CALAC+
Programa Clima y Aire limpio
en Ciudades de América Latina

Ministerio de Energía
Gobierno de Chile

Methodology for analyzing the viability of an electric vehicle fleet.

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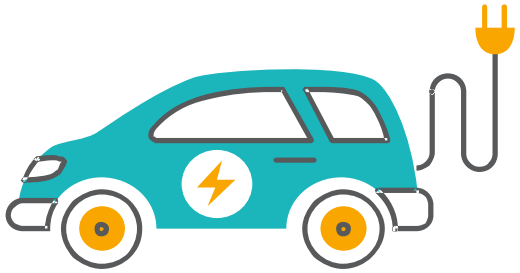
Motivations

- **Increase** supply of electromobility (vehicles, chargers, related services, etc.).
- **Information needs**for decision-making in the **generation of public policies**
- **Information needs** for:
    - Electric fleet **adoption.**
    - **Operational and Energy Electric Fleet Management.**
    - New Business Models generation.



Objectives

- To develop a methodology for determining the baseline of energy consumption and the operational characteristics of a vehicle fleet to compare efficiency between internal combustion vehicles and electric vehicles.
- To generate **real case information where the methodology is applied** to allow decision-making for conversion to electric mobility.
- To **collaborate in the dissemination of the experience** of vehicle fleet pilots that presents potentials of greater energy and operational efficiency.
- **To generate information for the state** on the basis of which you can subsequently **develop and promote public policies** on the subject.
-

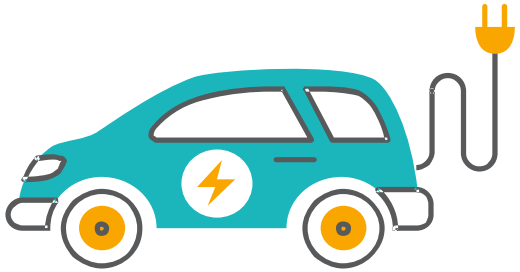
General Methodology

Design of Experiments

Implementation

Data Analysis

Knowledge generation



Methodology – Design of experiments

Sample selection

- Electric Bus Measurement Universe
  - 101 Electric Buses.
  - Fixed trips
- Electric vehicles Measurement Universe
  - 26 electric vehicles
  - Fixed and random trips.
- 95% confidence and 10% error.

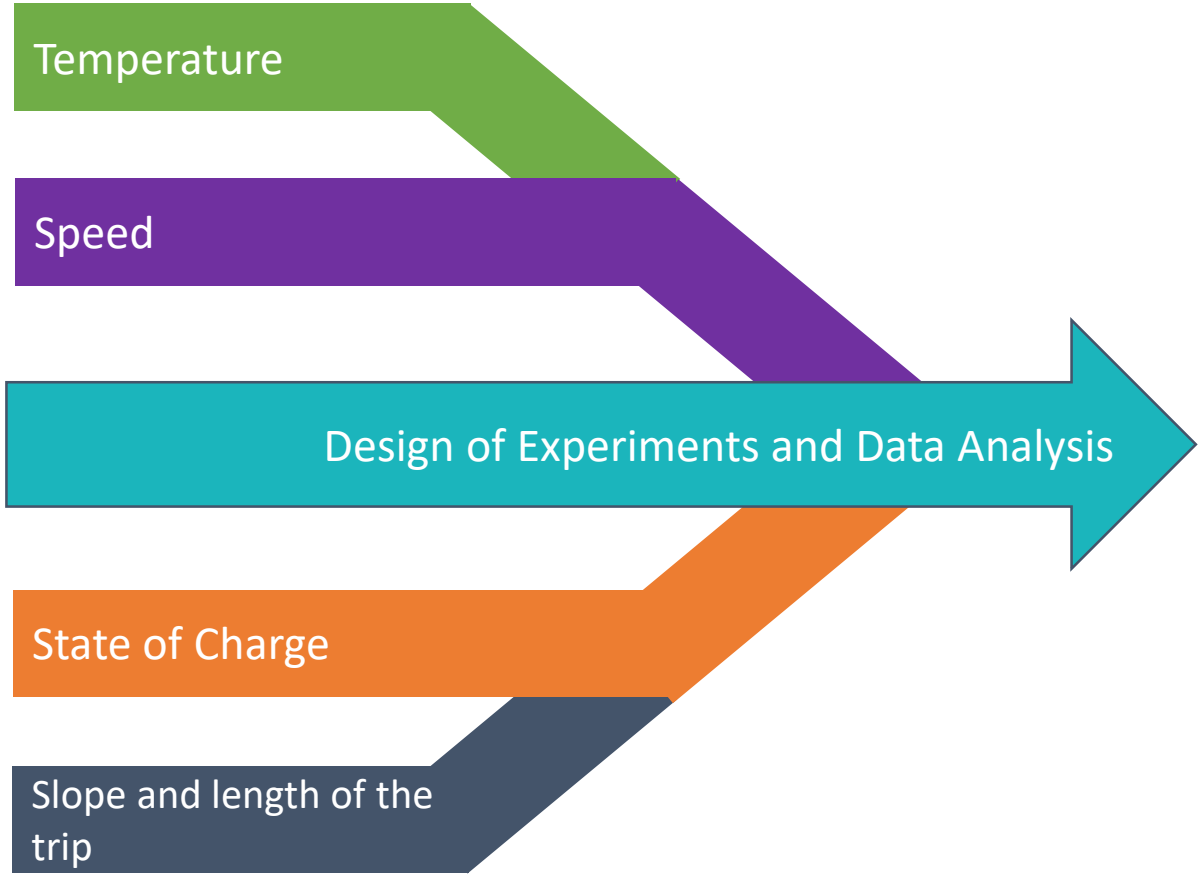
e: Margin of error
N: Population size
p: Probability
z: Confidence level
n:Sample size

$$n = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1 + \frac{z^2 \times p(1-p)}{e^2 N}}$$

