

## **Noise and Emissions Monitoring**

NEMO stands for Noise and Emissions MONitoring and was an EU-funded project to improve air quality and reduce noise pollution in cities across Europe [1], [2], [3]. It uses cutting-edge technology to monitor noise and emissions from individual road vehicles and trains in real time. NEMO has reached the stage of a proof of concept (PoC). Test results were promising, but the path to a commercial solution still requires further development and planning in a larger organisational context, such as legal regulations, their practical implementation and responsibilities.

### **How emissions are measured**

At the heart of NEMO is the Exhaust Emissions Remote Sensing Device (E-RSD), an innovative measuring device that can measure the emissions of individual vehicles in moving traffic with a high degree of accuracy. The E-RSD is based on a laser technology, whereby a laser beam is sent across a lane between the measuring device and a reflector, thus measuring the particles in the air (see Figure 1). The actual vehicle emission measurement works – here in a simplified way – in such a way that measurements are taken shortly before and after a vehicle. The measurement taken before the vehicle is the reference measurement, i.e. the measurement without emissions. The measurement taken immediately after the vehicle is the measurement of the emitted emissions, and the difference between these two values determines the emission level. This is also compared with the vehicle type, which is identified by a camera, so that it can calculate whether the vehicle has a correct or excessive emission level.

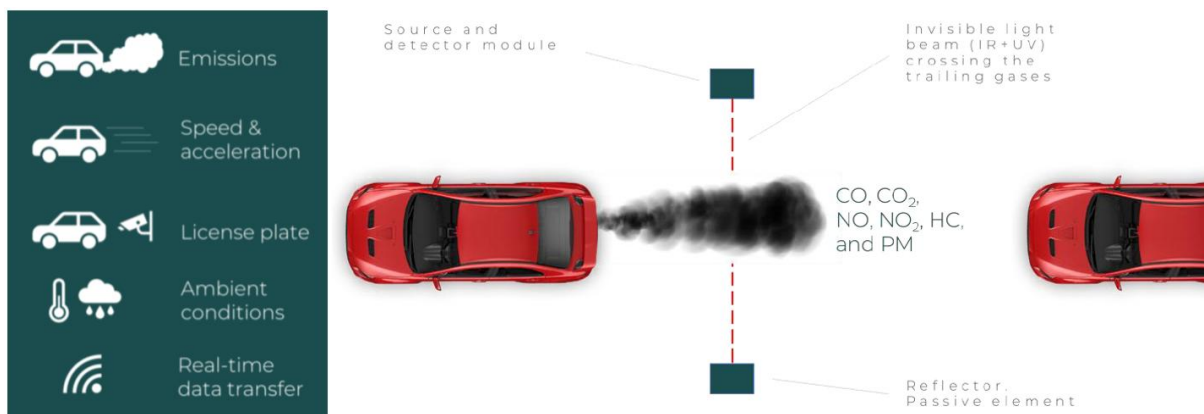


Figure 1: Schematic representation of the NEMO laser-based test method [1].

In a real environment, the E-RSD measurements were carried out for vehicles in flowing traffic and were compared with measurements from a standardised and calibrated reference system, the so-called Portable Emissions Measurement System (PEMS), which is usually installed in one vehicle at a time. The comparison of the measured values is carried out, where the laser-based E-RSD is set up. The evaluation of the PEMS measurement data with the E-RSD shows very good statistical agreement (see Figure 2).

### **Measuring noise emissions**

Another aim of NEMO is to measure not only pollutants but also the noise emissions of individual vehicles on the spot. The measuring station consists of several microphones to capture various noise sources of the vehicles and, with the help of a radar system, information about the speed and acceleration of the measured object is recorded. A camera records the number plate in order to compare the measured values with the normative values of the vehicle. Since the measuring station is operated in a normal traffic flow, the measured vehicle noise levels must be separated from

background noise and separated into their noise components (e.g. drive noise). The measured value is then compared with the permissible values for the corresponding vehicle type.

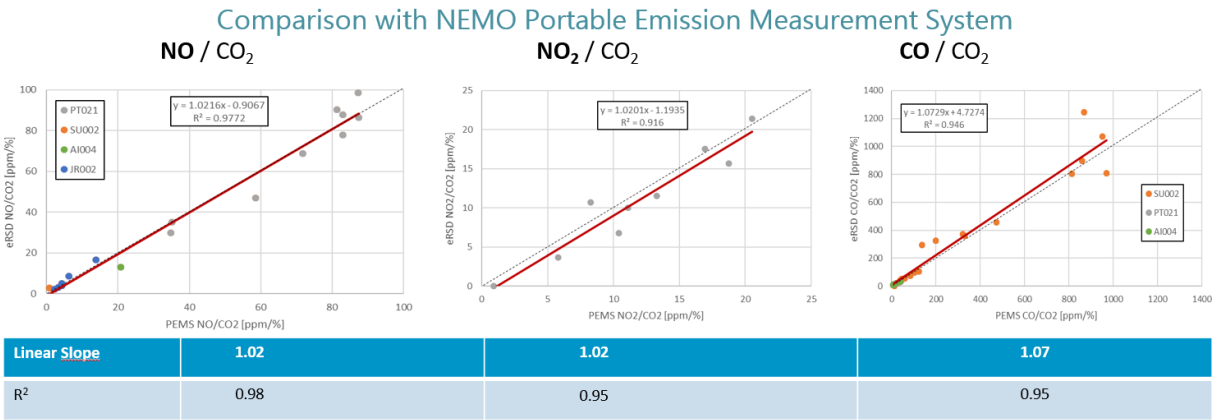


Figure 2: The agreement of the measured values is statistically determined by the slope of the regression line and the coefficient of determination R<sup>2</sup>, which, when the two statistical quantities are exactly the same, results in 1 for both statistical quantities. The analysis yields values very close to 1 and thus statistical equality of the two measurement systems [1].



