



Institut du véhicule innovant

Innovative Vehicle Institute

DESIGN, CALIBRATION AND REAL WORLD DATA OF AN ELECTRIC SCHOOL BUS

PRESENTED BY

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ABOUT IVI

IVI employs 24 persons (15 engineers) that are dedicated to accelerate innovation into enterprises. IVI is a recognized research center part of 2 important networks: Trans-Tech (49 centers across Québec) and TACCAT (25 technology access centers across Canada)



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ABOUT IVI

IVI works primarily at reducing the environmental impact of transportation. The team is committed to make things happen. Already, half of our staff drives a plugin car.



IVI HISTORY

- // IVI started in 1996 under the name CEVEQ
(Quebec electric vehicle experimentation center)
- // A research laboratory (ITAQ) was founded in 2002
- // CEVEQ changed name to CNTA in 2008 to reflect its greater involvement in vehicle development
- // CNTA and ITAQ merged in 2015 to become a single entity: IVI



+ CNTA =



Innovative Vehicle Institute

OUR MISSION

SUPPORT ORGANISATIONS WITH APPLIED RESEARCH,
DEVELOPMENT, ASSESSMENT AND IMPLEMENTATION OF
INNOVATIVE VEHICLE TECHNOLOGIES.

AREAS OF EXPERTISE:

- // Electric & hybrid propulsion
- // Vehicular intelligence
- // Energy efficiency



ACCESS TO TEST ENVIRONMENT

// Saint-Jérôme, a living lab to test non-CMVSS/FMVSS vehicles



// Transport Canada test center nearby (20 minutes from IVI)



DESIGN, CALIBRATION AND REAL WORLD DATA OF AN ELECTRIC SCHOOL BUS



**ELECTRIC SCHOOL
BUS**

WITH



INTRODUCTION

- // Lion bus is a school bus manufacturer located in Canada.
- // It has designed, from the ground up, a new innovative vehicle.
 - composite material outer shell, single piece roof, no rivets, etc...
- // Winter 2012: datalogging of real-life bus routes
- // Fall 2014: Lion bus asked IVI to be part of the design and prototyping team for an all-electric version of its school bus.
- // Summer of 2014: Prototype build.
- // Fall 2014 / Winter 2015: Many thousands of kilometer of test and active revenue service.
- // Summer 2015: Second engineering phase, re-design the battery pack and production optimization.

