

***NCTCOG Meeting
August 19, 2021***

EDAR Update



Hager Environmental & Atmospheric Technologies (HEAT)

“EDAR” The Only 24/7, Unmanned, Remote Sensing System



Aerial Unit

- Laser Based Aerial Remote Sensing Unit that Can Detect Emissions From Vehicles with High Accuracy (No Matter Where the Tailpipe it is Located)
- Unmanned and Sits at 5 meters on **Multi-lane Roads**
- Accurately detects and quantifies pollutants being emitted on-road using the DIAL method (Differential Absorption LiDAR Spectroscopy)

CO₂

CO

NO

NO₂

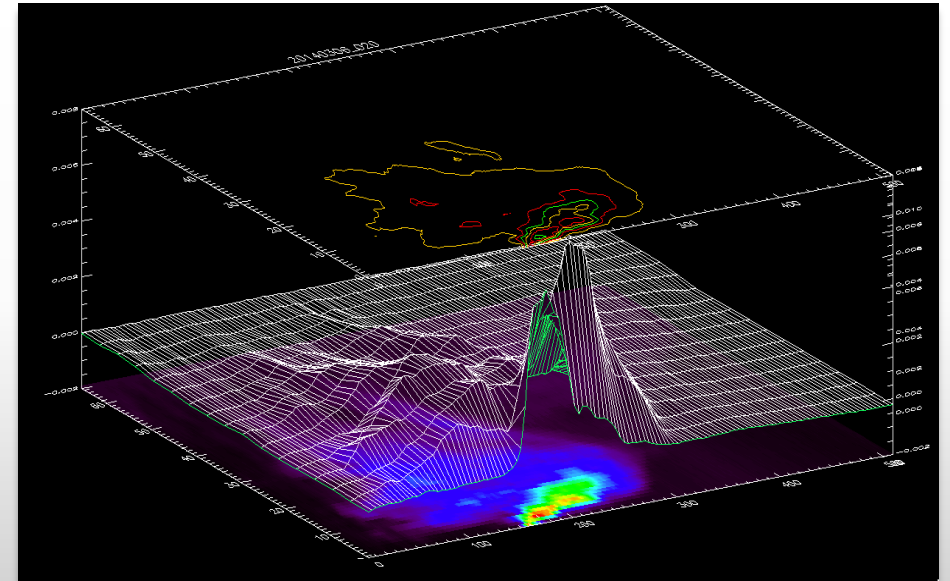
HC

PM

- One Unit Can **Detect Both Heavy- and Light-Duty**, as well as **Petrol and Diesel** Vehicles in **One Footprint**
- Detects the Temperature of Vehicle Exhaust
- The Only Remote Sensing Technology with the Ability to Detect Emissions from Vehicles Traveling on **Multi-lane, High-speed Motorways**
- **Operates 24 hours a day, 7 days a week, 365 days a year unmanned without calibration**

Measurement Technique & Validation

- EDAR is a NASA Spinoff, Unmanned, Laser-based System that Does Not Require Calibration
- Using the DiAL Method, EDAR detects 512 pixels per gas per scan
- Creates a 3-D multi-spectral image of an entire exhaust plume
- Valid Hit Rate between 90 to 98 Percent
- No Seasonal or Temperature Restrictions
- Not Affected by Light Rain, Fog, Smog, Humidity or Extreme Temperatures



Validated & Tested By Multiple Agencies Including:



US EPA:

"EDAR is more much accurate than existing Remote Sensing technology"



**Department
for Transport**

The EDAR technology uses principles similar to space satellites to detect and quantify gases in the earth's atmosphere using lasers and the Differential Absorption Spectroscopy LiDAR (DiAL) method.

EDAR's R² Accuracy: An "r squared" of one means a perfect fit and, an "r squared" of zero indicates no fit.

EDAR's r-squares show excellent fit:

