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#RTRConference2023

MODALES project

modales

Adapting driver behaviour for lower emissions

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 815189

Overall project presentation

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Adapting driver behaviour for lower emissions

MODALES Vision: To **reduce air pollution** (e.g. NOx, PM, PN) from all types of road vehicles by encouraging adoption of **low-emission driving behaviour** and **proper maintenance choice**

Key objectives	Targets
Understand the **nature of driving behaviour** with respect to vehicle emissions	Variables for driver behaviour and their variability (speed, road condition, etc.) validated with data
Correlate **driving behaviour variability** with real **powertrain, brake and tyre emissions**	Mathematical equations defining powertrain, brake and tyre emissions as a function of driving behaviour
Propose and validate a real-time driver assistance **smartphone app** for low emission driving	App available for demonstration and testing, to be opened for further exploitation post-project
Promote low-emission oriented driving via **training courses and an awareness campaign**	Courses set up for various user groups, and feedback used to assess user acceptance and awareness
Assess the real effectiveness of **on-board diagnostics (OBD)** and **technical inspections** and investigate the legal situation of **tampering** in Europe	Analysis for OBD and inspections to detect high emissions due to different causes; Study report on legal aspects of vehicle tampering
Assessment of the potential impact of diesel **retrofits**	Diesel retrofit to a van and emissions tests. Monitoring and data analysis for retrofitted HDVs. Review of technologies/ performance for car retrofits

Project data overview

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Adapting driver behaviour for lower emissions

Dates:	1 Sep 2019 to 31 May 2023
EC H2020 Call:	MG-1.1: “Reduction of transport impact on air quality” (INCO Flagship)
Budget:	€ 4.72 million
Consortium:	16 EU-funded partners (coordinated by ERTICO) + 2 International partners in China

- Associations
- Universities
- Research institutes
- Industry and technology
- Legal experts

ERTICO, RACC Mobility Club, IRU, FIA, ITS University of Leeds, Istanbul Okan Üniversitesi, Southeast University 東南大學, VTT, Luxembourg Institute of Science and Technology LIST, CERTH Centre for Research & Technology Hellas, Cerema Climate & Regions, the future, Brembo, Bridgestone, Michelin, Proventia, Dynnoteq, Sample, Spark Legal network

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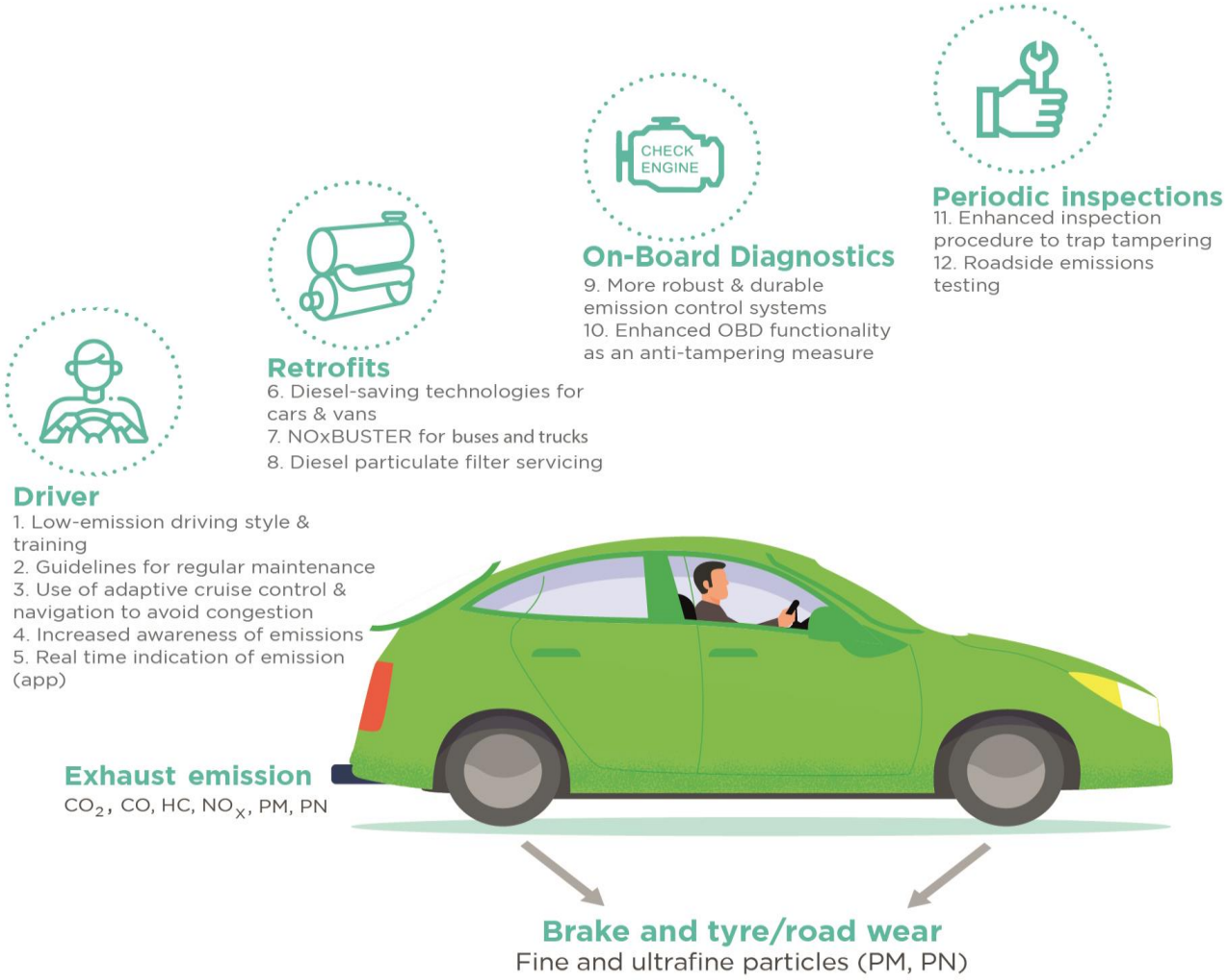
Project innovation areas