Figure 3: Testing of the measurement system consisting of the measuring station and the reflector on the KTC test track in Teesdorf with different vehicle classes (top); real-world test of the emission measurement system in Spain (bottom) [1], [2], [3].

**Integration tests on the Teesdorf test track**

A central part of the NEMO project was the testing on the Kapsch TrafficCom test site in Teesdorf, Austria (see Figure 3). The focus of this test phase was the integration of the emission measurement

system into a modern toll system, which represents a possible realistic scenario for the application of the NEMO emission measurements and classification system for road traffic. The validation of this integration confirmed the successful functionality of the NEMO system under realistic conditions.

The combined system was able to measure the noise and emissions of individual vehicles independently of each other and to synchronise the measurements of the NEMO sensors with the tolling system sensors. This includes DSRC toll transactions, taking pictures of the vehicle, identifying the registration plate, classifying the vehicle according to its dimensions, and automatically requesting the vehicle's registration data and a V2X (vehicle-to-everything) report. The collected data was merged into a single vehicle data set (roadPassBy report), which can be sent to the central database system. During the pass-by, the classification is carried out and if the vehicle is equipped with a V2X-OBUE, the driver can be informed of the classification result.

### **The result and possible NEMO use cases: applications for enforcement and clean air zones**

From this combination of vehicle detection, the vehicle behaviour consists of speed and acceleration and with the measurements of the various emissions a vehicle can be classified as a 'high emitter'. NEMO can thus support compliance with regulations, provide sound data when implementing targeted strategies to reduce emission-intensive sources and also contributes to a better understanding of the influence of vehicles on the environment.

The NEMO system can be used for several applications: the immediate application is to control whether vehicles such as trucks are driving according to their alleged EURO emission class or with an AdBlue exhaust gas cleaning system that might be switched off to save costs for the AdBlue additive and the catalyst [4], [5]. An Austrian study by the Vienna Chamber of Labour showed that these toll frauds, due to non-compliance with the EURO emission classes alone, amount to around €60 million per year for Austria [6]. Another application can be measurements of pollutants and noise levels of vehicles that want to enter a low-emission zone or a clear air zone. This way, vehicles with high pollutant emissions can be identified or warned when entering such an urban environmental area.

### **Conclusion**

The NEMO project is an important step forward in our ongoing efforts to solve environmental problems quickly and reliably through innovation. However, the necessary legal framework and regulations for control and accountability for the execution of offences still need to be defined in some countries in order to implement solutions such as NEMO.

*Authors: Robert Kölbl, Martin Linauer, Katharina Rynes (Kapsch TrafficCom)*

### **References:**

- [1] "Nemo-EU-Project." Accessed: Nov. 06, 2024. [Online]. Available: <https://nemo-cities.eu/>
- [2] "Nemo Cities: Posts | LinkedIn." Accessed: Nov. 06, 2024. [Online]. Available: <https://www.linkedin.com/showcase/nemo-cities/posts/?feedView=all>
- [3] Kapsch TrafficCom, *Kapsch TrafficCom | Nemo*, (Oct. 22, 2024). Accessed: Nov. 06, 2024. [Online Video]. Available: <https://www.youtube.com/watch?v=e39JW94U1B4>
- [4] Camion Pro e.V., *3sat Spediteure sparen sich das AdBlue im Lkw und richten so Schaden an*, (May 14, 2018). Accessed: Nov. 06, 2024. [Online Video]. Available: <https://www.youtube.com/watch?v=NC0I2mP6L-c>
- [5] Camion Pro e.V., *AdBlue Manipulation - Polizei Mittelfranken jagt Abgas Sünder*, (Dec. 26, 2017). Accessed: Nov. 06, 2024. [Online Video]. Available: <https://www.youtube.com/watch?v=8-vG38HQq1M>

- [6] A. Friedrich, S. Annen, R. Helmerich, and Deutsche Umwelthilfe Berlin, "Abgasmanipulation und Mautbetrug durch Lkw: Wie sauber sind Lkw tatsächlich?," Kammer für Arbeiter und Angestellte für Wien, Wien, 205, 2022. [Online]. Available: [https://www.arbeiterkammer.at/interessenvertretung/umweltundverkehr/verkehr/strasse/Abgasmanipulation\\_und\\_Mautbetrug\\_durch\\_Lkw\\_2022.pdf](https://www.arbeiterkammer.at/interessenvertretung/umweltundverkehr/verkehr/strasse/Abgasmanipulation_und_Mautbetrug_durch_Lkw_2022.pdf)