NEMO

Pilot summaries

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Introduction

The NEMO project, funded by the European Union's Horizon 2020 research and innovation programme, encompasses a series of pioneering pilots and demonstrations aimed at environmental sustainability in urban areas. This document presents a comprehensive summary of four distinct pilots conducted in different European locations, each addressing unique aspects of environmental monitoring and improvement.

Valencia Pilot: Focused on measuring ship gaseous and noise emissions, and train gaseous emissions in the port landscape of Valencia. It utilized advanced remote sensing instruments and developed new methodologies for accurate environmental data collection and analysis.

Florence Pilot: Aimed at identifying high noise and exhaust gas emitters in urban settings, utilising portable remote sensing technologies. This pilot also tested the performance of innovative asphalt mixtures in reducing urban noise levels.

Madrid Pilot: Concentrated on measuring on-road vehicle noise and emissions. It included the deployment of a multifunctional barrier to absorb noise and emissions from road traffic, integrating remote sensing devices into existing infrastructure for environmental monitoring.

Tilburg Haaren Rail Pilot: Located in the Netherlands, this pilot focused on rail noise from trains and individual wagons, employing novel remote sensing systems to autonomously measure and identify high noise emitters in railway traffic.

Each pilot provides valuable insights and key takeaways for European cities, demonstrating the effectiveness of remote sensing devices and collaborative efforts in enhancing urban environmental quality. The document provides an overview of the methodologies, data analysis, and the collaborative efforts involved in these pilots, offering a roadmap for future initiatives in similar contexts.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement n° 860441.

Florence Pilot Summary

Pilot Overview

The Florence pilot aimed to identify high noise and exhaust gases emitters (HEs) vehicles at a wide range of driving conditions by a new remote sensing technologies in Europe. Portable remote sensing devices for noise and gaseous emissions developed in the NEMO project (N-RSD and E-RSD) were used in several real-world settings around European cities and in Florence in particular.
In parallel to remote sensing activities, a real-life performance of innovative asphalt mixtures was conducted on an urban road of the municipality of Florence. Seven months from the laying of the new pavement, new road pavement has confirmed an excellent acoustic performance with a significant reduction in noise levels.

Key take-aways for European cities

- Remote sensing devices is a realistic option for European Cities to continue to follow up on existing regulation and to revise and develop new environmental quality standards of urban air and acoustic environments.
- In order to regulate a high-emitting vehicle, there must be a local legislation in place. The new introduction of the "Green Shield" in Florence aimed to restrict the most polluting vehicles in the historic city centre, can be used as an inspiration for other European cities. This solution will be able to make use of custom alerts based on messages with panels for Low Emission Zone (LEZ) or personalized communication to drivers for example by using SMS messages.

The project leader and key participants

The demo project in Florence was a collaboration between several NEMO partners: Müller-BBM and OPUS applied a methodology to individually identify high emitters) vehicles The University of Cantabria (UC) conducted the asphalt mix development. The Environmental Protection Agency of Tuscany Region (ARPAT) conducted air quality measurements by its mobile laboratory and the characterization of the vehicle population. The municipality of Florence provided administrative support, identification of test sites and coordinated laying and characterization of new pavements. And lastly Ricardo air quality modelling was used for impact simulation.

Pilot Duration

The remote measurement campaign was conducted between June 6 and June 22, 2022. New asphalt layers were monitored from June to Dec 2022.

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Deployment and Monitoring

The NEMO-projects emission remote sensing (E-RSD) and noise remote sensing (N-RSD) devices were co-located at two to seven different sites in the municipality of Florence. In order to reduce uncertainty and biases improving the usability of collected data monitoring stations have been placed in open avoiding canyon effect both for noise and air pollutants.

The E-RSD individually measures free circulating vehicles' tailpipe emissions using Interband and Quantum Cascade Lasers (ICL and QCL) for the precise and highly sensitive detection of several pollutants (CO, CO2, NO, NO2, hydrocarbons and NH3) with a spectroscopic approach.

