Low-Carbon Smart Mobility (LCSM) Supercluster Consortium

Supergrappe D’Innovation en Mobilité Durable et Intelligente (SIMDI)

Brought forward by the Canadian Urban Transit Research & Innovation Consortium (CUTRIC)

www.cutric-crituc.org

CUTRIC CRITUC

FASTER • SMARTER • GREENER

RAPIDE • INTELLIGENT • VERT

Background Information

Budget 2017 proposes to establish Innovation Canada, a new platform led by Innovation, Science and Economic Development Canada as a one-stop-shop for Canada’s innovators that will coordinate and simplify the support available to Canada’s innovators by:

- Leading the creation of Canada’s economic growth strategies
- Initiating a whole-of-government review of business innovation programs

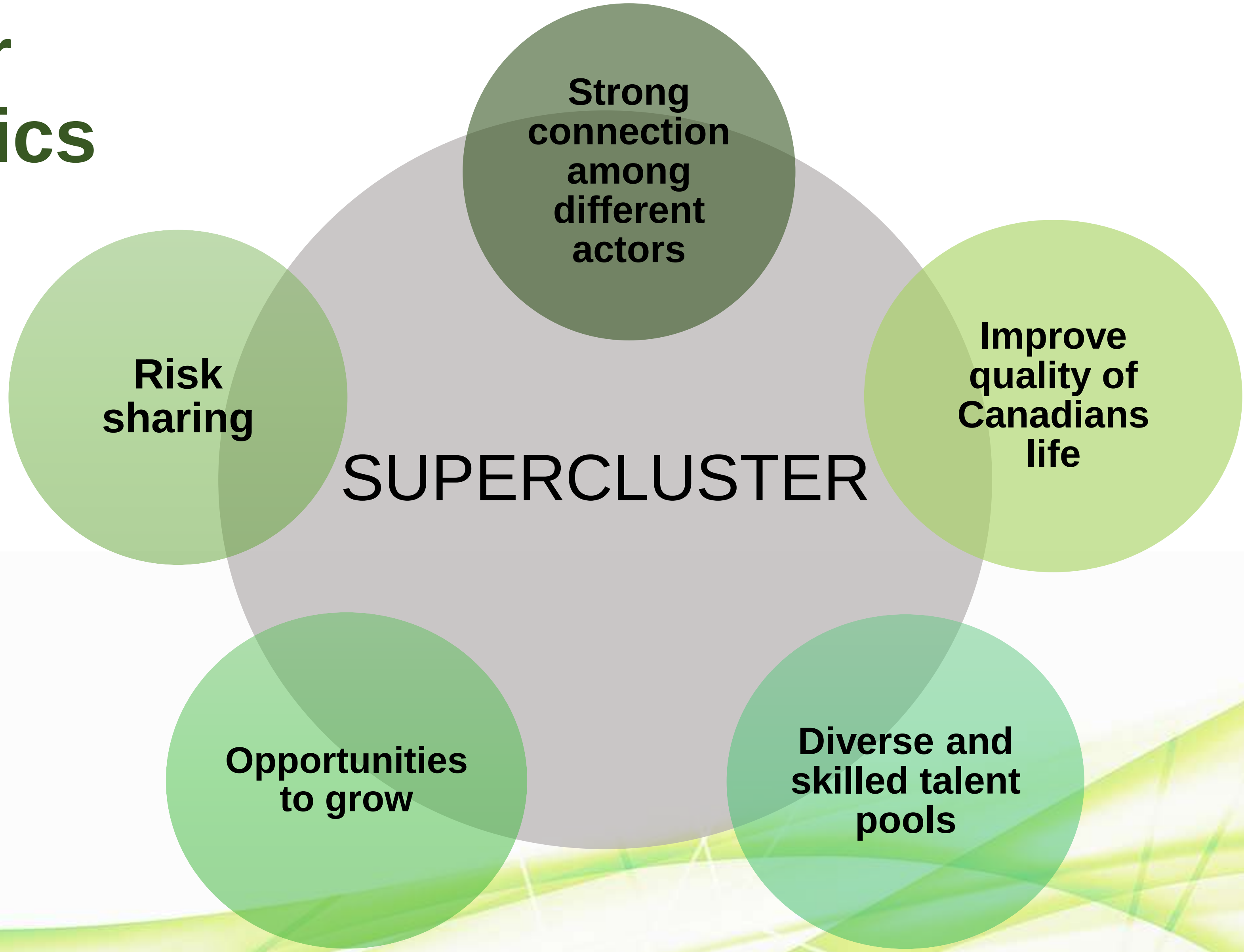
Supercluster Characteristics 2017

Up to $950 million over five years: competitive basis, for business-led Superclusters with high potential to accelerate economic growth.

Focuses on highly innovative industries such as advanced manufacturing, agri-food, clean technology, digital technology, health/bio-sciences and clean resources, as well as infrastructure and transportation.

Of the $950 million, $800 million will be drawn from the Budget 2016 provision for innovation networks and clusters and $150 million will be drawn from the public transit and green infrastructure allocations provisioned in the 2016 Fall Economic Statement.

Supercluster Characteristics 2017



Canadian **Low-Carbon Smart Mobility** Supercluster Consortium

VISION

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

Canadian **Low-Carbon Smart Mobility** Supercluster Consortium

MISSION

To support commercialization trials and relevant research, development, and demonstration (RD&D) projects through industry-led collaborations that bring innovative design to Canada’s low-carbon smart mobility eco-system

Canadian **Low-Carbon Smart Mobility** Supercluster Consortium

DOMESTIC & GLOBAL STRATEGY

To develop *and* apply next-generation mobility and transportation technologies within and across Canada

To grow the low-carbon and "smart" technology eco-system in the country, leading to domestic job growth and economic development over the long-term

To export IP and know-how to the global marketplace in low-carbon smart mobility

Pillar #1
Zero-emissions & low-carbon propulsion systems with fueling & charging system integration

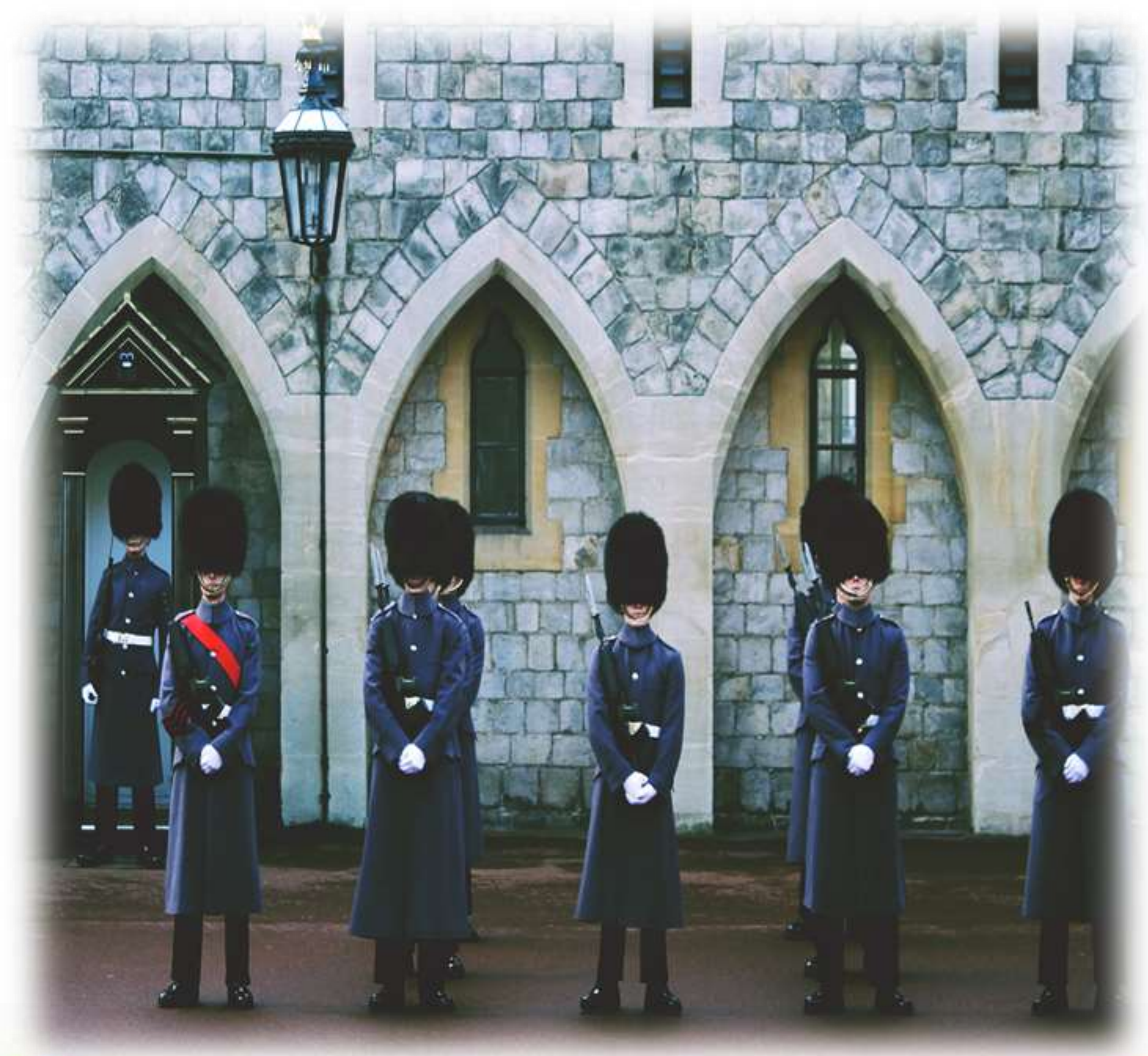
- Supporting battery electric (BEV), plug-in hybrid electric (PHEV), hydrogen fuel cell electric (FCEV), compressed/renewable natural gas (RNG) & dimethyl ether (DME) technologies for light- and heavy-duty vehicle platforms
- **LOI: ~$45 Million**

Pillar #2
"Smart" vehicles and "smart" infrastructure

- Solutions in automated, autonomous and connected vehicle systems
- Sensors, signaling, and control systems that advance the autonomy and digital connectivity of "smart" vehicle systems (on roads & rail) and infrastructure
- **LOI: ~$40 Million**

Pillar #3
Big data advanced mobility

- Optimization of public and private fleet networks (transit, integrated and urban mobility)
- Big data use in descriptive, analytic, and predictive mobility solutions
- Artificially intelligent data-driven systems
- **LOI: ~$10 Million**



Pillar #4
Cybersecurity in mobility

- Securitization of low-carbon and smart mobility systems, including autonomous and connected vehicles as well as real-time communications for mobility applications
- **LOI: ~$10 Million**

Pillar #5
Light-weight materials & manufacturing

- Development of advanced materials, such as composites, polymers, advanced metals, and multi-material designs for light-weight vehicles
- **LOI: TBD**

Fragmented, insufficient & inappropriate funding options for low-carbon mobility innovation projects: federal

~~APC (Automotive Partnership Canada)~~	NSERC CRDs	SSHRC	ASIP
SDTC	NRCan Energy Innovation Programming	Western Development (WD)	FedDev
NRC-IRAP	PTIF Phase I	*PTIF Phase II*	FCM Green/Sustainable Funding

CUTRIC Federal Funding Ask *was* $185M/4yrs (2017-2021)

Low Carbon Smart Mobility Innovation Supercluster Consortium -- Supergrappe D’Innovation en Mobilité Durable et Intelligente

Supercluster project funding distribution options

Does your company or organization wish to carve out funding for innovation projects and activities within the LCSM supercluster bid?

YES

1. Does your company have an active collaborative project having started in fiscal year 2017-2018, or planned to start in fiscal years 2018-2022, for which it is seeking a $1 : $1 contribution match?
2. Does your company have an internal Technology Roadmap identifying investments that are planned to occur between 2017-2022 in projects that relate to the LCSM supercluster's five pillars of innovation, for which it would like to seek a $1 : $1 match (assuming projects are collaborative)?

