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CUMIN - TIM

RÉPUBLIQUE FRANÇAISE
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ADEME
AGENCE DE LA TRANSITION ÉCOLOGIQUE

TIM – Traction-braking Integrated with Modularity

LaM CU3E
Laboratoire de mécanique, multiphysique, multiéchelle

L2EP
Laboratoire d'électrotechnique et d'électronique de puissance de Lille
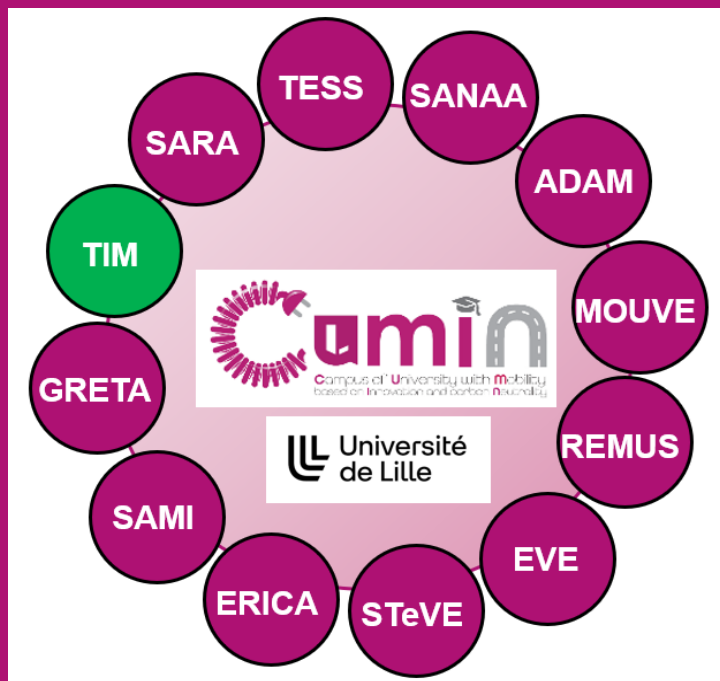
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BRUNEL Jean-François
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12/02/2025

Outline
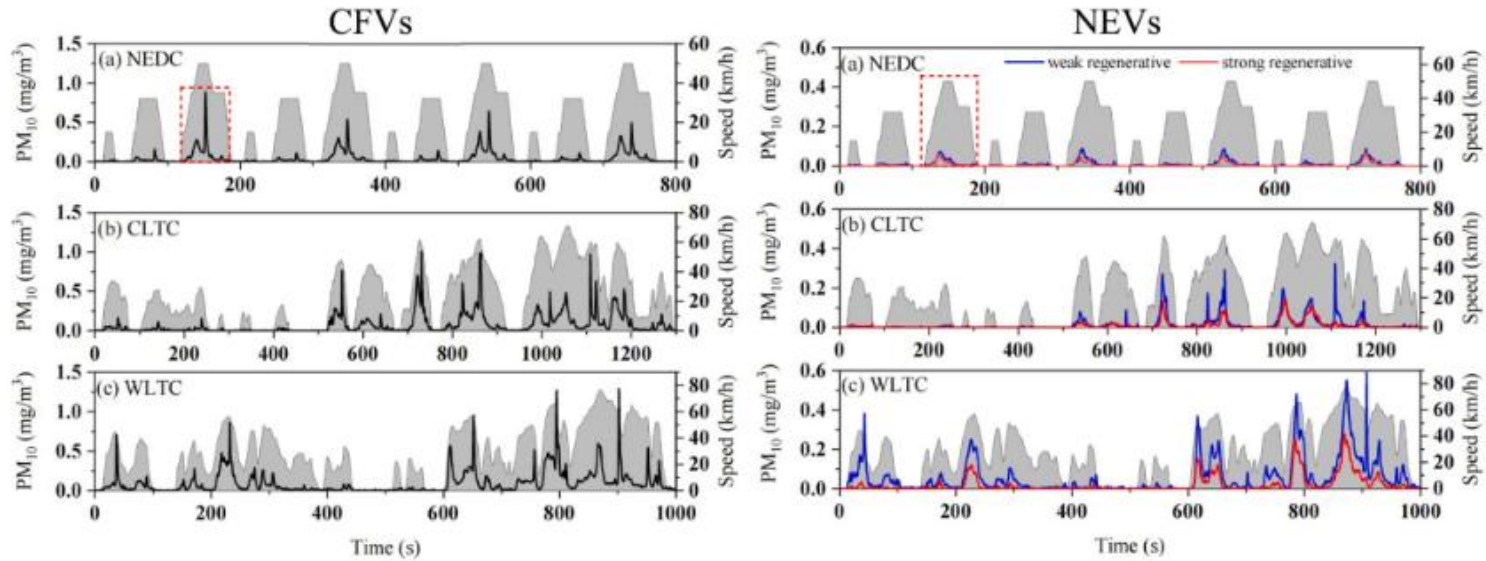
1 **Context of the work**
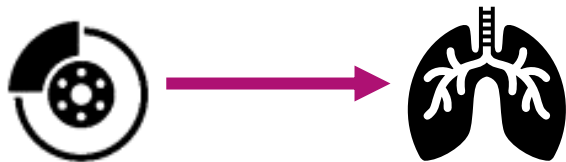
2 **Objectives**