The N-RSD includes a microphone array and other technologies to differentiate between noise originating from vehicles and other noise sources, for example a nearby construction site. In addition to the noise, the velocity and acceleration of the vehicle is measured which is necessary to correct for the influence of tyre-road-noise.

The experimental pavement developed under the project was subjected to a performance evaluation process. Noise measurements were performed before and after deployment to evaluate the performance of the aged preexisting pavement and compared with the newly developed pavement.

Data Analysis

After a data cleaning procedure, license plate data of around 10 000 vehicles were available for analysis. Since EUR standards could not be directly retrieved, the environmental category defined the date of registration of the vehicles was used as a proxy. The remote sensing data were compared with additional ambient air and noise quality measurements and at data points from municipal and regional measurement stations.

For the innovative asphalt pavement, measurements were carried out June 2022 and analysed by a standard protocol.

High-Emitter Notification

As a result of the pilots, high emitters were identified, and postal letters were sent to 100 owners of high-emitting vehicles. The letter informs the vehicle owner that his/her vehicle has been identified with very high emission levels and recommends the user to check his/her vehicle. The Municipality of Florence received 10 replies to the letters: 5 users responded that they would check their vehicle, and 5 users said they were no longer in possession of the vehicle or were about to sell it.

Integration and Collaboration

Ricardo's RapidAir® was used to model the dispersion of pollutants in Florence defining an air pollution map. Meteorological dataset from Florence Airport was also used. The pilot could not have been conducted without the help form the Municipality of Florence managing authorization procedures and the technical support from ARPAT. Municipal Police secured the areas.

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Conclusion and Future Steps

The dynamic monitoring champaign of Florence show in a real-life scenario that a high-emitter control program in European city is a realistic option as a measure to ensure urban environmental sustainability improvements. The pilot is carried out together with local administrations and related stakeholders, to guarantee the smooth execution of each activity. A remote sensing measurement system can be crucial with introducing local restrictions to improve the liveability of cities and can be successfully combined with new asphalt layers proven to reduce noise emission.

For the future, definitions for who is the high emitter needs to be further developed. In the Florence pilot, different options for emissions levels have been evaluated with strength and weaknesses. Validation of the performance of the high emitter methodologies would require vehicles flagged as high emitters to undergo emissions testing at a vehicle inspection centre.

The City of Florence collaborated with ACI (Italian Automobile Club) to extract vehicle data. In the NEMO-methodology, information derived from the license plates, such as model, European standard, fuel, age, engine size is analysed in correlation with real-time emissions. The motor registry data retrieval was tedious and costly process and lacked the EURO classification data as well as information on noise limits. Because of vehicle data restrictions, only around 20% of the measured vehicles was used.

The process of collecting license plates data may differ from one Member State to another due to the privacy legislation. More streamlined legal framework and user-friendly interphases should be promoted in all member states by the European level.

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Madrid pilot summary

Pilot Overview

The Madrid pilot focused on measuring on-road vehicle noise and emissions, as well as deploying a multifunctional barrier to absorb noise and emissions from road traffic. The pilot also included identifying and notifying high emitters among the fleet of vehicles screened and encouraging drivers to get their vehicles checked. The pilot successfully installed top-down prototypes in different real-world environments and site types, proving that noise and emissions remote sensing devices can be integrated into existing infrastructure.

Key take-aways for European cities

- Remote sensing devices can be integrated into existing infrastructure to measure vehicle emissions and noise levels.
- Encourage drivers to get their vehicles checked for emissions after remote detection from road sensing devices.
- Involve stakeholders, such as local businesses and associations, in the planning and implementation of mitigation measures.
- Continue investing in research and development of innovative technologies to reduce traffic-related emissions and noise.

The project leader and key participants

Javier Buhigas (ORSE), José Fermoso (CARTIF), Francisco Verdugo (CARTIF), Ignacio Riesco (AUDIOTEC). The pilot was conducted in collaboration with the Madrid City Council and the Valladolid City Council, as well as the private companies INDRA, MASMOVIL and APPLUS+ that supported key activities

Pilot Duration

9 months.

