Consumption calculation of vehicles using OBD data

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CTL introduction

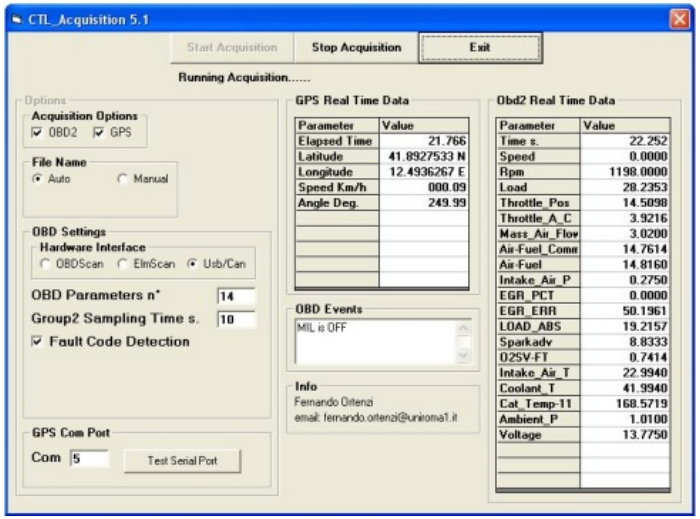
- The Centre for Transport and Logistics of the university of Rome “La Sapienza” was funded by the Italian Ministry in 2003 as a national centre of excellence
- It follows a multi-disciplinary approach, involving Mechanics and energy, Information science, Telecommunications
- Mission
  - Bridging the gap between research and applications, between universities and industries
- Main research themes
  - Transport, Safety, Freight and Logistics
  - ICT applications for transport
  - Vehicles energy and emissions monitoring

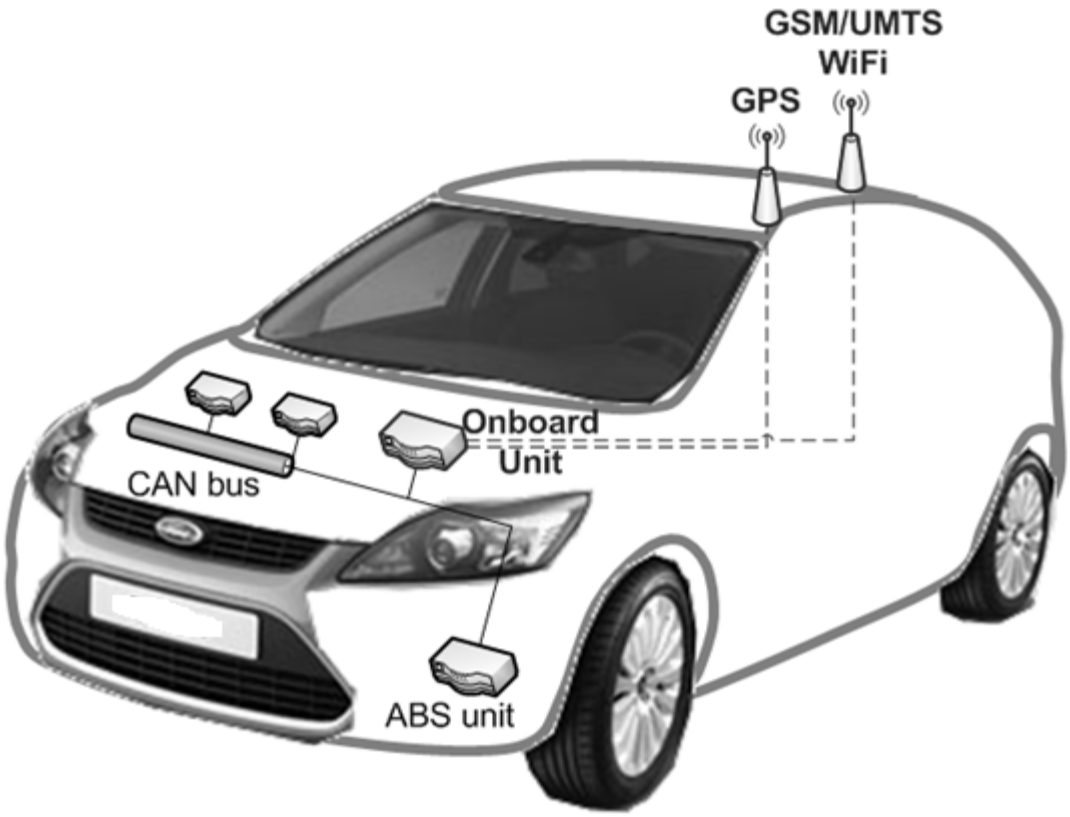
Contents

Method and models to calculate instantaneous power and consumption

- On-board tool
- Available onboard sensors
- Power calculation
- Consumption calculation
- Accuracy of the models

The Onboard Unit





Available sensors on-board

- Vehicle speed
- Rpm
- Accelarator pedal
- Engine Load%
- Intake Airflow
- Air/fuel Ratio
- Coolant Temperature
- Catalyst Temperature
- ……..