3 **Work in progress**

Context of TIM

Mass concentration emission characteristics of BWP from CFVs and NEVs under standard test cycle [Zhang 2024]
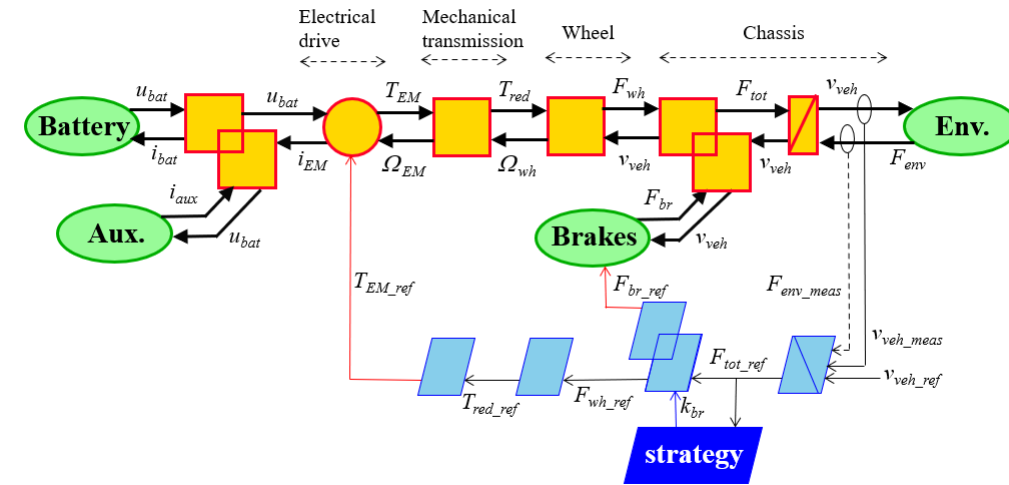

- Using mechanical braking leads to pollutants emissions such as noise and fine particles