Project Description

The Madrid pilot project focused on road transport only, and aimed to measure vehicle noise and emissions, as well as deploy a multifunctional barrier to absorb noise and emissions from road traffic.

Deployment and Monitoring

The remote sensing systems were deployed in vertical mode to measure vehicles in more than one traffic lane.

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The multifunctional barrier consisted of 15 individual modules that were assembled on-site. The choice of a U-shaped structure added rigidity and stability to the assembly.

High-Emitter Identification

11 High-emitting vehicles were identified from 830 screened vehicles from a controlled fleet. The drivers of these vehicles were contacted to encourage them to get their vehicle checked. 8 vehicles were tested in a traditional emissions inspection centre, showing that that a vehicle with high particulate emissions detected on the public road by a remote sensing device would be corroborated as a vehicle with emissions outside the permitted limits in a subsequent PTI test.

Data Analysis

The collected data was analysed to identify high-emitting vehicles and to compare real-world emissions to emission tests at a Periodical Technical Inspection centre.

Integration and Collaboration

The project collaborated with the Madrid City Council and the Valladolid City Council to secure permits for the installation of all the different systems. The project also collaborated with private companies for integrating the systems on different real-world setups and executing high-emitter enforcement.

Environmental Impact

The noise measurements showed that the barrier was effective in reducing traffic noise in the area where it was installed. The barrier also served a dual purpose by removing environmental pollutants, such as particulate matter and nitrogen oxides, from the air. The pilot showed that screening emissions on the road can be used to improve emission testing programs, radically improving the emission condition of the fleet, thereby reducing transport emissions.

Conclusion and Future Steps

The remote sensing devices were able to measure emissions and noise levels from vehicles driving in multiple lanes, and they demonstrated the capability to measure 24/7 on a fixed location.
For the reduction of noise levels, a maximum reduction of up to 6 dB has been achieved, and efficiencies of between 68-88% have been achieved in the case of Nitrogen Oxides (NOx), while in the case of Particulate Matter (PM), this elimination rate has been quantified at between 30-81%.

The multifunctional barrier solution serves a dual purpose: on one hand, regarding acoustic properties, it isolates the area to protect from road noise and improves the acoustic conditions of the space behind the barrier to provide pedestrians with greater acoustic comfort. On the other hand, due to the biofilter installed, environmental pollutants (Particular matter and nitrogen oxides) are removed from the air, improving the air quality.

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The project showed that high emitters can be found on public roads using remote sensing devices and that the worst cases of these polluting vehicles can already be identified with today’s European PTIs. The project's findings can be used to adjust the calculation of externalities and proposed charging methods.

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Tilburg Haaren Rail Pilot Summary

Pilot Overview

The NEMO rail pilot located in the Haaren region in the Netherlands focused on rail noise from trains and individual wagons. Two novel remote sensing systems were put to the test autonomously measure and identify high emitters. The highly successful tests yielded a large dataset for rail traffic. The pilots succeeded to separate trains into wagons/train units and classify them according to their noise emissions, quickly and reliably picking out 'high emitters'.

Key take-aways for European cities

Remote sensing devices can be integrated into existing railway infrastructure. Repetitive 'high emitters' could quickly be found and sanctioned based on European, national, regional or local legislation. Remote sensing systems can identify malfunctions and help regulators introduce more stringent measures for wheel irregularities or outdated brake systems. It can help handle complaints to certain trains, traffic load or secondary factors such as rail roughness.

Many European cities are operating or financing passenger trains. Early detection of high emitters not only helps fleet operators and owners to efficiently schedule maintenances, it gives authorities the tools required to respond to the public demand for quieter routes. Countries such as Switzerland and Germany, that have banned the most noise emitting train technologies, such as freight wagons with cast iron brakes from its routes, saw significant drops in rail traffic noise emissions.

The project leader and key participants

Nathan Isert (MRAIL), Markus Naumann (MRAIL), Stefan Lutzenberger (MRAIL)

Pilot Duration

September 2022 and February 2023 (6 months)

Project Description

The Haaren rail pilot focused on noise emission and aimed to measure and analyse train noise from individual wagons/ train units and identify high emitters.