CO = 0.996

NO = 0.998

HC = 0.996

CH₄ = 0.983

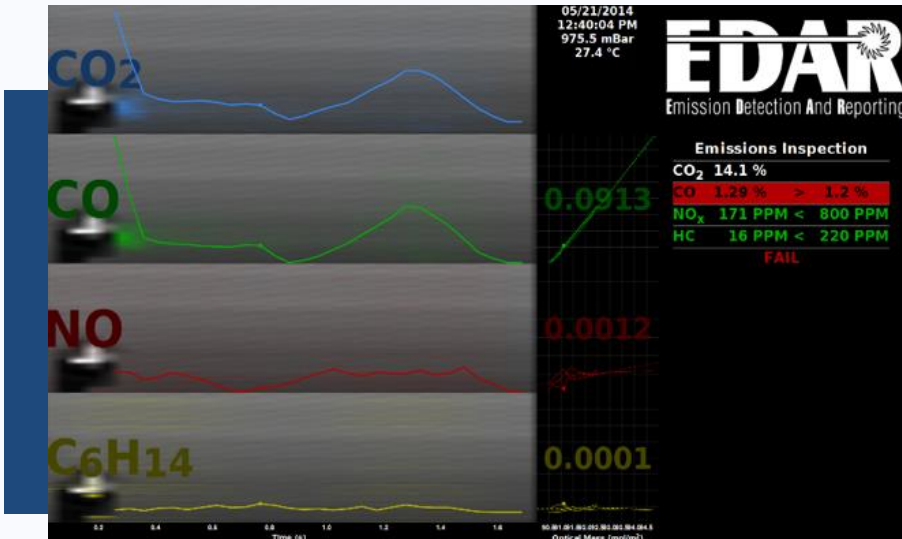
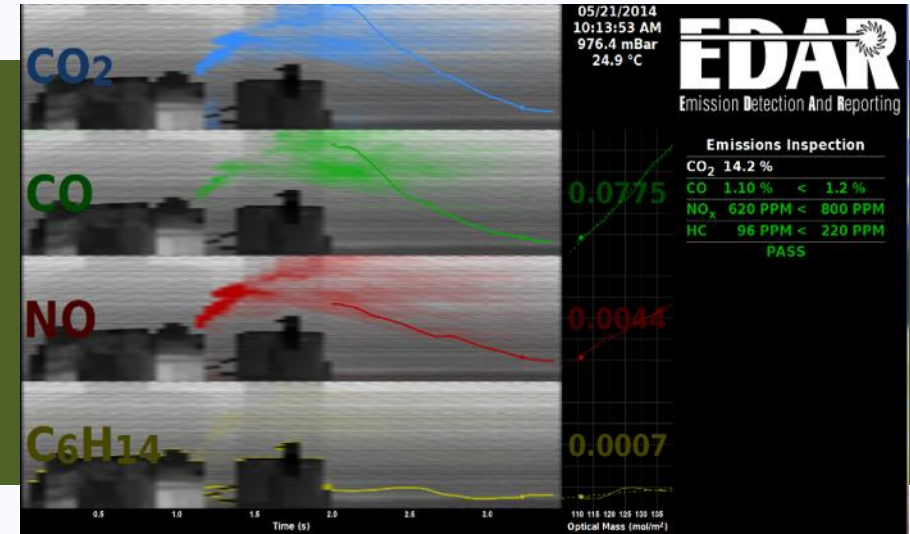
PM = 0.937



Source: Tim DeFries (ERG), Carl Fulper (USEPA, Jim Kemper (CDPHE), Sandeep Kishan (ERG), Jim Sidebottom(CDPHE), "Independent Testing of EDAR Accuracy and Sensitivity Performed by EPA, Colorado, and ERG," Denver, Colorado, January 2, 2016.