- Security norms impose the usage of mechanical brakes

- Not using enough mechanical brakes leads to instabilities

Brake-by-wire and electrical braking
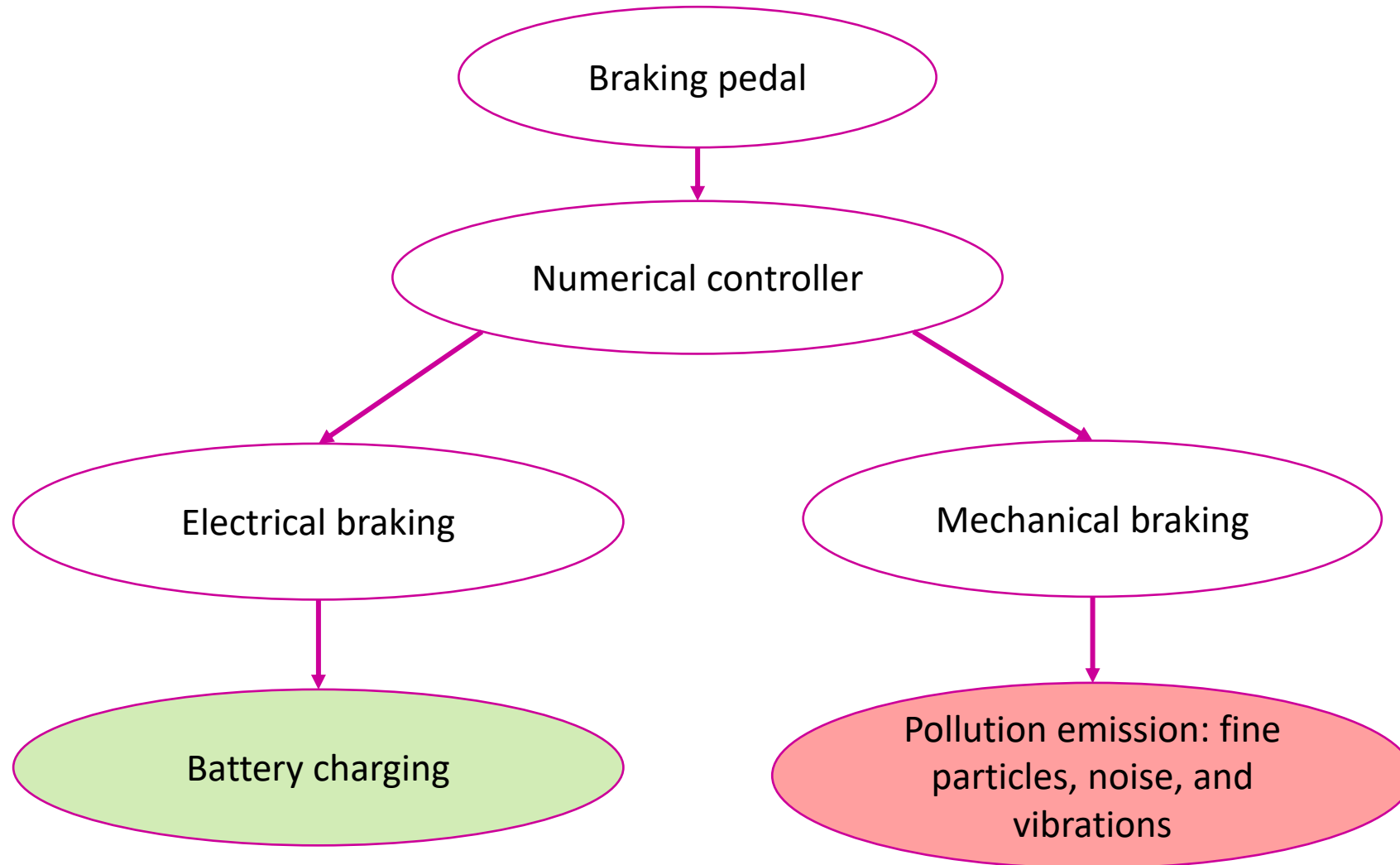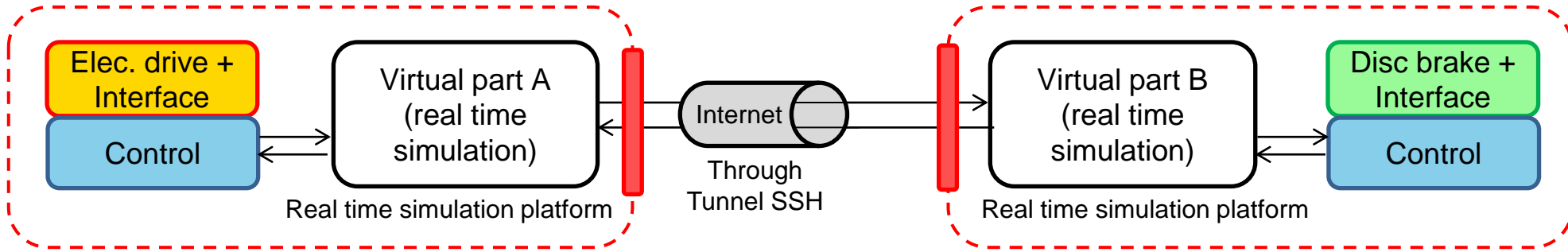
Working schedule

1. Energetic model on a real battery EV (Nissan Leaf) eV platform / L2EP

2. Tribological characterization on the brakes of the Leaf 4MAAT-Tribo platform / LaMcube

3. Multi-physical modelling and EMR of the Leaf by taking into account both models

4. Multi-objective braking strategy: battery regeneration / particle emissions

5. Validation of the strategy using multisite distributed Hardware-in-the-Loop (HiL) testing eV platform (L2EP) & 4MAAT-Tribo platform (LaMcube)