Deployment and Monitoring

Two remote sensing prototypes (N-RSD) were built and setup for the pilot on the two-track line 125 between Tilburg and Boxtel in the Netherlands. Each prototype covering one train line. The prototypes

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included microphones, sensors to determine the axle pattern, speed, and indication to categorize the trains as well as RFID readers and cameras to identify owner/operator and brake type labels. Additionally, the prototype included a weather station.

High-Emitter Identification

The real-world emission data was combined with the type-approves tests in the latest European standard Technical Specifications for Interoperability (TSI). The pilots succeeded to separate train noise into their respective wagons/ train units and classified into noise emission based of TSI limits. Each wagons/ train unit have a unique number, a so called UIC-number, that was read from camera systems and RFID readers. This provided the information required so that ‘high emitters’ could quickly be found.

Data Analysis

Over the course of 165 days of continuous, automated operation the two N-RSD registered more than 25 thousand trains with 290 thousand individual wagons/train units and about 1.1 million axles. Flat wheels have been identified as the largest contribution to high noise emissions, while for freight wagons the choice of composite brake type had a significant impact on overall noise emissions.

Integration and Collaboration

The pilot project data was validated though a data collaboration with a Quo Vadis systems set up adjacent to the pilot. Several rail operators have also provided data.

Environmental Impact

Freight wagons classified as ‘high’ emitters made up only 4 percent of all freight wagons but contributed. almost 20 percent of the total freight wagon noise emissions. If all freight wagons were made TSI compliant and assuming the given ratio between ‘low’ and ‘normal’ emitters, noise emissions from freight wagons would drop by 27 percent (-1.4 dB). For passenger wagons/units making all wagons TSI compliant would lower emissions by 25 percent (-1.2 dB).

Conclusion and Future Steps

The NEMO rail noise pilot the NEMO project showcases a model to lower train noise emissions by offering a broad, reliable, and fast identification of high emitters from remote sensing and track side rail monitoring. The train detection rate was found to be very reliable resulting in >99.8% of the trains being registered during the pilot. Over the half year pilot none of the rail sensors failed, showing that the system can largely be operated autonomously.

The NEMO project focus on high emitters but the broad set of data and information available also allows to constantly evaluate the traffic and look for changing dependencies and root causes, and for

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deducting current state of the fleet. For example, 60 percent of all wagons in the class of ‘high’ emitters were also registered as having wheel irregularities and wagons with a certain type of brake system (LL-brake) was severely overrepresented in the ‘high’ noise emitter class.

Furthermore, the results in NEMO could be used to evaluate the impact of rail grinding or monitoring obsolete systems. By the end of 2024, new regulations will limit the use of cast-iron braked wagons, and they will largely be phased out. Remote sensing solutions as the one presented will become vital tools to support the authorities in monitoring the rolling stock on the quieter routes and identify non-permitted wagons.

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Valencia pilot summary

Pilot Overview:

Emissions in port areas can be a significant environmental concern and can have negative impacts on the environment and health for the citizens living close to ports. To tackle this issue, new regulations are launched for ships operating outside the designated emission control areas, and while at berth.

The Valencia pilot have measured emissions from three different emission sources in ports: ship gaseous emissions, ship noise emission and train gaseous emissions (diesel locomotives). The three different types of emissions have been measured by remote sensing methods in Valencia in the period from October 2022 to April 2023.

The pilot shows that it is possible to deploy different instruments and measurement techniques to measure noise and emissions from ships and trains remotely, and thus, can be deployed to monitor emissions continuously and unassisted.

Key take-aways for European cities

Ports are busy areas with many different emission sources coming from logistics, services, building and maintenance. The Valencia pilot show that it is possible to monitor emissions from trains and ships despite this complex environment. Having empirical and real-world ship and rail emissions data from ports allows authorities to understand the current levels and to act on the problem.

