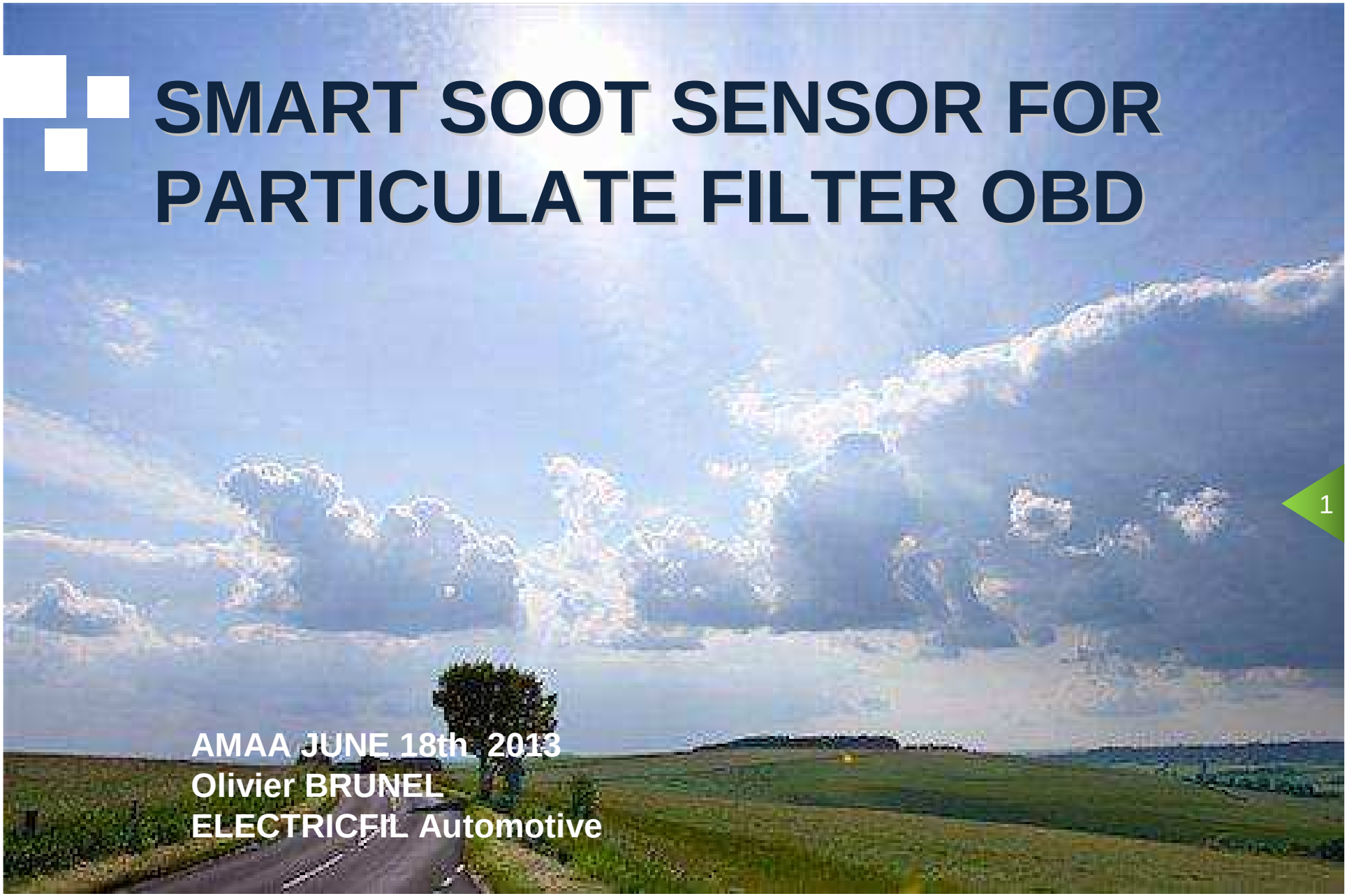
SMART SOOT SENSOR FOR PARTICULATE FILTER OBD



