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Avoiding another dieselgate:

Current Practices and Concepts for Future Proposals

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General Concepts

Traditional methods for emission control are based on:

- **Type Approval certification**, through standard driving cycle to assure proper technology;
- **In-Use Vehicles Annual Inspection** to check maintenance conditions

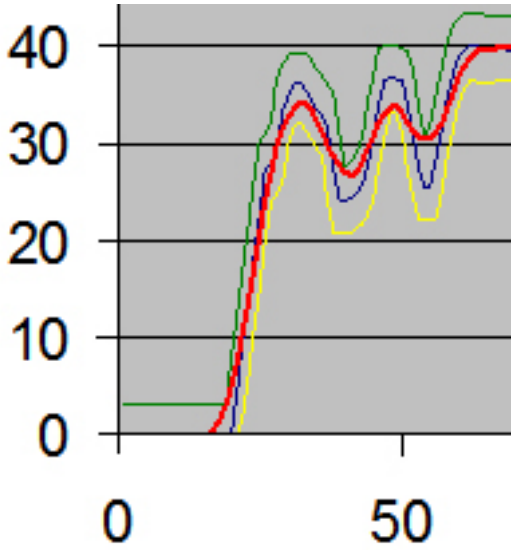
But this is not enough: Vehicle technology has been improved and new methods are necessary for

- Better control of **vehicle tuning** before dynamometer tests
- Better knowledge of **vehicle calibration strategies**
- Monitoring vehicle **response parameters**
- Vehicle **testing under normal driving**
- **Statistical correlations** to follow-up fleet in field, considering
  - Annual inspection;
  - Remote sensing and
  - Correlation of all results to type approval emission levels

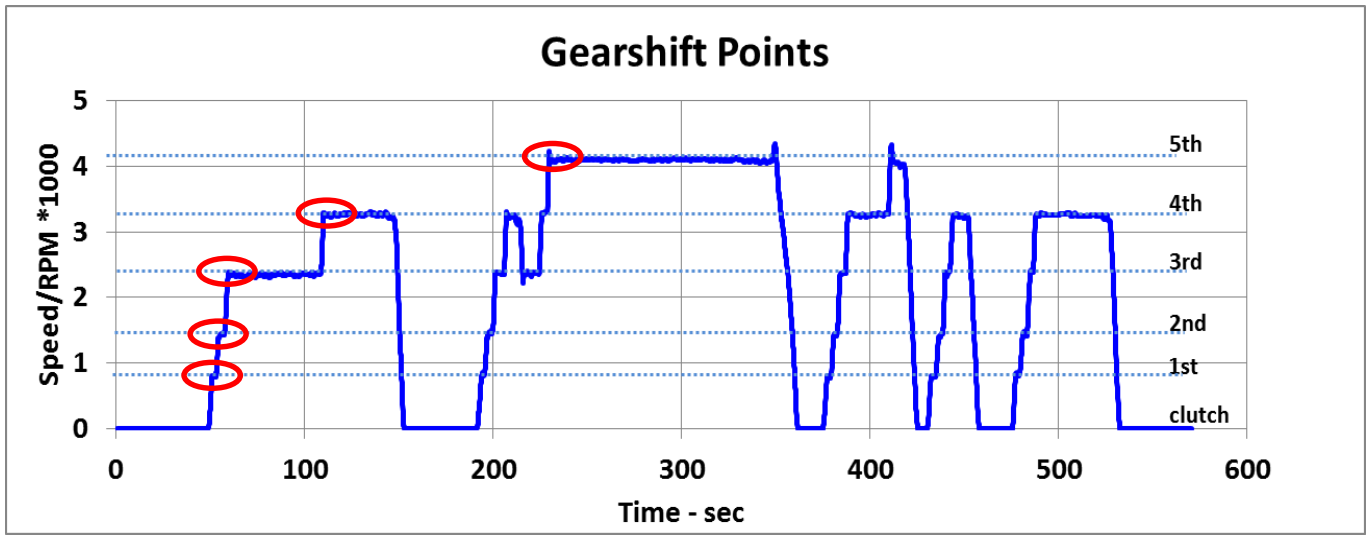
This may bring a Broad Evaluation of vehicle models conformity in real world

Necessary Test Procedures Improvements

Usual sources of systematic deviations:



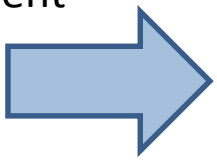
- **Vehicle driving** – needs to check tolerance parameters graphically:
  - Smoothing speed cycle using procedure tolerance (theoretically up to 12% less energy)
  - Reducing speed for gearshifts –
    - identifying #gear by controlling a new function: ➔ speed/rpm



Necessary Test Procedures Improvements

Usual sources of systematic deviations:

- **Coast down bias** using vehicle tuning tolerances:
  - Optimization of suspension tuning and wheel alignment
  - Avoiding braking before coasting
  - Tire pressure etc.



Lower f_0; f_1 and f_2

- **Electronic management "on board intelligence"**
  - Where adaptive calibration management **ends** ...
  - ... and the cycle recognition for defeat devices **starts** .
- **All these aspects are found in both Diesel and Otto cycle engines**

- **THEREFORE, WE NEED**

  NEW PARAMETERS SHALL BE MEASURED AND THEIR STRATEGIES COMPARED
  - Complementary **OBD/CAN parameters** to be monitored
  - **Statistical comparisons** between **driving cycle** and **on road trip**
  - **Real Driving Emission Test - RDE**
  - **Criteria for ROUTE VALIDATION as representative of official regulations**