YES

Examples of industry sectors & stakeholders integrated into current CUTRIC projects

Manufacturers
- New Flyer
- Motor Coach Industries
- Nova Bus
- Volvo
- Bombardier
- ABB Group
- Siemens
- BAE Systems
- Cummins
- Toyota
- FVT

Energy Providers
- Enbridge
- Ontario Power Generation
- Toronto Hydro
- Alectra
- BC Hydro
- Manitoba Hydro
- Hydro Quebec
- Air Products

Communications& Software
- Thales
- Trustpoint
- Blackberry/QNX
- IBM
- Ericsson
- Cisco

Public Transport Fleets as Testbeds
- ATUQ
- Toronto Transit Commission
- Translink
- Brampton Transit
- York Region Transit
- London Transit
- Waterloo Transit
- Calgary Transit
- Halifax Transit
- BC Transit

Automotive Suppliers in Advanced Propulsion
- Ballard
- TM4
- D&V Electronics
- Inmotive
- Linamar
- Magna

Research Organizations
- National Research Council
- Canmet Labs
- University of Victoria
- York
- Queens University
- University of Alberta
- University of British Columbia
- Universite du Quebec a Trois Rivieres

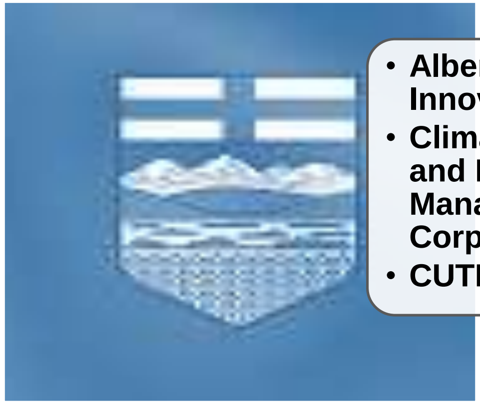
Other
- Brens
- Faromar
- GV Energy
- Transpod
- Avalon Ontario Cleantech Materials Group

Insufficient & Inappropriate Funding Options for Low-Carbon Mobility Innovation Projects: Provincial

British Columbia

- Innovative Clean Energy (ICE) Fund
- BC Tech Fund

Alberta



- Alberta Innovates
- Climate Change and Emissions Management Corp.
- CUTRIC-Alberta

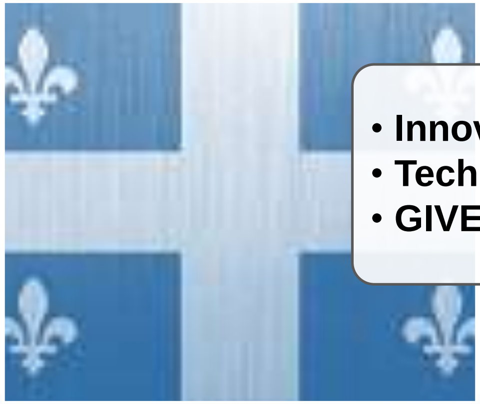
Manitoba

- Research Manitoba
- Vehicle Technology Centre

Ontario

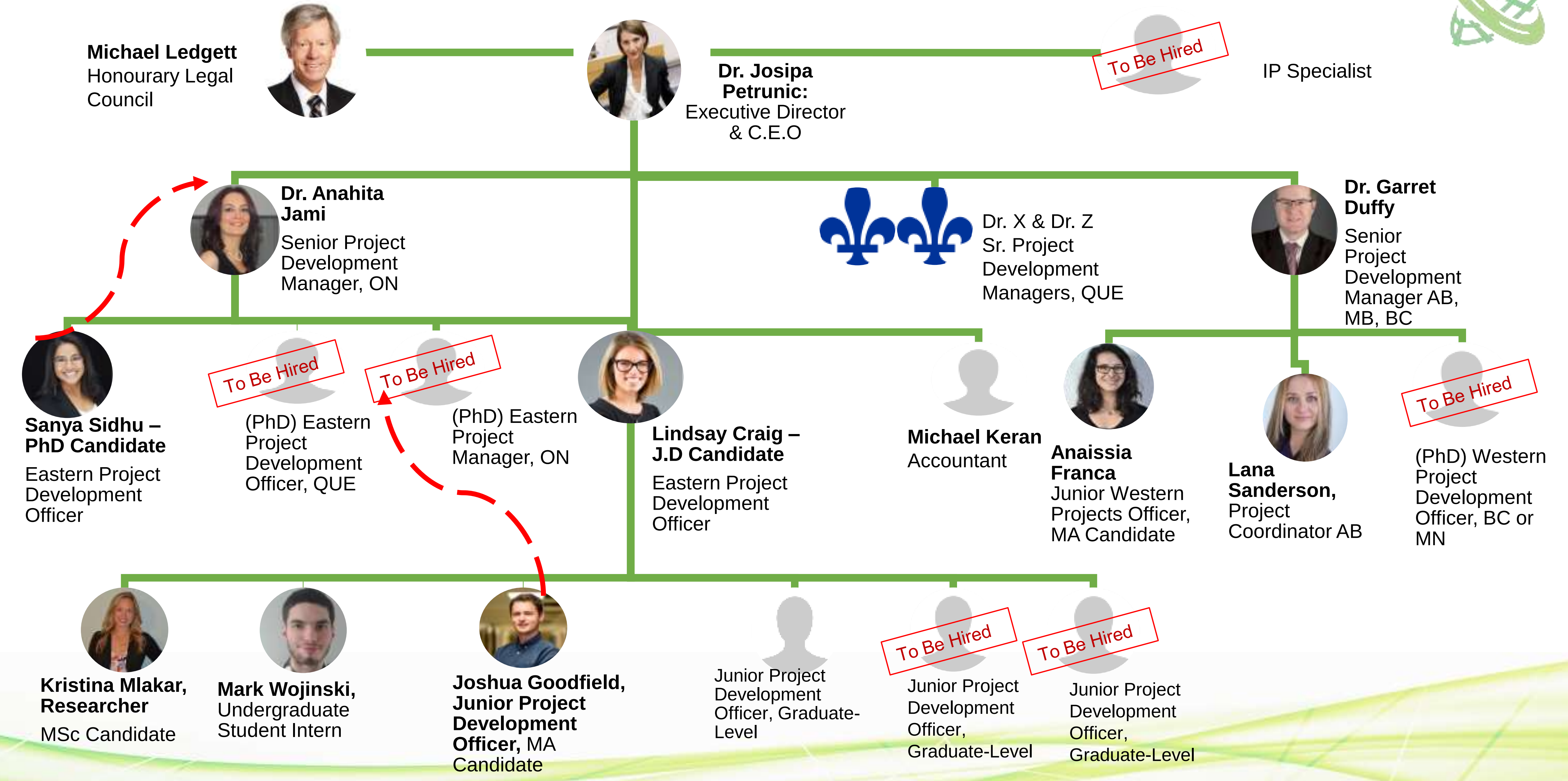
- OCE Programming
- CUTRIC-Ontario
- ORF

Quebec



- InnovEE
- TechnoMontreal
- GIVEI

CUTRIC Organization Chart



CUTRIC 2017-2018 Board of Directors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CUTRIC Low-Carbon Smart Mobility **Clusters**

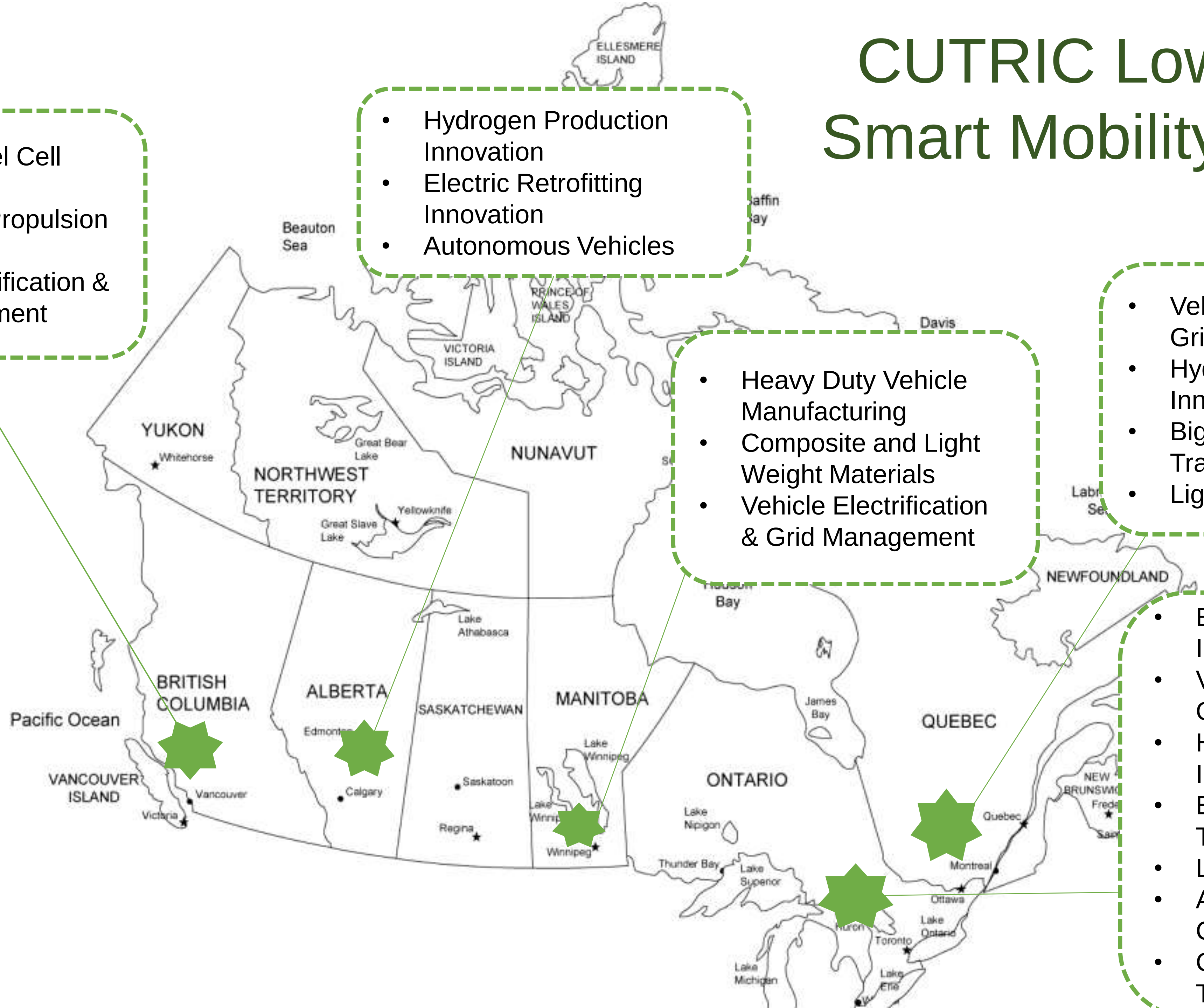
- Hydrogen Fuel Cell Technology
- Natural Gas Propulsion Innovation
- Vehicle Electrification & Grid Management

- Hydrogen Production Innovation
- Electric Retrofitting Innovation
- Autonomous Vehicles

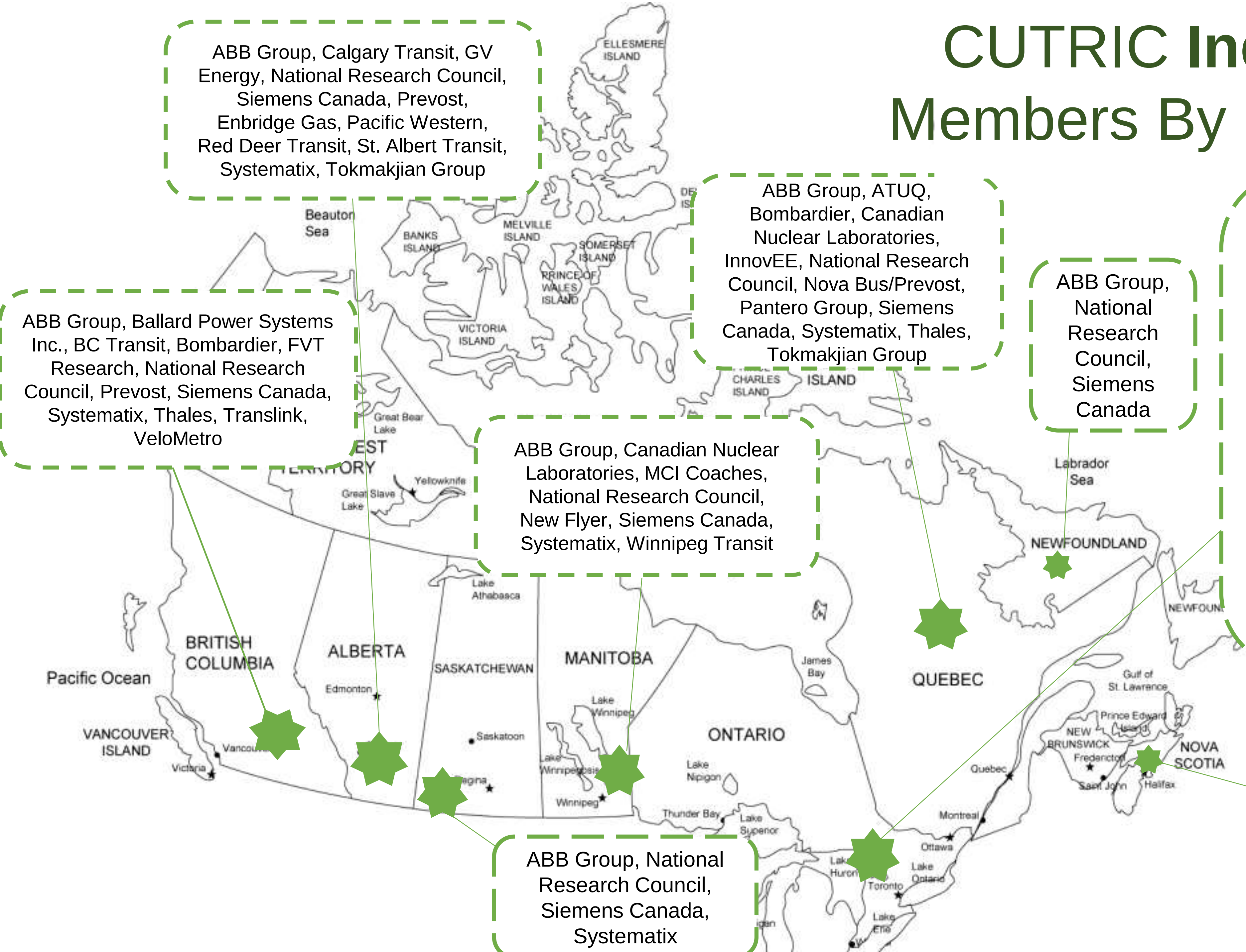
- Heavy Duty Vehicle Manufacturing
- Composite and Light Weight Materials
- Vehicle Electrification & Grid Management