OBD Parameters: Calculated Engine Load

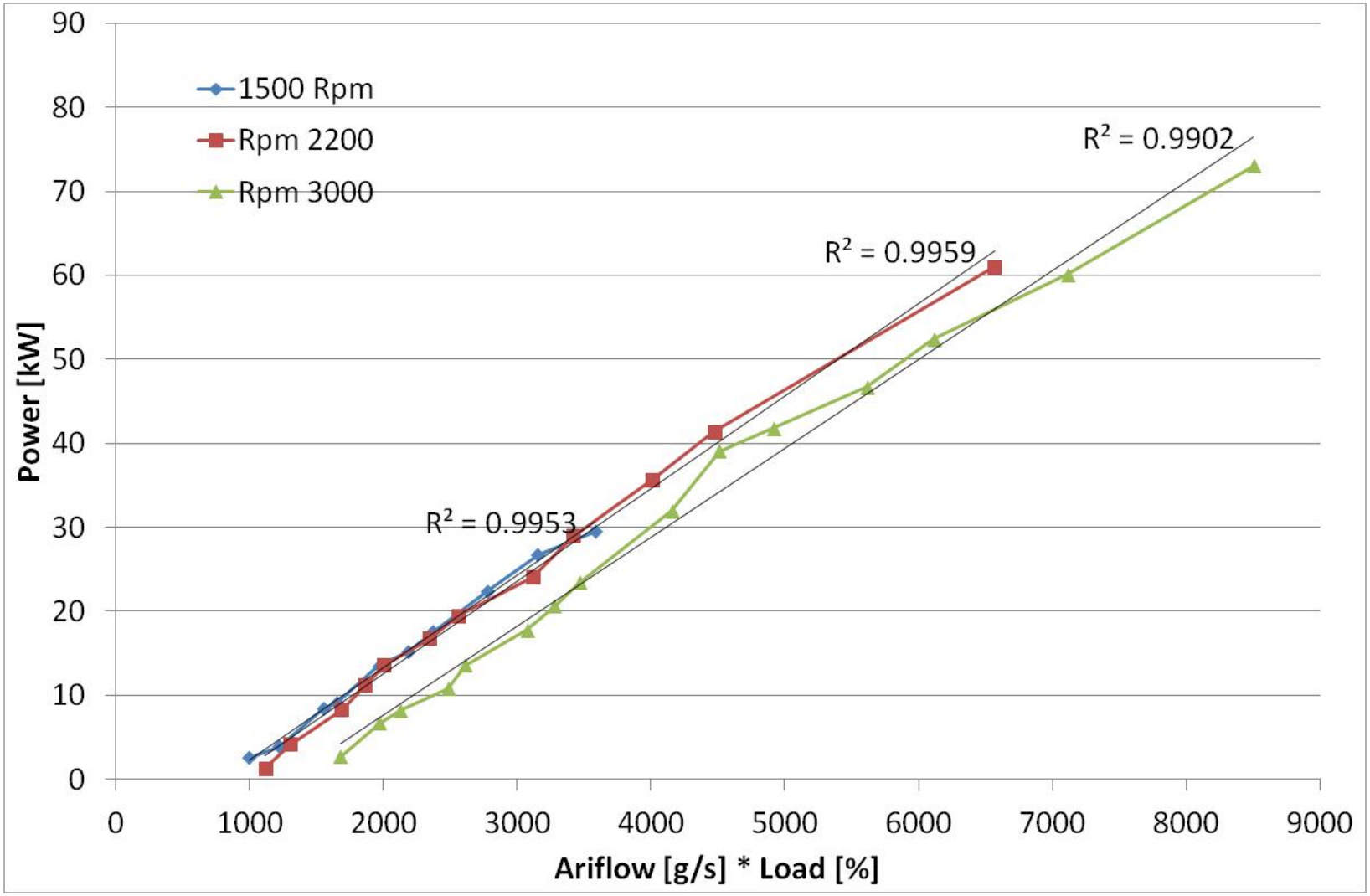
$$Engine\_Load = \frac{Current\_AirFlow}{Max\_Airflow(Rpm) \cdot \frac{Baro}{29.92} \cdot \sqrt{\frac{298}{T_{amb} + 273}}}$$

- Reaches 1 at full open throttle for any altitude, temperature and pressure or rpm for both naturally aspirated and boosted engines;
- Indicated percent of peak available torque;
- Linearly correlated with engine vacuum;
- Often used to schedule power enrichment.
- Compression ignition engines (Diesels) shall support this parameter using fuel flow in place of airflow.