Results (1 - Driver)

Driving behaviour factors derived from emission monitoring (exhaust ,brakes and tyres)

Powertrain

Driving behaviour KPIs for exhaust emissions	Ranking (1: most important)
Aggressiveness (% of time in acceleration > 0.9 m/s$^{2)}$	1
Average acceleration	2
% of time in speed interval of 20~50 km/h	3
Average speed	4
Average driving speed without stops	5
% of time in deceleration interval of -0.9~0 m/s^2	6
Average deceleration	7
% of time in acceleration	8
% of distance in acceleration	9
% of time in deceleration	10
% of distance in deceleration	11
% of distance in speed interval 50~70 km/h	12
Gear upshift speed	13
Gear downshift speed	14

Brakes

Driving behaviour KPIs for brake emissions	Unit	Ranking (1: most important)
Deceleration rate of braking	m s^{-2}	1
Average deceleration rate of braking	m s^{-2}	2
Braking distance	m	3
Braking time	s	4
Initial speed when braking	km/h	5
Average initial speed when braking	km/h	6

Tyres

Driving behaviour KPIs for tyre emissions	Wear amount (m^3/rev)	Wear mass (g/rev)	Ranking (1: most important)
Deceleration rate when right braking	5.43E-10	6.30E-04	1
Acceleration rate when right accelerating	4.13E-10	4.80E-04	2
Initial speed when right braking	3.14E-10	3.64E-04	3
Initial speed when right accelerating	2.82E-10	3.27E-04	4
Deceleration rate when straight braking	2.51E-10	2.91E-04	5
Acceleration rate when straight accelerating	1.78E-10	2.07E-04	6
Initial speed when straight braking	1.49E-10	1.73E-04	7
Initial speed when right cruising	1.27E-10	1.47E-04	8
Initial speed when straight accelerating	1.07E-10	1.24E-04	9
Driving speed when straight cruising	4.73E-11	5.49E-05	10
Deceleration rate when left braking	4.14E-11	4.80E-05	11
Acceleration rate when left accelerating	3.79E-11	4.40E-05	12
Initial speed when left braking	2.65E-11	3.07E-05	13
Driving speed when left cruising	2.59E-11	3.00E-05	14