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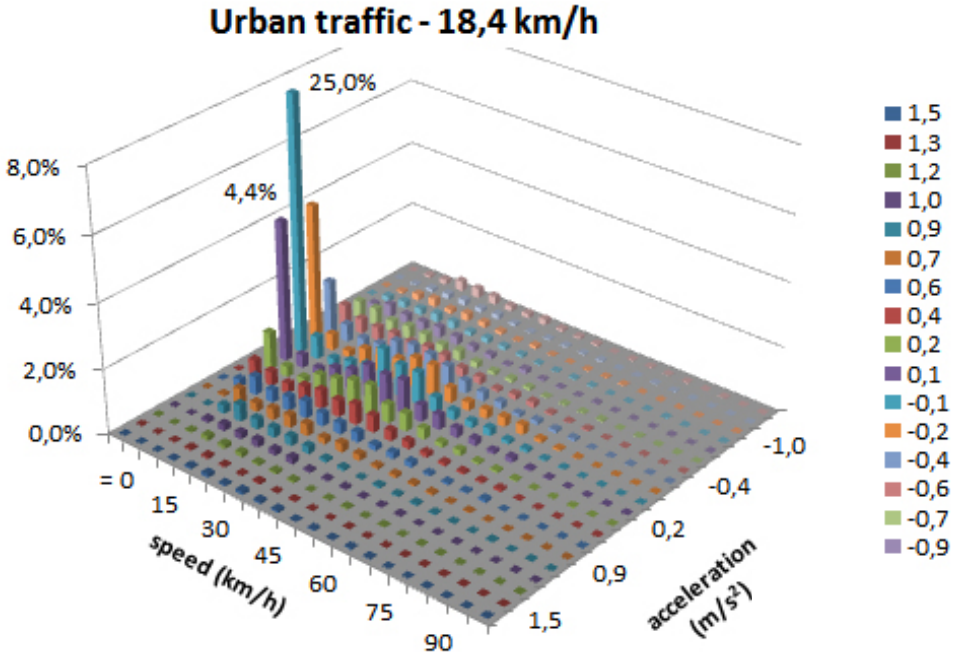
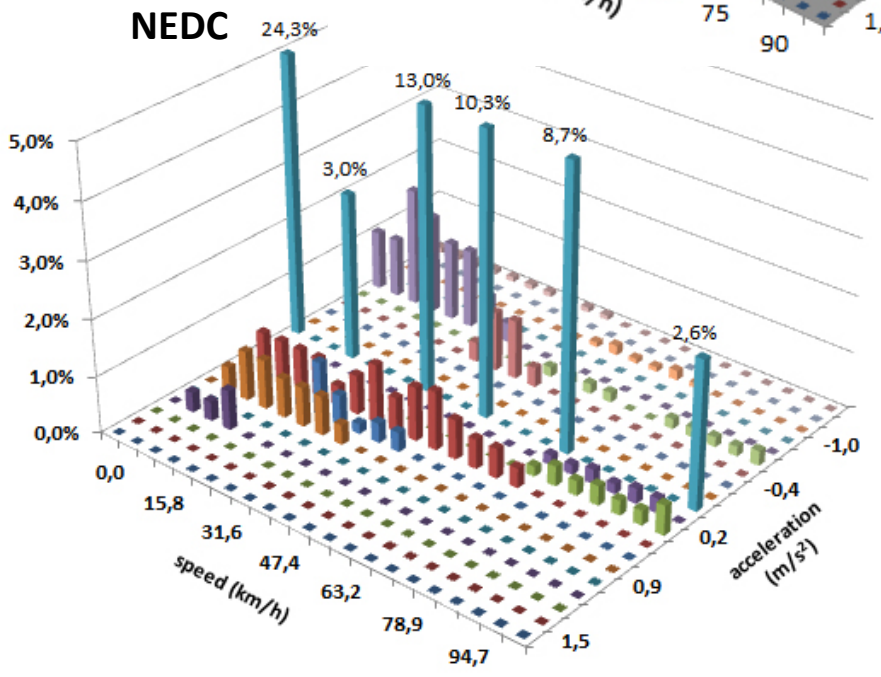
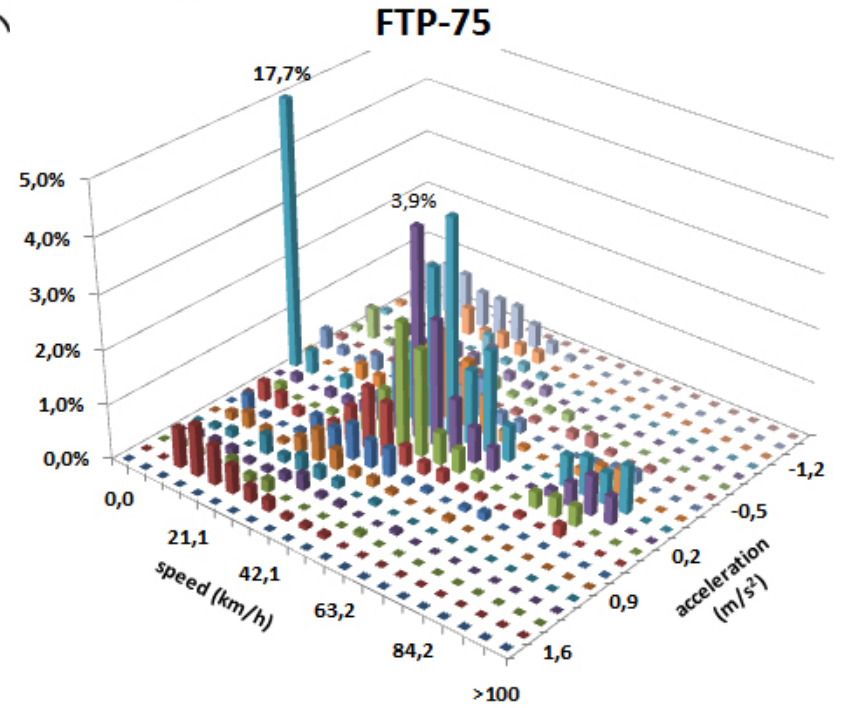
Route Validation as Cycle Representative