AMAA JUNE 18th 2013
Olivier BRUNEL
ELECTRICFIL Automotive

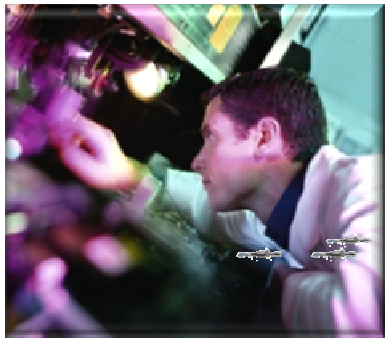
CONTENTS

1 Introduction

6 Conclusion

2 Challenges & Benchmarking

3 EFI Sensor Design

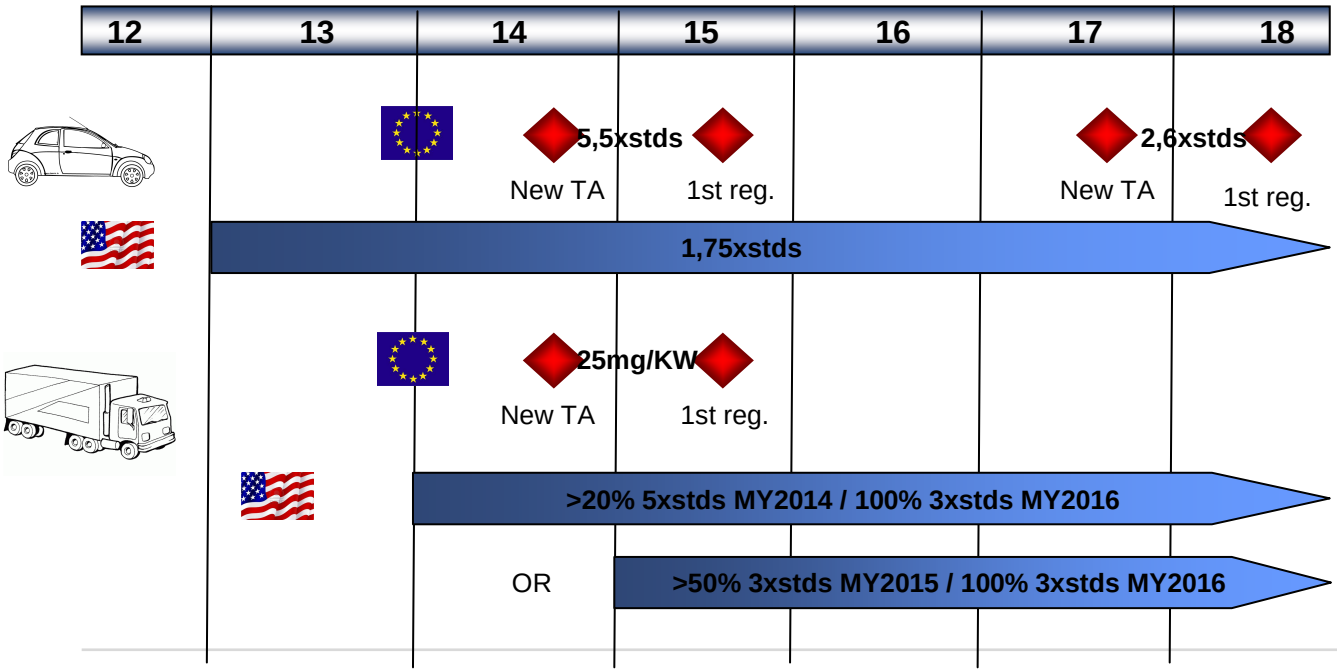


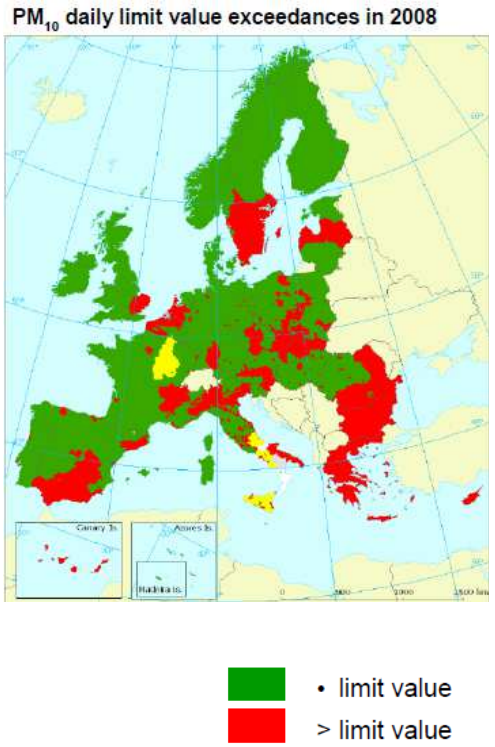
4 Simulation results

5 Experimental results

Particulate Filter OBD Background

- Particulate emission is a worldwide concern
- Standard will require Particulate Filter OBD