There are several upcoming new regulations, for example on fuel types. Port authorities can identify the few ships/train operators that violate the regulated limits and put in efforts to quickly correct the problem or use the data to introduce new and stricter emission regulations in port areas.
Reducing emissions in port areas, requires advanced planning and the collaboration between all the different stakeholders (port administration, ship owners, shipping companies and city planners).

The project leader and key participants

The lead organisation for the pilot - Fundación Valenciaport (FV), coordinated with the Port Authority of Valencia to facilitate all permits for access and installation of the equipment. Müller-BBM GmbH (MLL undertook tests, measurements and analysis related to the ship noise remote sensing and Opus RS Europe (ORSE) undertook the tests, measurements and analysis related to the vessels and trains gaseous emissions.

Pilot Duration

7 months

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Project Description

The Valencia pilot have measured emissions from three different parts of the port landscape: ship gaseous emissions, ship noise emission and train gaseous emissions from diesel locomotives.

Deployment, Monitoring and Data Analysis

The methodology used, the data collected, and the analysis performed for the three activities varies between the three different scenarios.

Ship gaseous emissions

Gaseous emissions from ships were measured using point-sampling remote sensing instruments measuring concentrations from the ships' plumes, by placing the instruments on land, close to the water. A method of comparing the measured emission of NOx to CO2 and SO2 to CO2 was used for the data analysis. The pollution level of each vessel was combined with technical data associated from each ship, such as age, gross tonnage, and ship dimensions. The data were filtered to isolate plumes during westerly winds. In total, 58 plumes from 36 distinct vessels were collected for analysis.

Ship noise remote sensing

There is no standardized method for measurement of pass-by ship noise, and a new methodology was developed. Technologies and knowledge derived from road vehicles NEMO (N-RSD) was used, and consisted of a noise monitoring station, including weatherproof microphone and integrated weather station, acoustic camera for sound source localization, and the ship distance was monitored using a laser. The data from each pass-by was analyzed and audio files were used to individually detect any non-related background noise for both transport and passenger ships. In total 20 different ships pass byes were identified and measured during the campaign.

Train gaseous emissions remote sensing

Port of Valencia has a train track for diesel trains loading and unloading of cargoes. The test targeted high emitting locomotives looking for serious malfunctions, tampering, etc. Technologies and knowledge derived from the remote sensing technology developed for road transportation NEMO (E-RSD) was used, including spectroscopy with radiations from lasers in the infrared spectrum. The sensors were placed 5 meters above the ground in order to cross the locomotive's gaseous plume.

High-Emitter Identification

The three tests in Valencia port show evidence of high variability in the emission levels, and high emitters in each category were detected. By identifying high-emitters, authorities can act selectively on these vehicles to reduce air pollution and noise annoyance.

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Integration and Collaboration

The pilots could only be established through a close cooperation with the Port Authority of Valencia. Some of the instruments were provided by the University of York, who assisted on the preparation and calibration of the instruments. Vessels were identified and characterized using Marine Traffic and Vessel Finder database.

Conclusion and Future Steps

The three tests in Valencia port have been an operational and scientific success. It has been possible measure noise and emissions from individual ships and trains, and the system can be deployed in any port to monitor emissions continuously and unassisted. Reducing emissions from ships in port areas requires collaboration between the shipping industry, port authorities, local governments, and the scientific community.

Techniques for on-road remote sensing can be modified to successfully monitor ship and rail transport (locomotives) emissions in port areas. Focusing on high emitters can help improve the living environment for visitors and citizens the from harbours.

The three pilots encourage continued future scientific efforts and modifications, such as deployment, location and data validation. The data can also be used to understand more about the low frequency noise caused by ship's auxiliary engines - the largest nuances reported for citizens living around posts. For ships gaseous emissions, the data can also be used to understand more on emissions in relation to ship characteristics such as fuel, engine type, age, performance, vessel load and operation regime. Further developments of the tools should be continued as they are important for authorities to identify "high emitter ships" and to implement planning actions accordingly. The project's findings can be used to further monitor implementation of new stricter fuel and emission policies or limits in the port landscape.

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