Hystograms of speed acceleration matrix





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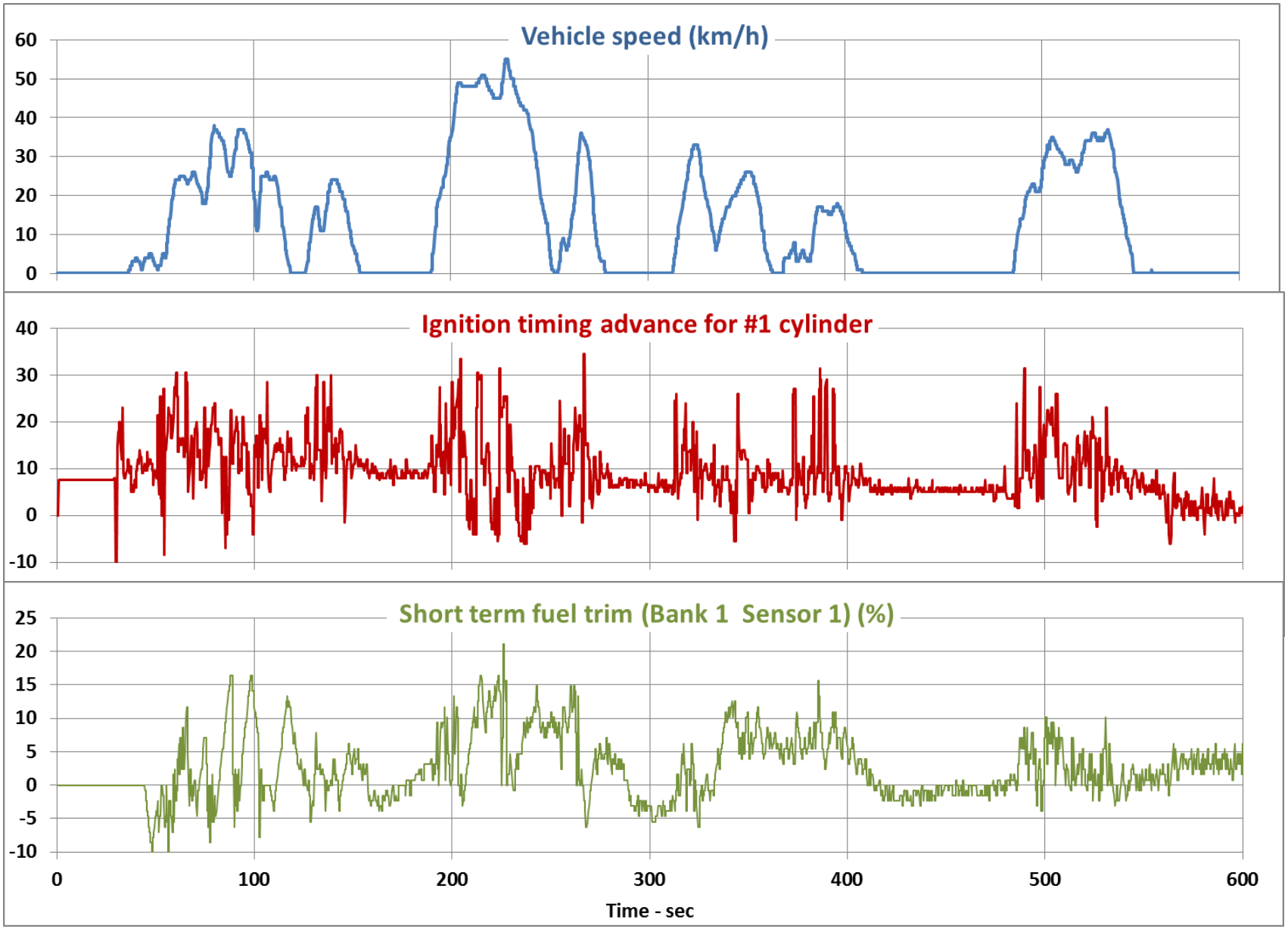
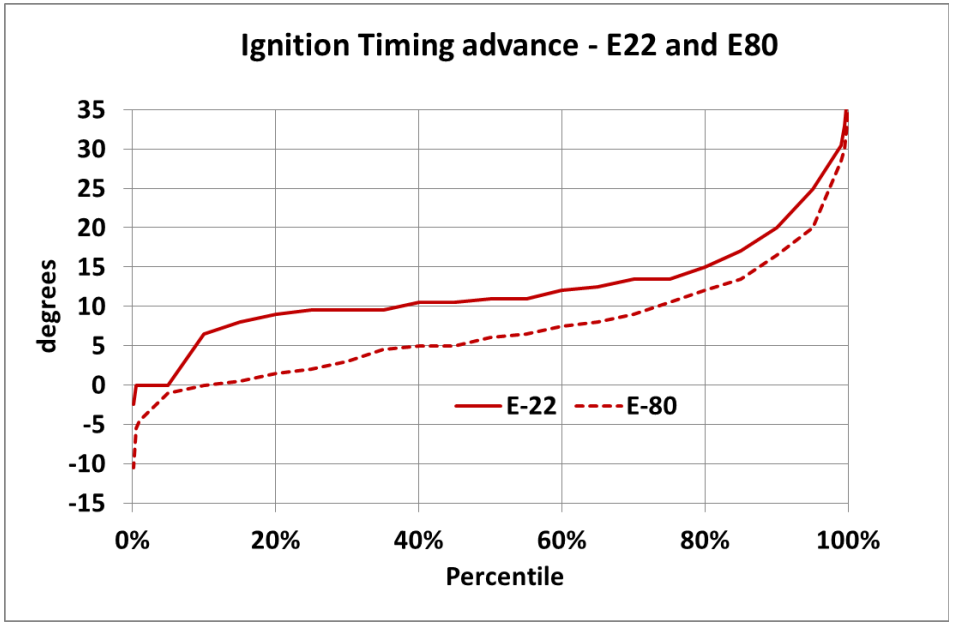
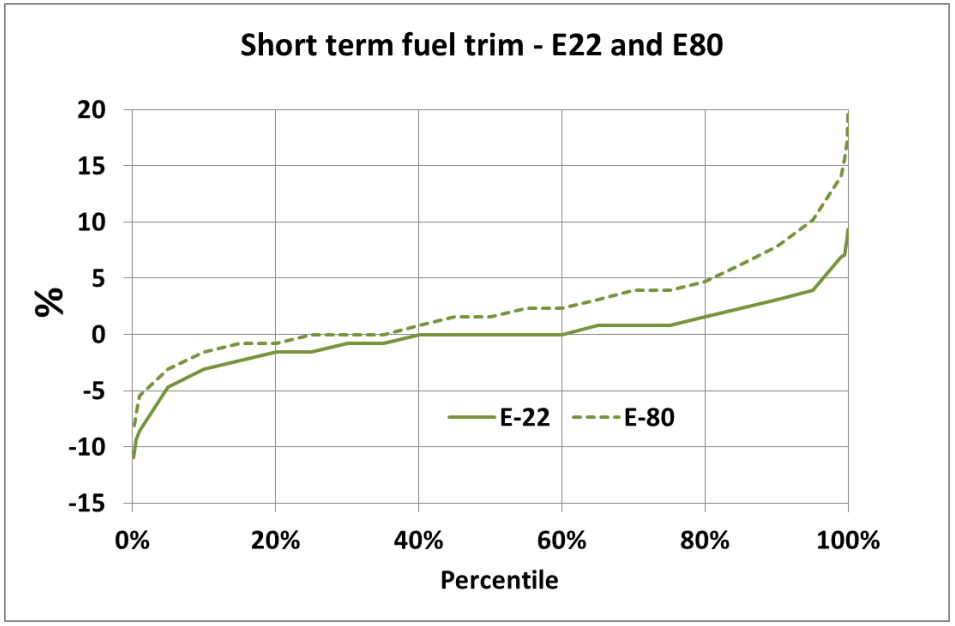
Download of OBD/CAN parameters