A. Jawlik Statistics from Ato Z, John Wiley & Sons, New Jersey 2016

Methodology – Design of experiments

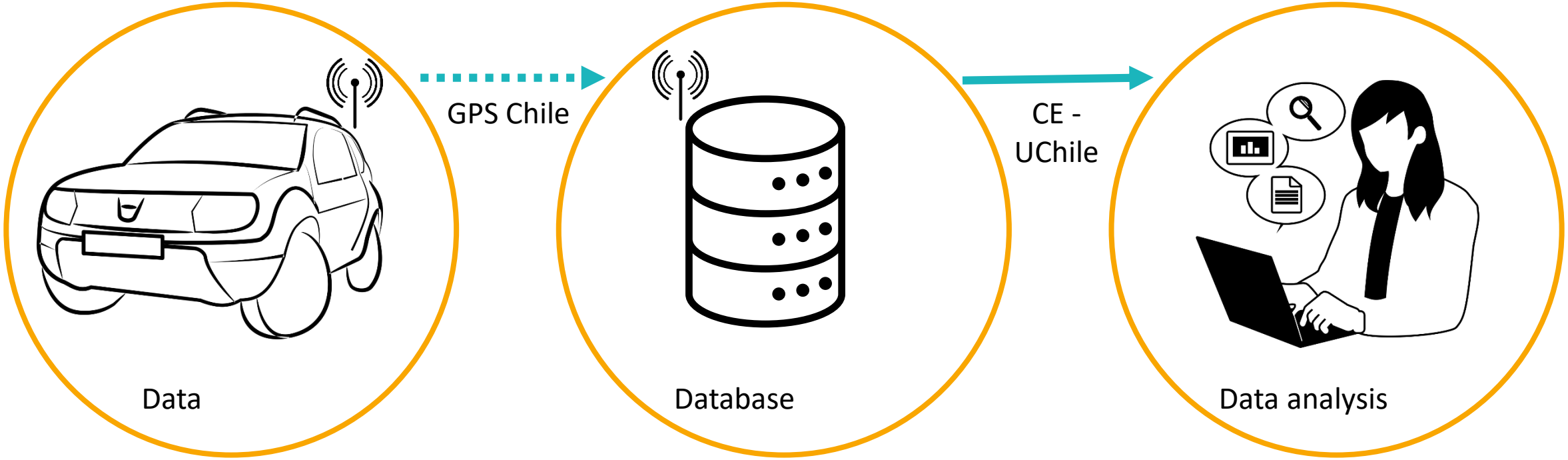
Data acquisition



- Energy performance analysis
- Performance dependency with operation variables.

Methodology - Implementation

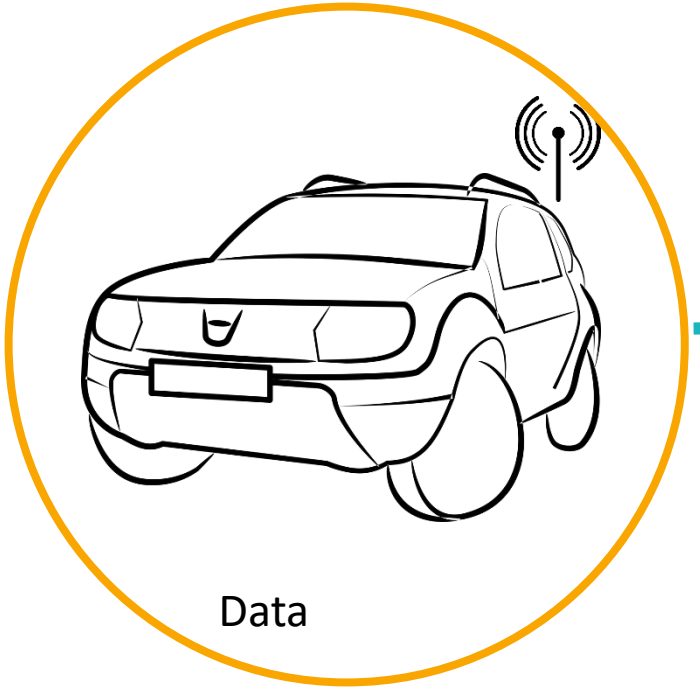
Data acquisition

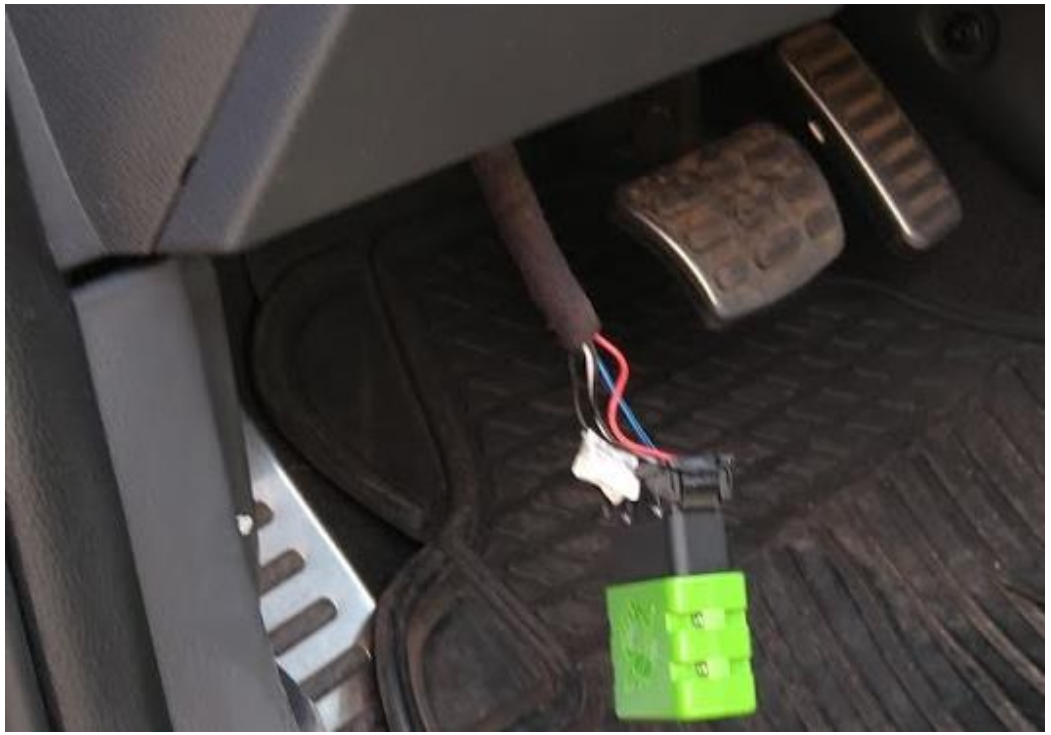


CE – UChile has an active participation in the design of the data acquisition system.