- Vehicle Electrification & Grid Management
- Hydrogen Fueling Innovation
- Big Data for Transportation
- Light weighting

- Electric Powertrain Innovation
- Vehicle Electrification & Grid Management
- Hydrogen Production Innovation
- Big Data for Transportation
- Lightweight Materials
- Automated Vehicles & Connected Vehicles
- Cybersecurity for Transportation



CUTRIC **Industry** Members By Province



- ABB Group, Calgary Transit, GV Energy, National Research Council, Siemens Canada, Prevost, Enbridge Gas, Pacific Western, Red Deer Transit, St. Albert Transit, Systematix, Tokmakjian Group
- ABB Group, Ballard Power Systems Inc., BC Transit, Bombardier, FVT Research, National Research Council, Prevost, Siemens Canada, Systematix, Thales, Translink, VeloMetro
- ABB Group, ATUQ, Bombardier, Canadian Nuclear Laboratories, InnovEE, National Research Council, Nova Bus/Prevost, Pantero Group, Siemens Canada, Systematix, Thales, Tokmakjian Group
- ABB Group, National Research Council, Siemens Canada
- ABB Group, ATES, Avalon Advanced Materials, Belleville Transit, Bombardier, Brampton Transit, Brens, Burlington Transit, CUTA-ACTU, Canadian Nuclear Laboratories, Durham Region Transit, Enbridge Gas, Faromar CNG, Grand River Transit, Kingston Transit, London Transit, Metrolinx, MiWay, National Research Council, New Flyer, Newmarket-Tay Power Distribution, Oakville Transit, OPTA, Oxford County, Ontario Power Generation, Pantonium, Plug N'Drive, Prevost, Rural Green Energy, Siemens Canada, St. Catharines Transit, Systematix, Tech-K.O., Thales, Thunder Bay Transit, TM4, Toronto Transit Commission, TransHelp, TransPod, Transport Canada, Windsor Transit, Woodstock Transit, York Region Rapid Transit Corporation, York Region Transit
- ABB Group, Canadian Nuclear Laboratories, MCI Coaches, National Research Council, New Flyer, Siemens Canada, Systematix, Winnipeg Transit
- ABB Group, National Research Council, Siemens Canada, Systematix
- ABB Group, Canadian Nuclear Laboratories, Halifax Transit, National Research Council, Siemens Canada

CUTRIC **Academic** Stakeholders by Province

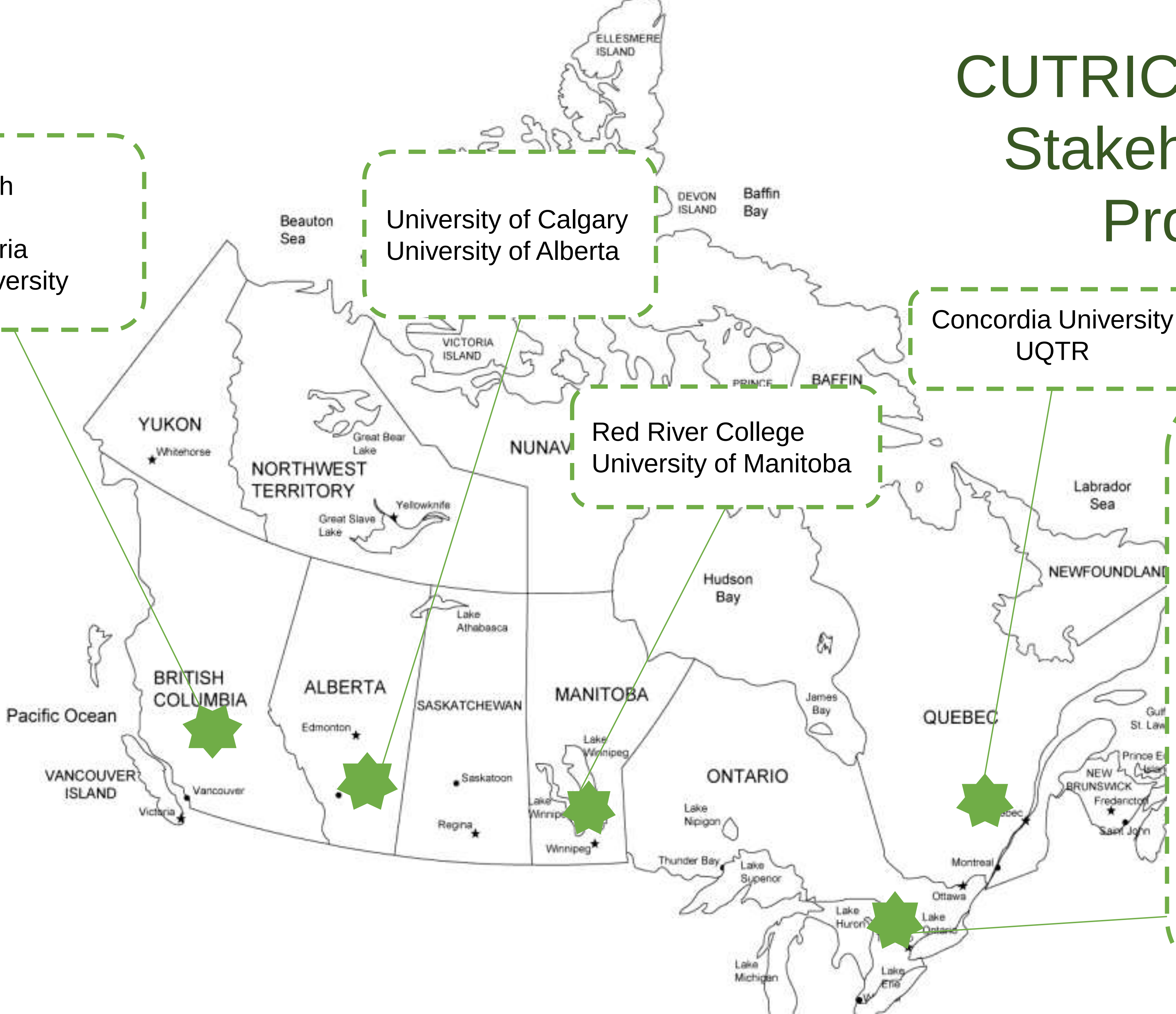
University of British Columbia
University of Victoria
Simon Fraser University

