BLACK SHEEP

DETECTING POLLUTING VEHICLES ON THE ROAD USING ROADSIDE PARTICLE MEASUREMENT

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Particulate Matter - Main Air Pollution Issue

World Health Organization: 4.2 million death globally every year caused by outdoor fine particulate matter pollution – PM$_{2.5}$

European Environment Agency: over 400,000 premature death in EU annually caused by PM$_{2.5}$ – mainly from transportation

Annual average concentrations of fine particles in air PM$_{2.5}$ in 2016

Source: World Health Organization
Despite Tighter Vehicle Emission Regulation
Air Quality is Not Always Improving – WHY?

Since 2011 all new diesel vehicles in EU must have diesel particulate filter (DPF)
Most harmful dust particles PM2.5 levels not improving – e.g. data from Prague

Why we do not see benefit of all new clean vehicles?
Hypothesis: small number of super polluters major source

PM$_{2.5}$ - Annual average concentration, Prague 2004-2016, multiple locations

Source: Czech Hydro-meteorological Institute
Roadside Particulate Matter Emission Measurement – Prague October 2017

Goals:
- evaluate air pollution from real life traffic
- determine contribution of individual vehicles
- assess vehicle compliance – DPF function

Quick facts:
- 10 days
- 25,000 vehicles
- Particulate matter measurement
  - PM PN
- Gaseous emissions - CO2, CO, NOx

Radar Speed detection
3 Cameras
Sampling line
5 Emission measurement instruments
Roadside Extractive Measurement Concept Verification

Trial run @ CULS in Prague, 27th October 2017
Pattern: High CO₂ & no soot indicates good DPF
Roadside PM Emissions
Measurement Sites - Prague October 2017

Slip roads - one way & single lane & uphill - engine loaded

Povltavská slip road

Hlavkuv bridge slip road
Results – Vehicle Registry Data
Vehicle Age Distribution

Registration plate recorded for 25,971 vehicles
Ministry of transportation provided data for 24,379 (94%)
Results – Vehicle Registry Data
Fuel Type and DPF

- 2/3 vehicles Diesel
- 1/2 of diesels with DPF
- 1/3 total with DPF

2/3 vehicles Diesel
1/2 of diesels with DPF
1/3 total with DPF
Over 50% of vehicle EURO 5 / V or 6 / VI
Cumulative Frequency Analysis
Particulate Matter Emissions

2000 vehicles matched with their unique emission trace, of which ~500 with sufficiently strong CO\textsubscript{2} emission level.

Very uneven distribution – small number of vehicles large contribution

5% vehicles ~ 50% PM emissions
Specific Particulate Matter Emissions
PN and PM calculated per 1 km travelled

Few older vehicles generate large amount of PM

PN, PM [#/km, mg/km]

* Emission limits for Euro standards for reference only
Key Findings from the Study

5:50 – 5% cars = 50% pollution

Quick facts: from 25,000 vehicles measured in Prague
- 2/3 diesel, from which 50% with DPF (1/3 from total)
- 50% particulate matter pollution from 5% vehicles
- Most pollution from older vehicles, ~9% DPF’s faulty

Law Enforcement
In-use Inspection
PTI, on-road screening

FIX IT!
OR
DUMP IT!
Law Enforcement - Remote Sensing as Pre-selection for Roadside Technical Inspection

Trutnov, May 2018

Pilot study with Ministry of Transportation, Ministry of the Environment and Police

3-phase high emitter vehicle detection

1. Pre-selection of suspect vehicle
2. Roadside technical inspection – Police
3. Periodic Technical Inspection – forced emission inspection

700 passing vehicles
28 suspect high emitters selected for roadside insp.

Opacity measurement
12 vehicles confirmed with repeatable excessive smoke

9 failed forced PTI
not roadworthy
1 month to fix and repeat PTI
28 vehicles subject roadside technical inspection by Police
- 12 vehicles found noncompliant - repeatable excessive smoke over the limit
- 9 failed the PTI test – mostly older vehicles without PDF
There is Still Work to Do

Thank you!