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#RTR2026

PAREMPI: Particle emission prevention and impact: from real-world emissions of traffic to secondary PM of urban air

PAREMPI

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PAREMPI

2ZERO ERTRAC CCAM European Commission | With the support of BATT4EU Batteries European Partnership

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Overall project presentation

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Consortium, partners, budget

VTT

Tampere University

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magellan circle

39	1.1.2023-31.3.2026 Months
6	Countries
8	Partners
3	MIL €

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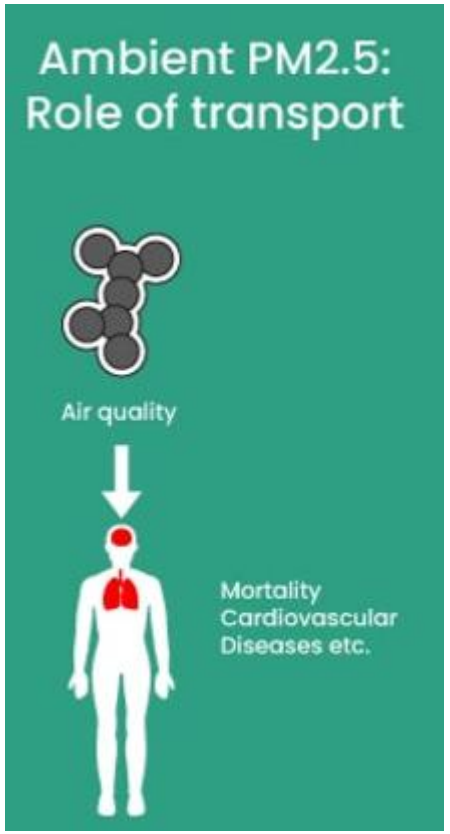
Objectives

- Generating scientific evidence
  - Contribution of transport sectors on total PM2.5 emissions, including secondary aerosols (SecA)
  - Harmfulness of transport sectors' total PM2.5 emissions
- Developing tools for policies
  - Digital ePMI module to estimate SecA potential
  - Health impact and externalities assessment
  - Robust measurement system evaluation
- Recommending policies



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Results presentation

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Transport sectors' aged PM emission results

- Road transport
  - **Aged PM has decreased with stricter rules**, but still exceeds regulated PM.
  - **Cold starts and PHEV engine-on events** elevate aged PM emissions, even for Euro 6d cars. Fast warm-up of exhaust aftertreatment (EAT) is needed.
  - **NH_3 driving aged PM** formation induced by EAT (TWCs and SCR).
  - **Aged PM would reduce** by stricter NMOG, NH_3, NO_x and fuel aromatic limits.
- Aviation and marine sectors
  - **Aviation:** CAST burner using jet fuels produced exhaust resembling aircraft operation at idle. **Very high aged PM emissions dominated by organics**.
  - **Marine:** diesel generator using **marine fuels emitted high aged PM levels**, especially with NH_3 injection in exhaust (NH_4NO_3 formation).
  - **Strict NMOG, NO_x and NH_3 limits** would decrease aged PM, as well as fuel aromatic and sulfur limits. Lubricating oil quality may also contribute.
- Brake wear particle (BWP) emissions
  - Of BWP PM10, ~30–50% in the PM2.5 range. Harsh braking produces ultrafine particles.

Results with cars published by Simon et al. 2025 (doi:10.1016/j.aeaoa.2025.100375).

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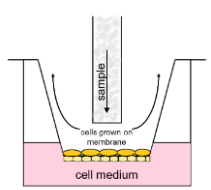
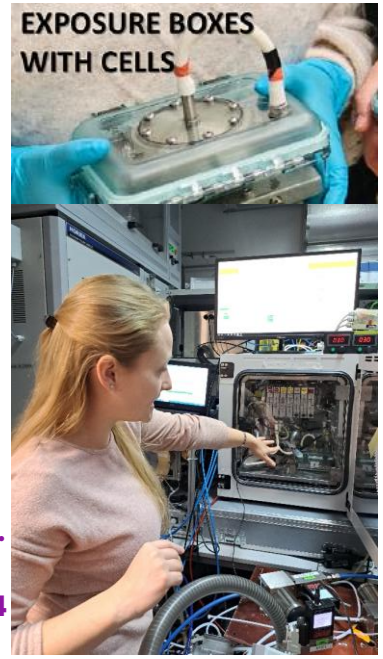
Toxicological results