6. Strategy modularity : use of the previous work on other vehicles
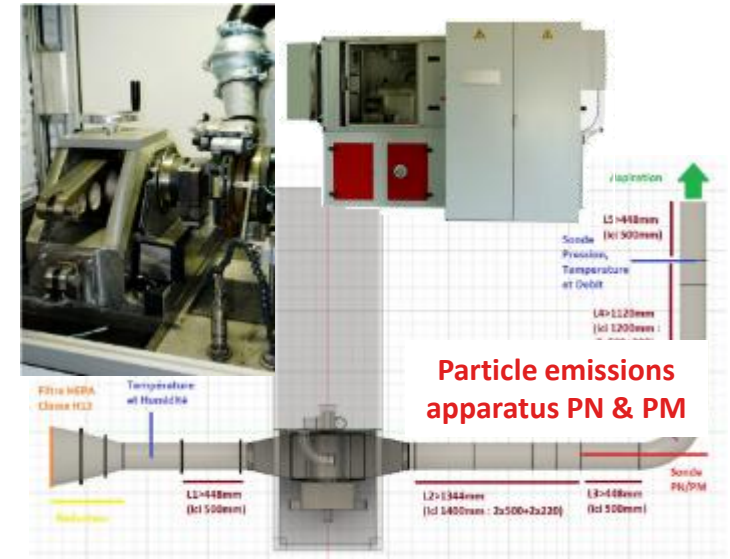

LEAF EMR

Multisite distributed HiL (Hardware-in-the-Loop) testing
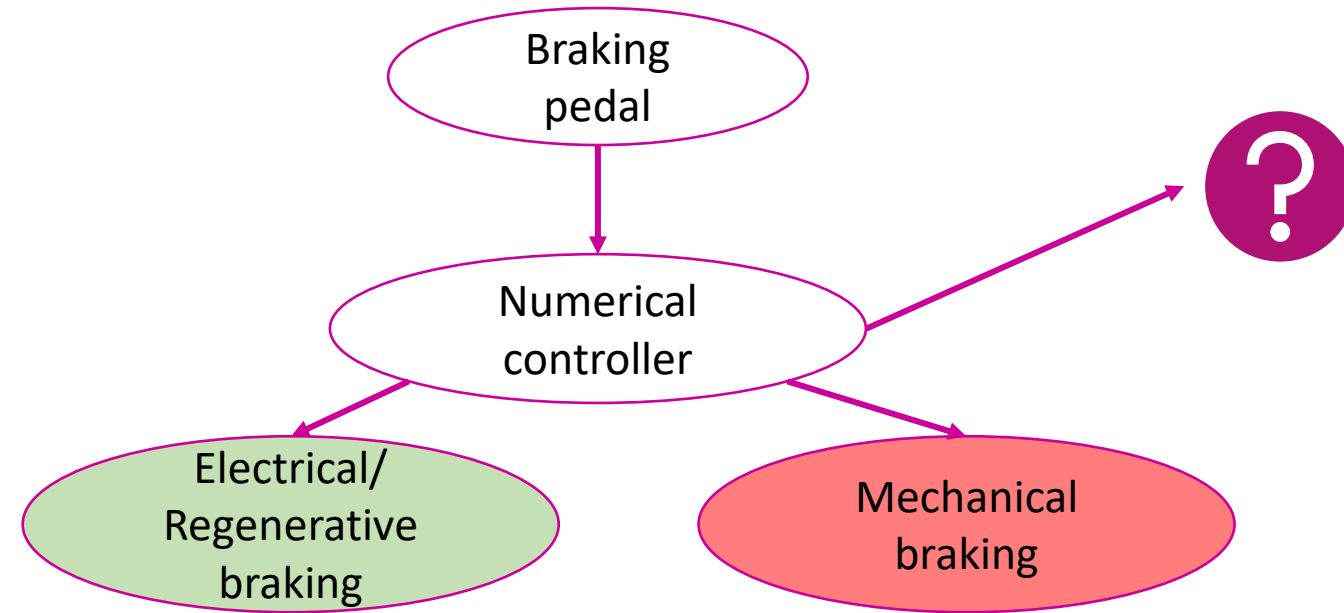
Method from [Tournez 23]

eV platform
University of Lille / ESPRIT

Tribo platform
University of Lille / CISIT

| Elec. drive + Interface | Virtual part A (real time simulation) | Internet | Virtual part B (real time simulation) | Disc brake + Interface |
| Control | | Through Tunnel SSH | | Control |

Real time simulation platform

Real time simulation platform

1:1 electrical drive test bench

Particle emissions apparatus PN & PM

6

Braking strategy

Braking pedal → Numerical controller

Numerical controller → Electrical/Regenerative braking

Numerical controller → Mechanical braking

Numerical controller → ?