Power: calculation

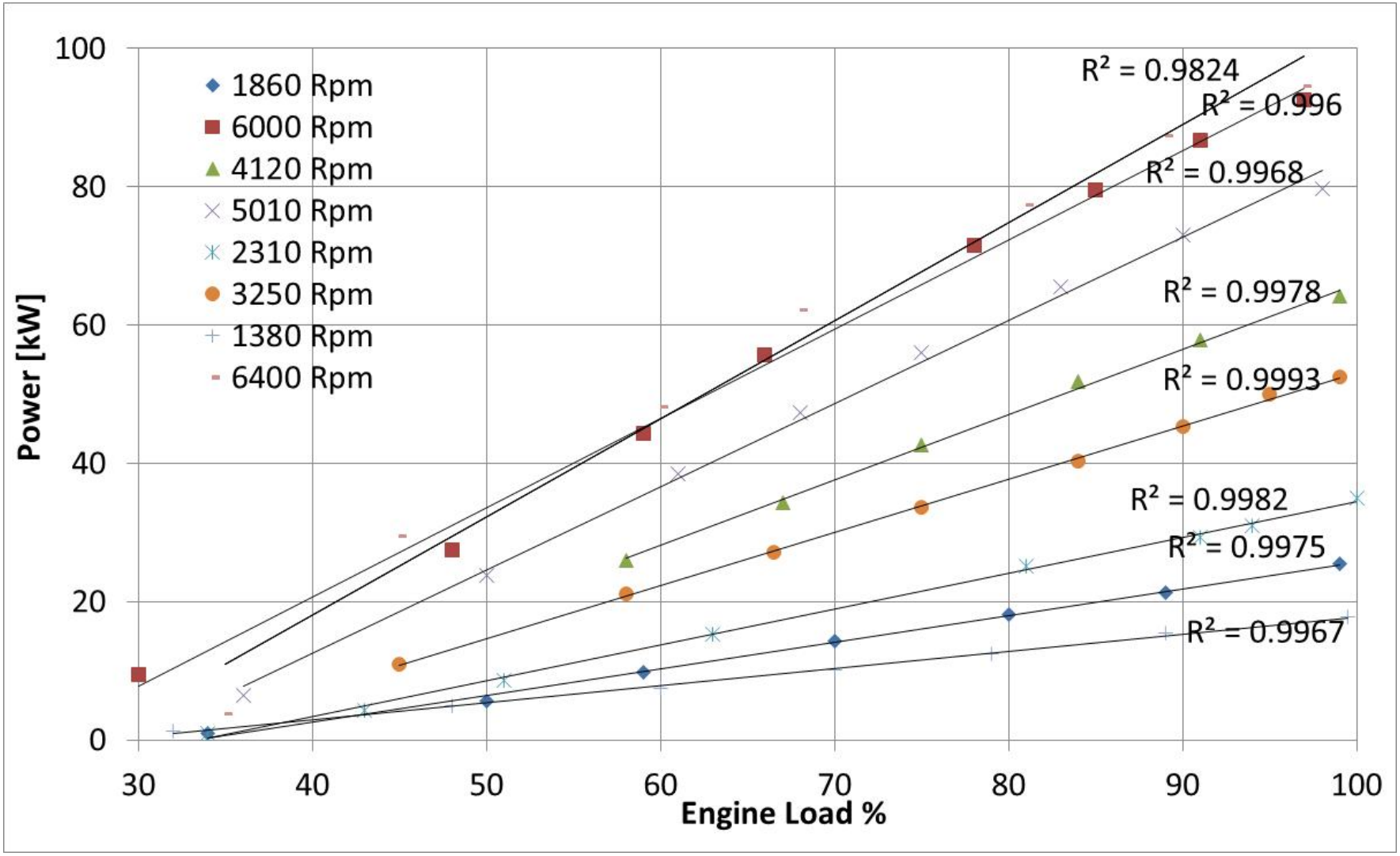
- Linearity,for each Rpm between Power and
  - engine Load (for Spark Ignition vehicles) or
  - Engine Load*Intake Airflow (for Diesel)
- Two curves needed: WOT curve and at idle (P=0)