Parameters and Strategies Compared

Statistical evaluations may indicate tendencies under different fuels and driving patterns



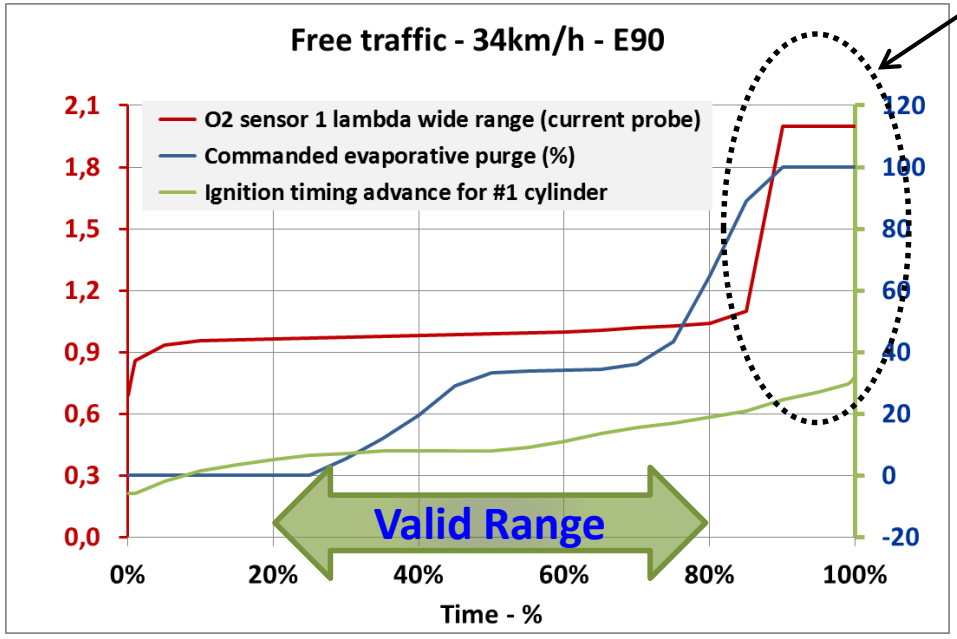


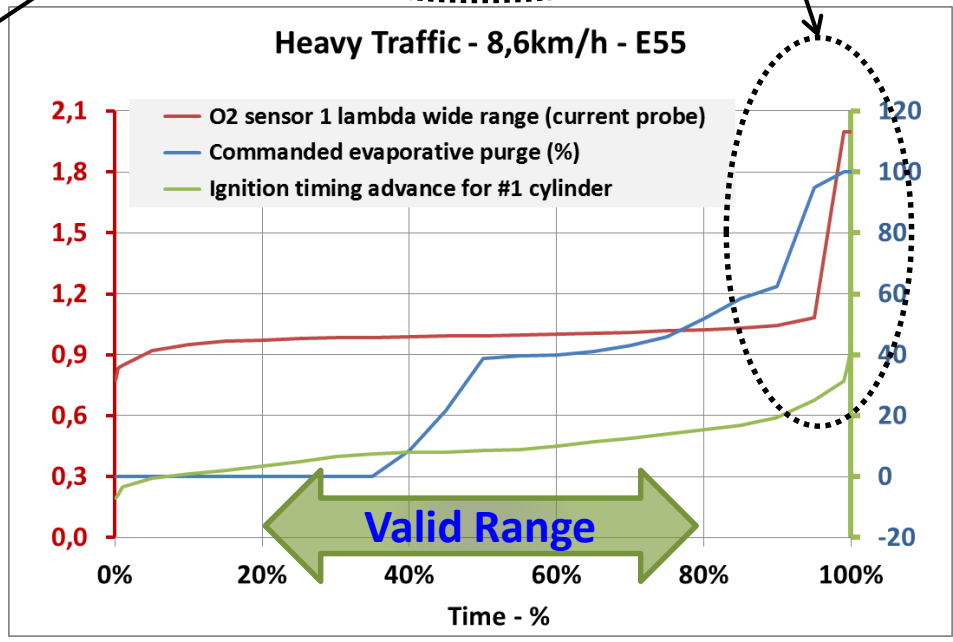
This flex fuel vehicle showed lower ignition timing with higher ethanol blends, which is not expected in optimized calibrations.

