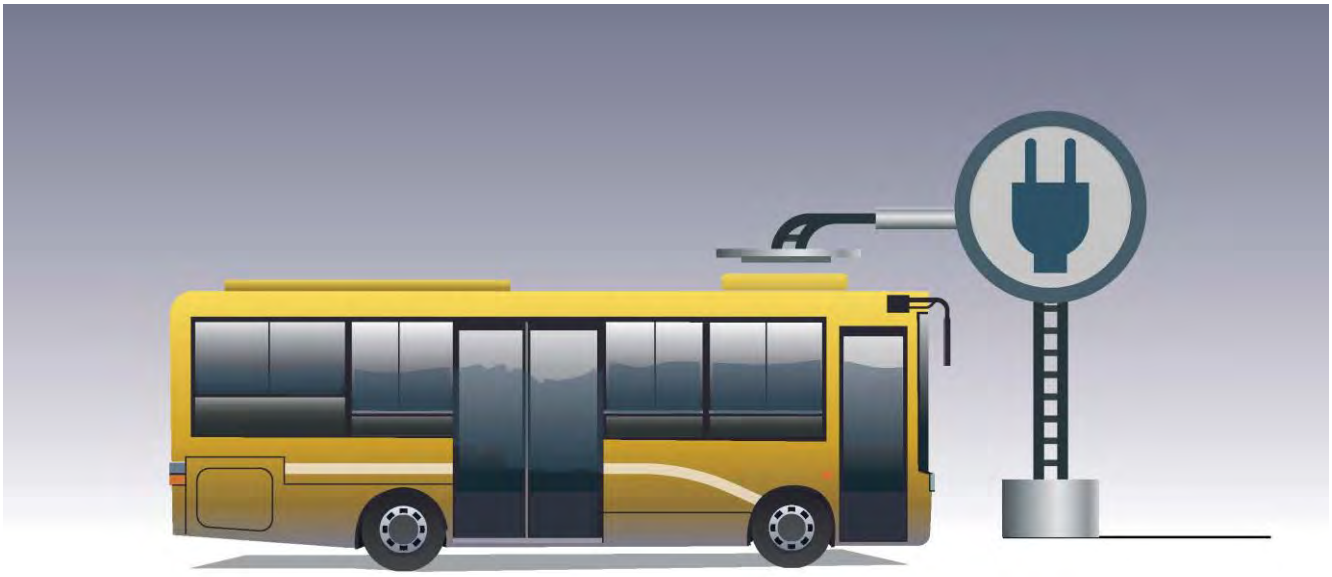
CUTRIC's RoutΣ.i™ research team can complete feasibility assessments on a block-based or route-based format.

For full fleet analysis, CUTRIC always recommends block-based analysis inclusive of pull in, pull out, and deadheading requirements to generate a full picture of the energy consumption and charging requirements of the transit system.

deCarbonify™

CUTRIC's deCarbonify™ tool helps transit agencies determine how their transit agency compares to other Canadian transit systems today on an energy intensity and pollution basis offering transit agencies a measurement of carbon dioxide equivalent (CO2e) emissions. These include CO2e/passenger, CO2e/revenue km, CO2e/total service kms (including deadheading), CO2e/service area density unit and CO2e/vehicle measures. CUTRIC's deCarbonify™ can also offer additional relative pollution measures such as CO2e per passenger per revenue kilometre.

These measurements help Transit Agencies determine whether reducing emissions is achieved faster or more substantially using alternative propulsion vehicles, improved route optimization, improved service area design or ridership improvement programs.