Power: correlation for Diesel Vehicles



Fiat Bravo diesel 1.6 Multijet

Power: correlation for Spark Ignition Vehicles



Consumption: Formulation

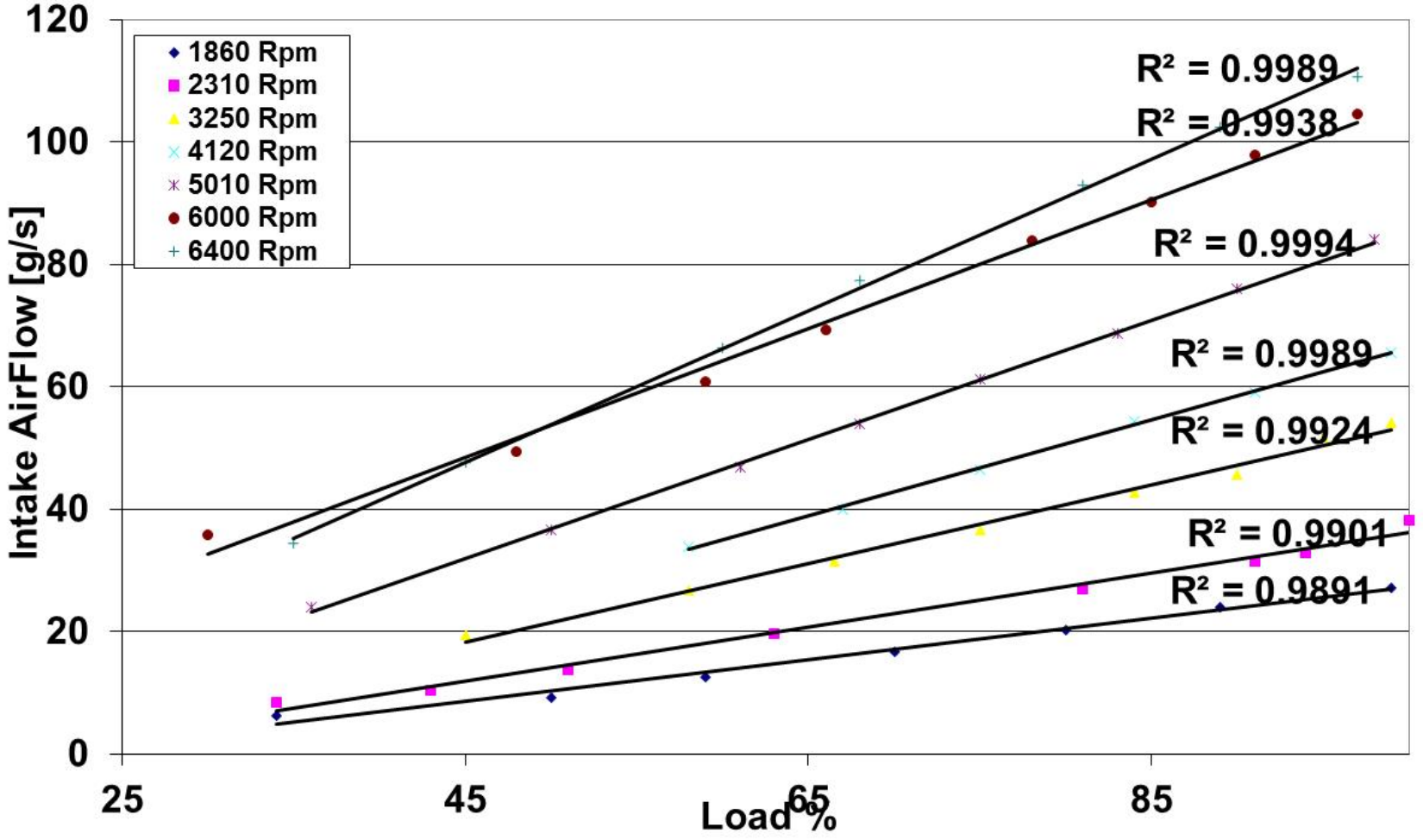
- Calculated directly from PID or
- Calculated by:
  - Airflow
    - Read from OBD
    - Calculated
  - Air/Fuel Ratio
    - Read from OBD
    - Calculated

Intake Airflow: Calculation (Spark ignition vehicles)