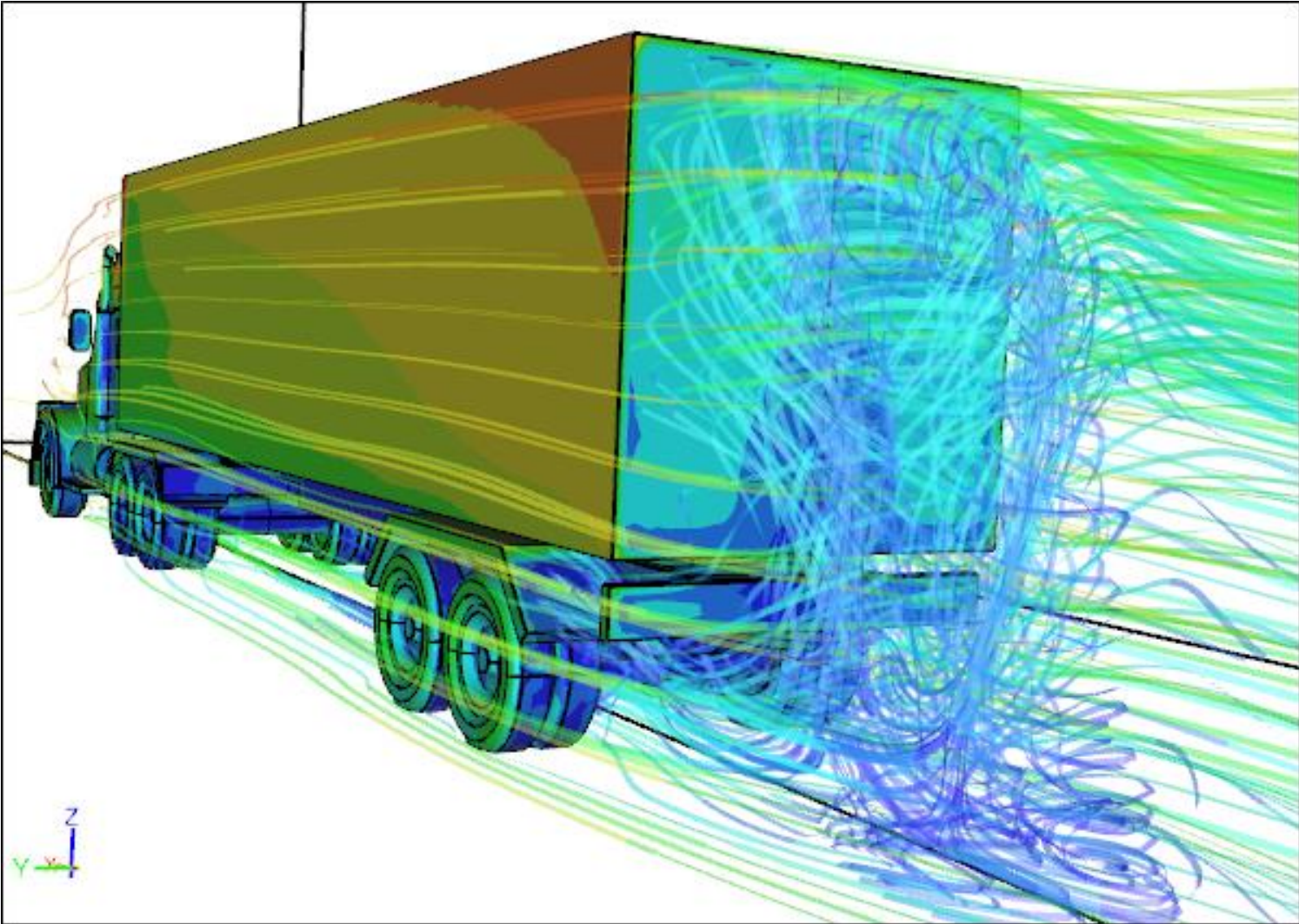
Trucks and Motorcycles

Image of a Truck Pulling a Trailer



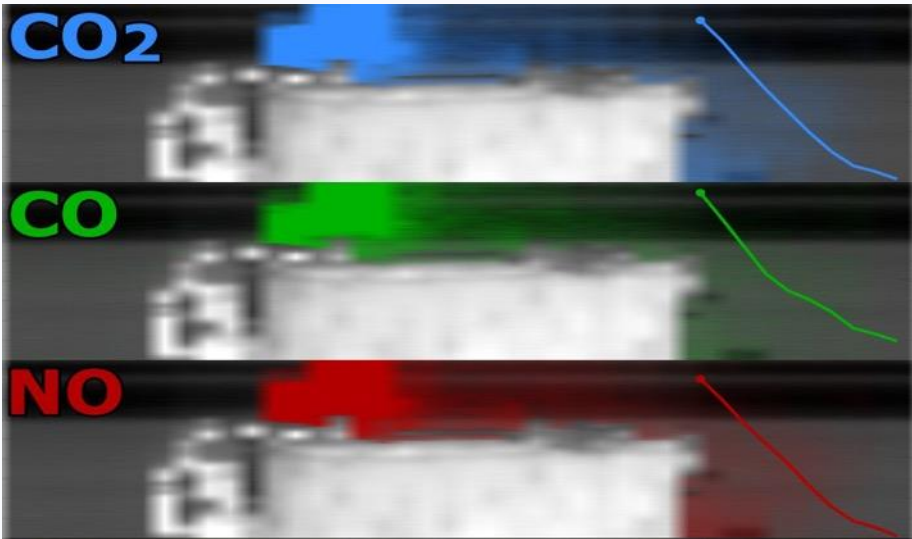
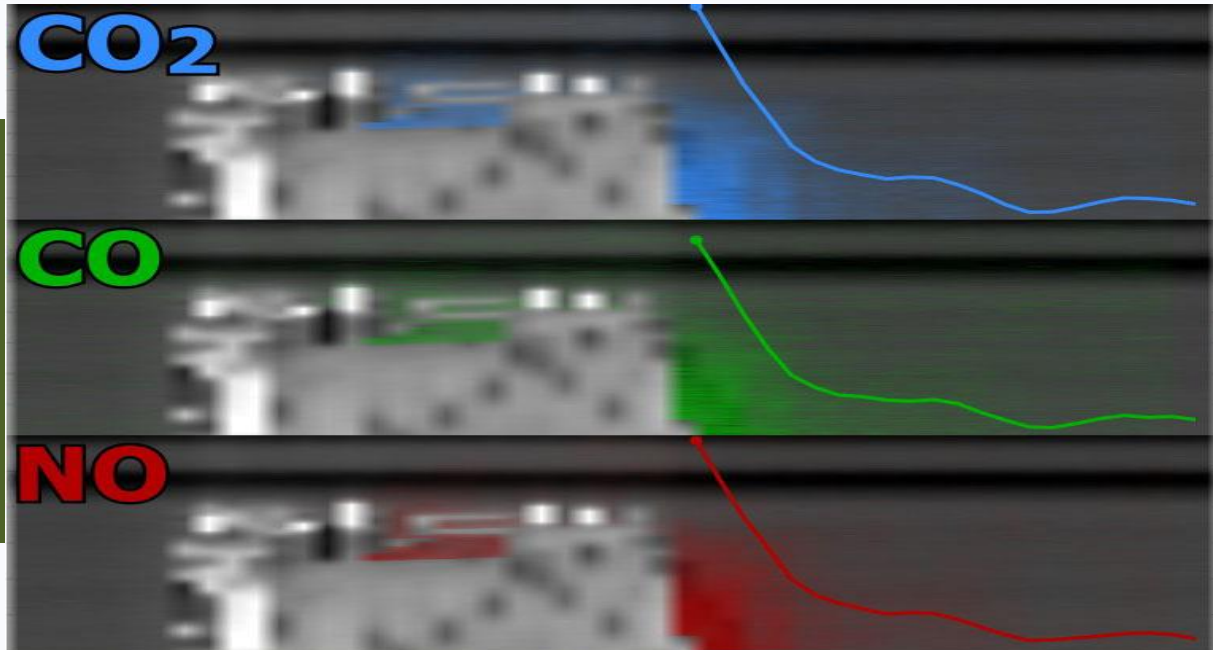
Two-Dimensional Image of a Motorcycle