Source EEA Copenhagen 2010

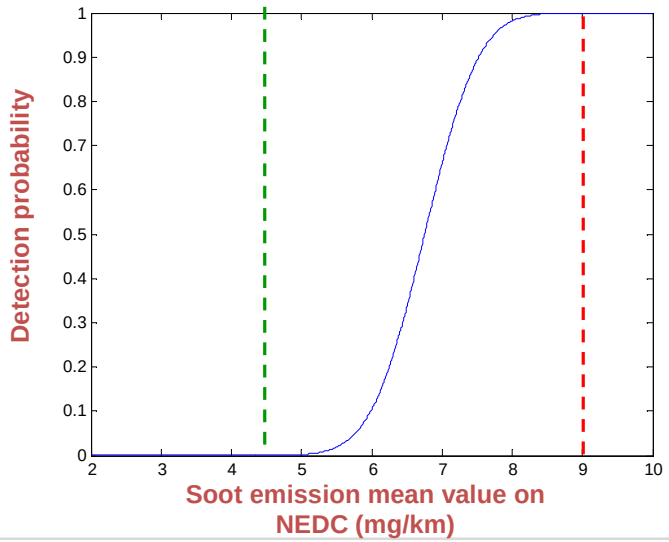
Particulate Filter OBD Background

- Today DPF leakage detection is performed through differential pressure sensor. This solution does not meet future standard due to poor sensitivity.

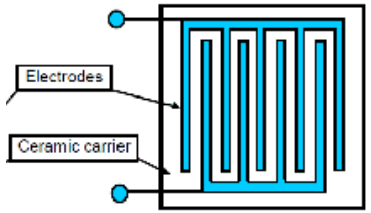
- There is a need for embedded DPF leakage sensor
  - Downstream DPF
  - High sensitivity

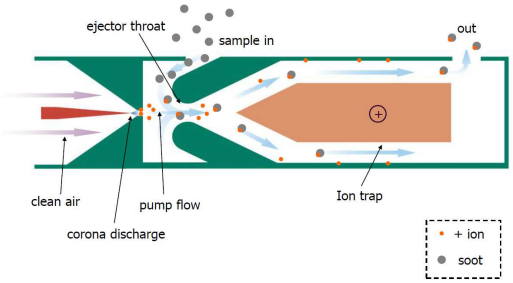
Particulate Filter OBD Challenges

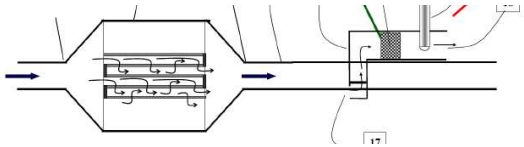
- Robust to exhaust line environment
- No cross sensitivities (NH_3,HC,H_2S,SO_x,H_2O,NO_x…)
- OBD OTL detection
  - Certification cycles (NEDC, WHTC, EUDC, FTP…)
  - Real drive conditions
  - IUPR standard
  - False detection and non detection performances
- Self sensor OBD

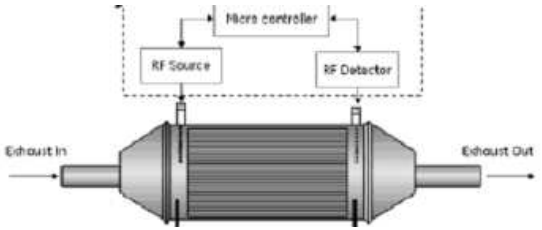


- Resistive technology
  - Cumulative, soot impedance
- Particle charge
  - Real time, soot particle charges
- Detection filter
  - Cumulative, temperature or pressure change
- Radio frequency
  - Real time, radio frequency transfer function