- The braking strategy is unique to each vehicle / manufacturer
- Several problematics
  - Influence of the driving patterns
  - Influence of the acceleration and velocity
  - Importance of the regenerative braking
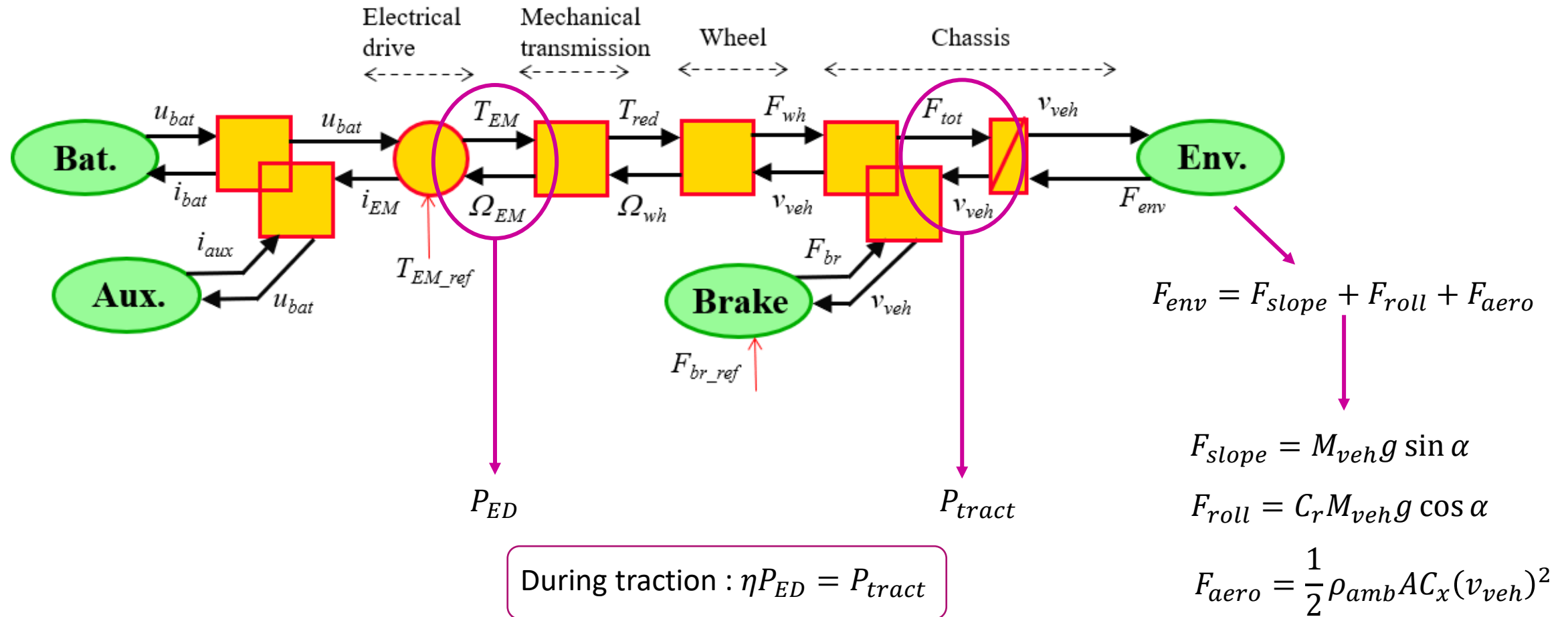

Nissan LEAF of L2EP

Bus CAN of the Nissan LEAF: data measured (with SARA project) such as:

- Speed of the vehicle
- Accelerator pedal position
- Voltage and current of the battery
- Traction machine speed (estimated value)
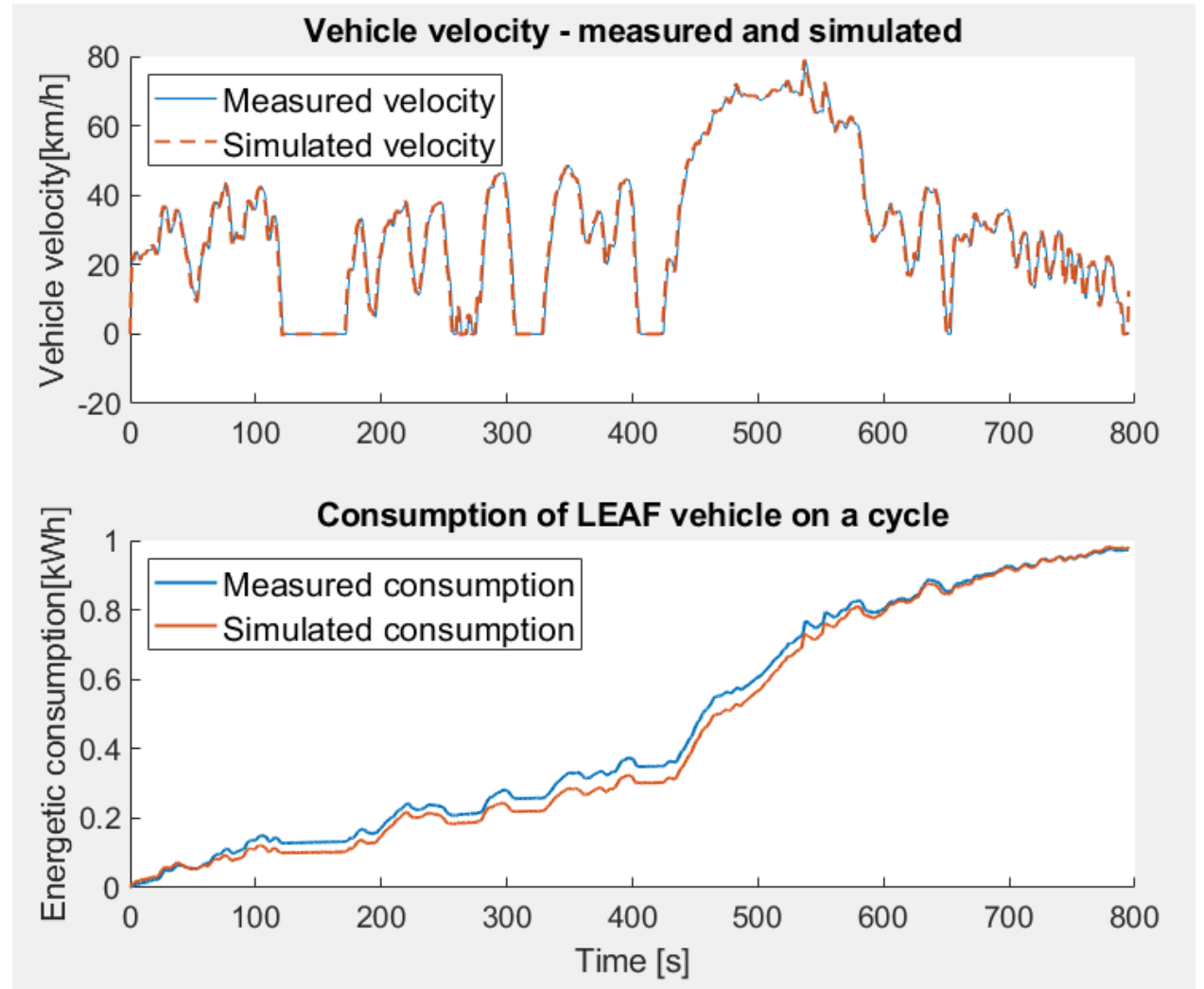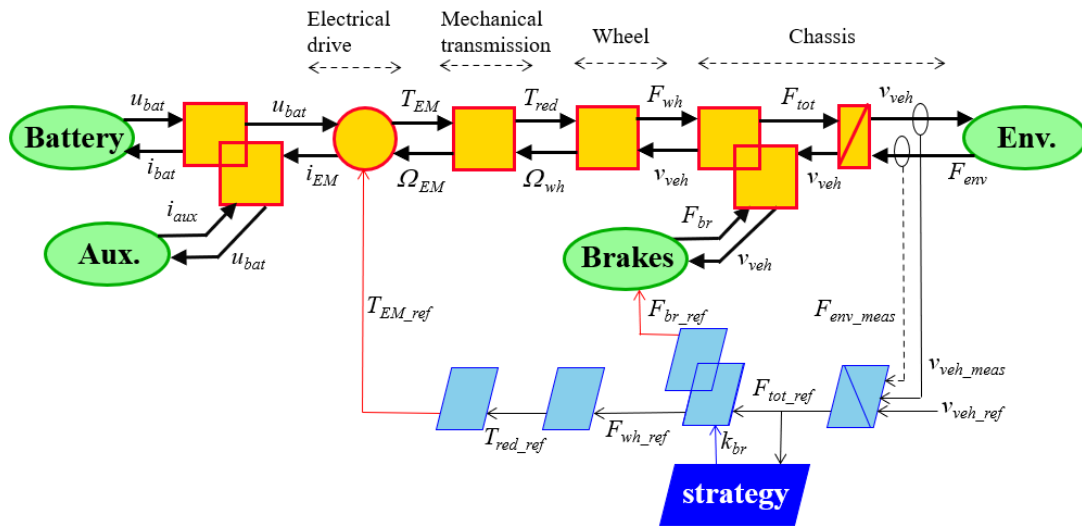- **Not enough information on mechanical braking**

Estimation of the resistive forces to motion

During traction : $\eta P_{ED} = P_{tract}$

$$F_{env} = F_{slope} + F_{roll} + F_{aero}$$

$$F_{slope} = M_{veh}\, g \sin \alpha$$

$$F_{roll} = C_r M_{veh}\, g \cos \alpha$$

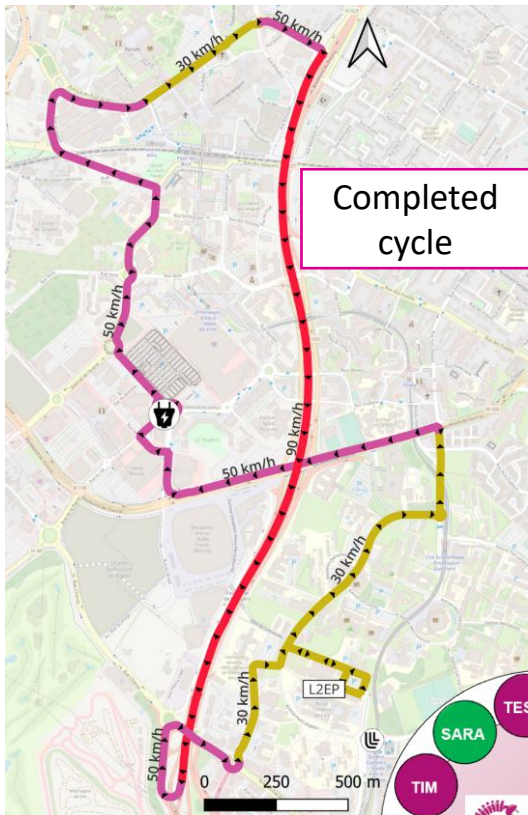$$F_{aero} = \frac{1}{2} \rho_{amb} A C_x (v_{veh})^2$$