EDAR Detects and Images the Vacuum Behind Semi-Trucks



Vacuum Behind Semi-Trucks

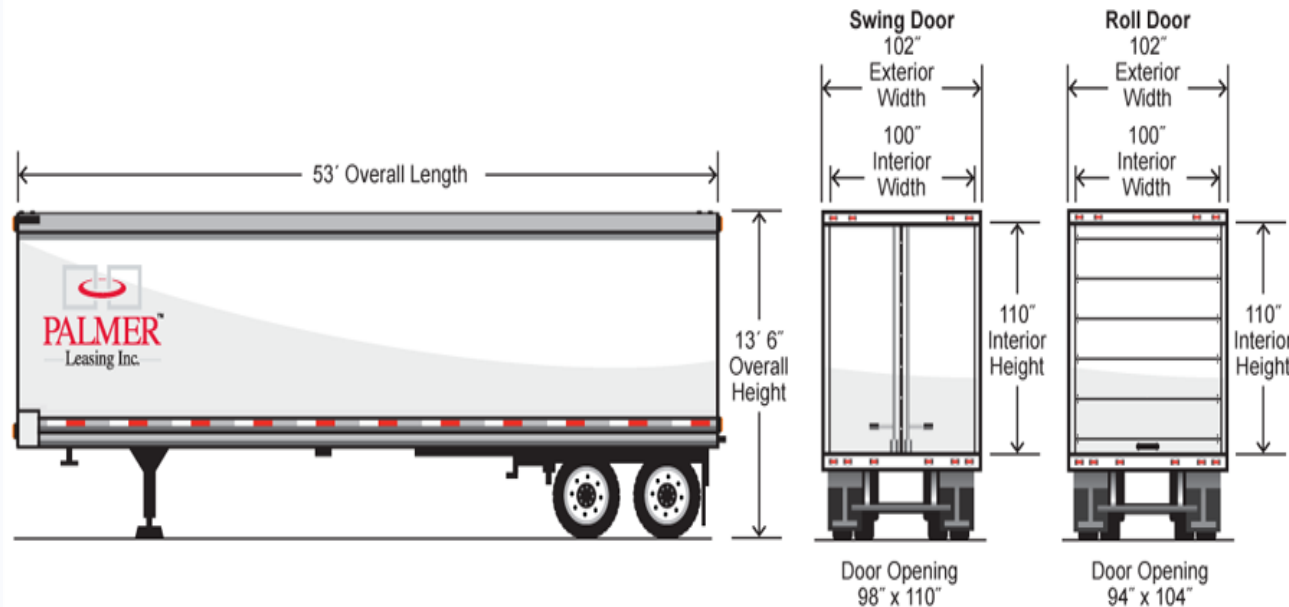
Large vacuum behind trailer sucks in the exhaust no matter its location.



Low and side exhaust pipes can be measured before the end of the trailer where it is highly concentrated.

Vacuum Behind Semi-Trucks

Large vacuum behind trailer sucks in the exhaust. Trailers are 13' 6" or 4.1m tall. This is a huge Path Length as compared to cars (~1m). The signal depends on Optical Mass, which is density of the gas multiplied by the Path Length. EDAR measures 4X the signal for semi-trucks through the geometry of the measurement alone.



Terms of the Beer-Lambert law:

$$\frac{I}{I_0} = e^{-S\rho l}$$

- $I_0 = \text{Intensity before}$

- $I = \text{Intensity after}$

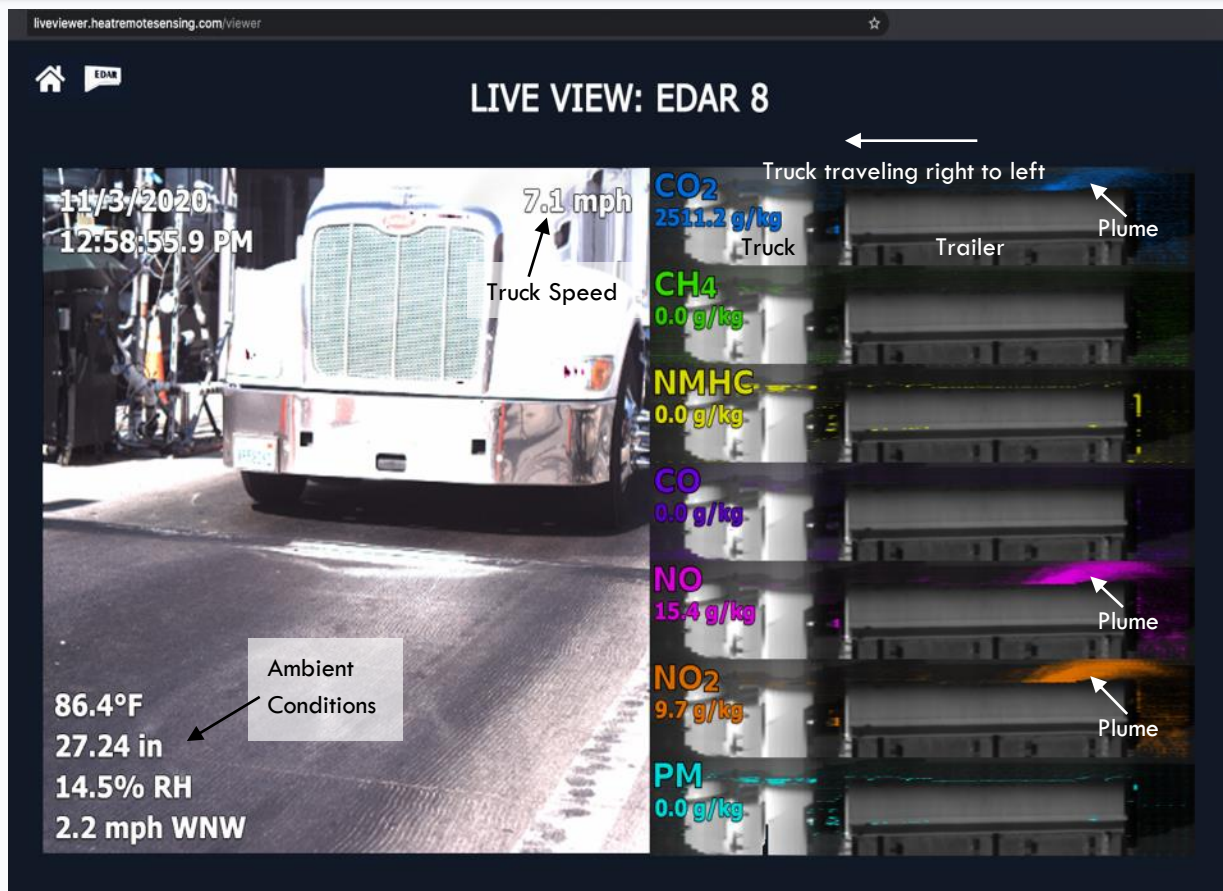
- $S = \text{Strength (m}^2/\text{mole)}$