ARCHITECTURE

// Mid motor, RWD

// Rear axle speed reduction only

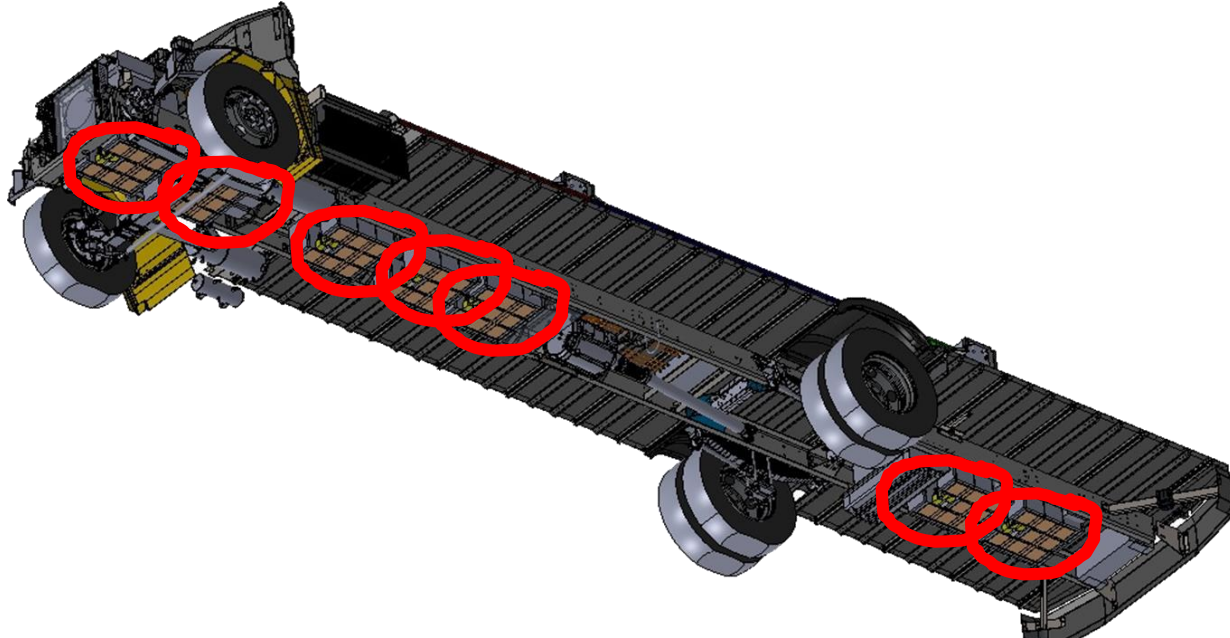
// High torque / low speed motor

Energy consumption in kWh/km in various cycles for a transit bus

Cycles	ideal	Multi Speed	Single Speed	Direct drive
Manhattan	2,00	2.4	2.3	2.25
Orange county	1.52	1.86	1.81	1.70
UDDS HD	1.48	1.66	1.66	1.52
	100%	118%	115%	109%

ARCHITECTURE

- // Rubber mounted components on the ladder frame to account for large chassis deflection
- // Weight distribution optimized by multiple battery packs



SIMULATION

- // Reliable model built using the Advisor simulator
 - // The model was tuned with real route operations using an Isaac Instrument data logger
 - // “Infinite” motor was added to model, to measure the actual power needed
 - // Motor was chosen within TM4 lineup to match torque and speed requirements
 - // With exact power and losses maps from drivetrain, optimal battery capacity was determined
- 

MOTOR SIZING

// Motor allows grades of over 15% loaded at GVW and over 20% empty

// Peak capacity
is 200kW / 2300Nm



BATTERY SIZING

- // Simulations showed 0.8kWh/km
- // Required range: 100km
- // Total capacity needed to be 80kWh + 20% margin
- // Packs are 26kWh, fitted within the frame rails
- // Bus can accommodate 2 to 5 packs (~65km / ~162km)
- // Custom design with plenty of on-grid heating capacity
- // Automotive modules from large South Korean manufacturer



CALIBRATION: MOTOR POWER

CALIBRATION GOAL: REPLICATE AS MUCH AS POSSIBLE THE DIESEL BUS

- // 200kW yielded a much too quick bus! Large motor was needed for gradability, not power
- // Tuning showed 135kW to make it equivalent to diesel bus