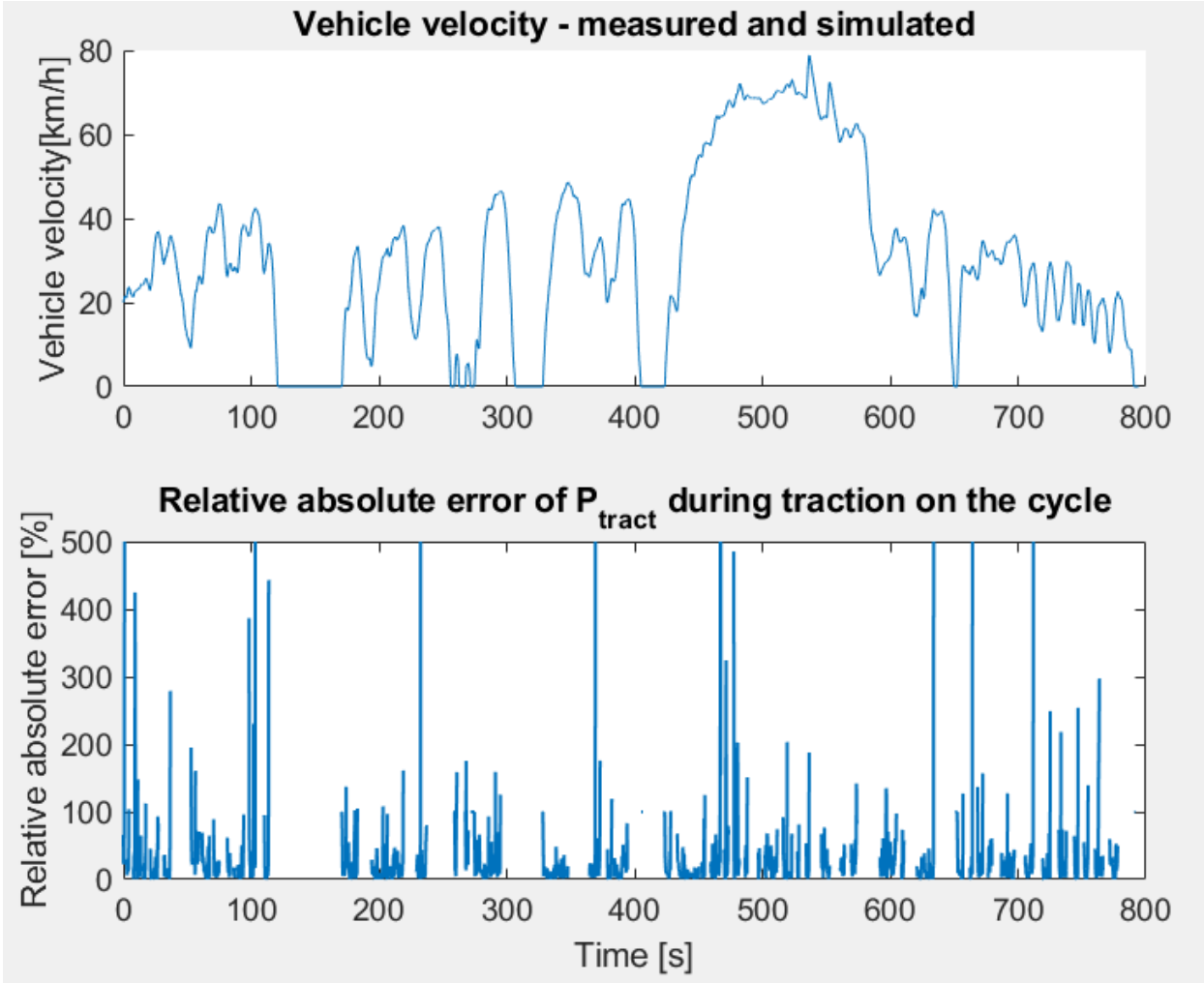# Energetic validation of the model

Error on energy consumption at the end of the cycle: <1%

Power validation of the resistive forces to motion during traction

During traction : $\eta P_{ED} = P_{tract}$

Completed cycle

The model chosen for the resistive force cannot be used for power applications, especially at low velocities.

Why is it not working?