- $\rho = \text{Density (mole/m}^3)$

- $l = \text{Path Length (m)}$

- $\rho l = \text{Optical Mass (mole/m}^2)$

- $S\rho l = \text{Optical Depth (unitless)}$



- EDAR HD is an all-in-one solution for regulating emissions from trucks traveling on-road in real-time.
- Identification of defeat devices, removed DPF filters or turned off SCR's
- Observing trends and the degradation of emissions control systems
- Governments can monitor all vehicles in real-time using a centralized portal that allows for visual confirmation of excessive emissions, tampering, cheating, or leaks.

Visualize a Network of EDARs where real-time on-road monitoring of the truck fleet occurs seamlessly and conveniently.

Handling all operations remotely, each EDAR is viewable via a user-friendly web portal.

Case Studies

Flanders Highspeed

EDAR Makes History in Belgium!

The First Remote Sensing Deployed on Highspeed Motorways

- 3-week testing period
- 210,000+ Valid measurements at speeds up 100mph
- 5 sites: Antwerp, Ghent, Bruges and Erpe-Mere



Scotland Pilot

- Over 140,000 valid measurements in 25 days at 3 sites in Edinburgh and Glasgow areas
- Over 92% Validity Rate
- The average NOx emissions of Euro 4, Euro 5, and Euro 6 diesel cars significantly higher than standards.
- The EDAR system measured vehicle exhaust in challenging Scottish weather conditions.





EDAR Installed on High-Speed Highways In Belgium and Scotland

Flanders Published Report

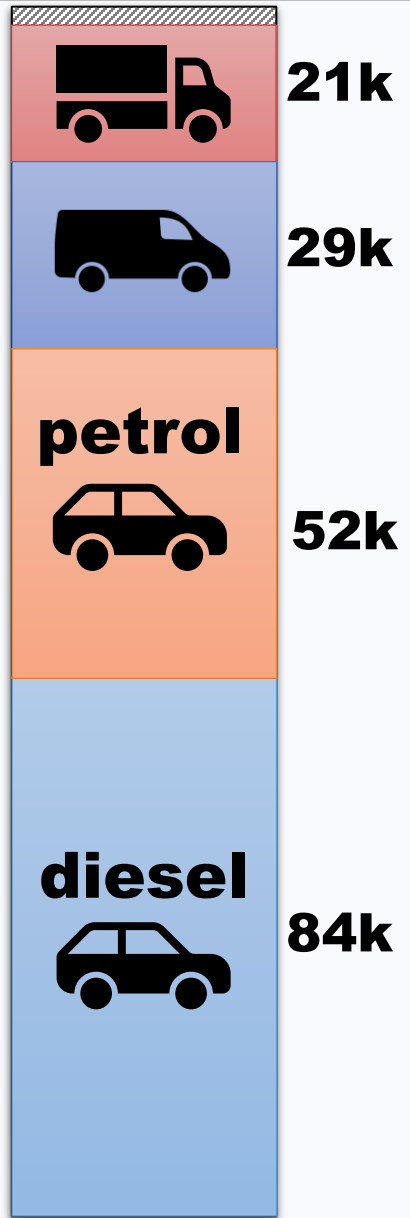
*“The 2019 Flemish remote sensing campaign was the **first in its kind** covering motorway emissions, which has the consequence of providing new insights for both passenger cars (PC), light-commercial vehicles (LCV), and heavy goods vehicles (HGV).” – Flanders Environment Agency Report, 2021*

Report: <https://www.vmm.be/lucht/luchtkwaliteit/emissiefraude-verkeer/wereldprimeur-voor-vlaanderen>