Methodology - Implementation

Data acquisition

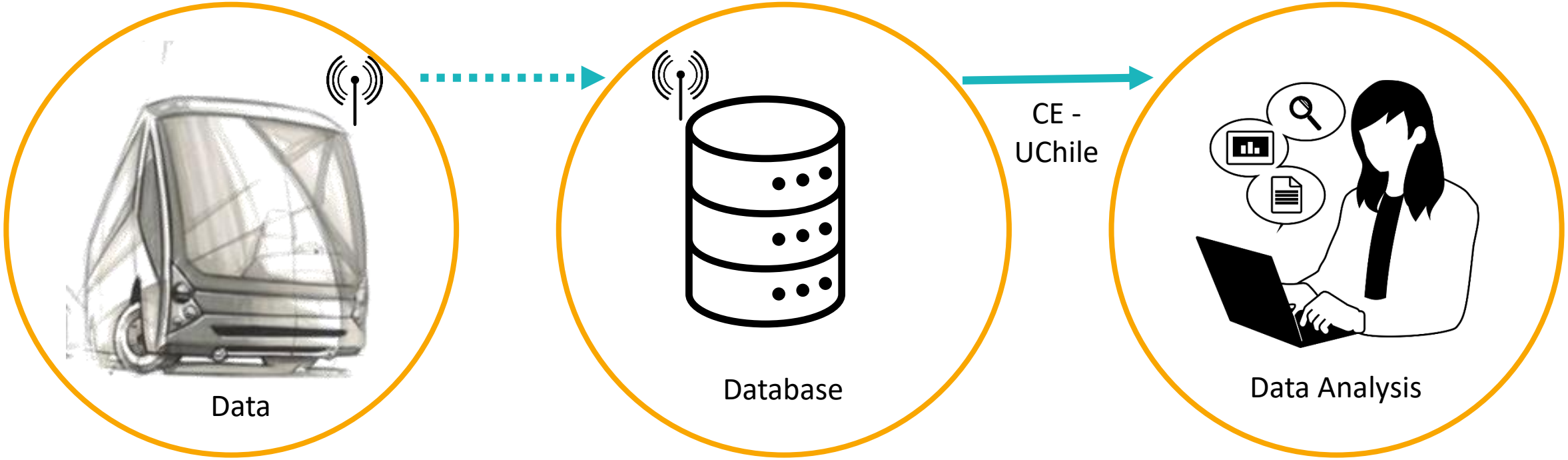




Device with ELM327 protocol connected to OBD2 port
8 seconds acquisition frequency

Methodology - Implementation

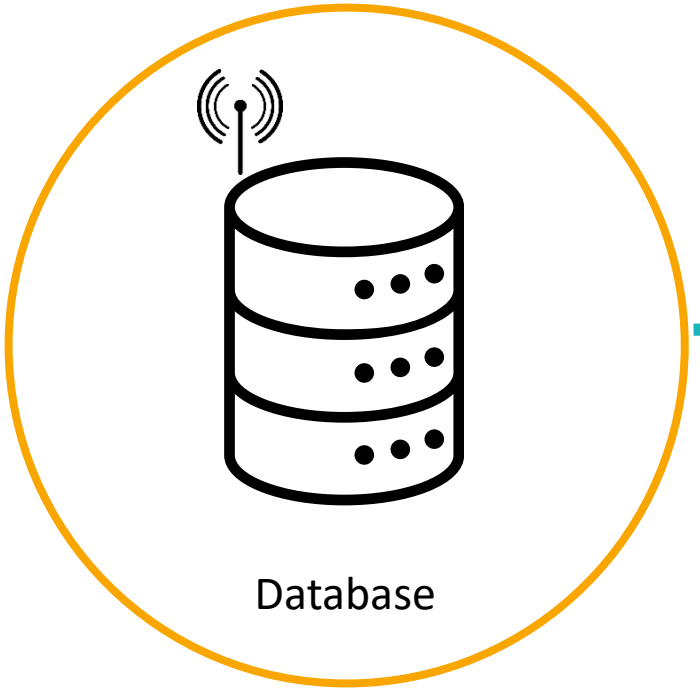
Data acquisition



CE - UChile receives data requested from the telemetry provider company.
Sampling by Bus event. "Moving" "Speed Excess" "Stopped", etc.

Methodology - Implementation

Data acquisition



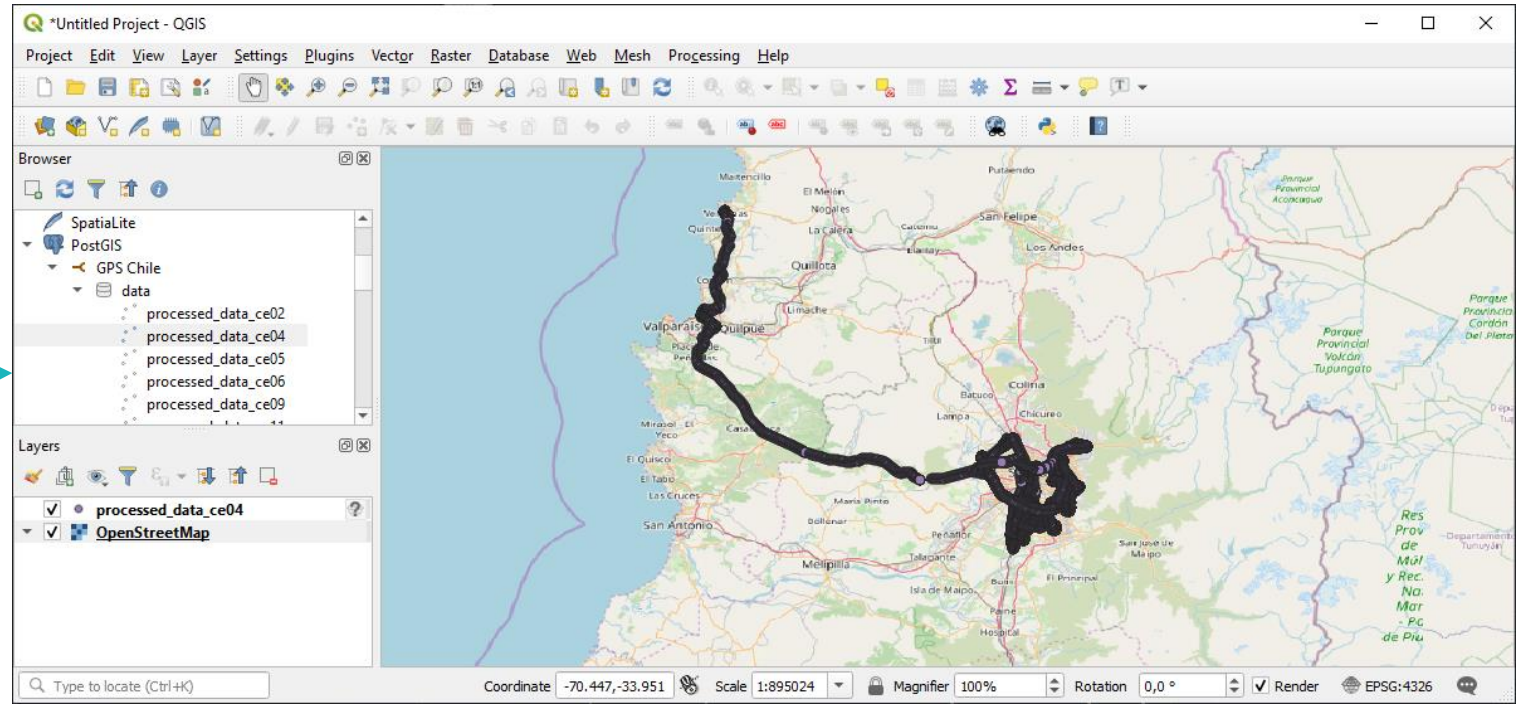
Data Output | Explain | Messages | Notifications