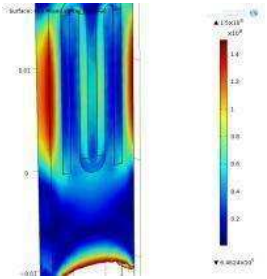




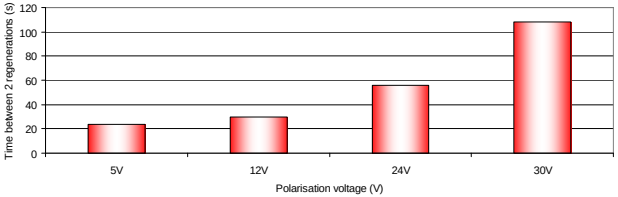




EFI Sensor key features - Hardware

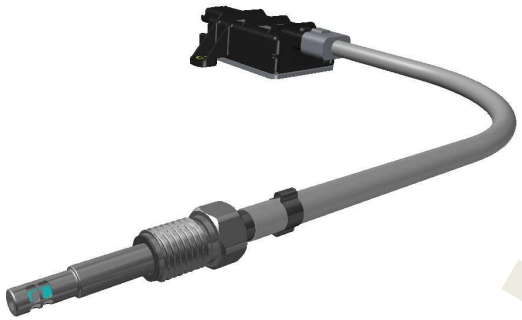


Optimized heater
- Von Mises stress
- Thermal homogeneity
- heating efficiency

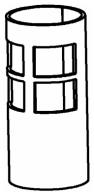


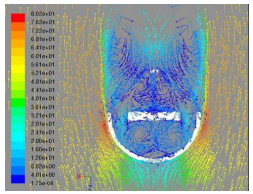
Electronic boost
- higher sensitivity
- response time

SCU

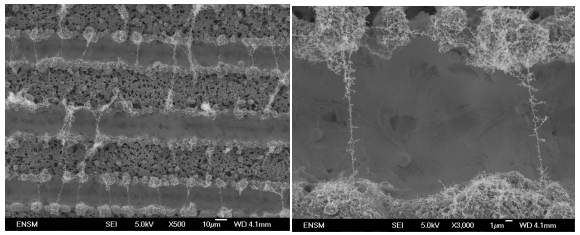


SENSING





Optimized tip
- heat shield
- passband filter



High resolution pattern
- higher sensitivity

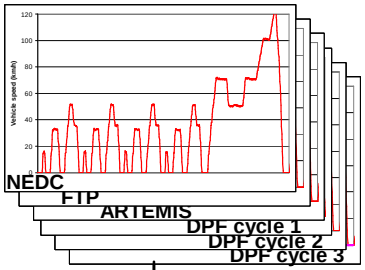
PM Sensor Development and Simulation for Diesel Particulate Filter On Board Diagnostic
CLEERS Workshop 2013
Dearborn, April 10-12th, 2013

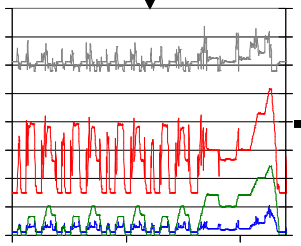
EFI Sensor key features - Software

- State of the art algorithm are model based
- EFI/IFPEN recommends a non model based approach
  - Classification method in a mapped calibrated xD space
- Referential: ECU + sensor signal
- Benefit:
  - No model of engine out soot, DPF and sensor,
    - Reduced development time and cost
  - Less tolerance errors
  - Quicker diagnostic time

Patent deposit number 13/00.184.