University of Calgary
University of Alberta

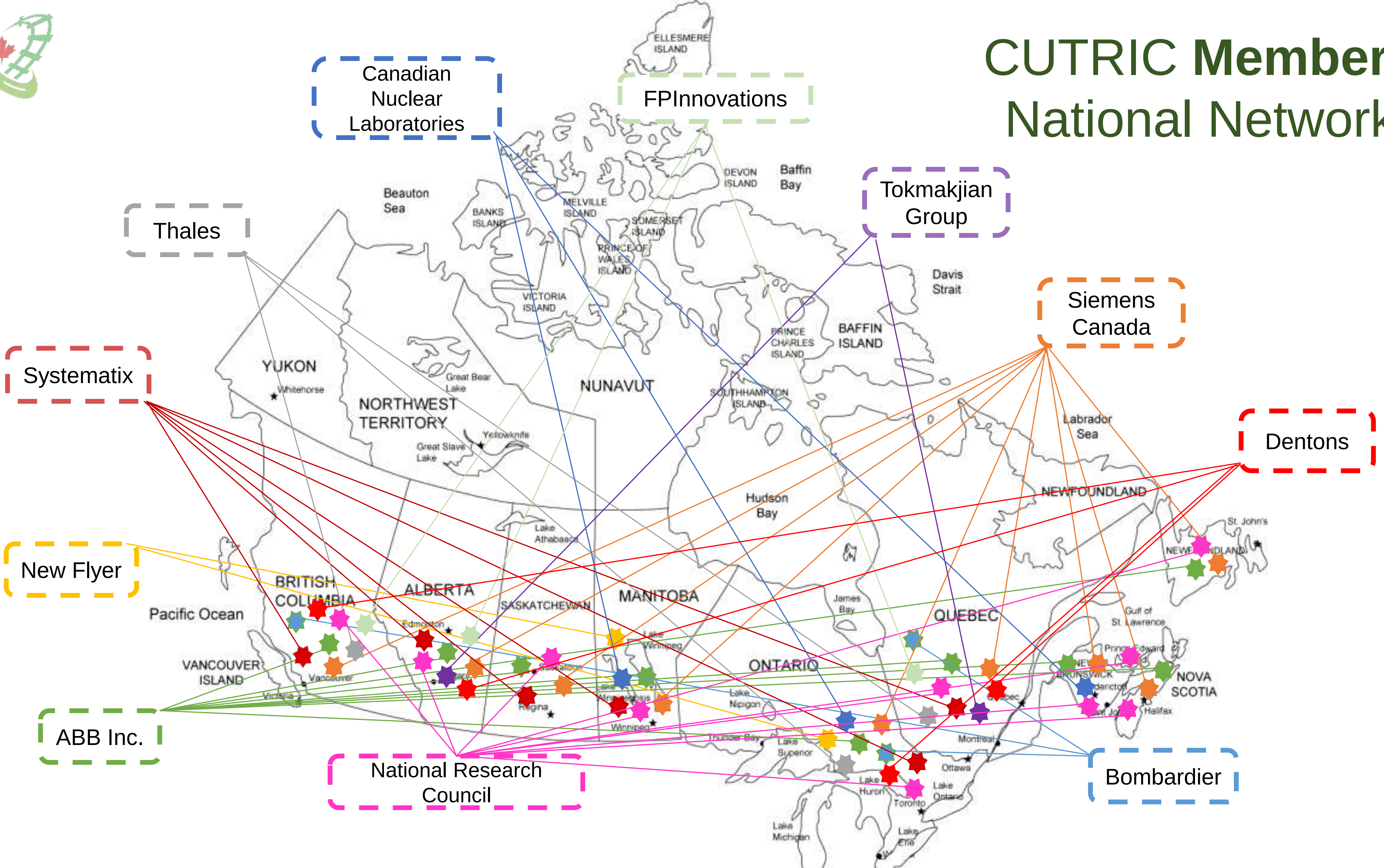
Concordia University
UQTR

Red River College
University of Manitoba

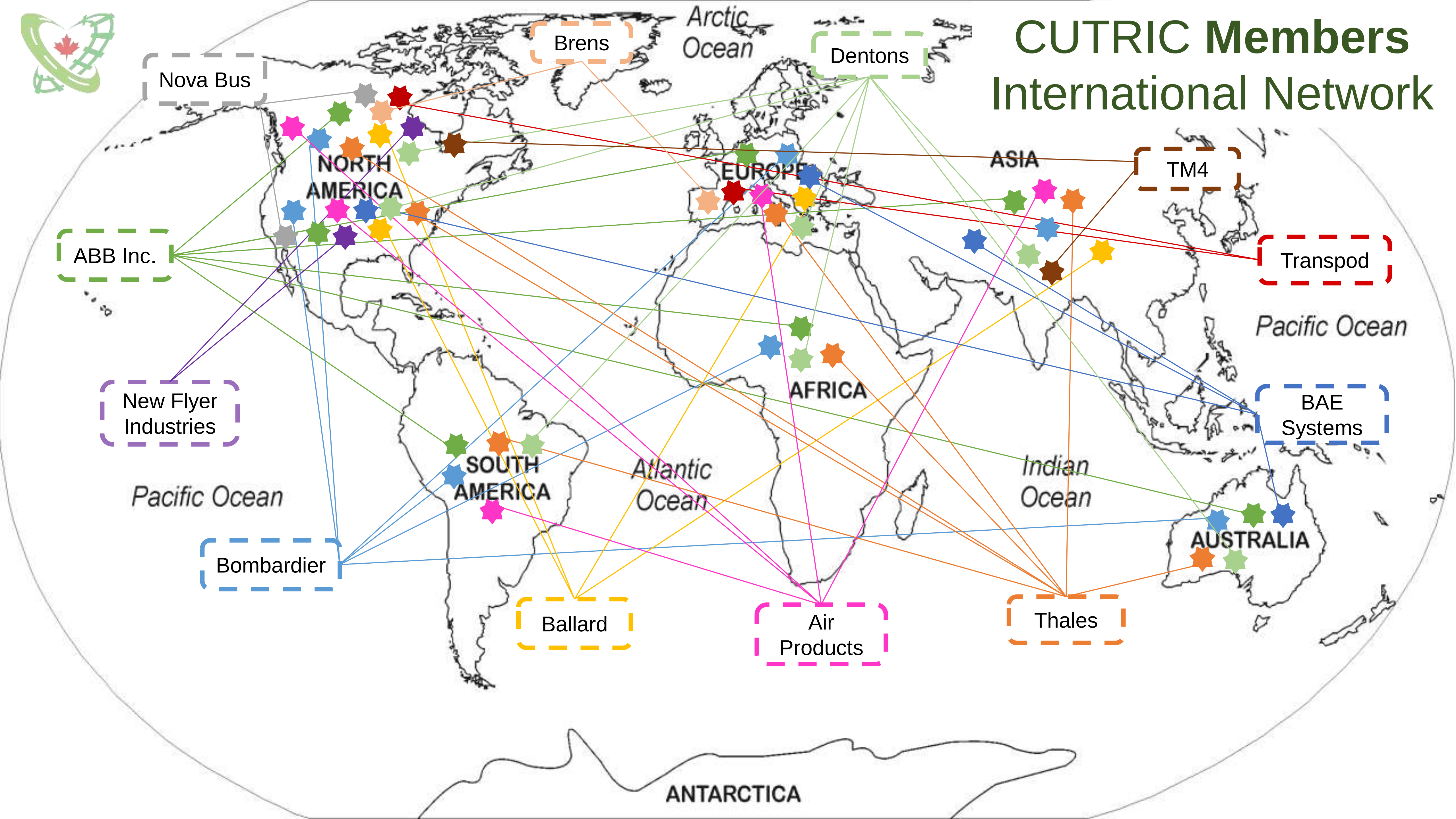
Brock University
Centennial College
Carleton University
Conestoga College
Lambton College
OCAD University
Queens University
Ryerson University
Sheridan College
St. Clair College
UOIT
University of Ottawa
University of Waterloo
University of Toronto
University of Western Ontario
University of Windsor
York University



CUTRIC **Members** National Network



CUTRIC **Members** International Network



Low Carbon Smart Mobility Supercluster Projects Ready to Launch!

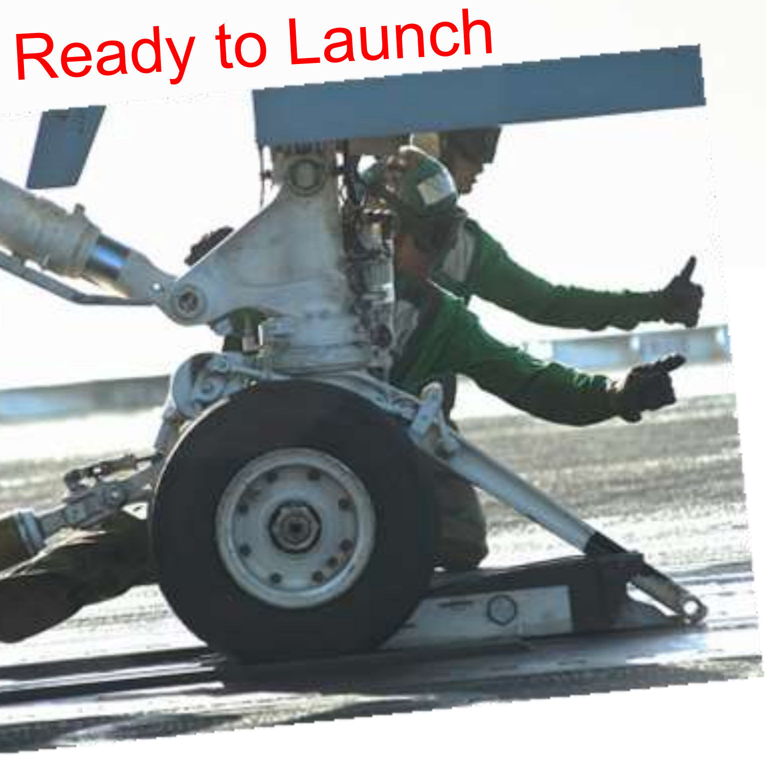
Project 1: Pan-Canadian Electric Bus Demonstration & Integration Trial

Project 2: Pan-Canadian Hydrogen Fuel Cell Vehicle Demonstration & Integration Trial

Project 3: National Smart Vehicle Demonstration Project

Project 4: Low-Vacuum Environment Ultra-High-Speed Transportation

Project 5: Ontario-Quebec Hydrail Connection: Zero-Emissions Passenger Rail



Project 1: CUTRIC Pan-Canadian Electric Bus Demonstration & Integration Trial Transit Planning & Environmental Objectives

Problem	Solution
Problem Need for high up-time (18-24h)	**Solution** Opportunity/on route charging
Problem Demand Charges	**Solution** Energy Storage with Super-Capacitors
Problem Driver Precision	**Solution** Automated Vehicle Controls
Problem Renewable Energy Slumps	**Solution** On-Route Charging and Energy Storage
Problem Recycling Fees and Battery Waste	**Solution** Small Batteries and Right Sizing EVs for routes

Project 1: CUTRIC Pan-Canadian Electric Bus Demonstration & Integration Technology Trial Outcomes Phase I, II, III

OppCharge Interoperability

J3105 Overhead Charging Standard

Energy Storage at Charger

At Garage Charging Integration

Automated Charging of Vehicle

Project 1: CUTRIC Pan-Canadian Electric Bus Demonstration & Integration Trial: Stakeholders: Phase I

NOVA BUS
Driven by your city

ABB

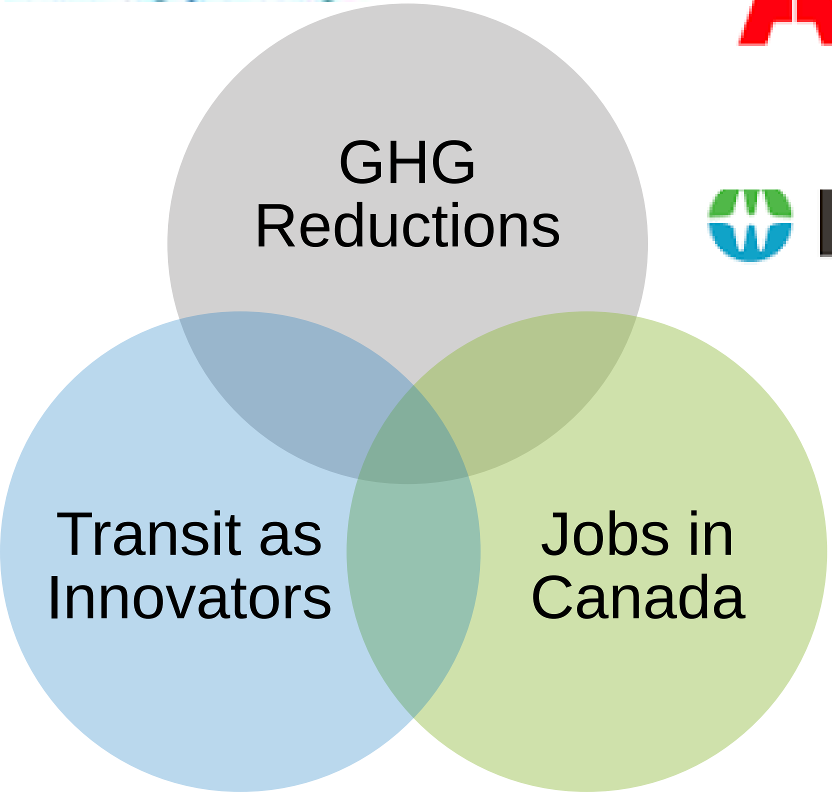
SIEMENS

NEW FLYER

Brampton Transit

BC Hydro

NEWMARKET Hydro



YORK REGION TRANSIT \ VIVA

Canada
NRC·CNRC

TRANS LINK

ST. CLAIR COLLEGE

CONESTOGA
Connect Life and Learning

YORK UNIVERSITÉ UNIVERSITY

Brock University

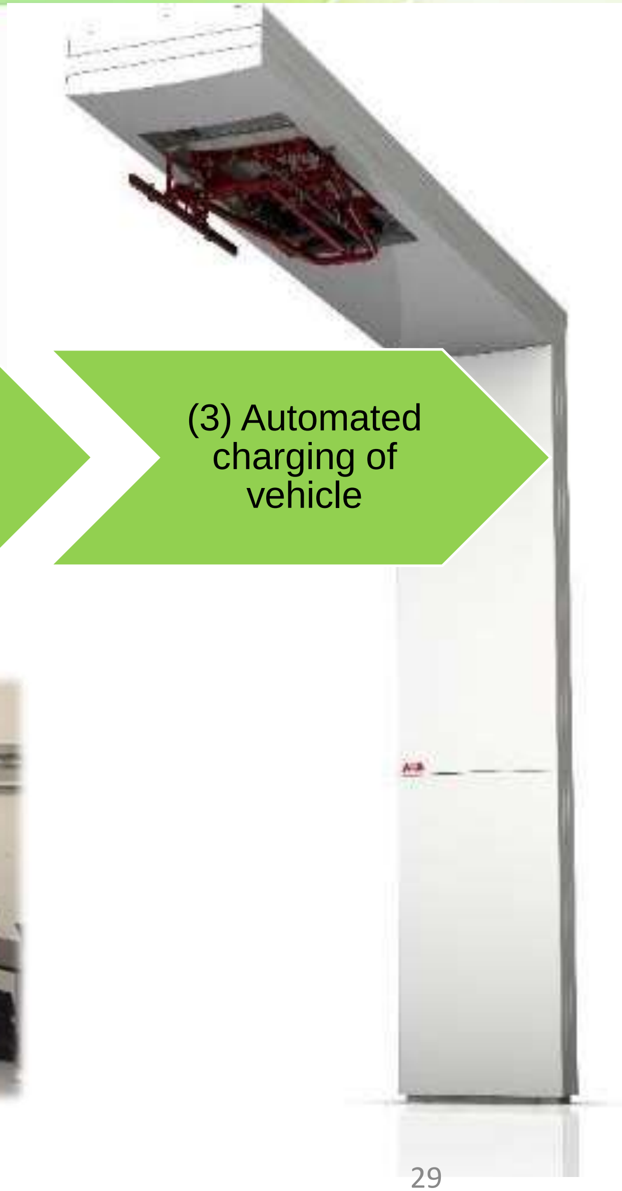
UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY

UQTR
Université du Québec à Trois-Rivières

University of Victoria

CENTENNIAL COLLEGE

Project 1: CUTRIC Pan-Canadian Electric Bus Demonstration & Integration Trial Technology Outcomes: Phase 2



- (1) OppCharge Interoperability
- (2) J3105 Overhead Charging Standard
- (2) Energy storage at charger
- (2) At garage charging integration
- (3) Automated charging of vehicle

Project 1: Pan-Canadian Electric Bus Demonstration & Integration Trial With Energy Storage: Phase II

ONTARIO POWER GENERATION
TORONTO HYDRO
BC Hydro
Manitoba Hydro
Powertech
The Power of Trust. The Future of Energy.
hydro one
alectra
Discover the possibilities
Hydro Québec
Institut de recherche
CITY OF Thunder Bay
Superior by Nature
OAKVILLE TRANSIT
TTC
YORK REGION TRANSIT
VIVA
STL
london transit
transit windsor
Brampton Transit
TRANS LINK
NOVA BUS
Driven by your city
NEW FLYER
BAE SYSTEMS
Cummins
SIEMENS
STORNETIC
The Energy Storage Company
tm4 Electrodynamic Systems
ABB
ecamion
NRSTOR INC

Project 2: Pan-Canadian Hydrogen Fuel Cell Vehicle Demonstration & Integration Trial