	gps_time text	device_time text	longitude text	latitude text	gps_speed_mpers text	hdop text	altitude text	bearing text	a ir
1	Mon Jan 20 1...	20-Jan-2020 11:...	-70.57980792	-33.413547...	0.0	11.792	696.471191...	0.0	
2	Mon Jan 20 1...	20-Jan-2020 11:...	-70.57980793	-33.413547...	0.0	11.792	699.788574...	0.0	
3	Mon Jan 20 1...	20-Jan-2020 11:...	-70.57980791	-33.413547...	0.0	11.792	701.026977...	0.0	
4	Mon Jan 20 1...	20-Jan-2020 11:...	-70.57980781	-33.413547...	0.0	12.864	701.564697...	0.0	
5	Mon Jan 20 1...	20-Jan-2020 11:...	-70.57980781	-33.413547...	0.0	11.792	702.393310...	0.0	
6	Mon Jan 20 1...	20-Jan-2020 11:...	-70.57920897	-33.405559...	13.64	10.72	701.581054...	284.7	
7	Mon Jan 20 1...	20-Jan-2020 11:...	-70.57981028	-33.413545...	0.24	11.792	701.393066...	249.0	
8	Mon Jan 20 1...	20-Jan-2020 11:...	-70.57982556	-33.413546...	0.53	11.792	703.790771...	252.1	
9	Mon Jan 20 1...	20-Jan-2020 11:...	-70.57695275	-33.407140...	0.0	9.6480...	708.208007...	0.0	
10	Mon Jan 20 1...	20-Jan-2020 11:...	-70.57980117	-33.413525...	0.0	11.792	699.616210...	0.0	
11	Mon Jan 20 1...	20-Jan-2020 11:...	-70.57983993	-33.413540...	0.0	10.72	697.005615...	0.0	
12	Mon Jan 20 1...	20-Jan-2020 11:...	-70.59236873	-33.405610...	16.85	8.576	678.0	247.7	
13	Mon Jan 20 1...	20-Jan-2020 11:...	-70.57983961	-33.413541...	0.0	12.864	696.328613...	0.0	

Methodology - Implementation

Data acquisition

Data analysis



Methodology - Data Analysis

Energy performance analysis

Data acquisition

- Sampling frequency.
- Variable identification.
- File format.

Data cleansing

- Data cleansing algorithm.
- Pre-processing routine.

Data processing

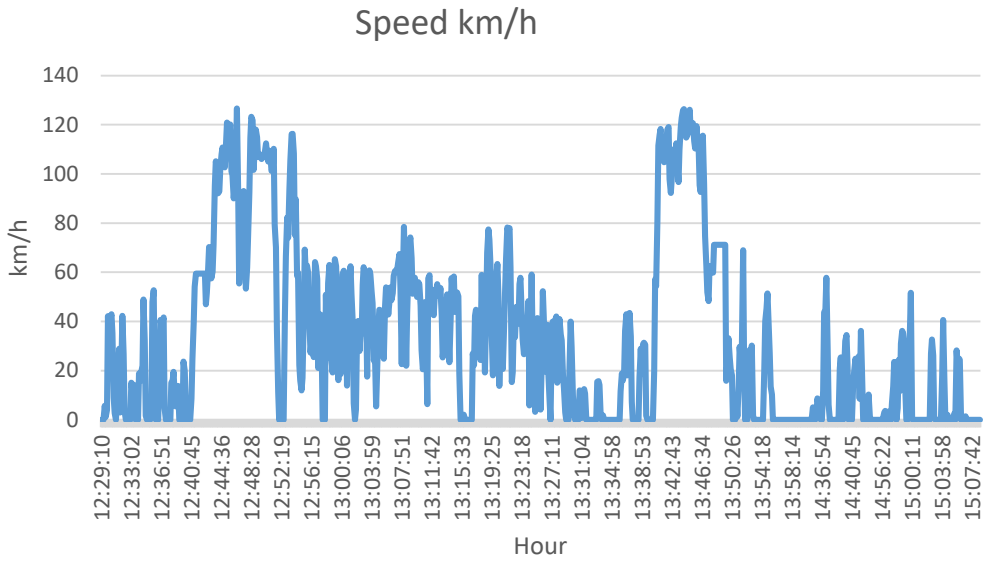
- Operational and energy analysis:
- Weekly
- Monthly
- Total