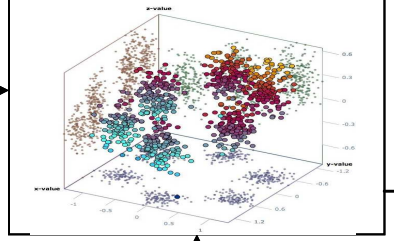
Simulation results



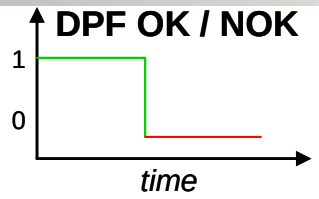


Simulated Vehicle data

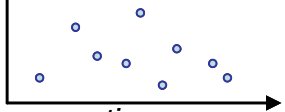
Diagnostic Strategy

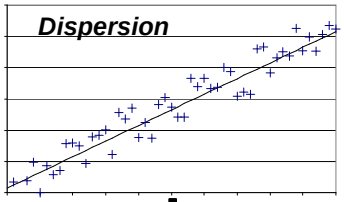


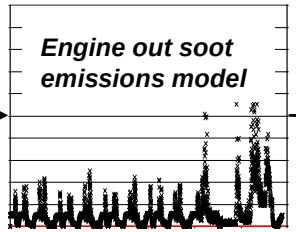
DPF OK / NOK

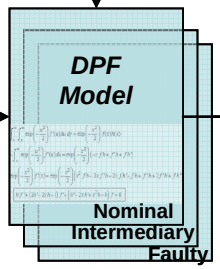


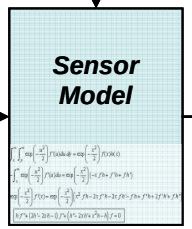
Leakage Etstimation



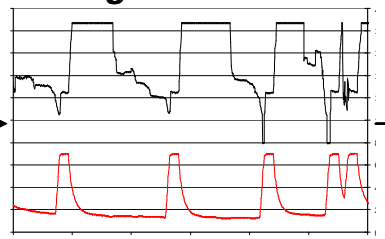


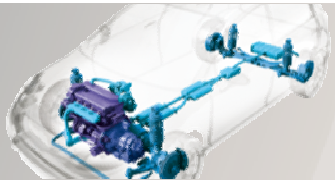






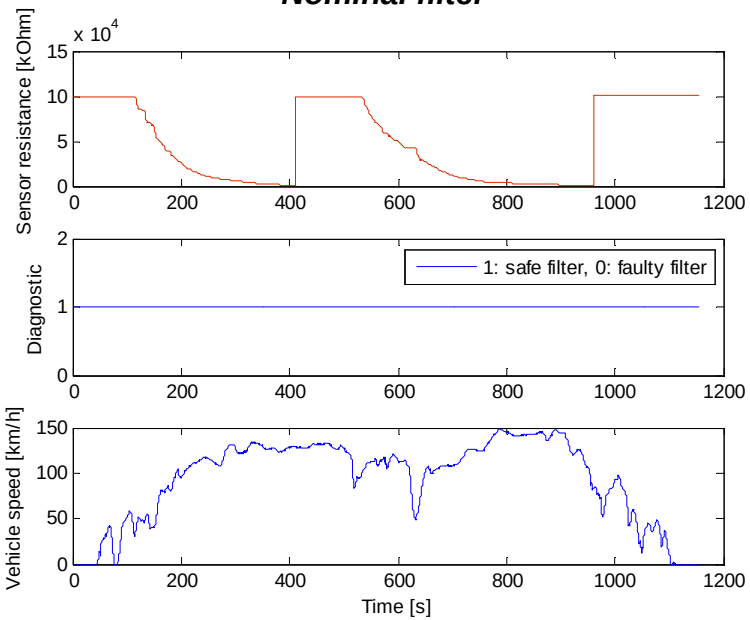
Simulated Sensor signal 2



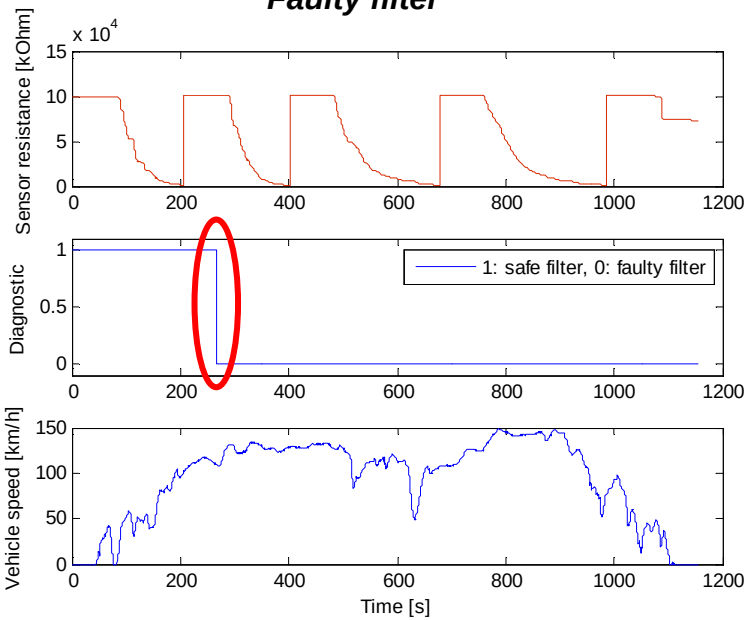