300 kg of hydrogen/ day/site

HYDROGENICS
SHIFT POWER | ENERGIZE YOUR WORLD

TOYOTA

ENBRIDGE

Oxford County
growing stronger...together

BALLARD

SFU
SIMON FRASER UNIVERSITY
ENGAGING THE WORLD

NEW FLYER

AIR PRODUCTS

HYDROGENICS
SHIFT POWER | ENERGIZE YOUR WORLD

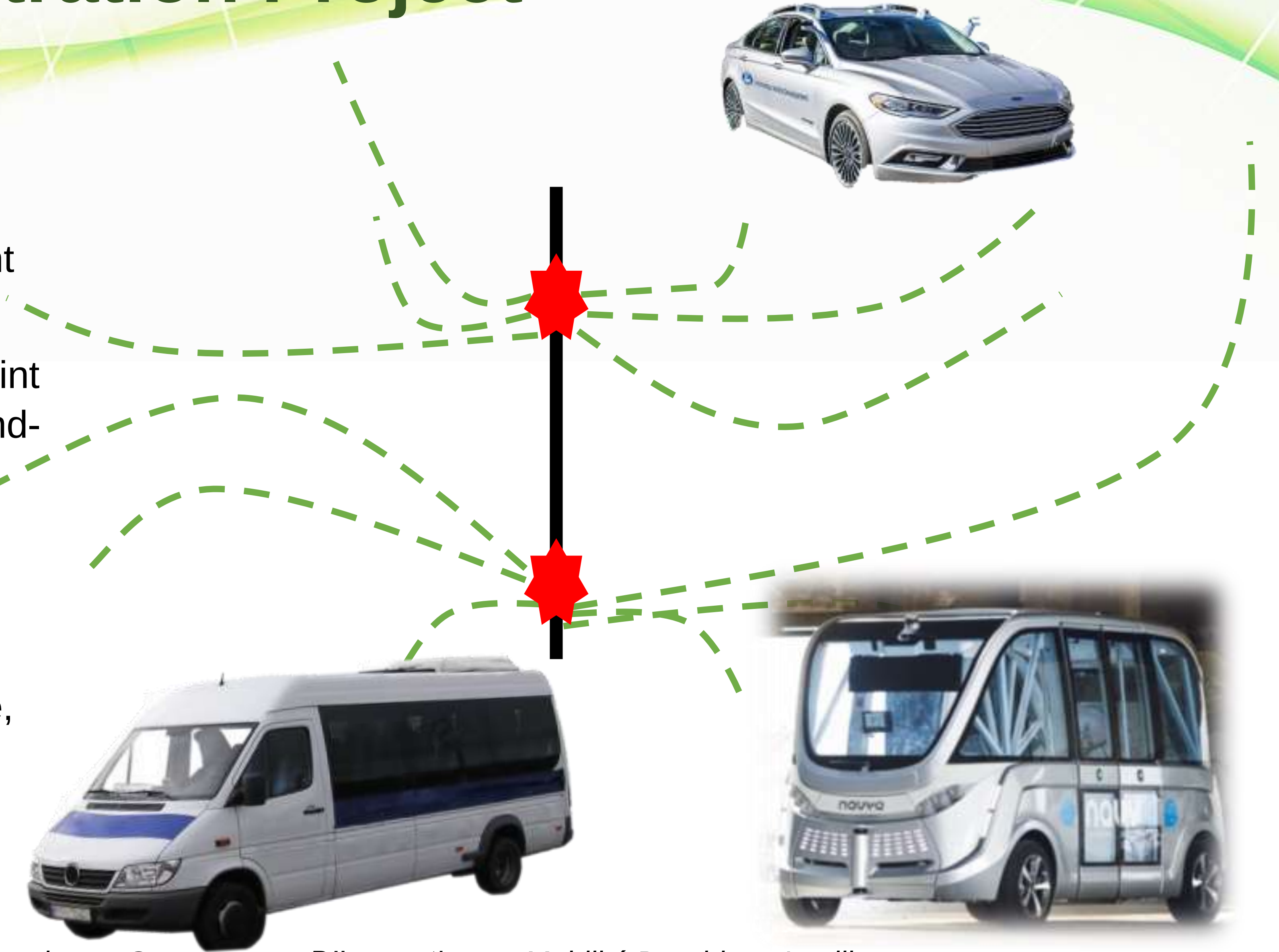
ONTARIO POWER GENERATION

ENBRIDGE

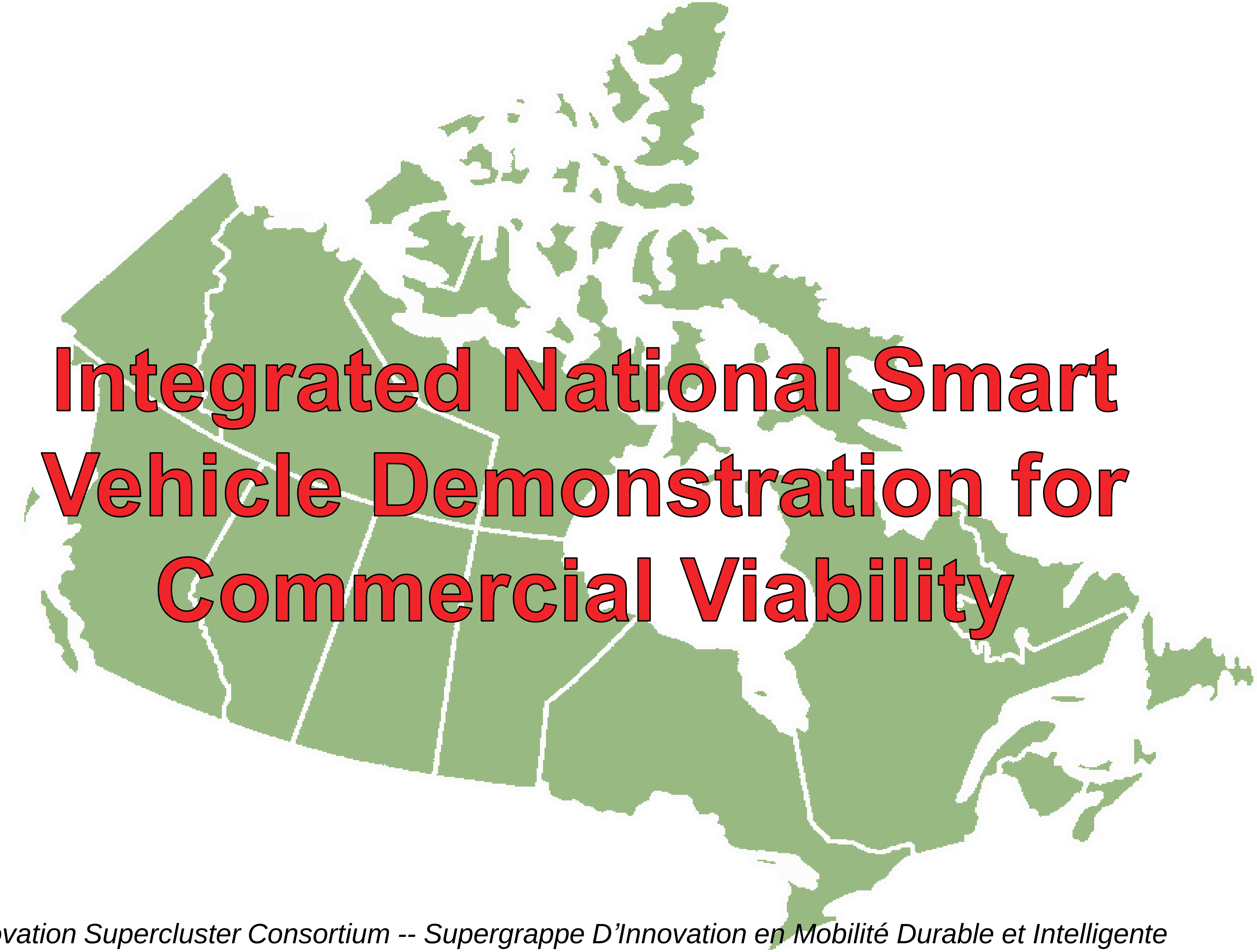
Project 3: National Smart Vehicle Demonstration Project

National AV pilot platform using low-speed electric vehicles and high automation to overcome challenges associated inefficient campus and industrial park fleet systems

- Facilitate a transition from a point-to-point conventional fleet systems to a trunk-and-feeder system
- Address first km/last km concerns and low-rider levels during specific hours of the day
- Test cameras, visual detection software, communications security, and artificial intelligence of AV systems



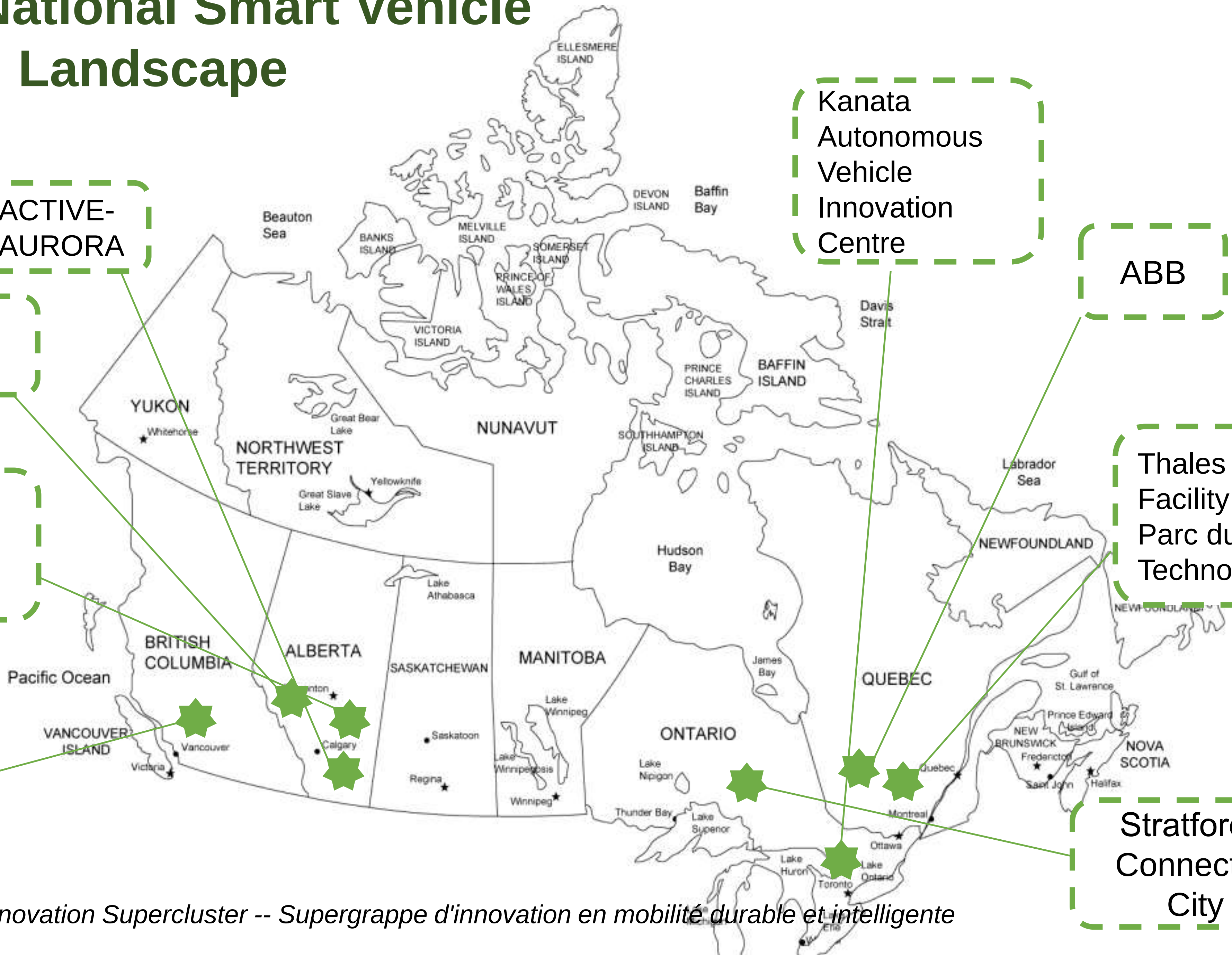
CUTRIC National Smart Vehicle Proposal for the Future



Integrated National Smart Vehicle Demonstration for Commercial Viability

Low Carbon Smart Mobility Innovation Supercluster Consortium -- Supergrappe D’Innovation en Mobilité Durable et Intelligente

Current National Smart Vehicle Landscape



ACTIVE-AURORA

Calgary Shuttle Pilot

Alberta's Industrial Heartland Autonomous Electric Shuttle Pilot

ACTIVE-AURORA

Kanata Autonomous Vehicle Innovation Centre

ABB

Thales R&D Facility at the Parc du Technologique

Stratford's Connected City

Project 3: National Smart Vehicle Demonstration Project
Current Stakeholders

- BAE SYSTEMS
- SEON – A Safe Fleet Brand
- CYCURA™ – Our tools, your security
- NEW FLYER
- PWTransit Canada
- safely home
- NOVA BUS – Driven by your city
- EASY MILE
- FLEET FREEDOM
- InnovÉÉ – Innovation en énergie électrique
- Stantec
- CITY VIEW – BUS SALES & SERVICE LTD.
- DiCAN – THE POWER OF PREVENTION
- UBC
- Calgary
- UQTR – Université du Québec à Trois-Rivières
- nauya
- FPInnovations
- LeddarTech®
- BOMBARDIER – the evolution of mobility
- PHANTOM INTELLIGENCE – Focused on people
- TRUSTPOINT INNOVATION
- Festival Hydro
- UNIVERSITY OF ALBERTA
- ABB
- THALES
- KARSAN
- The City of Edmonton
- cradlepoint
- Pantonium

Project 4: Low-Vacuum Environment Ultra-High-Speed Transportation

Project 4: Low-Vacuum Environment Ultra-High-Speed Transportation

TECHNOLOGY OVERVIEW

TRANSPOD

TransPod advantages

- Aircraft-based control system
- Reduced tube infrastructure cost, from innovative tube design
- Advanced power-transmission system for high-speed
- Artificial intelligence-based stability mechanism

Vehicle subsystems

- Axial compressor: to bypass air flow
- Cabin air system: similar to aircraft air system
- Linear magnetic propulsion drive
- Active magnetic levitation
- Pressurization and thermal management

Project 4: Low-Vacuum Environment Ultra-High-Speed Transportation

APPLICATION: PASSENGER TRANSPORTATION

TRANSPOD

Economy Class	Business Class	Luxury Class
		

Safer

- The technology doesn't require any human intervention to operate, reducing accidents caused by human error.
- A reduction in the use of cars and other forms of transportation will have a direct impact on saving lives.