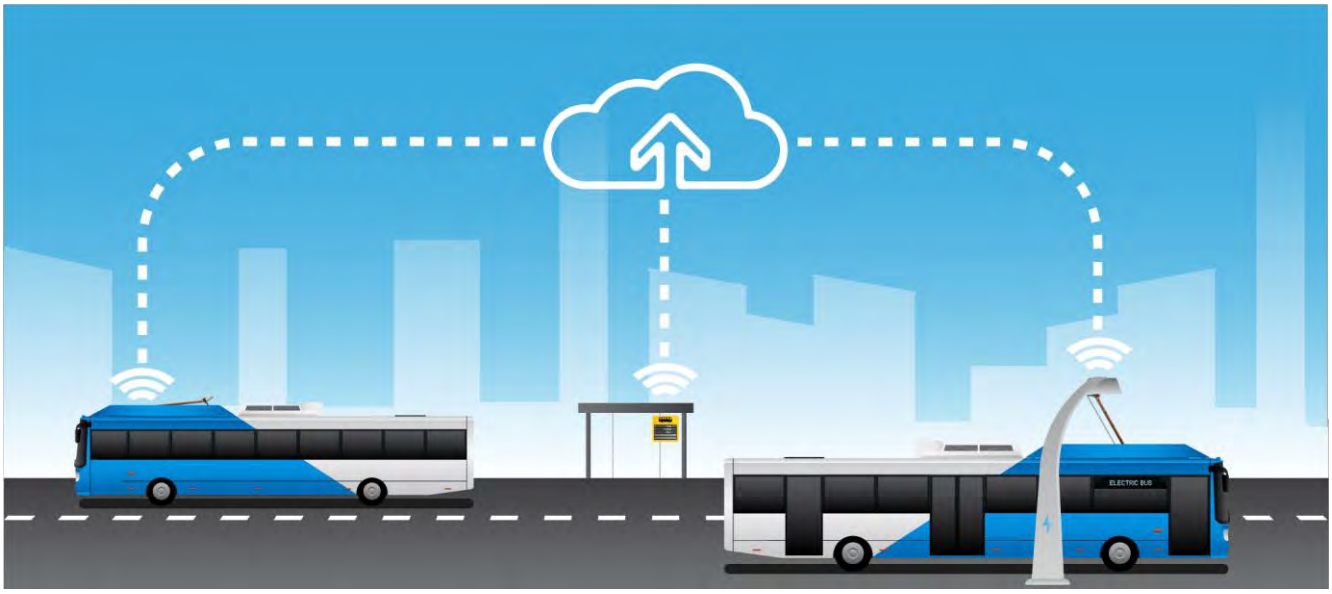
ZEVMapper™

This tool helps cities and municipalities determine the potential, required and optimal locations for their electric vehicle supply equipment (EVSE), i.e. “EV charging station” installations.

The tool uses original methodological insights to determine optimal EVSE locations based on the needs of residents, commuters and through-traffic into and out of a community. It also integrates local and global EV adoption rates to assess the need for growth in charging stations over the next five to 20-year period.

Developed on the basis of early research conducted by the U.S. Department of Energy’s plug-in electric vehicle infrastructure studies (The EV Project and the ChargePoint America Project), ZEVMapper™ utilizes three categories of variables including (1) optimal location variables, (2) installation costs variables, and (3) EV driver charging patterns in calculating and mapping ideal EV charging locations. The tool also maps specific siting choices including long-term parking opportunities (Level 1 & 2), special applications for Level 2 and highway intersectionality (Level 3).

ZEVMapper™ produces outcomes in a “Best Case – Worst Case” scenario assessment which identifies the total number of EV chargers required at a given location or within a given service area to fully satisfy charging needs based on range capabilities of various makes and models of vehicles, drive cycles associated with EV drivers (including commuters, tourists and residents), and minimum required time to charge and “return to home base” for overnight charging.