Parameters and Strategies Compared

Percentile curves allow for comparisons of parameters levels

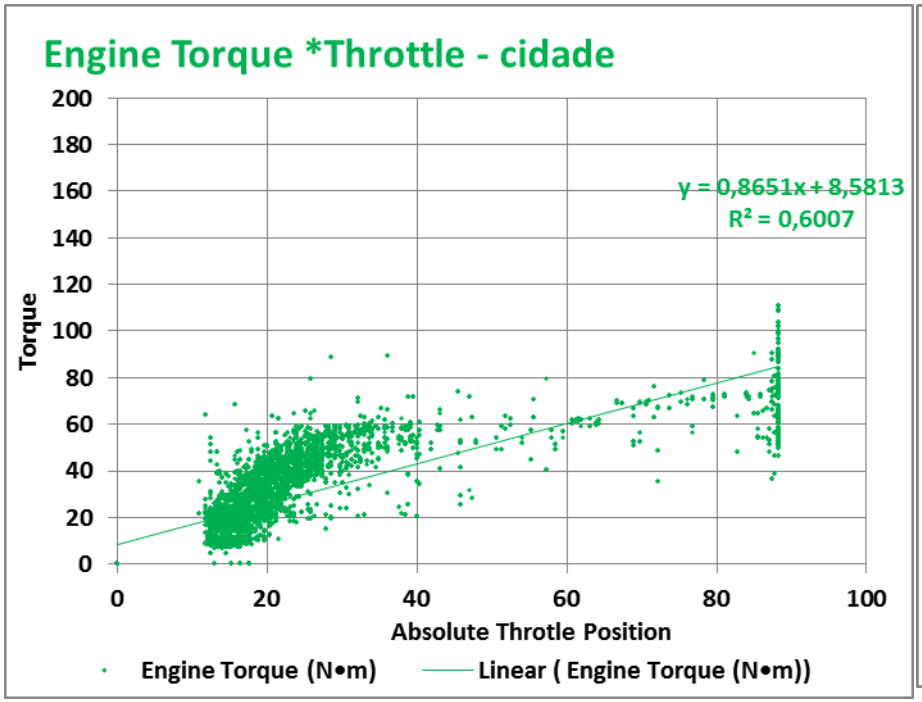
Traffic influences

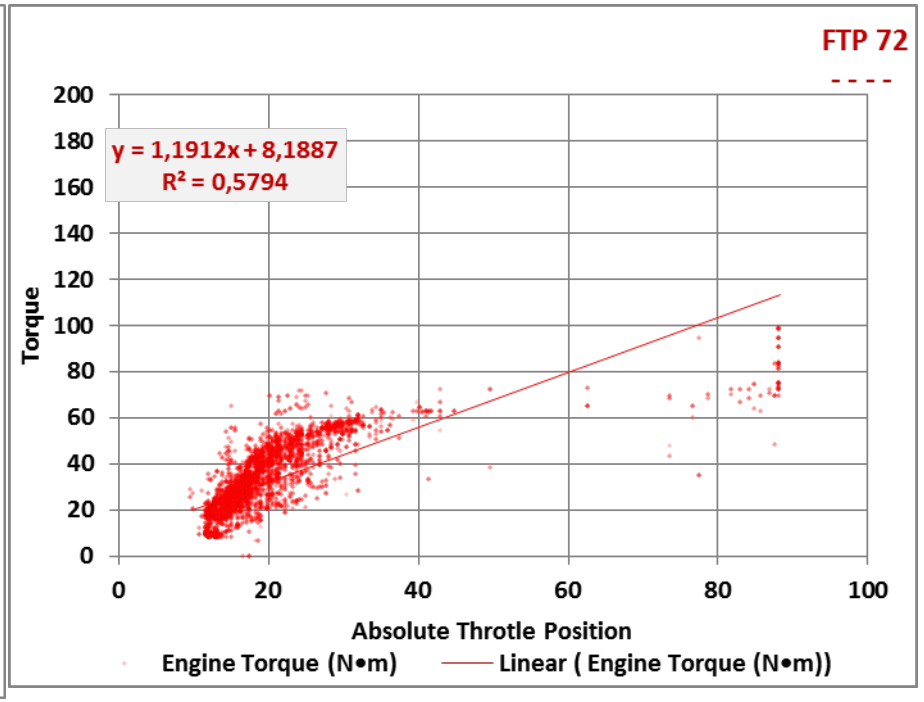




- Higher speeds present more time under deceleration (lambda >1)
- Canister purge have same behaviour in both traffic conditions
- This other flex fuel vehicle didn't show different timings for higher ethanol blends