More convenient

- Hyperloop pods are expected to arrive at frequent intervals, making it easy to go to the departure stations whenever you need to.
- No more worrying about missing your flight, or being bumped. More trips mean more flexibility.

Social impact

- Improved work-life balance. Less time in traffic means more time for the important things in life.
- Solves affordable housing, aging infrastructure and other urban issues.

Project 5: Ontario-Quebec Hydrail Connection: Zero-Emissions Passenger Rail

HYDROGENICS
SHIFT POWER | ENERGIZE YOUR WORLD

National Alliances In Progress

British Columbia
- CHFCA clean energy now

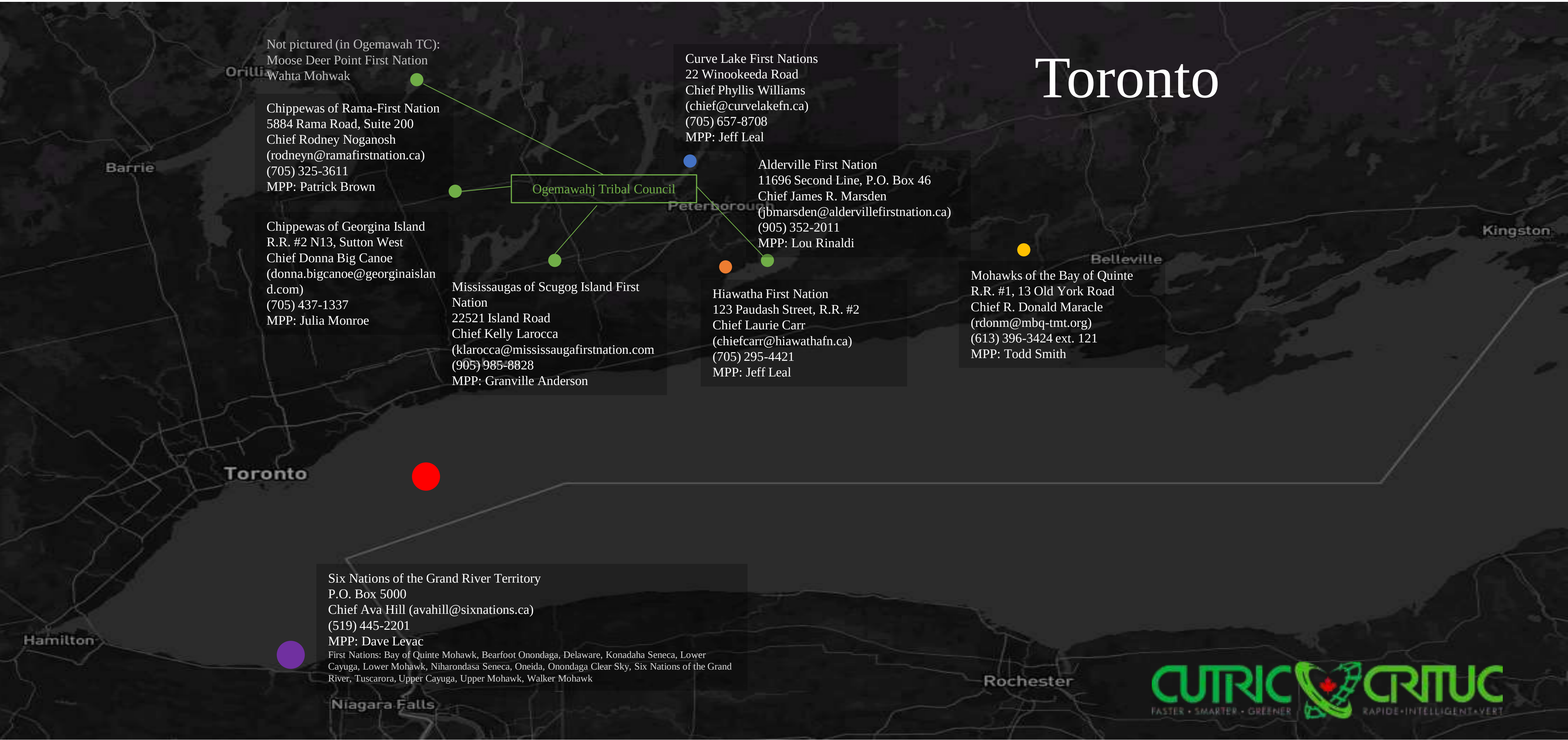
Ontario
- Ontario Centres of Excellence — Where Next Happens
- Ontario Cleantech Materials Group

Quebec
- InnovÉÉ — Innovation en énergie électrique
- techno MONTRÉAL

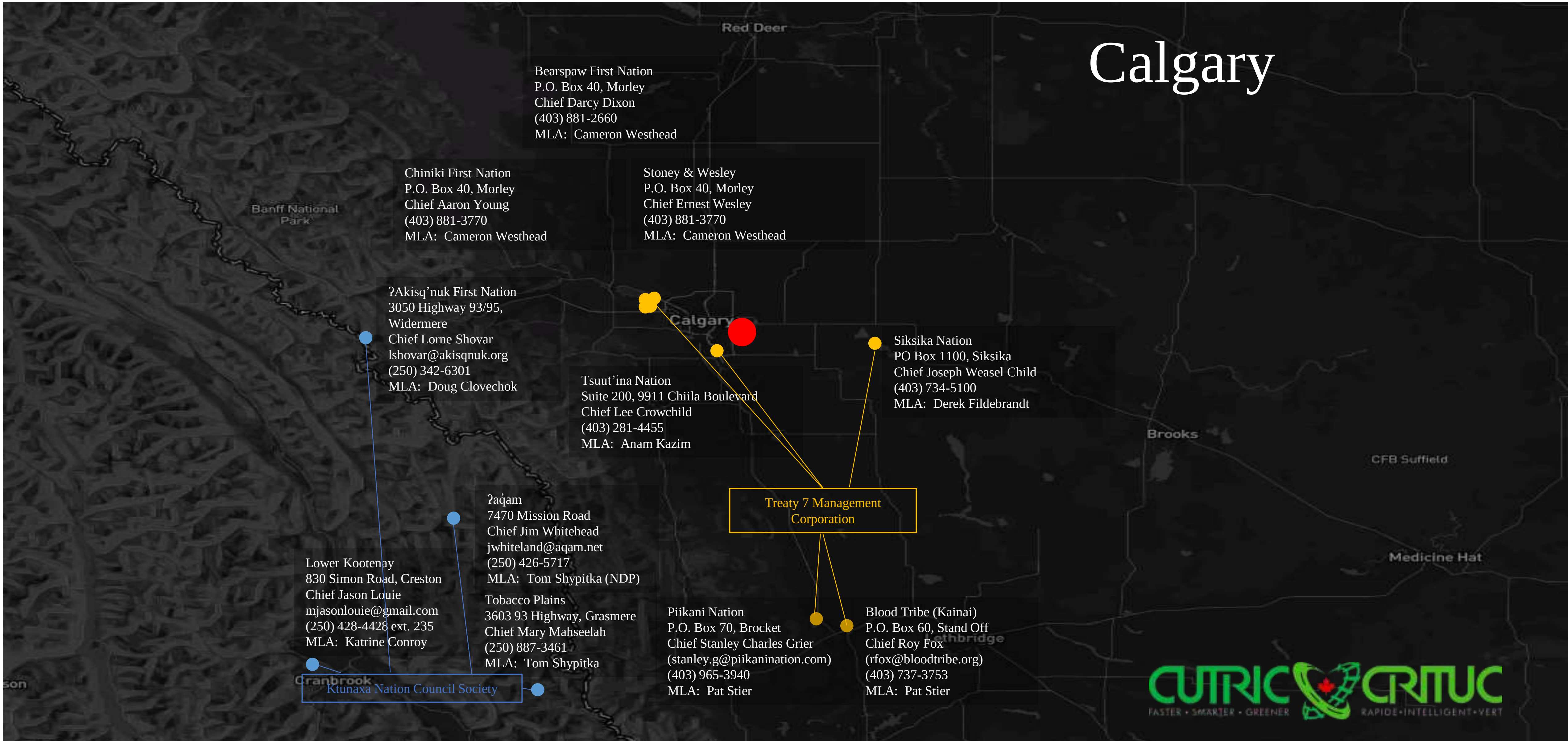
Manitoba
- Vehicle Technology Center

United States
- Center for Transportation and the Environment (CTE)

Mobility for First Nations Communities



Mobility for First Nations Communities



Next Steps

June 15 - July 7	Draft letters of commitment sent to members & core stakeholders
July 7-14	Revisions of letters. One-on-one clarification meetings. Project specific webinar updates.
July 14-20	Full proposal completion; shared with signatories.
August-October	Updates to signatories. Development of Stage 2 submission. Addition of new projects & signatories. Refinement of Roadmap commitments.
Fall 2017	**Full Stage 2 Submission for $150 Million - $250 Million , 2017-2022.**

Contact

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Techno-economic modeling of an electric bus demonstration project in BC Translink Route #100

- Pouya Amid
- Mojtaba Lajevardi
- Anaissia Franca
- Curran Crawford

01 March 2017

Revised version 2: 28th June 2017

University of Victoria
Institute for Integrated Energy Systems

Outline

- Routes and duty cycles
- E-bus energy consumption and charging power calculations
- Charging infrastructure modeling
- Modeling comparative diesel bus fuel consumption
- Electricity costs estimations and simulation results for each route

Routes and duty cycles

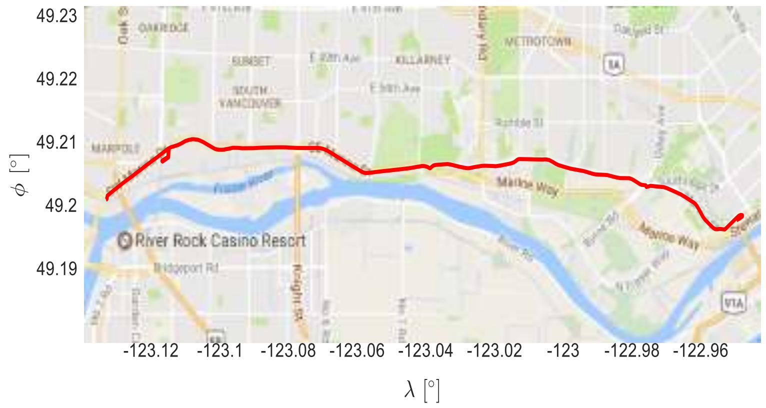
- Routes’ statistics & topography
- Elevation profile
- Duty cycles development
- Example duty cycles

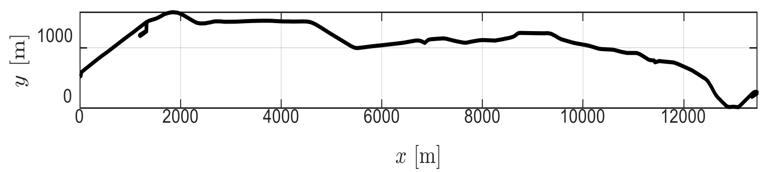
Routes' Statistics

	Length of Route (Km)	Estimated time (min)	Number of major bus stops	Number of all bus stops	Number of traffic lights	Number of stop signs
Translink # 100 (East ward)	15	40	5	44	25	13

Route’s topography

- Used Google Earth to define the path (.kml files)
- Calculated the distances between the nodes