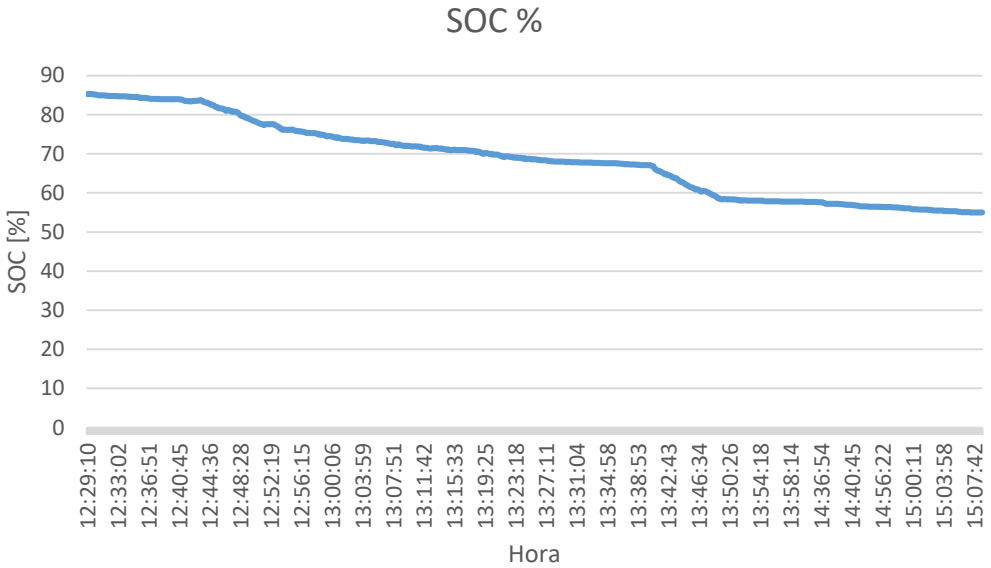
Knowledge generation

- with respect to distance
- Speed performance
- Performance over initial SOC
- Ambient temperature performance

Preliminary Results

Example of light vehicle measurements

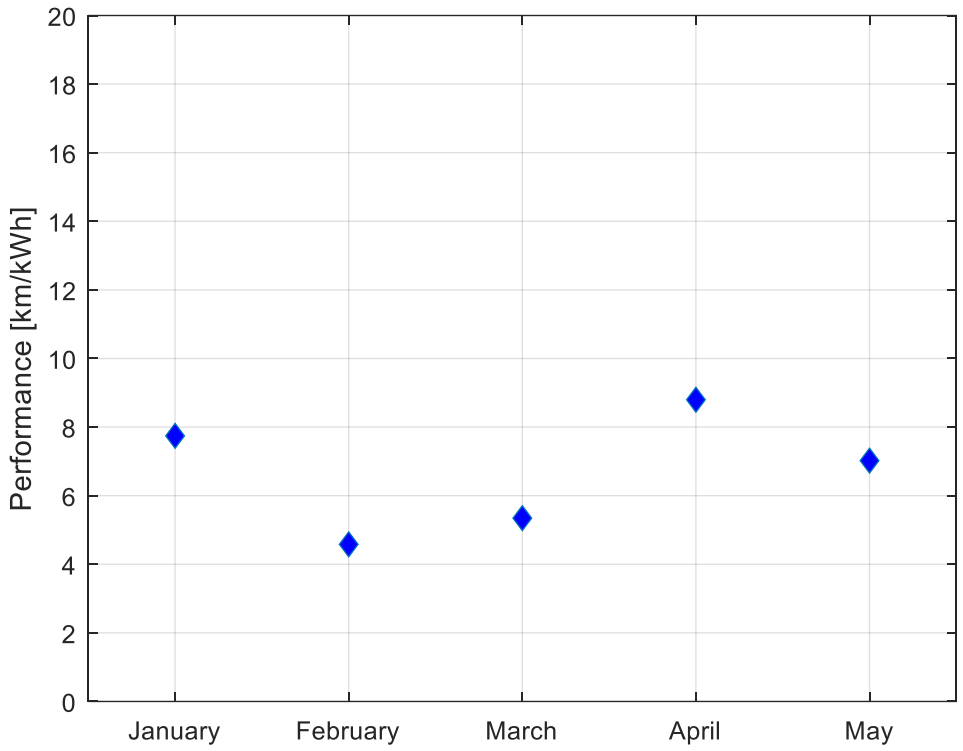




Example of SOC behavior on urban road with highway with their respective speed variations