Scatter Plots Compared





Regression lines may indicate different behavior in different trips

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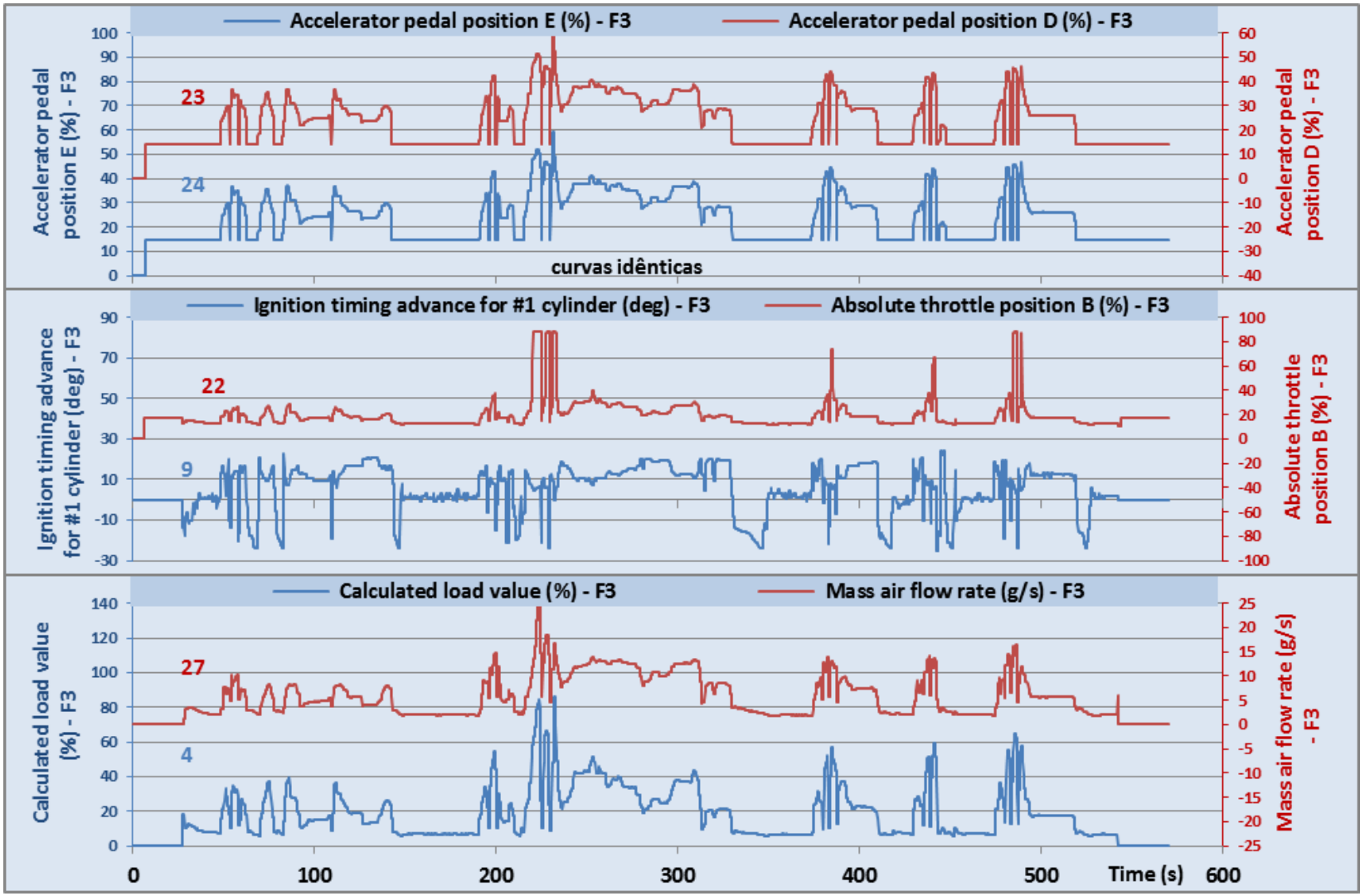
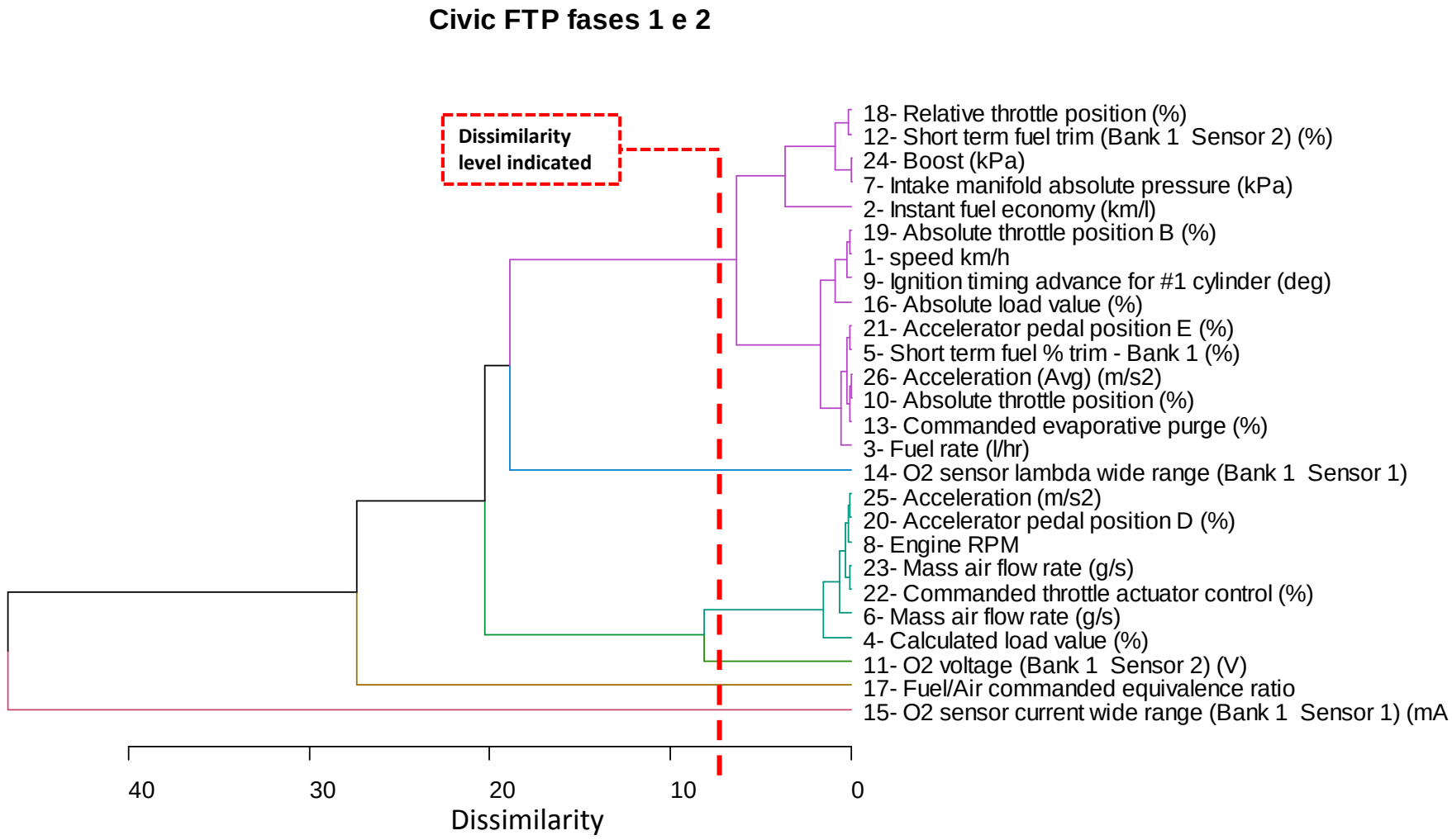
Spectra Analysis and Similarities

Decomposing time series into fundamental frequencies, the spectrum comparison shows the similarities in structural behaviour of vehicle software - Dendograms



Spectra Analysis and Dendograms



Dendograms allow for comparisons of structural behavior of vehicle software, preserving the time series characteristics.