- Artemis Motorway cycle
  - Sensor signal
  - Strategy Diagnostic

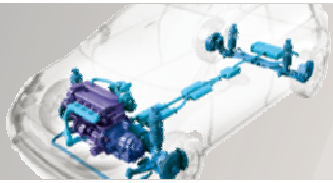
Nominal filter



Faulty filter



Simulation results

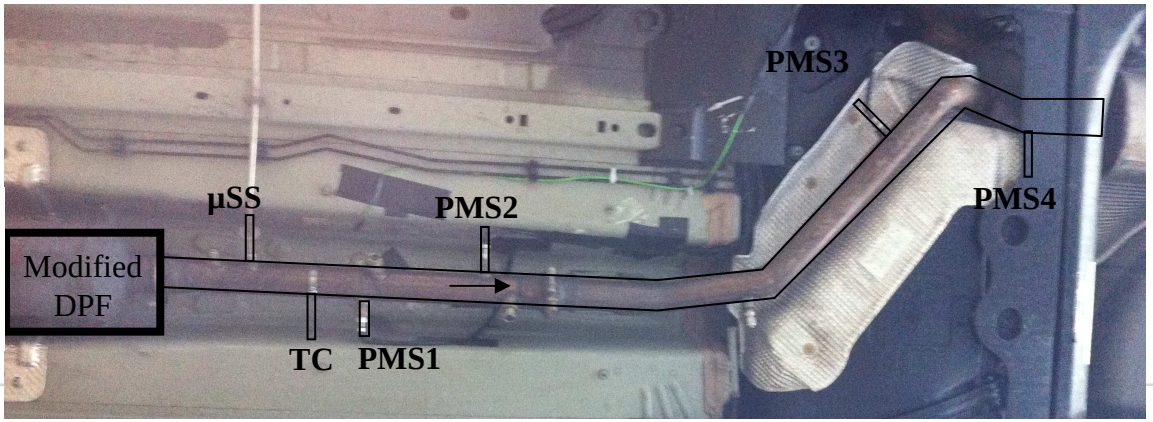


6 cycles 100K/runs	False alert rate (Nominal DPF) GOAL < 1 ppm	Non detection rate (Faulty DPF) GOAL < 100 ppm
Case 1 Soot dispersion 3 σ = 25 %	0	60 ppm
Case 2 Soot dispersion 3 σ = 35 %	0	75 ppm
Case 3 Soot dispersion 3 σ = 45 %	0	90 ppm

Experimental results – test set up

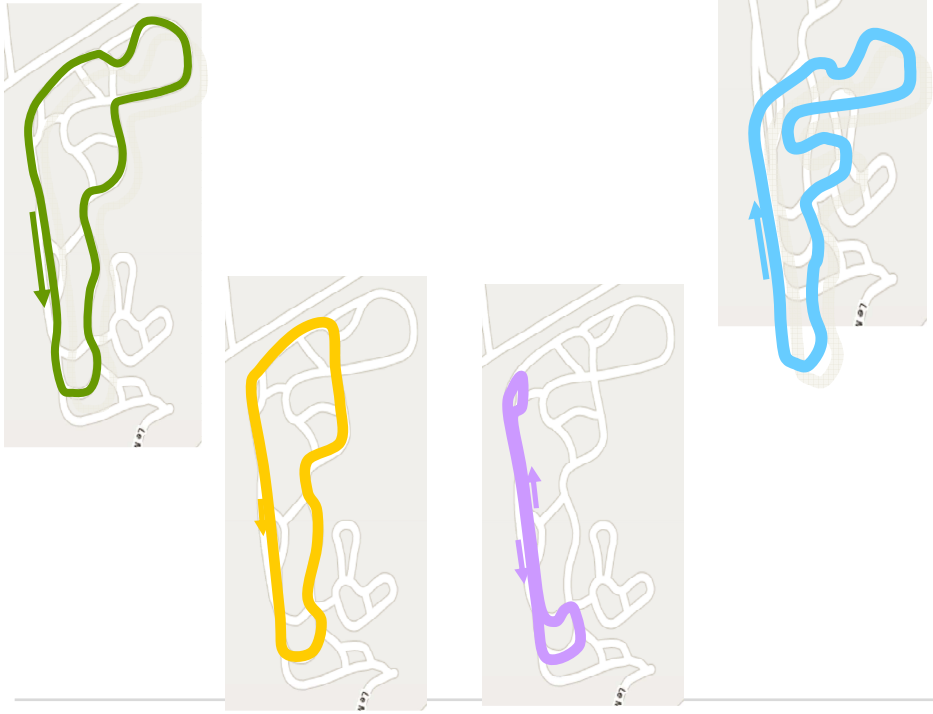
Test conditions:
C4 norme €4
Exxotest recording