Preliminary Results

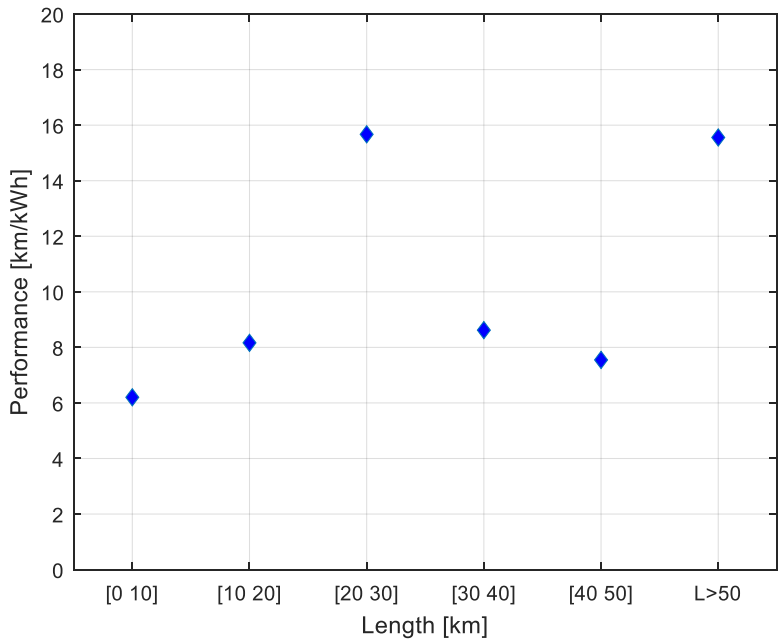
Light vehicle performance

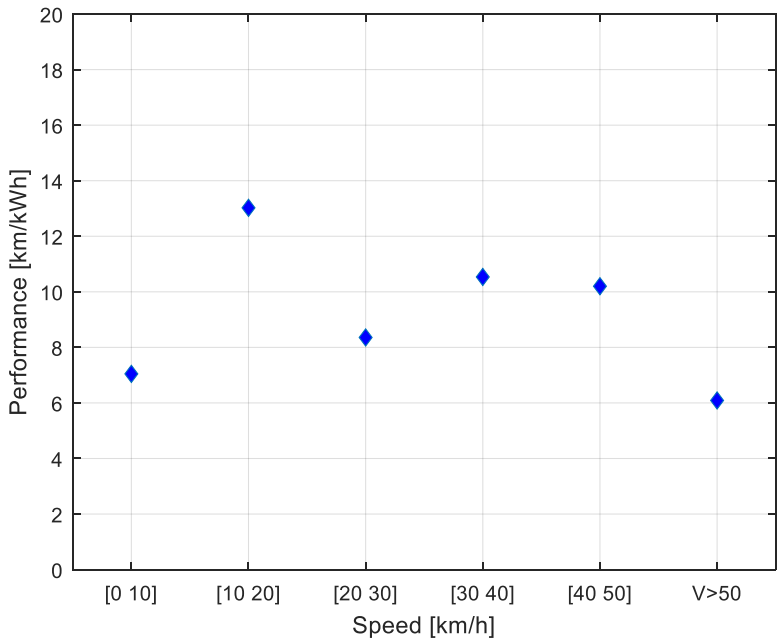


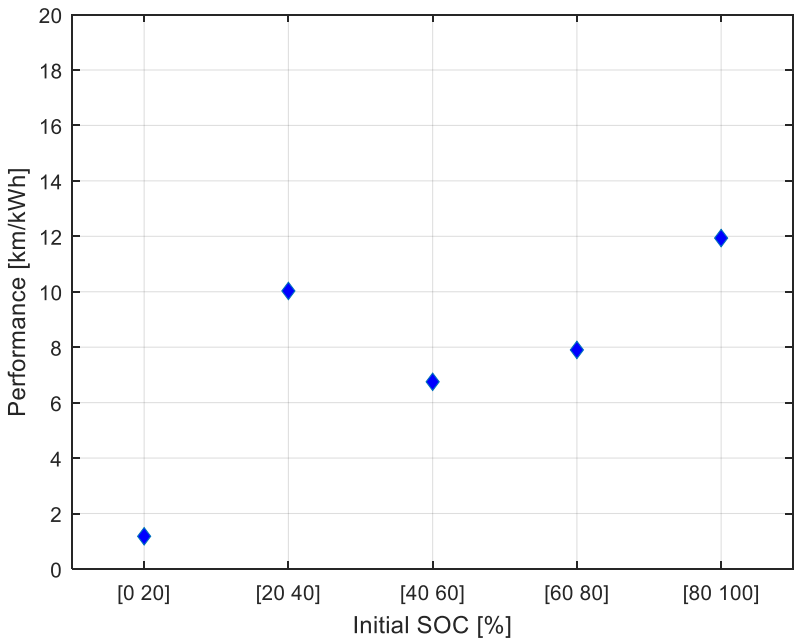
Average monthly battery performance for a light vehicle

Preliminary Results

Light vehicle performance



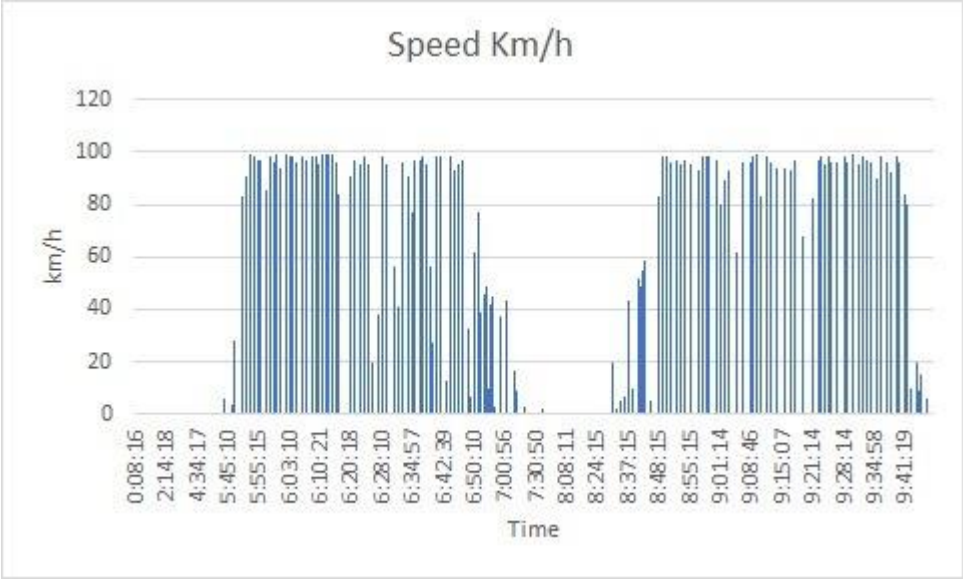


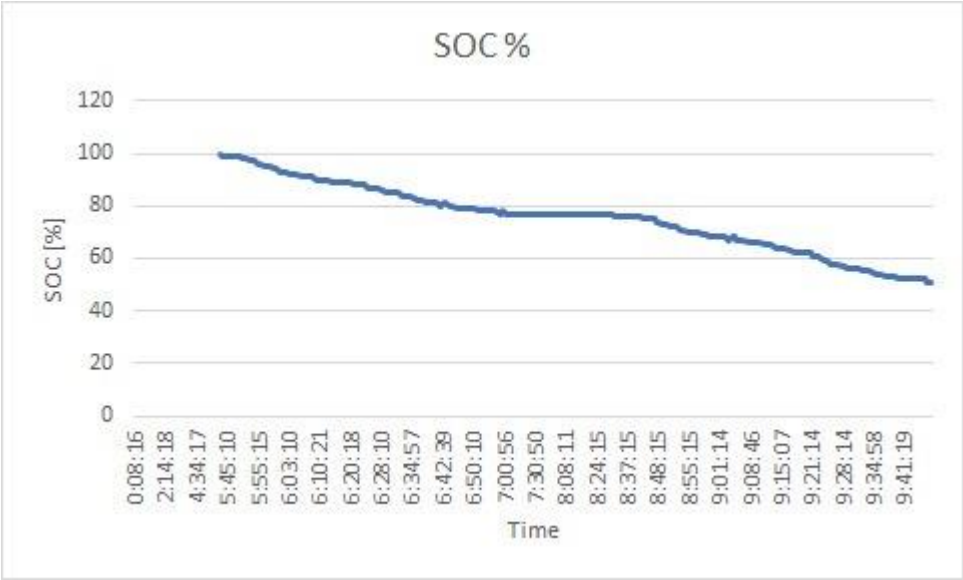


The characterization of speed, distance, driving profile and initial SOC allows to determine the energy performance of the vehicle