- **The robust toxicity measurement system** was a significant achievement.
  - A portable-size ALI* exposure chamber suitable for real-life conditions. Employed all measurements, even in a moving truck on-road and in situ toxicity testing.
- **Despite low overall toxicity**, gene expression changes revealed.
  - Conventional assays lack sensitivity for clean technologies, while transcriptomic endpoints detected early effects.
- **Findings**
  - **Aged and fresh exhaust** exhibited in the same direction indicating their harmfulness.
  - Toxicological differences indicated for **varying PM compositions (organics, NO_3, NH_4 or SO_4).**
  - **Even short exposures and the clean technologies** caused relevant toxicological responses indicating health risks, influenced by ambient temperature.
- **Toxicological insight** should be included in design of engines, fuels, and EAT systems.



- TEER (transepithelial resistance, cell tissue integrity)
- Cytotoxicity (cell culture medium, T0, T24 an T48)
- DNA damage – Comet assay and Histone H2AX (cell lysates)
- Gene expression (RNA)
- Oxidative damage – Isoprostane (cell lysates)

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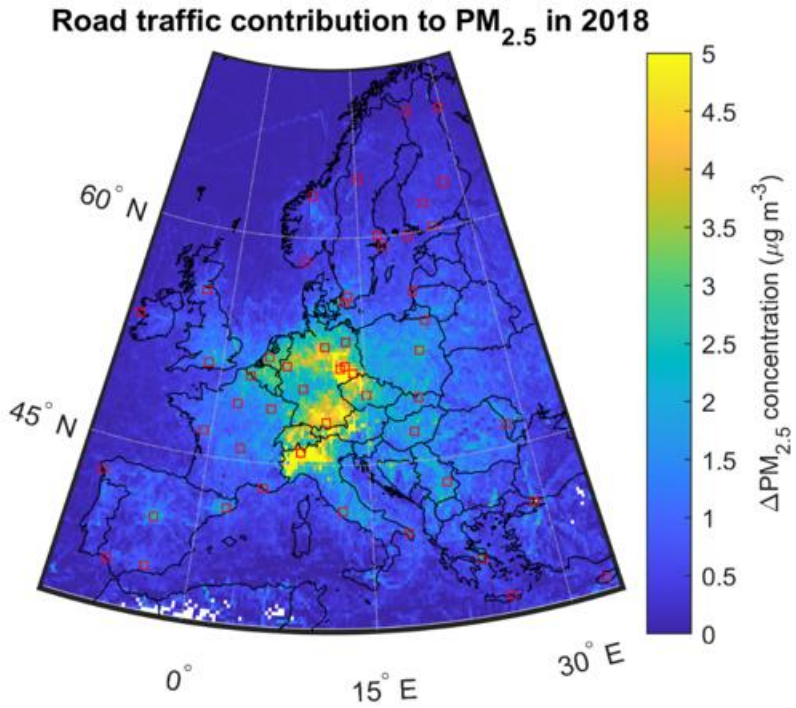
Portable toxicity system published by Vojtisek-Lom et al. 2025 (doi:10.1016/j.scitotenv.2024.178010).

*ALI = Air-Liquid Interface

Modelling of secondary aerosol formation and molecular level experiments

- **Transport emissions impact on the air quality in Europe**
  - Road traffic strongly influences NO_x, and indirectly ozone and PM level in central and urban Europe. NO_x with NH_3 is a major source of PM2.5 .
  - Nitrate dominates PM2.5 in many continental regions during winter and spring. Models may still underestimate effect of traffic on SOA*.
  - Ships increase ultrafine particles, affecting ocean and coastal regions
  - Reductions in road traffic NO_x and VOC emissions would reduce both the PM2.5 and surface ozone levels in Europe.
- **Digital equivalent total particles emissions index module (ePMI) software**
  - ePMI software developed for evaluation of primary and secondary aerosol particle number and mass formation from transport sources.
- **In molecular level secondary organic aerosol modelling**