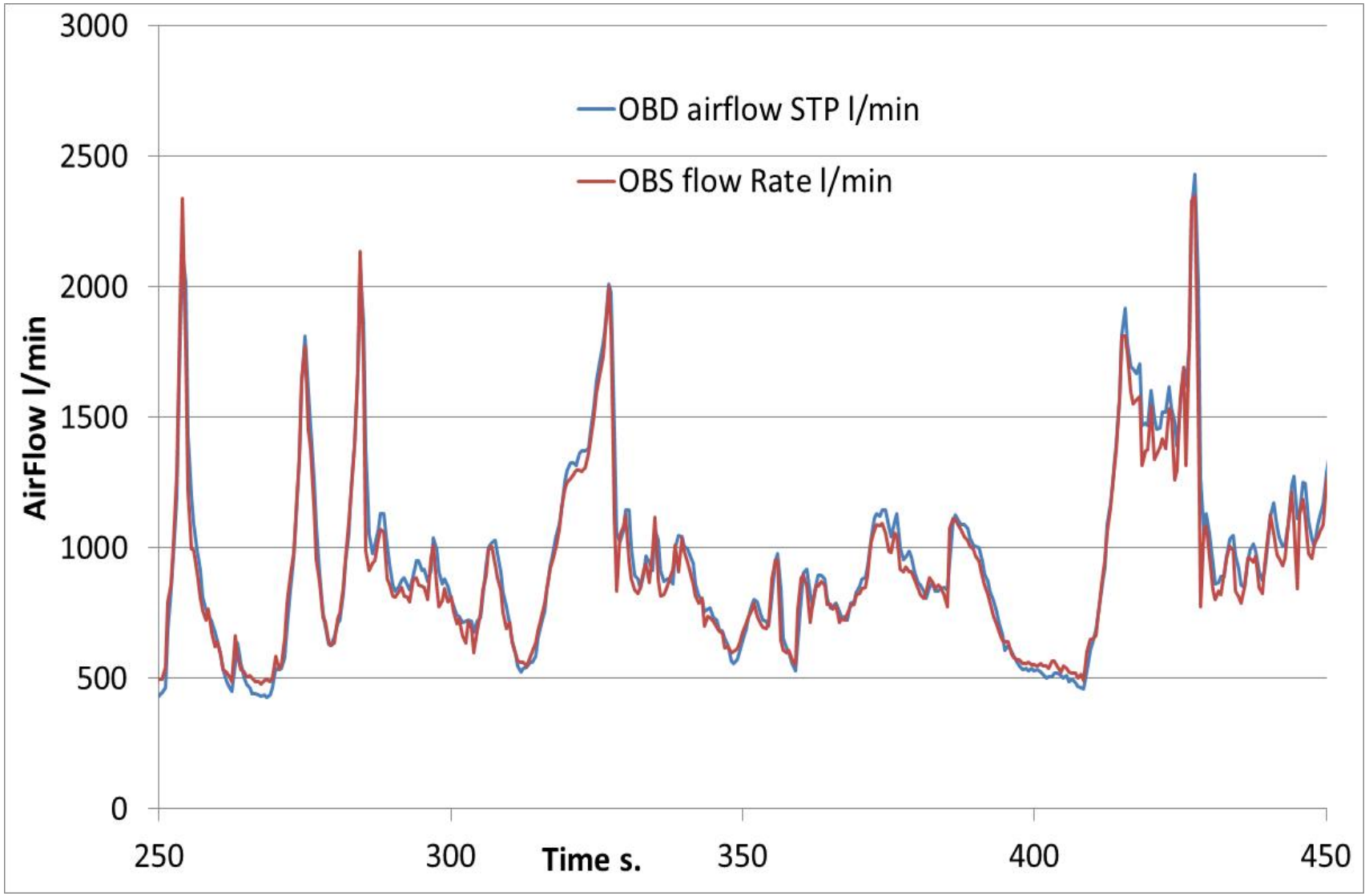
- Linearity correlation between airflow and engine load (or engine Load*airflow for diesel):
  - Maximum and minimum values are measured (at full load and idle) for each rpm
  - linear interpolation at fixed Rpm between the extreme points

$$AirFlow_{actual} = AirFlow_{idle} + \frac{\left(AirFlow_{WOT} - AirFlow_{idle}\right)}{\left(Load_{WOT} - Load_{idle}\right)} \cdot \left(Load_{actual} - Load_{idle}\right)$$

Intake Airflow: Correlation (Honda Civic 2.0 SI)