Preliminary Results

Example of Buses measurements

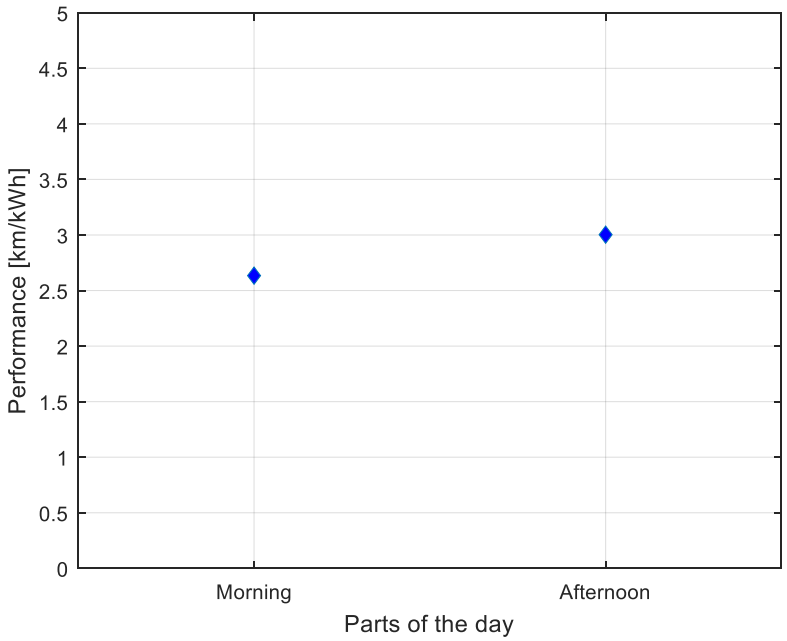


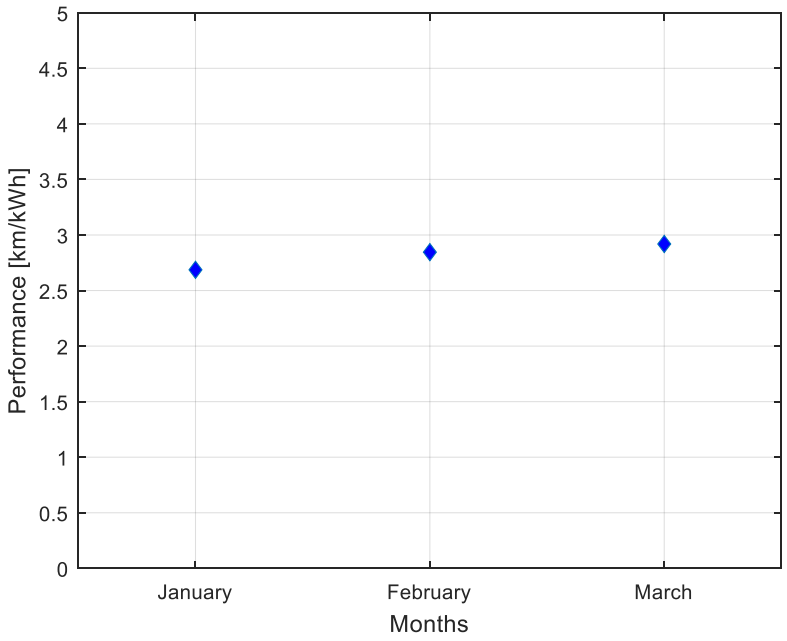


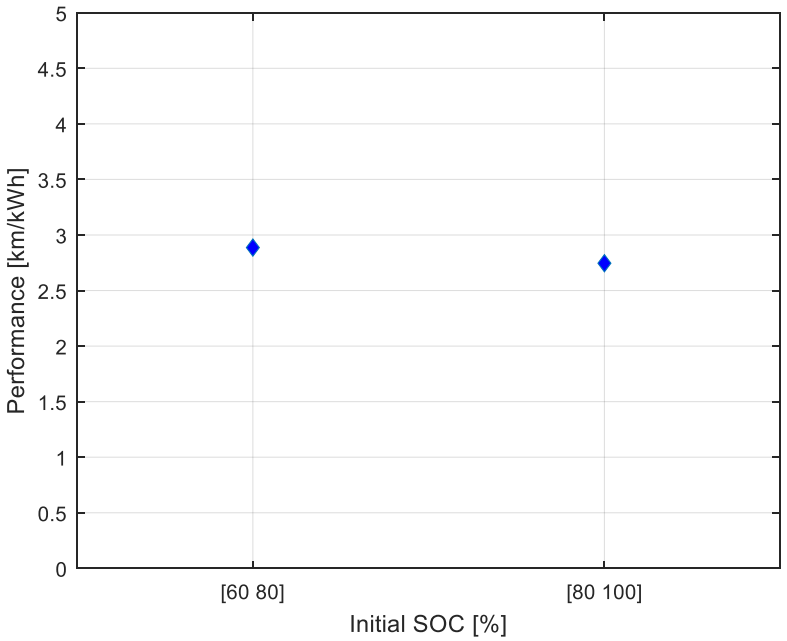
Example of SOC behavior on urban routes with their respective speed variations