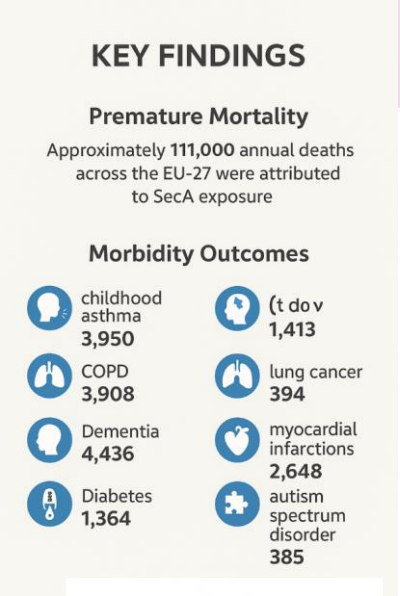
Road traffic contribution to the yearly average $PM_{2.5}$ levels in Europe (ADCHEM).

*SOA = secondary organic aerosol

Nucleation predictions published by Svenhag et al. 2025 (doi:10.5194/gmd-17-4923-2024).

Health impact assessment and external costs evaluation

- **Road and ship traffic impacts on $PM_{2.5}$ exposure, related health effects and external costs in Europe** assessed based on toxicological and epidemiological studies in Europe.
- **Mortality-related external costs.**
  - Considered both direct (e.g. healthcare) and indirect (e.g. productivity losses) impacts.
  - Excess cases (mortality and morbidity) estimated using modelled PM2.5 concentrations, baseline country-specific incidence rates (EU-27), gridded population data and relative risks (RRs) for each health outcome.
- **The link between PM2.5 and mortality is strong**, while the effects of individual components are less certain.
  - Following WHO and EPA guidance, the analysis applied a toxicity assumption for all PM2.5 mass, supported also by PAREMPI findings on toxicity responses.
- **PAREMPI estimates approx. 111,000 premature deaths per year in the EU-27 attributed to SecA exposure, and respective total annual societal cost of these health outcomes is estimated at €367.3 billion.**



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Policy recommendations and databases

Policy recommendations

- **Fuel shifts:** Promoting cleaner fuels can offer fast impact. Standards with stricter limits on fuel sulfur and aromatics.
- **Advanced engines and EAT** promotion.
- **Stricter emissions standards** (NO_x, SO_x, NH_3, NMOG)
- **Measuring, reporting and monitoring** of emissions.
  - **Harmonisation** of methods to gain reliable and comparable data. **Robust aged PM measurement systems** capable for real-world measurements. **Toxicological studies** in the evaluations and early stage of development.
- **Systematic approaches**
  - **Transition to zero-emission mobility**, e.g. EVs. Urban planning and traffic management. **Integrated strategies** targeting both traffic-related and agricultural NH_3. **Public Health Co-Benefits**.

PAREMPI Database supports future initiatives

- Emissions database
  - Data from literature and results from the complementary PAREMPI measurement campaigns for precursor gases, aged PM, and its composition.
- Toxicity database
  - A semi-quantitative toxicity classification system.
  - Scoring on a scale of 0–5:
    C: Cytotoxicity (cell viability);
    G: Genotoxicity (DNA damage);
    O: Oxidative stress;
    D: Other effects (e.g., immune response, epithelial damage).

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Mid to long term expected impacts of the PAREMPI project

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Impacts

- The results and tools of the PAREMPI are **efficiently disseminated** to be adopted and further advanced by other researchers, stakeholders, and policy-makers.
- **Preventing actions of the ambient PM2.5 levels derived by transport** based on the results.
- **Evaluation of SecA formation potential** by utilizing and further developing the ePMI module.
- **Investment decisions based on the clean technologies** identified based on the scientific evidence of the transport sectors' contribution to ambient PM2.5 levels, and the related external costs.
- **Implementation of policies favouring do-no-significant-harm technologies**.
- Potential to significantly **contribute to meet the challenges Europe faces today** to make its transportation system clean, secure, and efficient.
- **Contribution in actions saving premature deaths** in Europe and globally.
- **Cost savings through lower external costs** achieved by reduced transport-derived ambient PM2.5.
- **Markets in Europe and globally for scientifically evidenced clean technologies**.

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THANK YOU

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