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Conclusions

The statistical analyses are extensive and time consuming, but they have to be recognized by the regulations, to help identifying suspicious behaviors.

The statistical analysis can use the following tools:

- **route validation: comparison of 3D histogram of speed-acceleration matrix**
- **vehicle acceptance (defeat devices):**
  - **direct comparison of their time series curves**
  - **comparison of scatter-plots and their linear regressions**
  - **comparison of percentile curves**
  - **comparison of dendrograms corresponding to the trip and the driving cycle**
- **RDE measurements**
- **Correlations between I/M, remote sensing and type approval levels also help to identify models non conformities and poor durability tendencies**

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Thank you !

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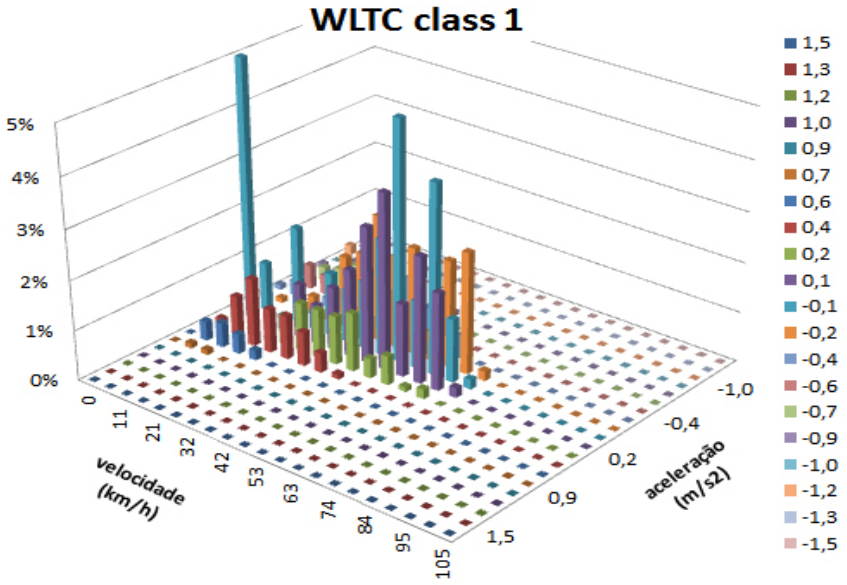
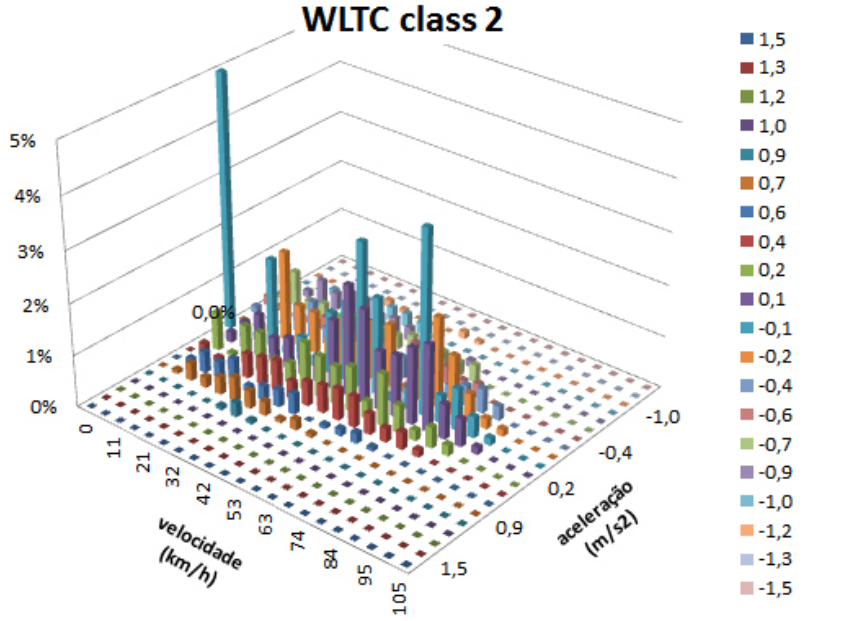
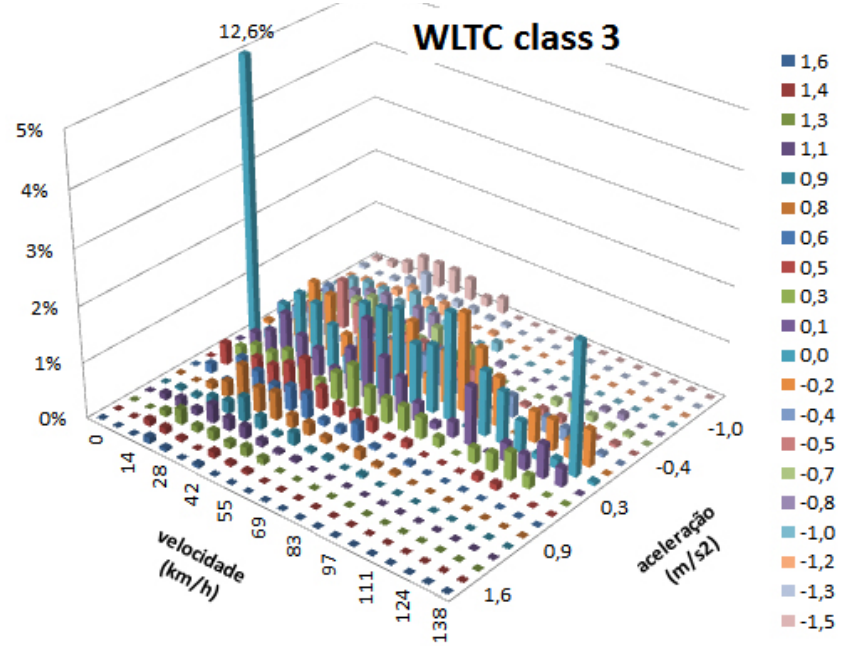
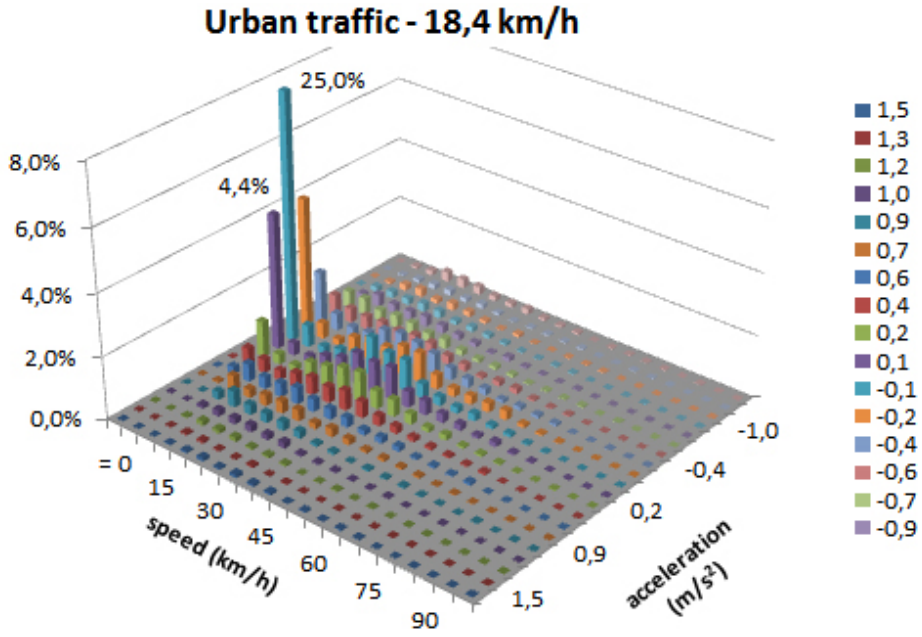
Backup