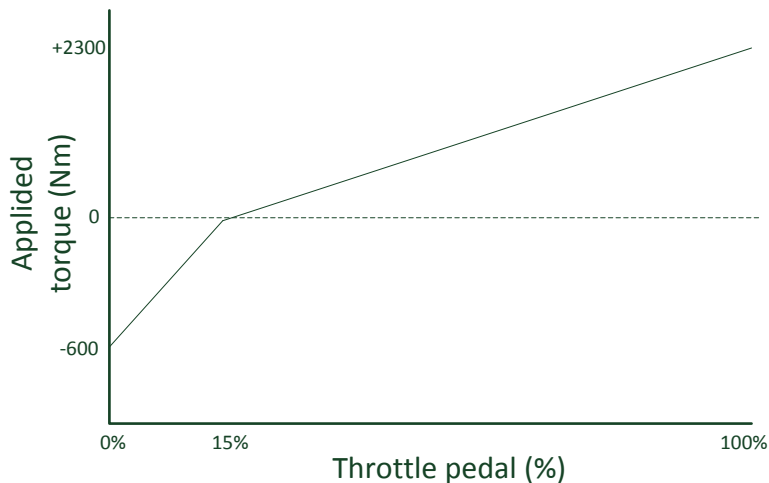


CALIBRATION: REGENERATIVE BRAKING

CALIBRATION GOAL: REPLICATE AS MUCH AS POSSIBLE THE DIESEL BUS

// Dual strategy regenerative braking, tuned by bus drivers

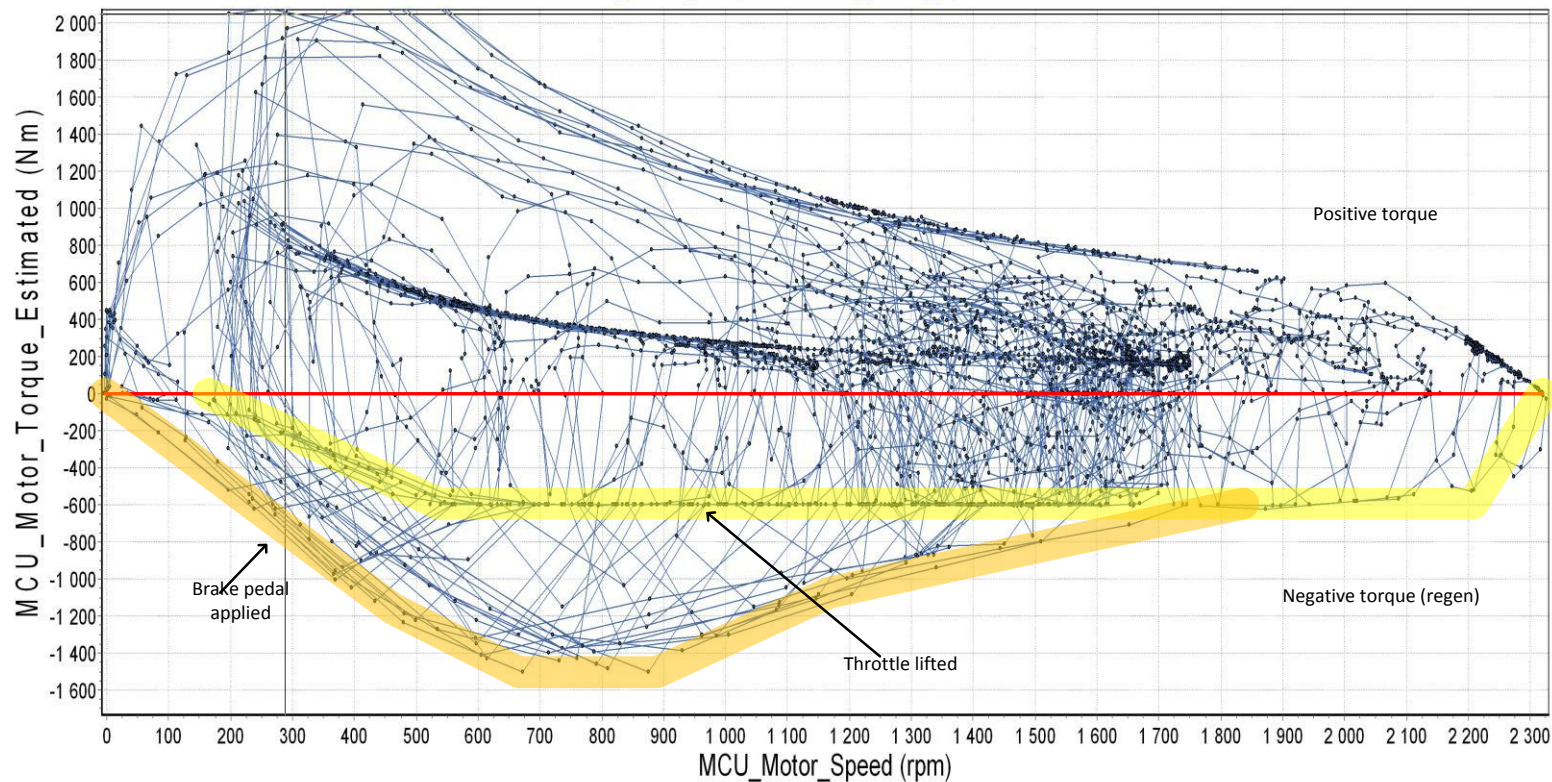
// Level 1: progressive lift-throttle mapping