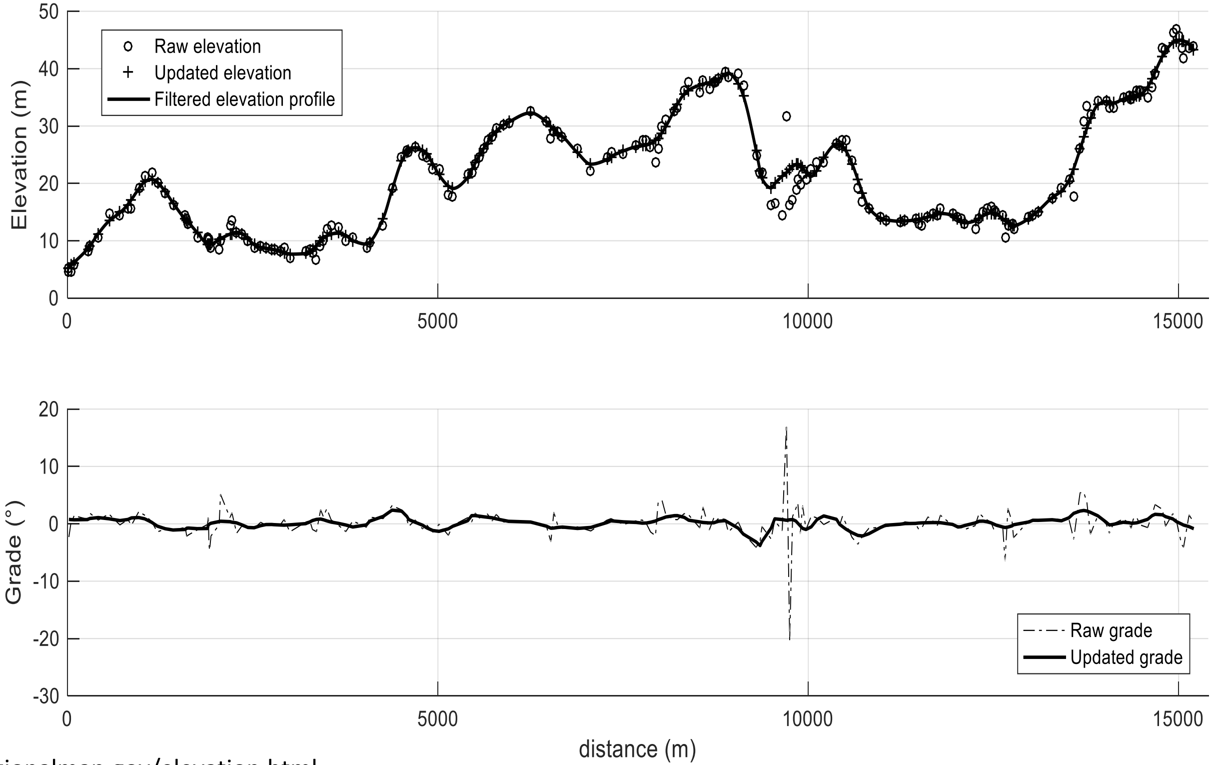




Translink bus #100

Elevation profile

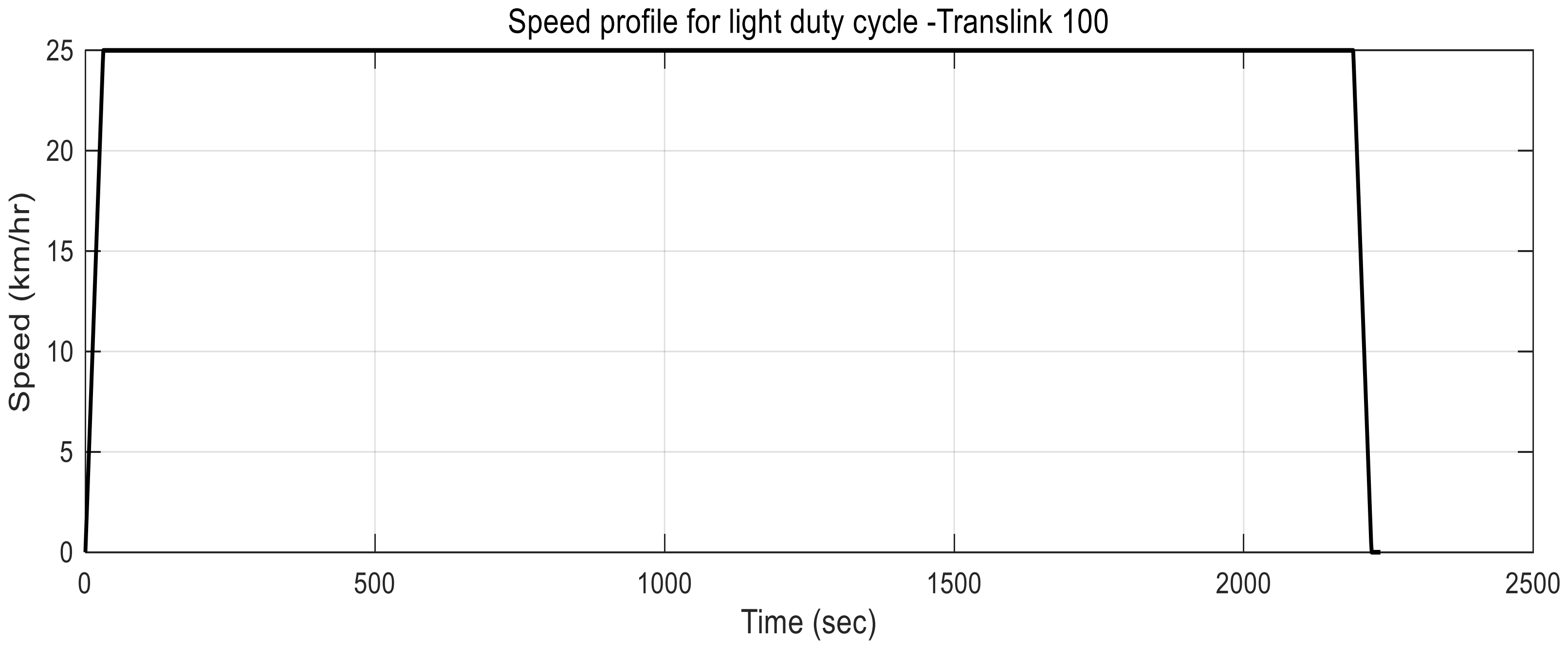
- Used DEM database[1] to obtain the raw data for elevations
- Used filtration/smoothing to obtain realistic road grades (multiple steps of Savittzky-Golay filter)



[1] - https://nationalmap.gov/elevation.html

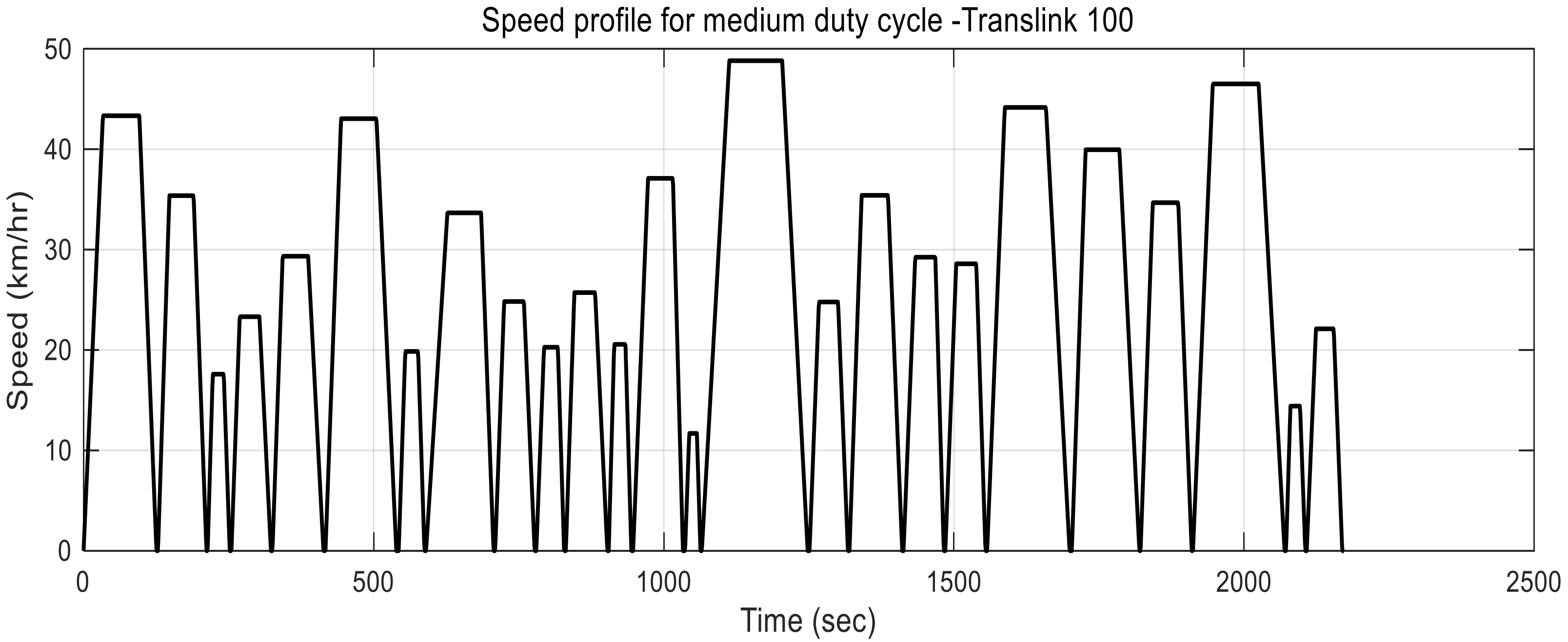
Duty cycles development

- Light duty cycle
  - Constant velocity, no stop



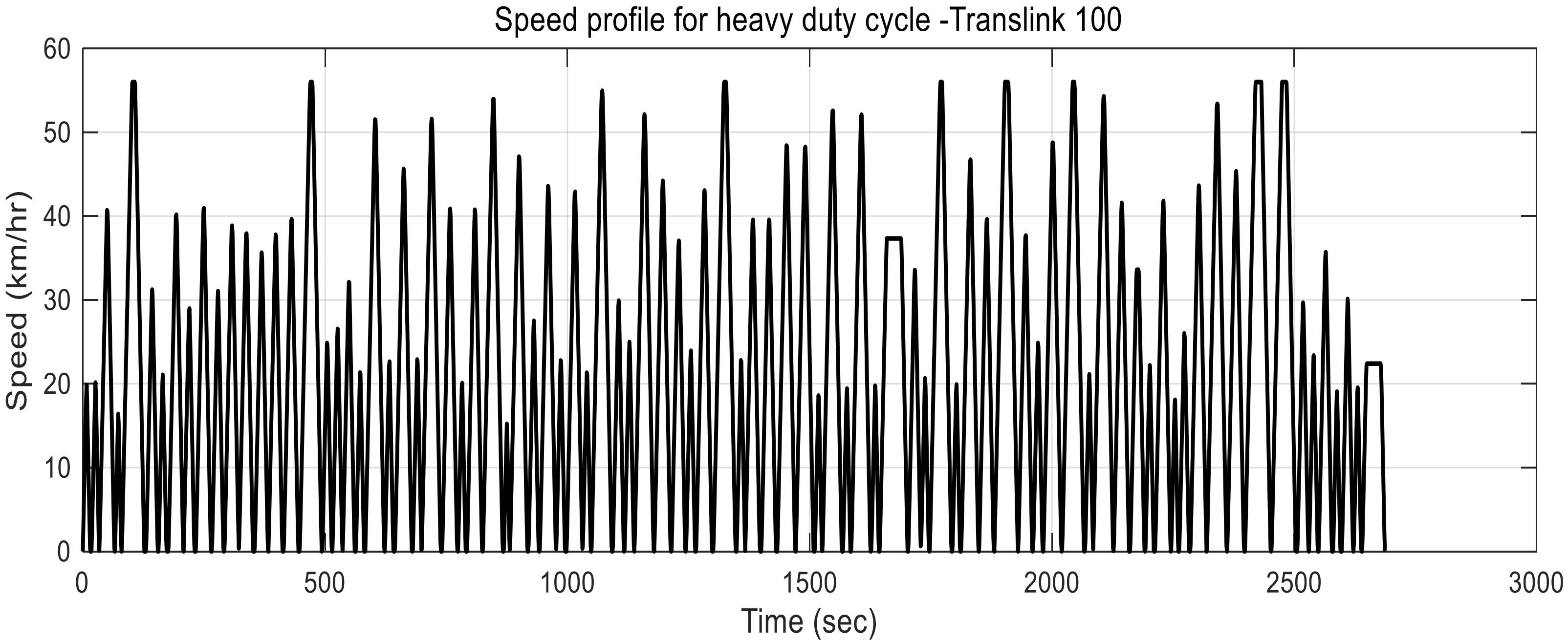
Duty cycles development

- Medium duty cycle
  - Stop for all scheduled (major) bus stops
  - Additional stops at 50 % of other stops: randomly selected from all the traffic lights, stops signs, passenger walks and other (unscheduled) bus stops