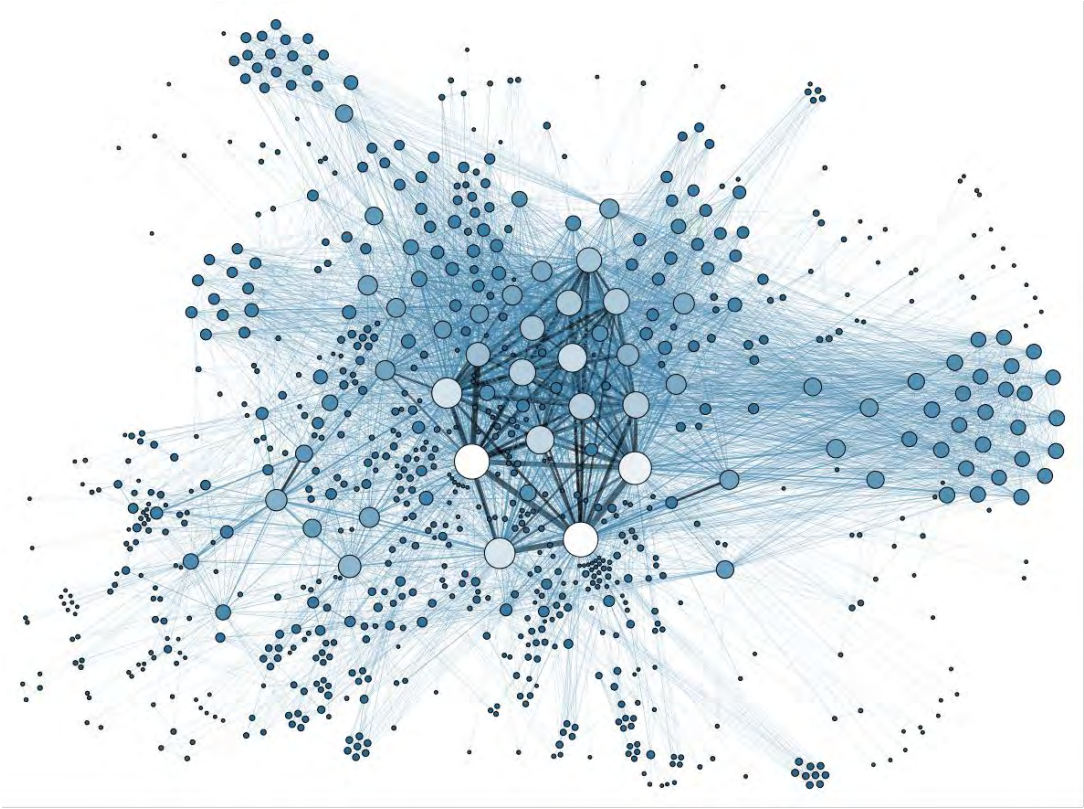


CloudTransit™

CloudTransit™ is CUTRIC's cloud-based platform which has been developed as part the Pan Canadian Electric Bus Demonstration and Integration Trial Phase I project to collect, integrate and view in-real time the data emanating from various electric bus and electric charging systems that form part of the Trial across multiple transit systems and cities and in partnership with multiple utility partners. This tool will allow transit and utility participants in the Pan-Canadian Demonstration and Integration Trial Phase I to view the performance of the assets across multiple jurisdictions. This platform will also form the basis for the integration and analysis of data from multiple sources as part of CUTRIC's ACES Big Data Trust for mobility data-driven innovation in the future.

STRATEGIC GOALS: GOVERNMENT RELATIONS

2020 Stimulus bid submissions



ACES Big Data Trust

CUTRIC has submitted this proposal to the federal government as well as submitted tailored versions of the proposal to the Governments of British Columbia, Ontario and Quebec.