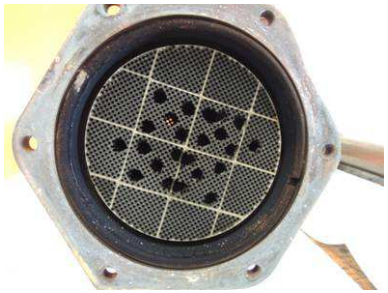
Protoype exhaust line in order to be instrumented (AVL 483 + Tc) and fit different faulty or not DPF



Calibration of the strategy took place 2 weeks in august 2012 with a

combination of several circuits with 2 filters



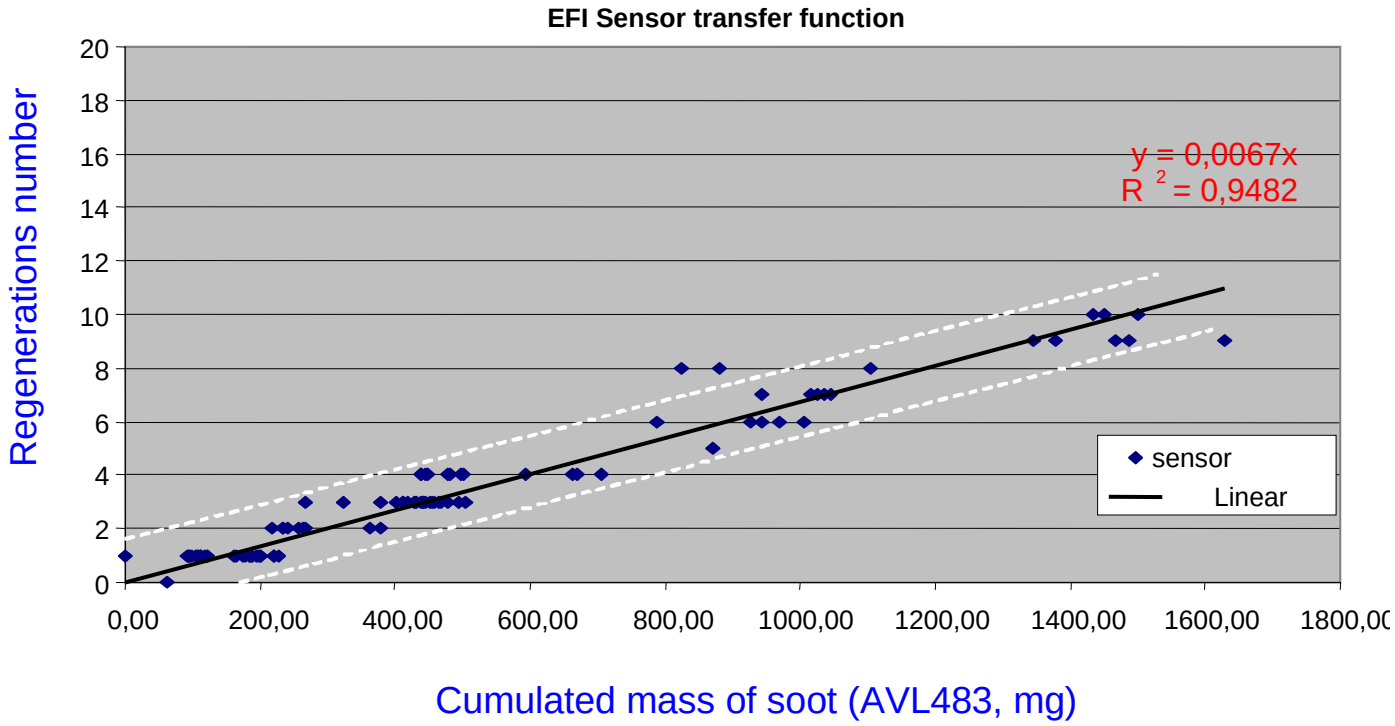


4,6mg/km
(NEDC)