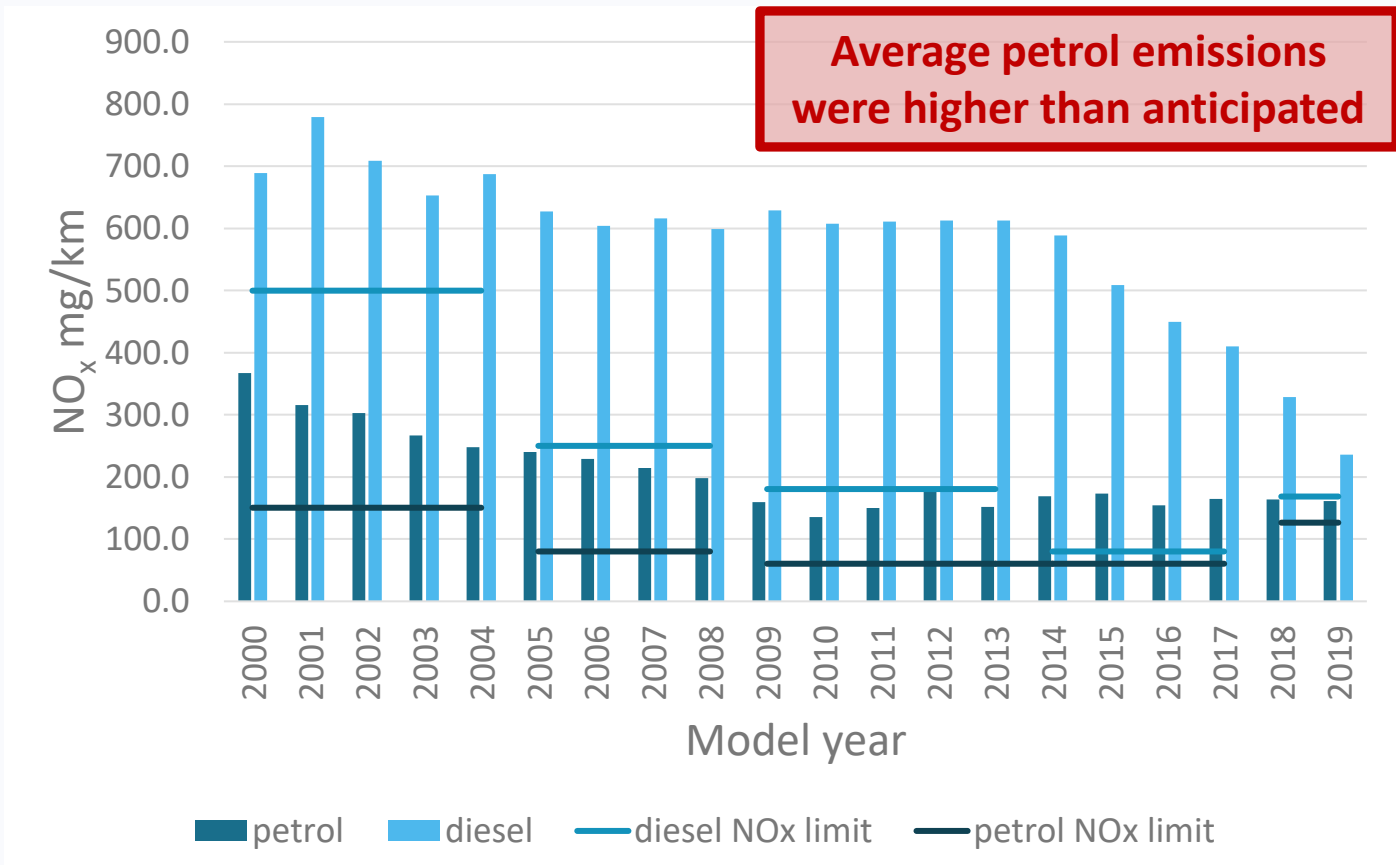
- Detecting tampering was the focus of this study.
- Remote sensing is found to be an **important tool** for detecting both fraud or design issues by manufacturers and vehicle tampering or poor maintenance by owners.
- Remote sensing can also help to identify vehicle segments and categories that significantly contribute to pollutant concentrations.



Flanders Pilot Results



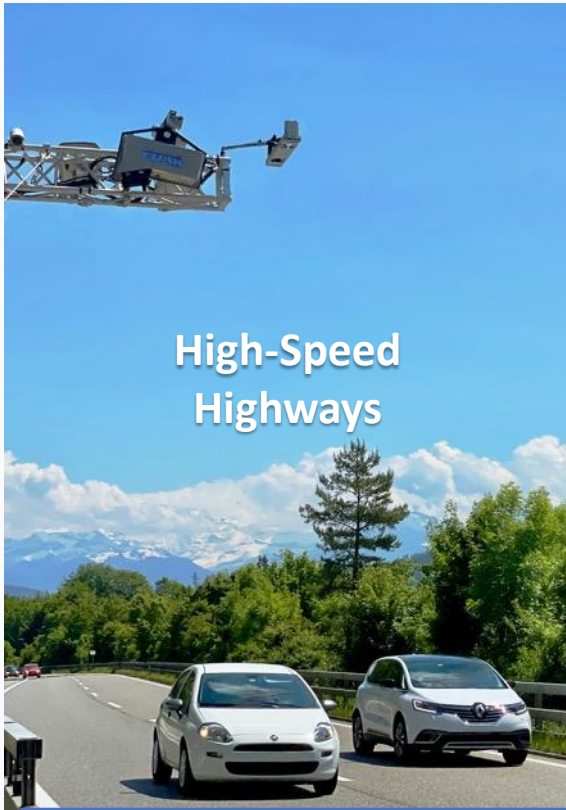
Remote sensing was part of a larger investigation to explore policy strategies to act against emission fraud by owner or by OEM



Source: Roel Vaneerdeweg, Flanders Environment Agency, *Taking Remote Sensing to the next level*, 2021

Rural, Urban, and Motorway Driving Scenarios

Additional Flanders Report Findings



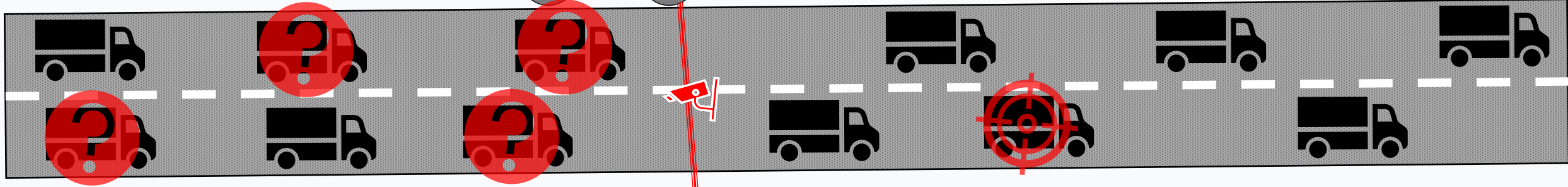
“Remote emission sensing on motorways is essential for SCR anti-tampering campaigns as in these circumstances SCR systems should work optimally. As such, the impact of tampering is distinguishable, unlike in urban situations. Moreover, motorway monitoring allows for high sampling rates and a large fraction of heavy goods vehicles, especially when compared to urban and rural monitoring.”