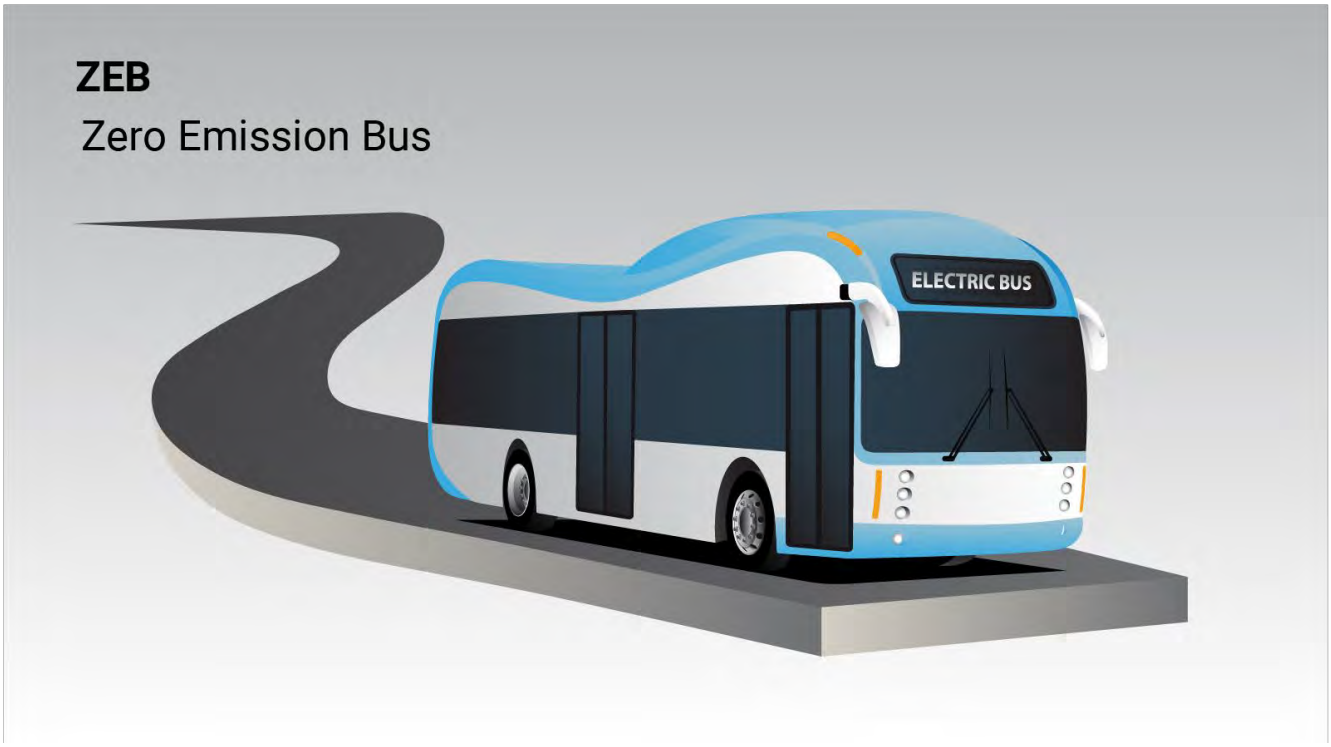
The ACES Big Data Trust will create between 120 and 150 highly-skilled jobs in STEM fields in Ontario.

The ACES Big Data Trust emanates from CUTRIC's Pan-Canadian Electric Bus Demonstration & Integration Trial, which is logging and monitoring (in real-time) the performance of BEBs and charging systems across Canada. The ACES Big Data Trust goes beyond electric buses, however, to include the logging, monitoring, data collection and data analysis of all electrified smart vehicles (shuttles, buses, rail vehicles, and other public fleet vehicles) in cities across the country within the next 12 months.

The ACES Big Data Trust will enable public transit agencies, cities and private entities to optimize the use of tax dollars that are invested into public fleet procurements by ensuring data-driven procurements, performance evaluation plans and innovative improvements to vehicle or fleet performance in real-time.

The Trust will drive job creation in Big Data across Canada and place Canadian fleets at the centre of a global technology innovation ecosystem that reduces greenhouse gases (GHGs), supports Canada's Paris Climate Agreement commitments, creates jobs in data science and Big Data analytics and helps to fast- track the federal mandate to roll-out 5,000 zero-emissions buses (ZEBs) and high-speed rail systems nationally.

CUTRIC is asking for $7.5 Million through the FedDev Ontario program to fund this program.



ZEB Simulation & Roll Out Plan

CUTRIC has submitted this proposal to the federal government as well as submitted tailored versions of the proposal to the Governments of British Columbia and Ontario.

The ZEB Simulation and Roll Out Plan Funding proposal is shovel-ready and will create or retain more than 80 jobs in high-end physics-based simulation work that predicts how battery electric buses (BEBs) and hydrogen fuel cell electric buses (FCEBs) perform in Canadian communities within specific local electricity systems. This simulation gives Canadian municipalities and transit agencies accurate predictions as to how many BEBs or FCEBs a system needs to fully electrify its fleet and how many BEB chargers and/or kilograms of hydrogen the transit agency needs to fuel the fleet. The ZEB Simulation program that CUTRIC runs also calculates actual electricity and hydrogen fuel costs and predicts the success and failure rates of ZEBs in operation so transit and cities can procure the right number of buses, chargers and fueling systems. Cities and transit agencies are in need of precise data-based ZEB Simulation outputs based on full-fleet analysis to rapidly scale to full-fleet electrification of transit.