Intake airflow calculation accuracy

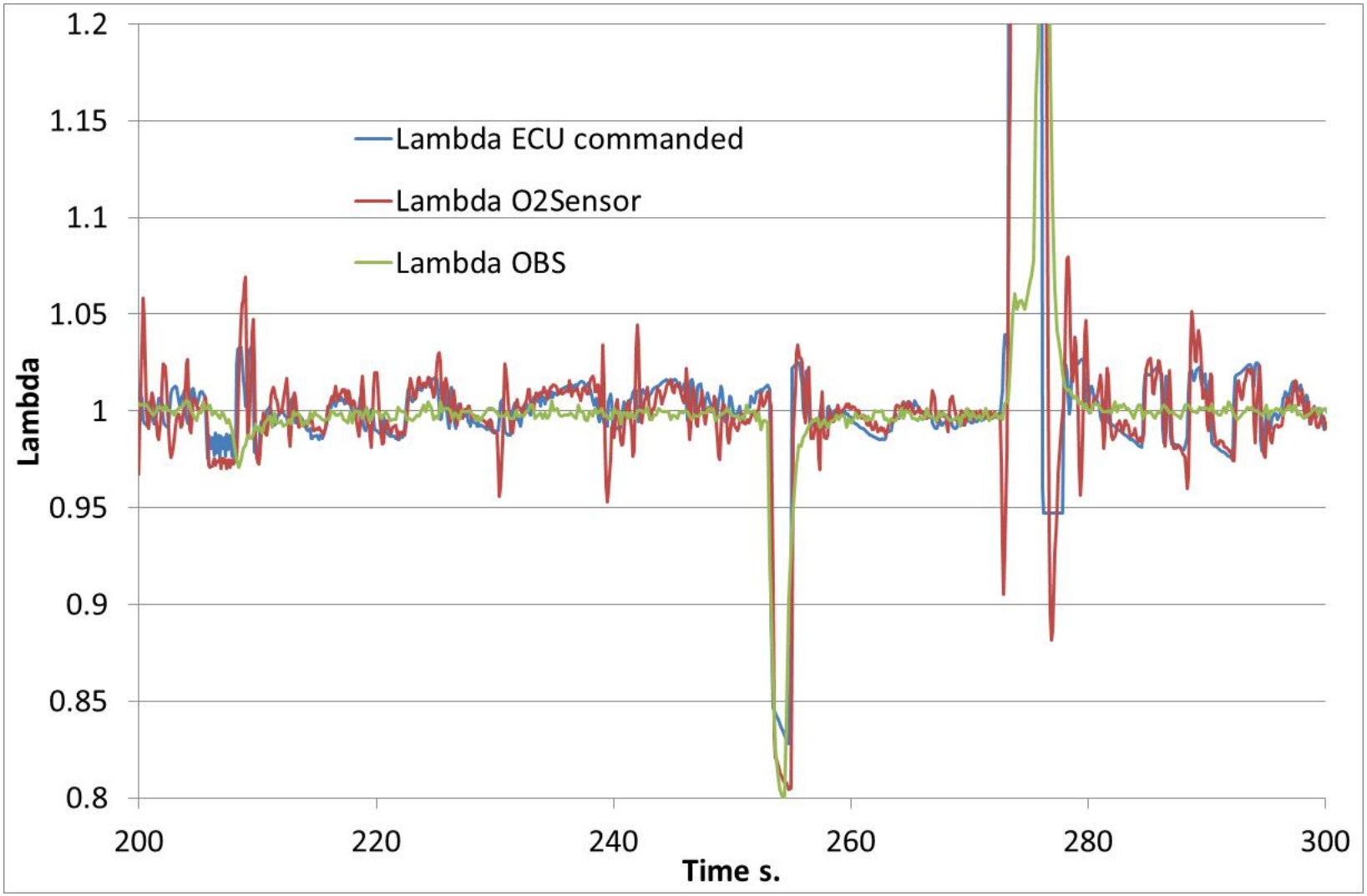


Air/fuel ratio for spark ignition vehicles

- Measured by OBD or
- Calculated:
  - Full load: $\lambda=\lambda(rpm)$
  - Cut-off: $\lambda=\lambda_{max}$ ($\sim\infty$)
  - Partial Loads: stoichiometric (~1)

    (with fuel enrichment with accelerator pedal gradients).