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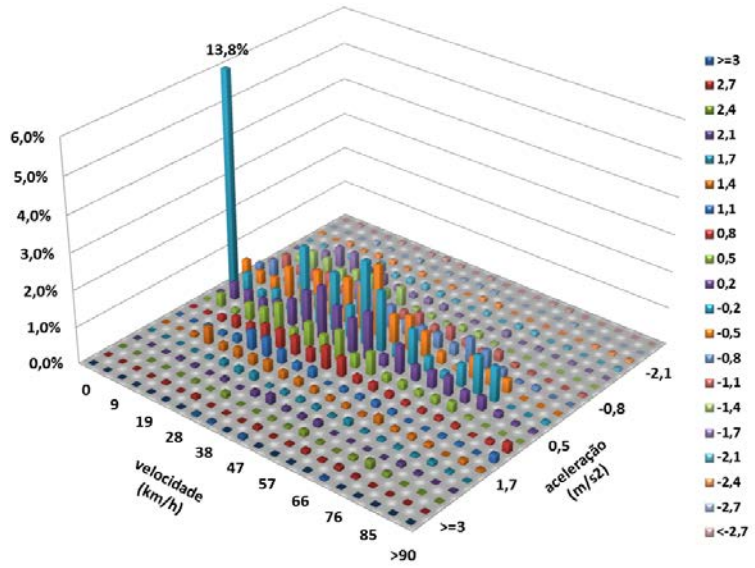
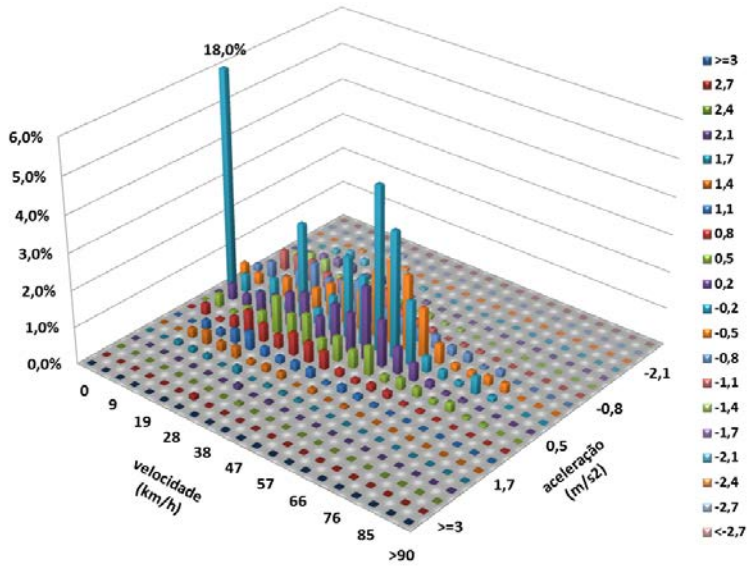
Backup

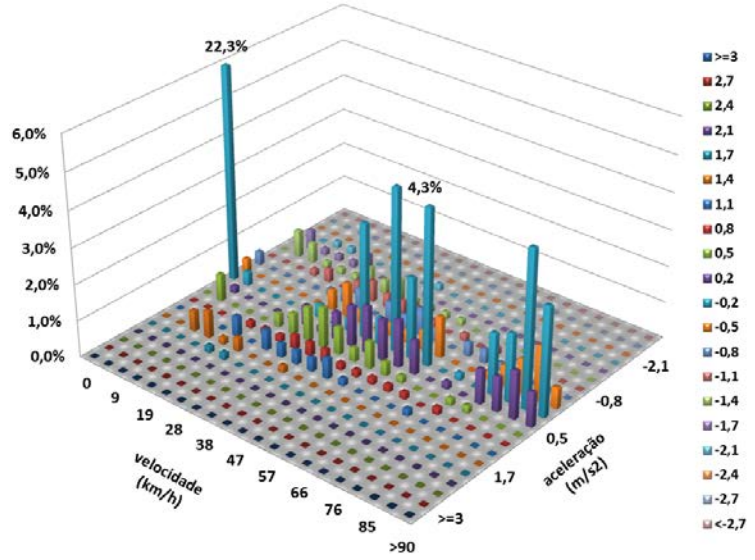
Ciclo rua agressivo UP!



Ciclo rua normal UP!



FTP 75 Fase 1



FTP 75 Fase 2