Duty cycles development

- Heavy duty cycle
  - Stop for all bus stops (scheduled/unscheduled), traffic lights, stop signs and additional stopping for pedestrians



Example duty cycles

- Some useful statistics about duty cycles

Name of route	Type of duty cycle	Average speed (km/hr)	Average moving speed (km/hr)	Average Acceleration (m/s^2)	Max Acceleration (m/s^2)	Average Deceleration (m/s^2)	Max Deceleration (m/s^2)
Translink bus # 100 (East)	Light duty cycle	24.47	24.66	0.22	0.23	0.22	0.22
	Medium duty cycle	25.19	26.10	0.40	0.61	0.38	0.60
	Heavy duty cycle	20.36	21.34	0.66	0.73	0.76	0.83
Translink bus # 100 (West)	Light duty cycle	24.55	24.66	0.22	0.23	0.22	0.22
	Medium duty cycle	22.42	23.40	0.42	0.63	0.42	0.62
	Heavy duty cycle	20.42	21.35	0.66	0.76	0.76	0.85

Ebus energy consumption and charging power calculations

- Modeling methodology
- Energy consumption

Energy consumption – Route 100 (200 kWh) Translink

	East direction					West direction				
	kWh per km	Total kWh used	SOC at route end			kWh per km	Total kWh used	SOC at route end		
			Ideal	**High Power NMC**	**High Energy NMC**			**Ideal**	**High Power NMC**	**High Energy NMC**
Light duty	0.92	14.04	93%	83%	88%	0.73	12.41	93.8%	83.8%	88.8%
Medium duty	1.64	24.97	87.5%	77.5%	82.5%	1.44	24.51	87.7%	77.5%	82.7%
Heavy duty	2.17	33.11	83.4%	73.4%	78.4%	2.05	34.82	82.6%	72.6%	77.6%

Note: Ideal battery initial SOC = 100%, High Power battery initial SOC = 90%, High Energy Battery initial SOC = 95%

Energy consumption – Route 100 (76 kWh) Translink

	East direction					West direction				
	kWh per km	Total kWh used	SOC at route end			kWh per km	Total kWh used	SOC at route end		
			Ideal	**High Power NMC**	**High Energy NMC**			**Ideal**	**High Power NMC**	**High Energy NMC**
Light duty	0.90	13.71	81.9%	71.9%	76.9%	0.71	12.12	84%	74%	79%
Medium duty	1.59	24.21	68.1%	58.1%	63.1%	1.40	23.8	68.6%	58.6%	63.6%
Heavy duty	2.13	32.46	57.3%	47.3%	52.2%	2.03	34.34	54.8%	44.8%	49.8%

Note: Ideal battery initial SOC = 100%, High Power battery initial SOC = 90%, High Energy Battery initial SOC = 95%

Charging infrastructure modeling

Estimation for the charging times
Estimation of power drawn from the grid

Electricity demand– Route 100 (200 kWh) Translink, 450 kW charger

	East direction		West direction	
	Charging time (min)	Energy from the grid (kWh)	Endpoint charging time (min)	Energy from the grid (kWh)
Light duty	1.87	15.44	1.65	13.64
Medium duty	3.33	27.47	3.27	26.96
Heavy duty	4.41	36.42	4.64	38.29

Electricity demand– Route 100 (76 kWh) Translink, 450 kW charger

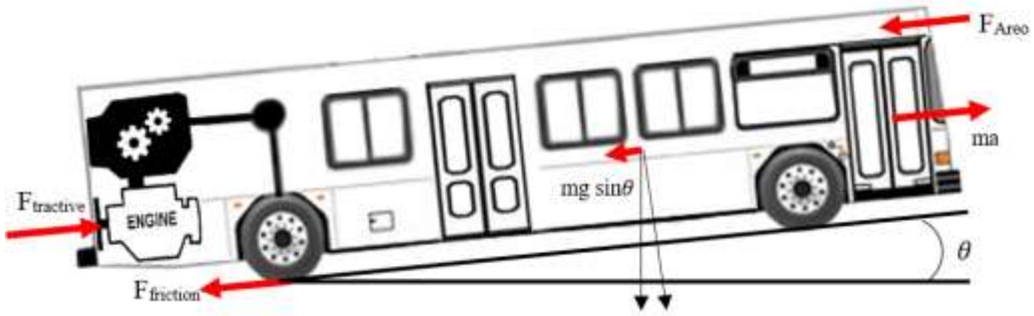
	East direction		West direction	
	Charging time (min)	Energy from the grid (kWh)	Endpoint charging time (min)	Energy from the grid (kWh)
Light duty	1.83	15.08	1.61	13.33
Medium duty	3.23	26.63	3.17	26.18
Heavy duty	4.33	35.70	4.58	37.77

Modeling comparative diesel bus fuel consumption

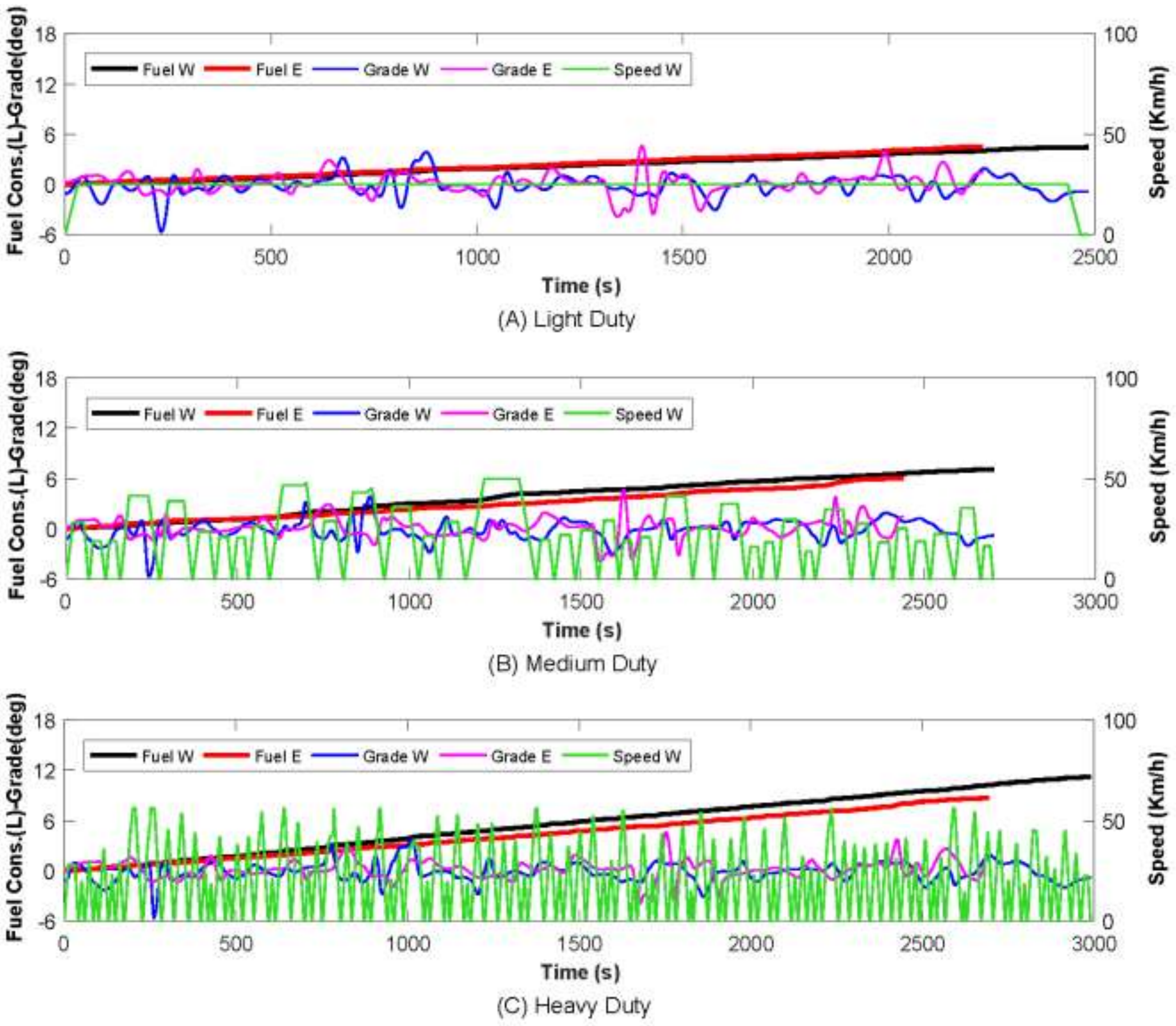
Modeling fuel consumption
Assumptions
Fuel consumptions and CO_2 reduction for different routes

Modeling fuel consumption

- Road load calculation is the core task in this computation process
- The road load is the result of the vehicle interaction with the surrounding environment
- Parametric model of engine efficiency used to compute the fuel consumption under various operational conditions



Simulating fuel consumption under light, medium, and heavy duty cycles for Translink route 100



Fuel consumption - Route 100 Translink

Route 100	Light-Duty	Medium-Duty	Heavy-Duty
Fuel used per run (L)	8.93	13.14	19.92
Fuel efficiency of diesel equivalent (L/100km)	27.90	40.85	61.80
On-road CO2 reduction per year (kg) *	146,654	215,248	325,860
Diesel cost per year @ diesel (1$/L)	$67,296	$93,586	$121,590
Diesel cost per year @ diesel (1.16$/L)	$78,064	$108,559	$141,044
Diesel cost per year @ diesel (1.34$/L)	$89,773	$124,843	$162,201

*Only on-road CO2 emission was considered and upstream diesel emission was neglected

Electricity costs estimations

BC Hydro rates

Charging costs

Number of run for each route

- Looked at bus' schedules, determined hours of service per weekdays, Saturday and Sunday
- Assumed a 10 minute break between each run plus the charging time
- Calculated maximum number of runs per day
- Generated a charging schedule to know at what time the buses recharge their batteries

BC Hydro rate

- Because chargers use > 150 kW, subjected to large general service customers
- Basic charge (per day) C_B: \$0.2429
- Demand charge (per month) C_D:

$$\$11.21 \times (450kW \times \frac{t_{charge}}{15\ min})$$

- Energy charge (per month) C_E:

$$C_E = (E_{month}) \times \$0.0550$$

E_{month} is the amount of kWh consumed per month

BC Hydro rate

- Discount: 1.5 % on entire electricity bill $C_{Elec\ Bill}$
- Rate ride: 5% on entire electricity bill $C_{Elec\ Bill}$
- GST and PST: 12% on the final bill
- Transformer owner discount (per kW): $-0.25

- The total price of electricity per year C_{Tot} is:

$$C_{Elec\ Bill} = 365 \times C_B + (C_D + C_E) \times 12$$

$$C_{Tot} = C_{Elec\ Bill} \times (1 - 0.015) \times (1 + 0.05) \times (1 + 0.12) - 0.25 \times 450$$

Charging costs – Route 100 Translink (200 kWh) assume 2 chargers

	Light	Medium	Heavy
Yearly MWh estimated	219.0	369.51	456.16
Basic cost (CAD $)	$177	$177	$177
Demand cost (CAD $)	$14,205	$26,635	$36,522
Energy charge (CAD $)	$12,045	$20,323	$25,089
Electricity cost (CAD $)	$26,427	$47,135	$61,788
Total charging cost for a year (CAD $)	$30,499	$54,487	$71,460
Diesel cost for a year (CAD $) @ diesel (1.16$/L)	$78,064	$108,559	$141,044
Diesel cost for a year (CAD $) @ diesel (1.34$/L)	$89,773	$124,843	$162,201
Benefits (CAD $) @ diesel (1.16$/L)	$47,565	$54,072	$69,584
Benefits (CAD $) @ diesel (1.34$/L)	$59,274	$70,356	$90,741

Charging costs – Route 100 Translink (76kWh) assume 2 chargers

	Light	Medium	Heavy
Yearly MWh estimated	212.4	358.5	457.8
Basic cost (CAD $)	$177	$177	$177
Demand cost (CAD $)	$13,882	$25,828	$35,957
Energy charge (CAD $)	$11,682	$19,718	$25,179
Energy cost (CAD $)	$25,741	$45,723	$61,313
Total charging cost for a year (CAD $)	$29,705	$52,851	$70,910
Diesel cost for a year (CAD $) @ diesel (1.16$/lit)	$78,064	$108,559	$141,044
Diesel cost for a year (CAD $) @ diesel (1.34$/lit)	$89,773	$124,843	$162,201
Benefits (CAD $) @ diesel (1.16$/lit)	$48,359	$55,708	$70,134
Benefits (CAD $) @ diesel (1.34$/lit)	$60,068	$71,992	$91,291

Thank you!