The ZEB Simulation work CUTRIC's consortium completes will then support ZEB Roll Out Plans which help cities plan for the additional infrastructure -- facilities redesign, energy and power level delivery by the utility, energy storage integration and civil works costs -- which is a necessary prerequisite to full-fleet BEB or FCEB procurements.

Research and Development Program

CUTRIC has submitted tailored versions of this proposal to the Governments of British Columbia and Ontario.

The CUTRIC-Ontario Innovation funding program has developed a strong track record in managing industry-academic job-creating innovation funding. The $10 Million funding program was fully deployed until 2019 when $2.5 Million intended for deployment in fiscal year 2020-2021 was cut by the current Government of Ontario. The Ontario program, which CUTRIC continues to manage, has created more than 230 new industry and academic jobs and dozens of intellectual property (IP) outputs logged to date by industry and academic partners.

There is no ramp-up time required. CUTRIC has built the funding program, the project review, the project approval protocol, and accounting and auditing practices over the past three years starting in 2016. This allows both the B.C. and Ontario programs to begin immediately. Both stimulus proposals will help to create over 100 jobs and dozens of new Intellectual Property outputs ready for commercialization in the smart mobility sector.

CUTRIC is asking for $2.5 - $5 million through the Government of Ontario and $3 million through the Government of British Columbia.

STRATEGIC GOALS: GOVERNMENT RELATIONS

Crestview Strategy Achievements

From left to right: Adi Ramesh (CUTRIC), Jeremy Bowes (Professor, OCAD University), MP Ruby Sahota (MP Brampton North), Dr. Josipa Petrunic (CEO, CUTRIC), Sarah Diamond (President, OCAD University), Marco D'Angelo (President, CUTA)

2019 efforts:

- Secured federal funding for the Pan-Canadian Electric Bus Demonstration and Integration Trial and organized the announcement of the project by the Minister of Environment and Climate Change
- Engaged with local Members of Parliament in the Brampton region to build support for the Pan-Canadian Electric Bus Demonstration and Integration Trial
- Secured federal representation of election candidates and department officials and municipal representatives at CUTRIC's Low-Carbon and Smart-Mobility Conference
- Conducted meetings with political staff and Ministers in the Ontario government, including the Offices of the Minister of Transportation, the Minister of Infrastructure, the Minister of Energy, Northern Development and Mines and the Minister of Economic Development, Job Creation and Trade
- Conducted a monthly webinar series to provide members with analysis and insights on the new federal government's priorities, the new federal Cabinet and alignment with CUTRIC priorities, provincial politics and other contemporary topics

2020 efforts:

- Secured introductory meetings with political staff in the new government following the 2019 federal election to position CUTRIC as a trusted stakeholder, in the Offices of the Minister of Environment and Climate Change, the Minister of Natural Resources, the Minister of Infrastructure and Communities and the Minister of Innovation, Science and Industry
- Conducted a successful Advocacy Day with CUTRIC Members in the provincial Legislature of British Columbia with attendance by multiple Members of the Legislative Assembly from government and opposition parties
- Organized an Advocacy Day with CUTRIC Members in the provincial legislature of Ontario; cancelled due to the COVID-19 pandemic
- Conducted meetings with local Members of Parliament to deepen CUTRIC's local and regional relationships and build champions for CUTRIC in federal caucus
- Secured representation from federal Members of Parliament for CUTRIC project announcements with members from academic institutions
- Advancing ACES Big Data Trust, ZEB Simulation & Roll-Out, and MiWay Hydrogen Bus Proposal with federal political and bureaucratic officials (in progress)
- Securing high-level municipal, provincial, and federal representation of government officials at CUTRIC's 2nd Annual Low-Carbon and Smart-Mobility Conference (in progress)

STRATEGIC GOALS: PUBLIC RELATIONS

Switchboard PR Achievements

From left to right: MP Brian Masse for Windsor West, Dr. Josipa Petrunic, Executive Director and CEO of CUTRIC, and MP Irek Kusmiercyzk for Windsor-Tecumseh join arms after the announcement of the first research group on smart and autonomous vehicles which will provide the research to enable flexible and reliable transit service for those living in underserved regions

Event Coordination & Support

Switchboard provided support for two federal funding announcements: CUTRIC's national Academic Committee on Zero-Emissions Buses (February 2020) and the National Academic Cluster for Smart Vehicles. Switchboard developed the news releases, media assets, speaker briefings, speaking notes, and assisted with event coordination.