Results (1 - Driver)
MODALES training videos and awareness campaign

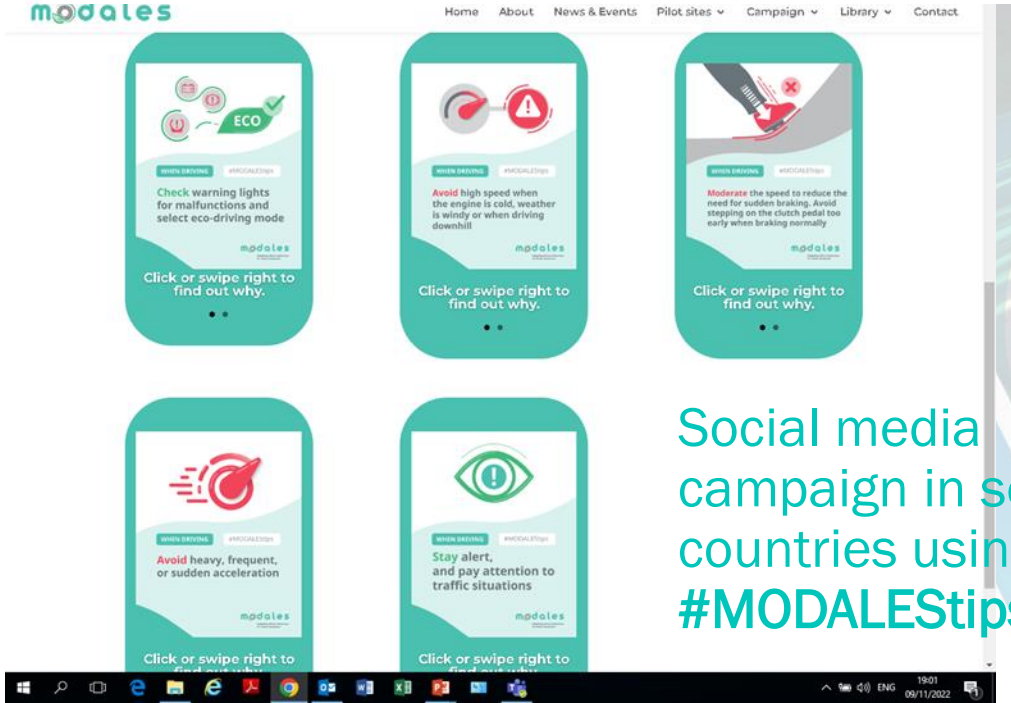
Videos (approx. 15 minutes) based on behaviour factors, for:

- Car drivers
- Professional drivers of light vehicles (LDV/vans, taxis)
- Professional drivers of heavy vehicles (HDV)

Low-emission driving tips aimed at car drivers:

- 3 categories: Before driving, When driving, Car maintenance
- Simple messages with animated graphics
- Available in 11 languages

https://modales-project.eu/campaign



Social media campaign in several countries using #MODALESTips

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Results (1 - Driver)
Smartphone app for low-emission driving

Simple interface

Available for Android and iOS

Paired with OBD dongle

Creates two types of recommendations:

- Active recommendations:
  - When the user is driving
  - Research prototype → simplified recommendations and HMI, using only the phone sensors
- Passive recommendations:
  - After a trip
  - Complete report, using the phone sensors, OBD data and external web services (e.g., weather, traffic index)

OBD dongle

Results (2 - Retrofits)

Real-world tests of NOx retrofits

Analysis of effectiveness of the NOxBUSTER® City Diesel Particulate Filter (DPF) + Selective Catalytic Reduction (SCR) Retrofit System by Proventia

Trial retrofit to a light van; Tested on a dynamometer in Finland

- Impact of applying diesel SCR retrofit systems on Euro 5 vehicles: NOx reduction of 51 - 65 % over the whole cycle may be achieved
- When retrofit system active, NOx conversion efficiency was between 59 - 78 %
- No significant effect on CO2, CO or HC found with usage of Proventia retrofit compared to OEM configuration
- Retrofit SCR efficiency highly dependent on the engine out exhaust temperature and retrofit system operating window highly dependent of upstream EGT conditions

Results (3 - OBD)
On-Board Diagnostics

How current OBD can be used and improved with respect to lack of maintenance or deliberate tampering

OBD and poor maintenance

- Within normal service intervals, excess emissions are quite negligible. Post-service emission levels in most cases were at the same level as before service.
- Negligence of motorists regarding service must be quite severe before exhaust emissions are critically affected and could lead to the triggering of an event through the OBD data.