CALIBRATION: REGENERATIVE BRAKING

// Level 2: Additional speed sensitive torque during active braking

MCU_Motor_Torque VS MCU_Motor_Speed

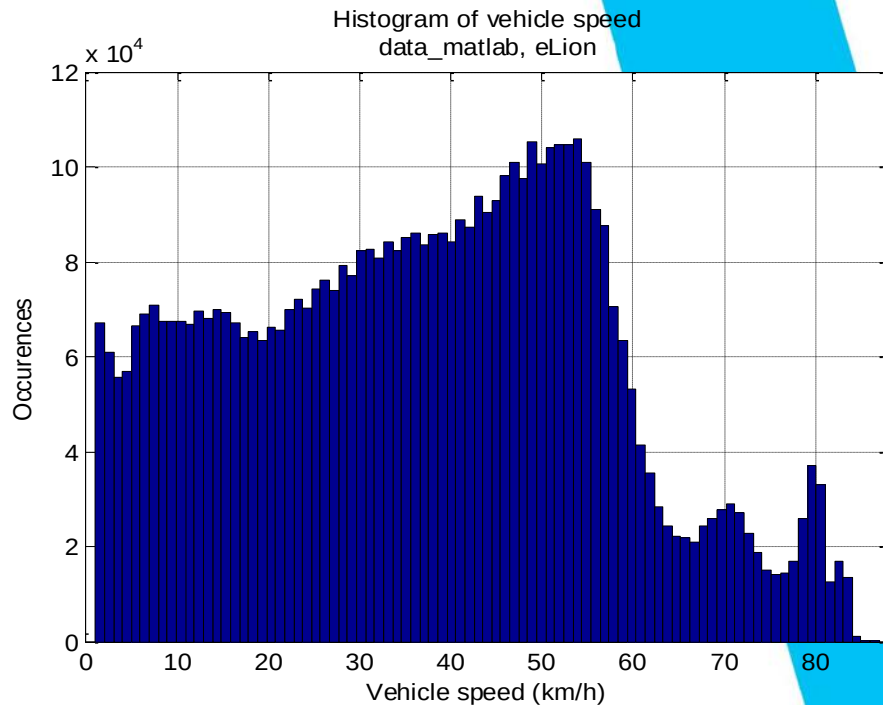
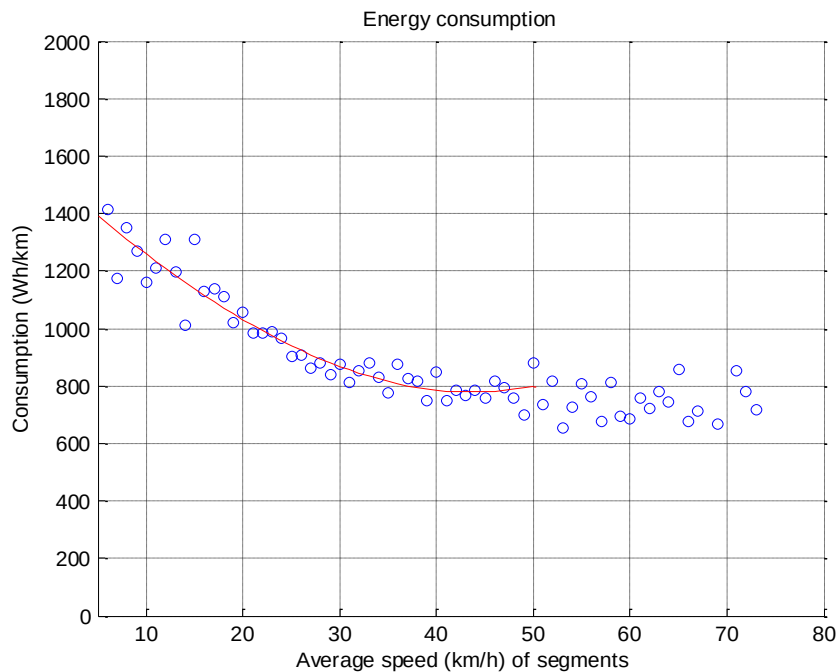