- Driving conditions on **highways** allow for optimal emission control system functionality, which makes such a **location ideal for roadside inspections**.
- Petrol cars, Euro-6d-Temp diesel cars and Euro VI diesel trucks combined contribute about one-quarter of the NO₂ emissions, per kilogram fuel, compared to the other diesel vehicle categories like vans, older trucks, and older diesel cars.
- In urban conditions, NO_x emissions by petrol cars are another 30% lower than the average based on all locations.
- On the contrary, NO_x emissions by Euro VI trucks in urban conditions are three times the average NO_x.

Flanders Anti-Tampering Campaign



1 manipulated Euro VI truck emits **15x** NO_x!



Highway locations are ideal for this type of roadside inspections

AdBlue tampering drastically increases NO_x emissions

Targeted selection via EDAR increased inspection efficiency:
9% → 83% !

Source: Roel Vaneerdeweg, Flanders Environment Agency, *Taking Remote Sensing to the next level, 2021*

EDAR AdBlue Police Campaign in Belgium



Over 83 % Valid Hit Rate

Ref_num	Speed	Make	Time	Issues & Comments	gNOx_kg	Exhaust temperature C
AdBlue13	89	MAN	14:11:18	Emulator+96:96	55	27
AdBlue15	90	TB	14:29:40	Pump	37	49
AdBlue17	88	MAN	14:32:34	Emulator	48	97
AdBlue19	90	Mercedes	14:49:41	Defect	68	70
AdBlue21	91	Mercedes	14:58:06	EURO IV, no AdBlue	65	76
AdBlue23	89	R560	15:15:58	Emulator	40	71
AdBlue25	81	Mercedes	15:16:36	Ambient temperature -39C, Mercedes said OK	51	116

Scotland

Three locations:

- Coatbridge in North Lanarkshire
- Edinburgh
- Broxburn in West Lothian



Coatbridge



Broxburn



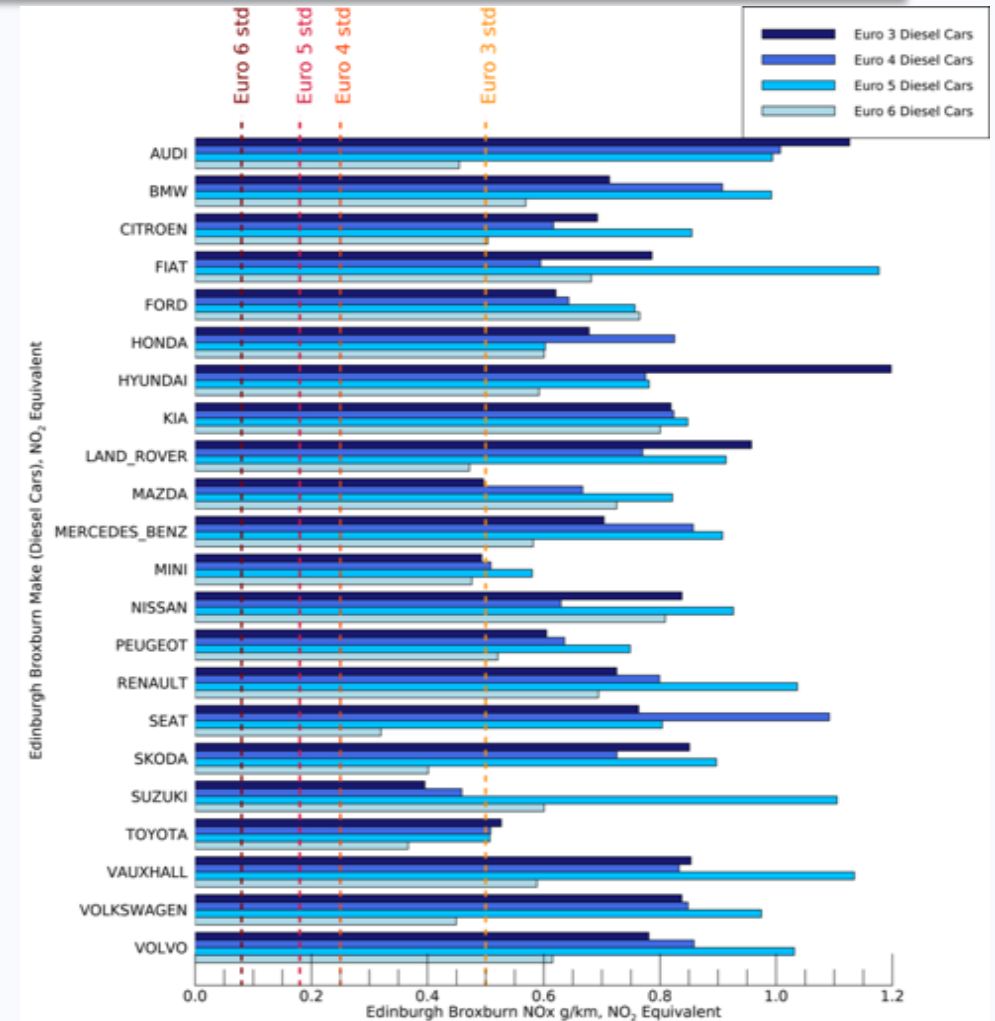
Edinburgh

Scotland Pilot - Results

EDAR Collected over 140,000 Valid Records at 3 Locations in Under 25 Days

Results Showed:

- The **average NOx emission value** of Euro 4, Euro 5, and Euro 6 diesel cars was **significantly higher** than EU standards.
- This data set provided substantial evidence that trying to lower ambient pollution levels in LEZs by **using the vehicle Euro Standards** as a proxy for in-use emissions levels will **not be a reliable method**.
- In most cases, the **manufacturer-average of Euro 6 vehicles failed** even the **Euro 4 Standards**.