Preliminary Results

Example of Buses measurements



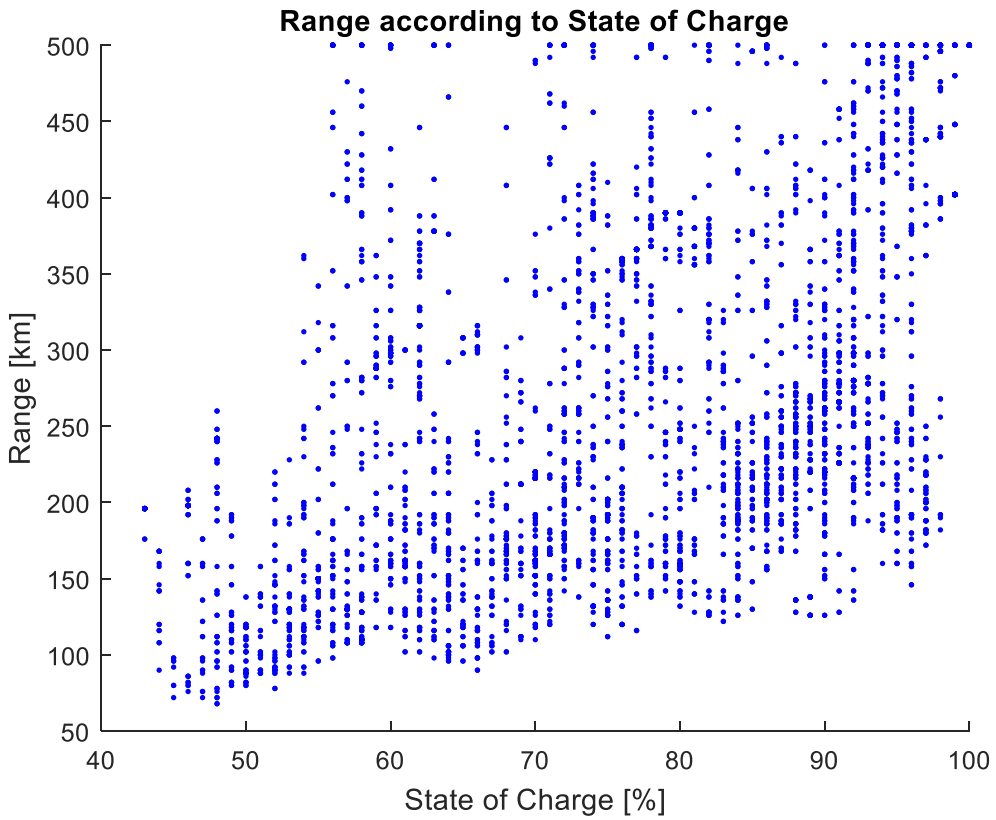




Load profile and route type impacts performance and availability

Preliminary Results

Example of Buses measurements



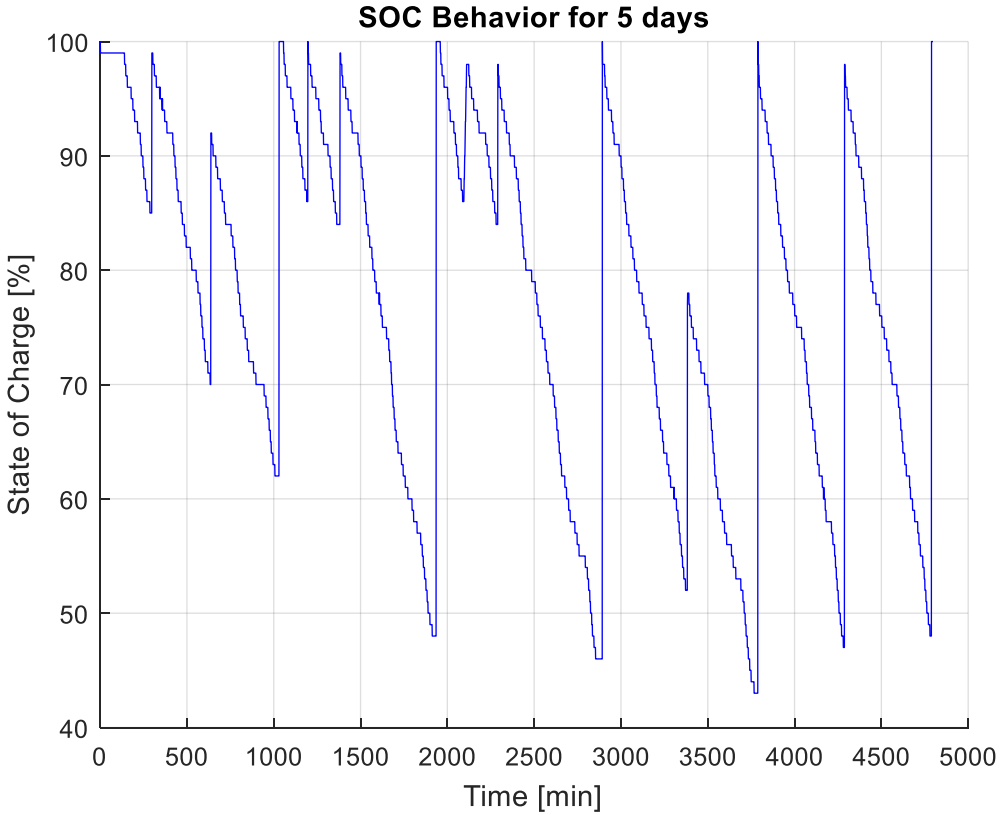
While there is high autonomy variability according to the SOC, there is dependence between autonomy and SOC

Preliminary Results

Example of Buses measurements

	Max SOC	Min SOC	km traveled	Δ SOC	km/SOC
01-04-2019			**287,1**		
1	100	85	57,6	15	3,84
2	99	70	114,4	29	3,94
3	92	62	115,1	30	3,84
02-04-2019			**287,3**		
4	100	86	57,6	14	4,11
5	100	84	57,3	16	3,58
6	99	48	172,4	51	3,38
03-04-2019			**286,9**		
7	100	86	57,2	14	4,09
8	98	84	57,4	14	4,10
9	98	46	172,3	52	3,31
04-04-2019			**225,5**		
10	100	52	135,5	48	2,82
11	78	43	90	35	2,57
05-04-2019			**225,2**		
12	100	47	114,2	53	2,15
13	98	49	111	49	2,27
		Total	**1312**		

More kilometers can be traveled per SOC unit when the battery is operated at high charge levels.



Battery life tends to be longer when operating between 100%-75% SOC than when doing between 100%-50%SOC.

Conclusions

1

Importance of design of experiments

- Sample size selection
- Time period selection
- Variable selection

2

Data acquisition and storage system:

- Frequency of data acquisition
- Data cleansing

3

Information generation and analysis

- Performance dependence on speed, travel distance and SOC
- Time performance projection

Task Team

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