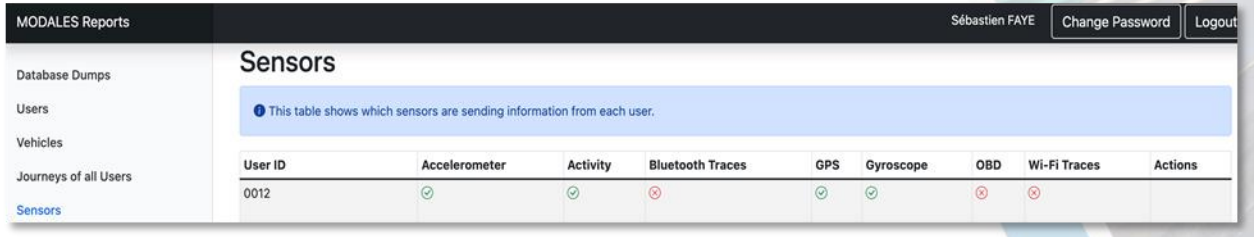
OBD and tampering

- Present OBD system is not robust against actions used to circumvent the system's ability to detect/report elevated emission levels due to tampering.

(OBD &) Trial site reporting platform for MODALES app

Anonymised datasets for analysis of driving behaviour & other indicators:

- From the smartphones' sensors
- From OBD dongles
- From external services for data augmentation



User ID	VIN	Manuf	Model	Cat	Eng	FC			EL	W	Tires			Km	Journeys	Actions
						U	EU	C			B	M	Y			
0012	⊗	✓	✓	⊗	✓	✓	✓	✓	✓	✓	⊗	⊗	⊗	✓	2	Journeys Delete

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Results (4 - Periodic Inspections)
Detection of tampering or malfunctions, considering technical, behavioural and legal criteria

Heavy Duty and NRMM (Non-Road Mobile Machinery) tampering customers' profile

Current customers (in HD- and NRMM sectors) are divided typically into three categories

1. Those who face NRMM EATS failures -> increased downtime -> requests that the EATS is disabled
2. Customers who believe that the engine power is lower than rated by the manufacturer
3. Customers who buy a "rescue kit" -> a backup ECU-flash that is used if any error codes appear that increase the downtime during the work days

Examples of legal recommendations

- Ensure alignment of legislation on heavy and light duty vehicles on tampering activities
- Adopting rules prohibiting vehicle tampering will enable authorities to apply anti-tampering measures outside the context of the type approval process.
- Increased harmonisation of sanctions across EU Member States could contribute to effectively tackling conducts where tampered vehicles or their parts are sold in Member States with lower sanctions.

Mid to long term impact (1)
Expected impact

Contribute to reduction of emissions from the existing combustion-engined car fleet

- OBD reporting platform allows detection of anomalies (tampering, poor maintenance) and if applied to a fleet could bring over 20% reduction in pollutant emissions
- Retrofitted vehicles reaching Euro VI standards showed a reduction of 51 to 65% (target 60%) in PMs & NOx, but this is a transitional solution for diesel vehicles prior to fleet replacement

Contribute to reduction of unnecessary driver-induced emissions though a better awareness by the public of their role in controlling polluting emissions

- 5-10% reduction of emissions (depending on vehicle type, Euro technology and baseline level of driving) by applying the MODALES low emission driving guidelines
- Potential for app/training to be adapted for EVs (not part of MODALES) to reduce brake and tyre emissions

Mid to long term impact (2)
MODALES steps to completion and the longer term

Completion of trials in 7 European countries (Phase 2 with app)

- to validate the capacity of MODALES app and training to change driving behaviour
- testing user reaction and acceptance
- also limited trials and user acceptance (training, awareness) in Nanjing, China

Analysis and impact assessment

- identification of user groups in which MODALES had most of the impact (age, gender, driving experience, types of roads used, type and age of vehicle
- Quantify the effects of reducing vehicle induced emissions by the MODALES app and training
- Quantify potential reductions in emissions through OBD optimisation, retrofits, enhanced periodic inspections and legal measures
- Potential longer term impact following fleet renewal (e.g. electrification)

Targeted dissemination

- Training material to be made public and also targeted to fleet operators
- Recommendations on technical and legal aspects to national authorities, type approval authorities, EU

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Thank you
Any questions?

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LinkedIn MODALES project

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