Data measured

- Measures of velocity : GPS or in-board sensors

- Initialisation of slope sensor

- Acceleration data : measured or calculated

Hypothesis on behaviours

- Constant efficiency of the mechanical transmission

- Constant resistance coefficient of the rolling

- Wind influence

- Straight-line travel, influence of turns ignored

Choices for certain values

- Aerodynamic values : frontal area of the vehicle, drag coefficient

- Mass of the vehicle

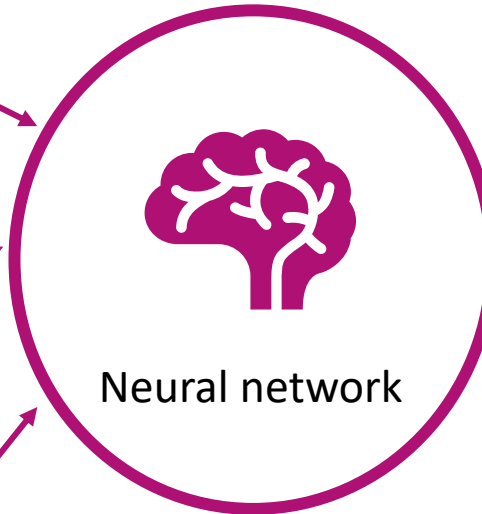# Next step: using a neural network

Equation:

$$F_{wh} - F_{env} - \cancel{F_{br}} = M_{veh} \frac{dv}{dt}$$

Measured data (SARA project):
- v_{veh}
- α : slope
- T_{EM}
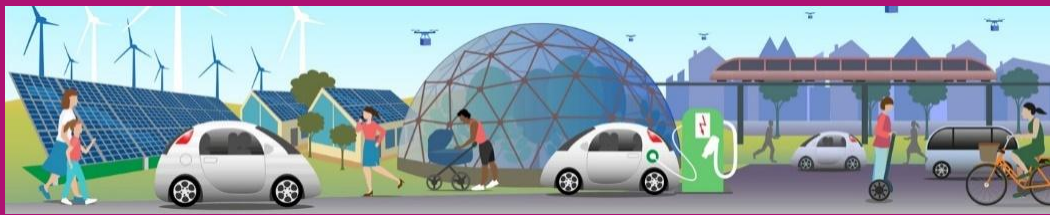- Tyre pressure
- GPS coordinates

Others values:
- M_{veh}
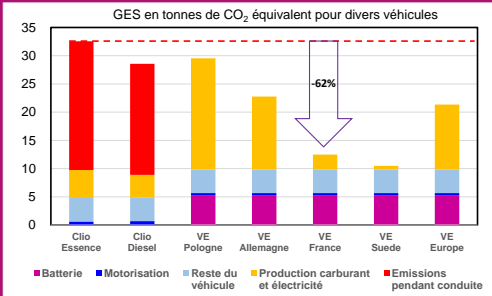- Wheel radius
- Efficiencies
- Wind velocity and angle

Neural network

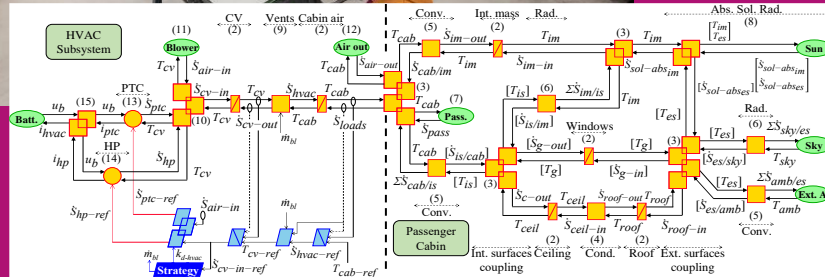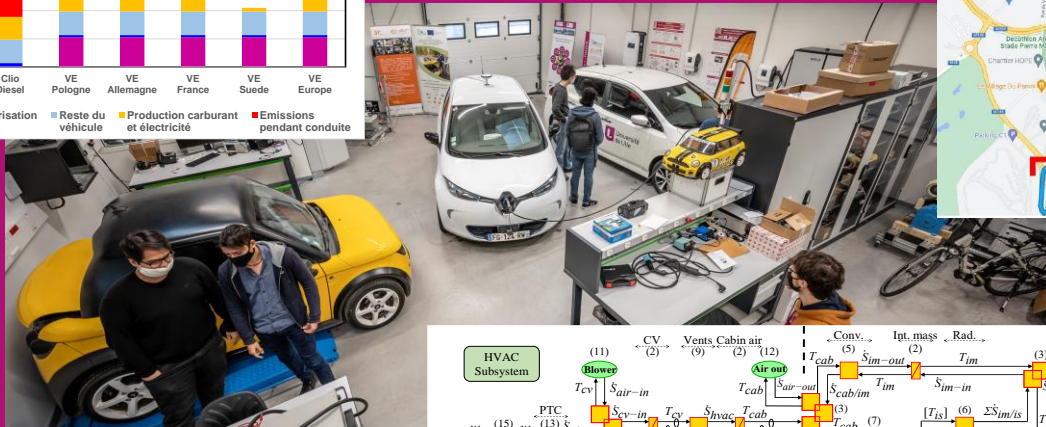Estimation of the resistive forces to motion during traction

Estimation of the mechanical braking force during braking

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Annex

Model of the Nissan Leaf