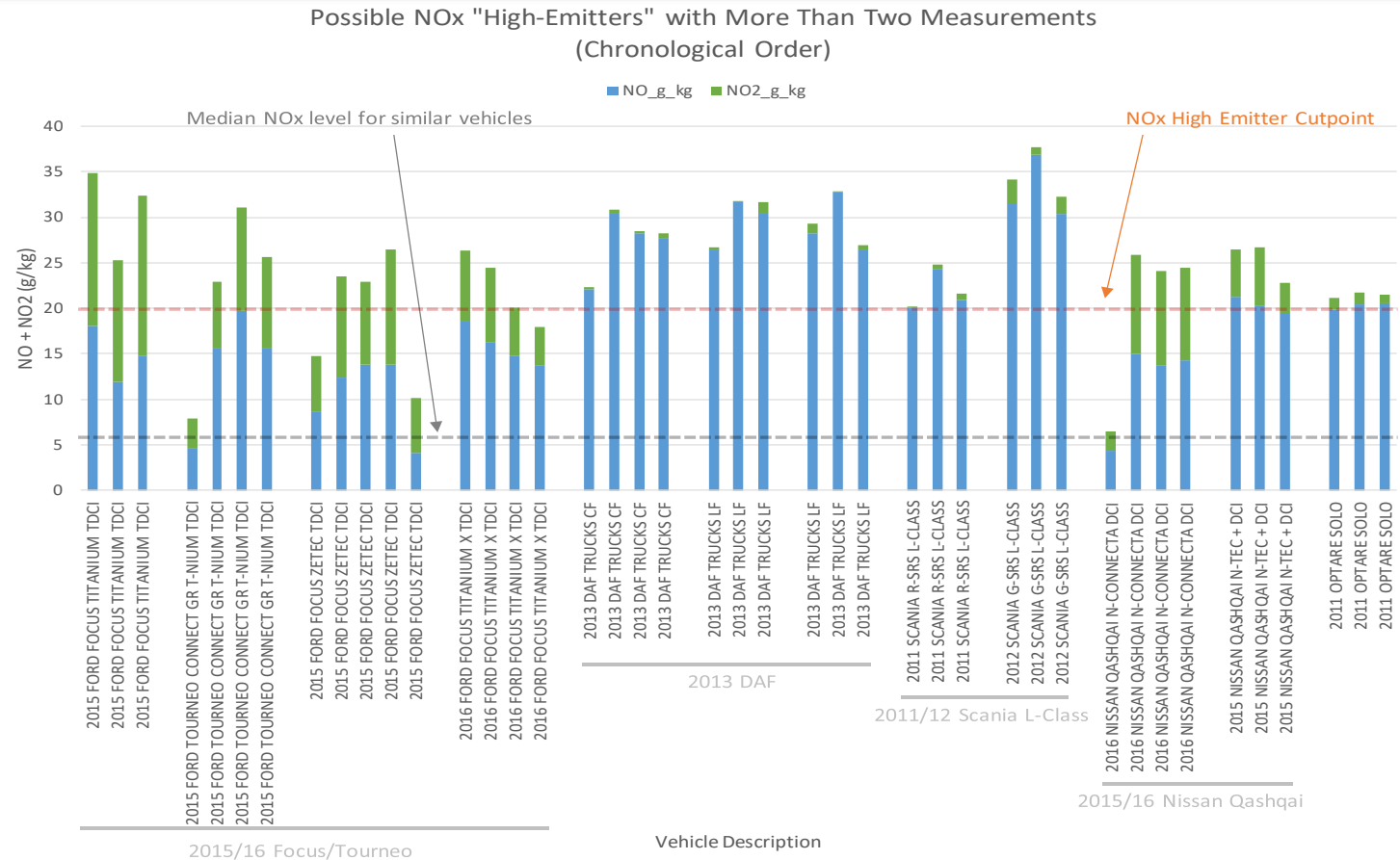


Scotland Pilot - Results

Continuous Monitoring can Provide Repeat Measurements which can Identify Anomalies in the Fleet

The evidence of repeat measurements show pattern failures and emissions system design deficiencies in the Scottish fleet

The strong and consistent patterns observed in these high NOx emitters indicate emissions control problems for these, and in some cases, for other similar vehicles that share their engine and emissions control platforms.



Conclusion



- EDAR is an all-in-one solution for detecting emissions in Heavy duty due to the geometry of the measurement.
- Provides a centralized portal that allows for visual confirmation of excessive emissions, tampering, cheating, or leaks.
- Identifies excessive pollutants such as NO, NO₂, and PM for the identification of SCR and DPF tampering.
- Not impacted by: Vibration, Fog, Wind, Dust, Humidity.
- Not seasonally dependent, operating in all climates and temperatures.
- Identifies the plume regardless of tailpipe location.
- Detects each pollutant independently.
- Successfully deployed in locations around North America and Europe providing municipalities with valuable data.



Thank You Questions?