REAL WORLD DATA: ANALYSIS OVER 5400KM

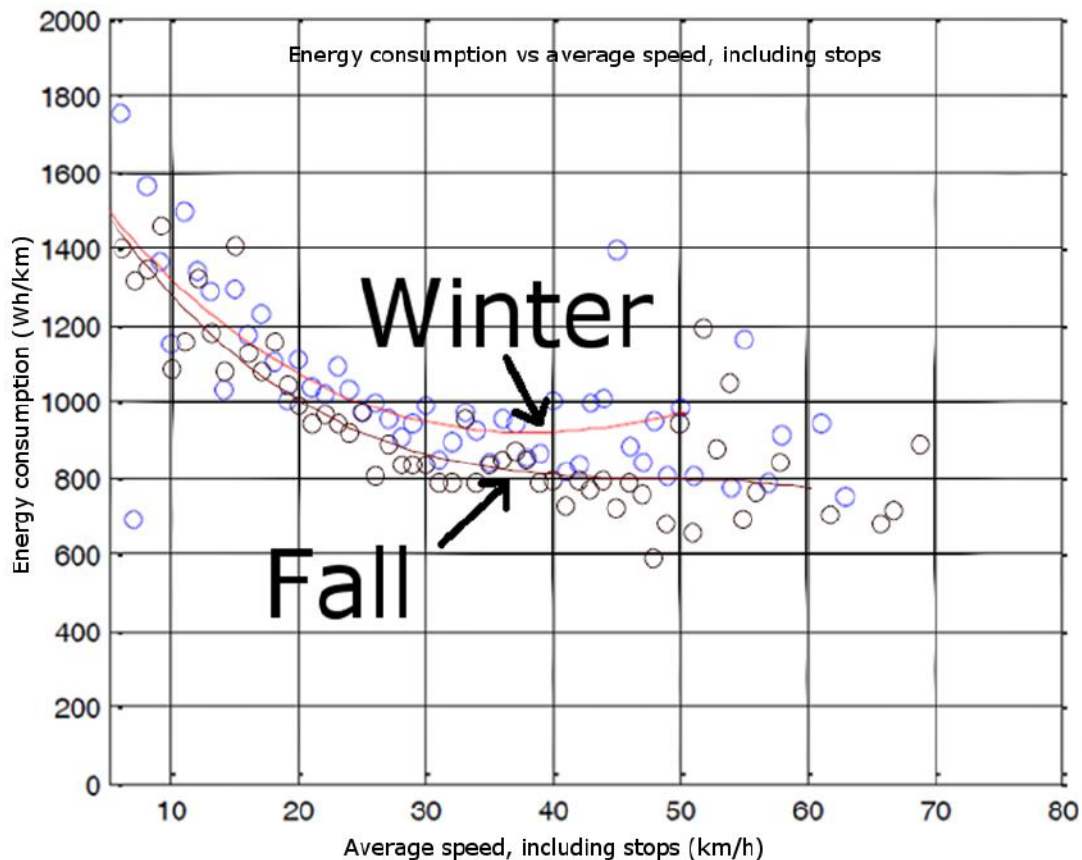
```
#####  
    __Statistics of data_matlab, eLion__  
5443.1km travelled  
4404.5kWh consumed  
4334.1kWh consumed while moving  
70.4kWh consumed stationary  
29.8km/h average speed  
36.9km/h average speed while moving  
0.81kWh/km average consumption  
0.80kWh/km average consumption while moving  
0.5m/s^2 average acceleration  
-0.4m/s^2 average deceleration  
#####
```

// Original simulations where right on!

REAL WORLD DATA: ANALYSIS OVER 5400KM



REAL WORLD DATA: ANALYSIS OVER 5400KM



CURRENT PROJECT STATE AND FUTURE DEVELOPMENTS

- // Nearly 3MWh of batteries produced
- // Over 20 buses in service
- // Production rate of about 1 bus per week
- // Single on-road battery failure, parallel pack architecture allowed bus to come back to garage without towing!
- // EV dedicated chassis is considered for the future



ACKNOWLEDGMENTS

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THANK YOU FOR YOUR TIME

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