Lambda measured (Honda Civic Hybrid)

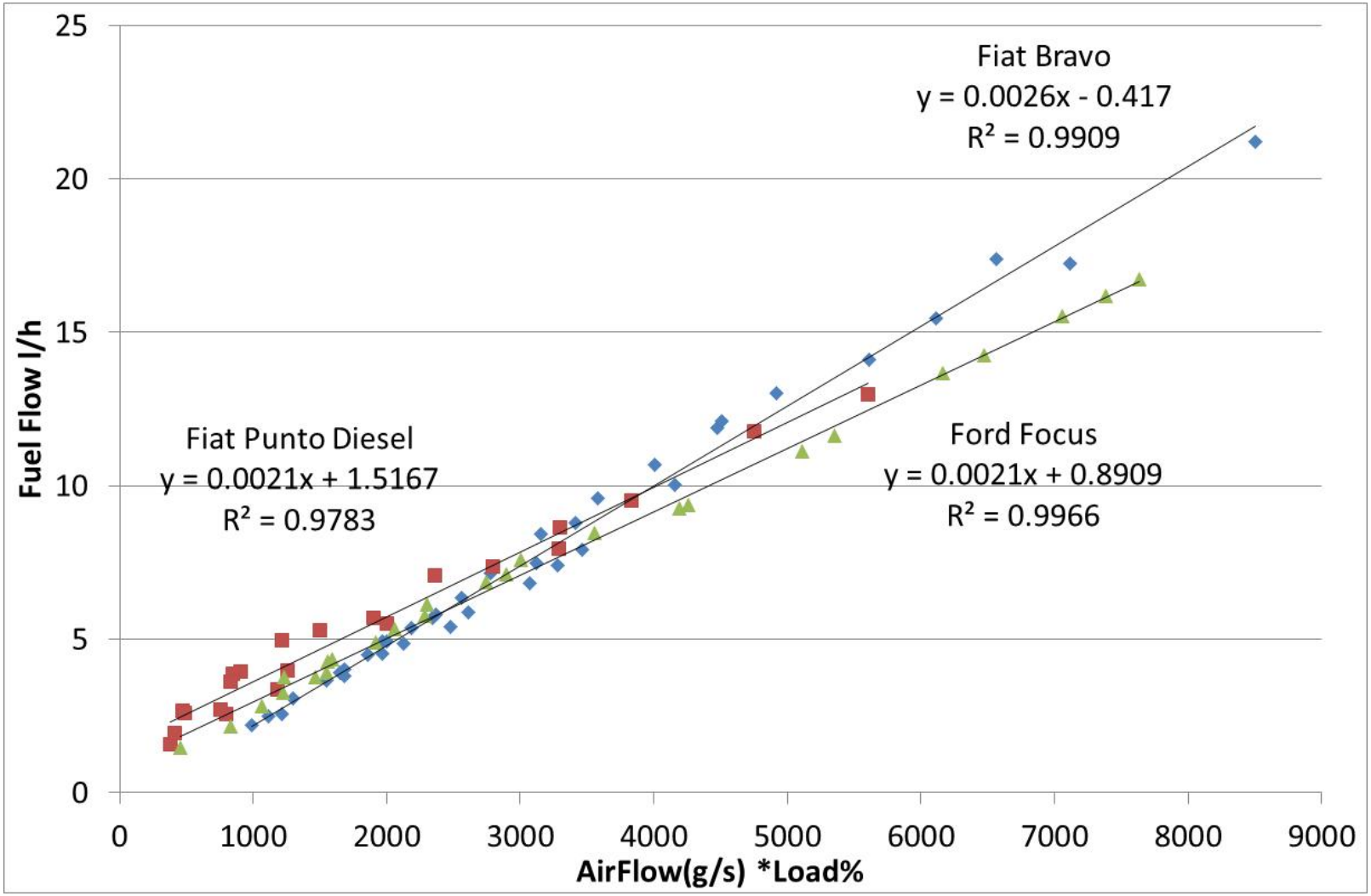


Consumption: Diesel vehicles

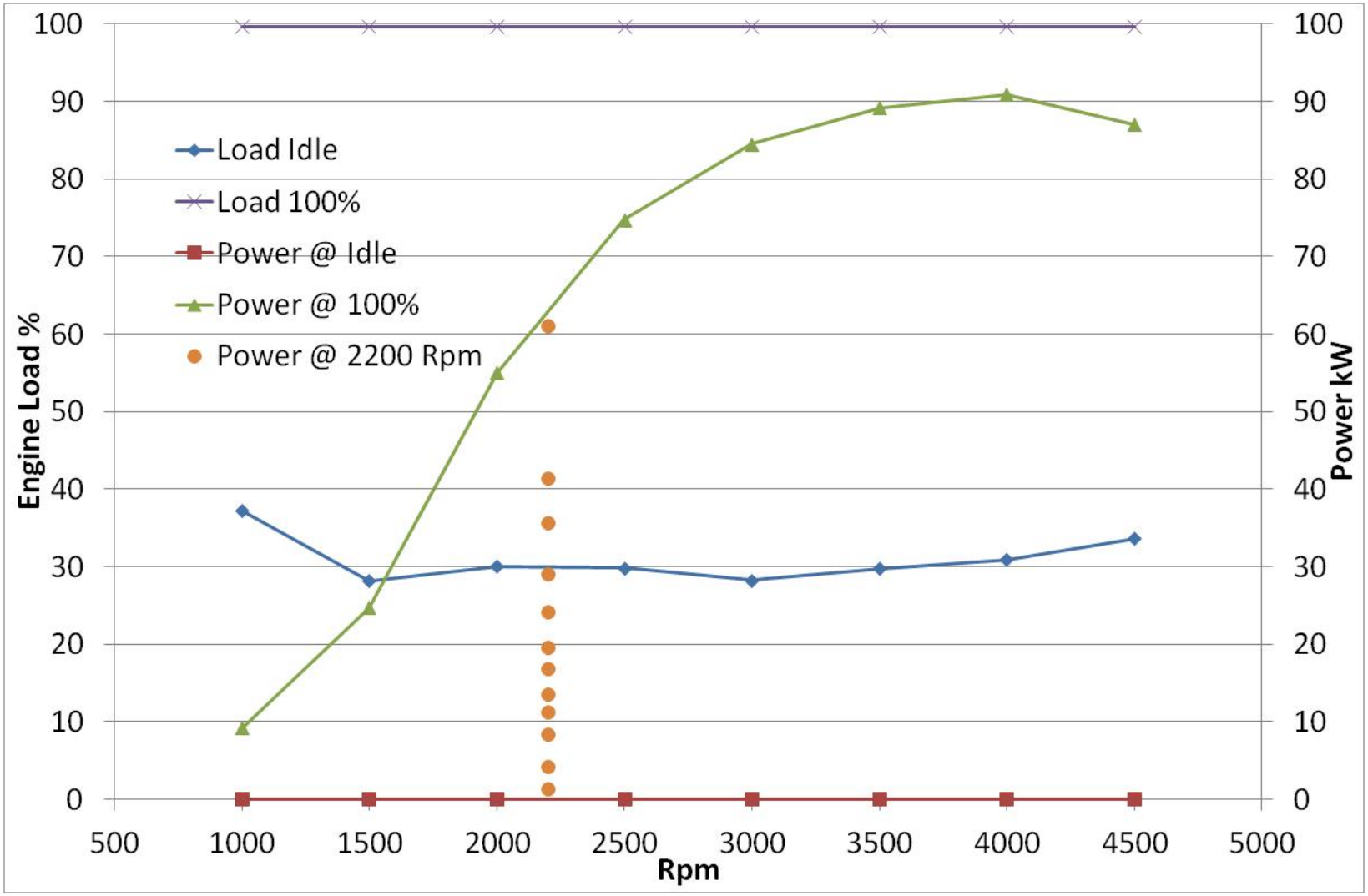
- Variable with:
  - engine load
  - Intake airflow

$$FuelFlow\left(l/h\right) = a \cdot \left(Airflow \cdot Load\right) + b$$

Consumption: Correlation (Diesel)



Calibration procedure



Consumption: Diesel Vehicles

Vehicle	Sensors used	Measurement System	Error %
Fiat Punto Diesel	Fiat Protocol	OBS	0.71
	AirFlow	OBS	0.06
Fiat 500	Fiat Protocol	CVS	3.184
		AMA	3.07
Ford Focus	Airflow	OBS	3.25
Fiat Bravo	Airflow	OBS	2.93

Consumption: Spark Ignition Vehicles

Vehicle	Sensors used	Measurement System	Error %
Alfa Romeo 147 1.6	Airflow	CVS	3.8
Honda Civic Hybrid	Airflow, AFR	CVS	4.00
Fiat 500 1.2	Fiat Protocol	OBS	2.37

Conclusions

- OBD data can be used as input to calculate instantaneous power and consumption of vehicles
- OBD sensors have been validated and have good accuracies to be used
- If not available on-board, airflow and air/fuel ratio can be calculated using rpm, engine Load and other parameters always available;
- Models have been validated on a dynamometer chassis with different vehicles and driving cycles.
- Consumption, for both Spark ignition an diesel Vehicles have errors always lower than 4% for the vehicles tested