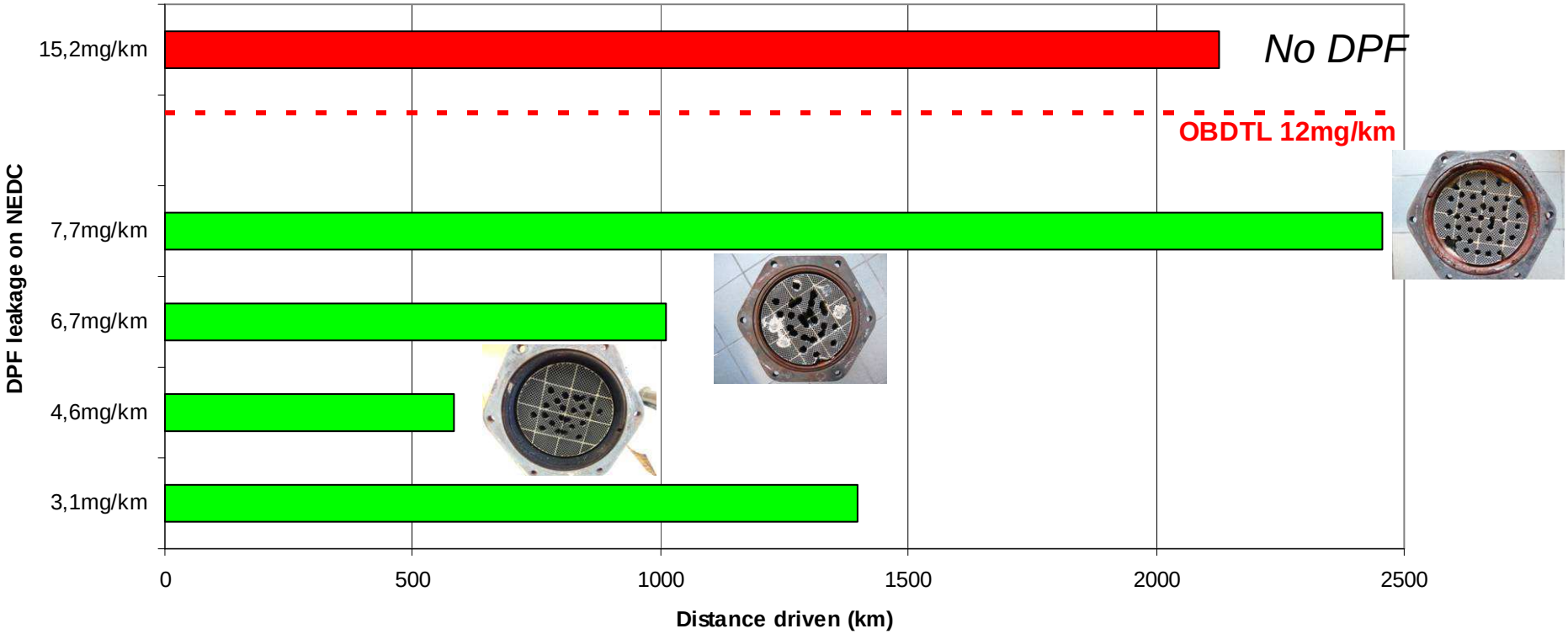
7,6mg/km
(NEDC)

96 runs
1015 km

Experimental results



Experimental results – test results



223 runs
6666 km
25s < Detection < 350s

Experimental results – test results

Number of regeneration events	FAP 3,1mg/km	DPF 7,7mg/km	No DPF
N =1	1	5,6%	0
N = 2	1	0,32%	0
N = 3	1	180ppm	0
N =4	1	10ppm	0

Conclusions

- A new approach for DPF OBD has been developped
  - Innovative sensing area, collecting tip and electronics
  - Non model base algorithm
- This approach has been validated on real driving conditions on a LV
- The high sensitivity of the sensor complies with the 12mg/km European OBD threshold limit (Euro 6.2 – 2017)
- Tests are ongoing to:
  - Assess durability and cross sensitivities
  - Evaluate DPF leakage value capability