Public Relations & Media Relations

Switchboard manages media pitching on behalf of CUTRIC, including announcement-related pitching, op-ed writing and pitching and managing media requests. CUTRIC's spokespeople are prepared with interview briefs and talking points. Coverage in 2020 includes:

CBC · THE POINTER · Corporate Knights · MASS TRANSIT · METRO · EnergiMedia

Communications & Member Relations

Switchboard conducted a Member discovery to solicit feedback on CUTRIC's current communications protocols. In cooperation with the CUTRIC team, Switchboard re-designed the monthly newsletter and weekly eblasts, developed and implemented a social media strategy. Switchboard continues to support the CUTRIC team with communications plans for all events and PR opportunities.

APPENDIX

Audited Financial Statements

Canadian Urban Transit Research & Innovation Consortium Statement of Financial Position

December 31	2019	2018
Assets		
Current		
Cash - unrestricted	$ 907,954	$ 44,394
Cash - restricted (Note 2)	3,242,720	6,575,945
Accounts receivable	707,143	89,750
Accrued billings receivable	835,545	91,699
Prepaid expenses	20,154	59,483
	$ 5,713,516	$ 6,861,271
Liabilities and Net Assets		
Current		
Accounts payable and accrued liabilities	$ 147,091	$ 100,695
Deferred revenue - unrestricted (Note 3)	1,174	34,500
Deferred revenue - restricted (Note 4)	3,282,587	6,575,945
	3,430,852	6,711,140
Net Assets		
Unrestricted	2,282,664	150,131
	$ 5,713,516	$ 6,861,271

Canadian Urban Transit Research & Innovation Consortium Statement of Changes in Net Assets

For the year ended December 31	2019	2018
Net assets, beginning of year	$ 150,131	$ 149,385
Excess of revenue over expenses for the year	2,132,533	746
Net assets, end of year	$ 2,282,664	$ 150,131

Canadian Urban Transit Research & Innovation Consortium
Statement of Operations

For the year ended December 31	2019	2018
Revenue		
Membership fees (Note 3)	$ 623,957	$ 649,613
Government funding - projects (Note 4 & 5)	3,971,843	247,019
Government funding - administration (Notes 4 & 5)	342,606	289,864
Fee-for-service	2,901,508	320,078
Sponsorship	50,248	58,354
Other income	107,380	-
	7,997,542	1,564,928
Operating expenses		
Advertising and promotion	8,762	33,578
Consulting fees	170,884	19,875
Funded project expenses	3,971,843	247,019
Meetings and events	155,356	94,366
Office and general	146,580	116,181
Professional fees	177,234	36,747
Project development	97,048	5,967
Salaries and benefits	917,265	832,806
Travel	220,037	177,643
	5,865,009	1,564,182
Excess of revenue over expenses for the year	$ 2,132,533	$ 746

Canadian Urban Transit Research & Innovation Consortium
Statement of Cash Flows

For the year ended December 31	2019	2018
Cash provided by (used in)		
Cash flows from operating activities		
Excess of revenue over expenses for the year	$ 2,132,533	$ 746
Adjustments to reconcile excess of revenue over expenses to net cash provided by (used in) operating activities		
Changes in non-cash working capital balances		
Accounts receivable	(617,393)	1,439,931
Accrued billings receivable	(743,846)	(79,198)
Prepaid expenses	39,329	(11,895)
Accounts payable and accrued liabilities	46,396	3,764
Deferred revenue - unrestricted	(33,326)	(13,000)
Deferred revenue - restricted	(3,293,358)	1,912,129
	(2,469,665)	3,252,477
Cash flows from investing activity		
Proceeds on sale of investments	-	3,220,815
Increase (decrease) in cash during the year	(2,469,665)	6,473,292
Cash, beginning of year	6,620,339	147,047
Cash, end of year	$ 4,150,674	$ 6,620,339
Represented by		
Cash - unrestricted	$ 907,954	$ 44,394
Cash - restricted	3,242,720	6,575,945
	$ 4,150,674	$ 6,620,339

CUTRIC-CRITUC
Annual Report 2019 - 2020
Rapport annuel 2019 - 2020

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