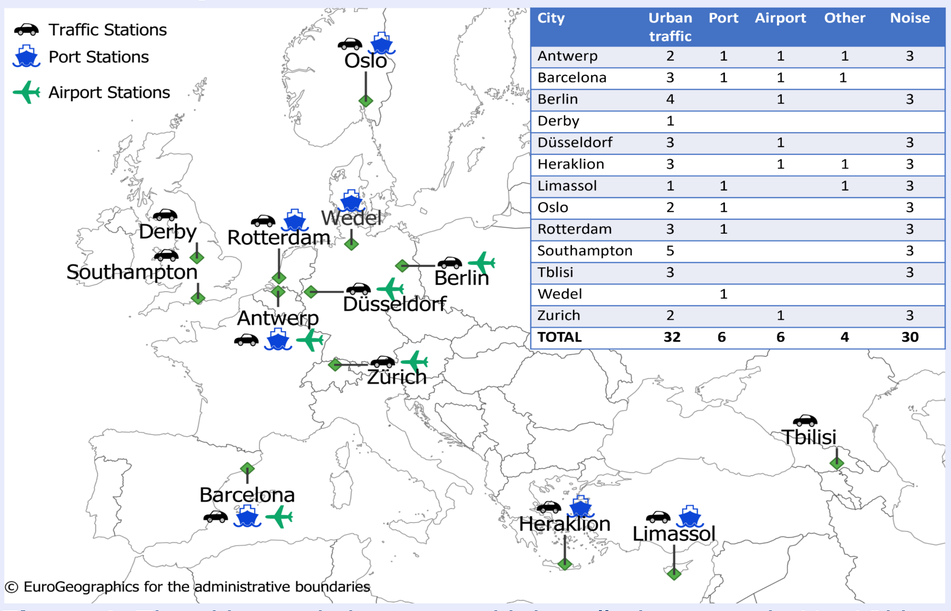
Continuous Monitoring of UFP Across 11 European Cities: First Results from the Net4Cities Project

S. Schmitz[1], S. Drossaart van Dusseldorp[2], A. Pajunoja[3], R. Balbaaki[4], G. Jibuti[5], S. Oftedal Barrault[6], F. Silva Domingues[7], E. van der Gaag[8], M. van Poppel[9], E. von Schneidemesser[1]* - on behalf of the entire Net4Cities consortium.

[1]Research Institute for Sustainability (RIFS) at GFZ, Potsdam, Germany, [2]Zurich University of Applied Sciences (ZHAW), Winterthur, Switzerland, [3]Airmodus Ltd., Helsinki, Finland, [4]Climate and Atmosphere Research Center (CARE-C), Nicosia, Cyprus, [5]Ivane Javakhishvili Tbilisi State University (TSU), Tbilisi, Georgia, [6]Norwegian Institute for Air Research (NILU), Kjeller, Norway, [7]Universitat Autònoma de Barcelona (UAB), Barcelona, Spain, [8]DCMR Environmental Protection Agency, Rotterdam, Netherlands, [9]Flemish Institute for Technological Research (VITO), Mol, Belgium

Net4Cities: expanding long-term monitoring of UFP across Europe



City	Urban traffic	Port	Airport	Other	Noise
Antwerp	2	1	1	1	3
Barcelona	3	1	1	1	
Berlin	4		1		3
Derby	1				
Düsseldorf	3		1		3
Heraklion	3		1	1	3
Limassol	1	1		1	3
Oslo	2	1			3
Rotterdam	3	1			3
Southampton	5				3
Tblisi	3				3
Wedel		1			
Zurich	2		1		3
TOTAL	**32**	**6**	**6**	**4**	**30**

Figure 1. The cities and site-types with installed sensors in Net4Cities.

- Horizon Europe Project Net4Cities (2024-2027) has expanded UFP monitoring to 13 cities in Europe, alongside other emerging pollutants.
- 33 naneos OEM LDSA sensors (OLS) and 24 Airmodus A30 CPCs were installed at traffic sites, ports, airports, and background sites.
- Aim is to support further development of transport and air pollution policy in Europe.
- Taking co-creative, transdisciplinary approach by working closely with stakeholders in each city.

LDSA and PNC as metrics of UFP in Net4Cities

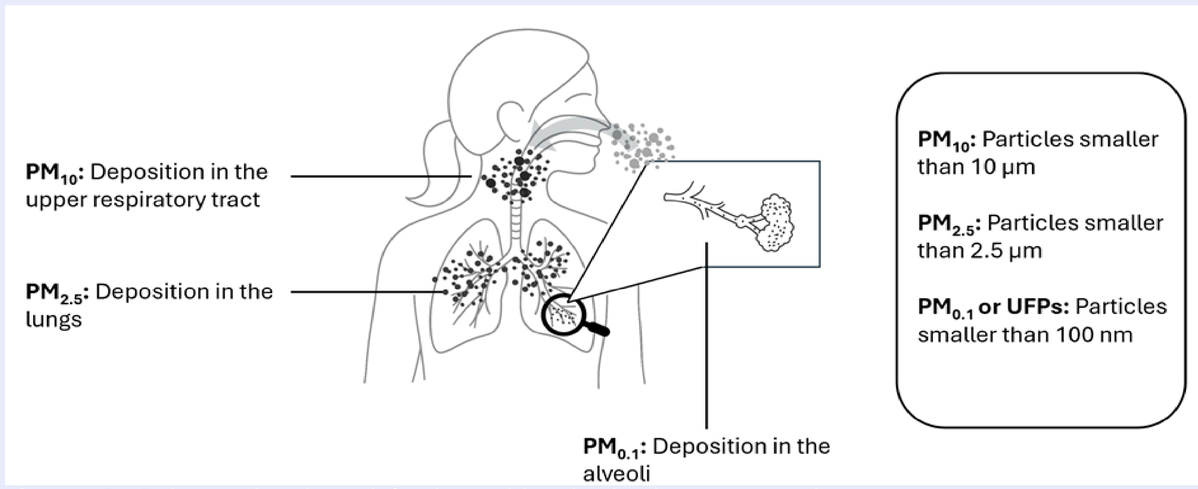
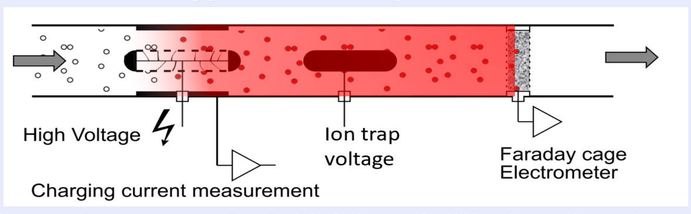


Figure 2. Schematic of particle deposition in the human respiratory system.

- **Definition:** Ultrafine particle (UFP) measurements of lung-deposited particle surface area (LDSA) concentration in µm²/cm³ and particle number concentration (PNC) in particles per cm³ (pt/cm³).
- **Data Gap:** Scarcity of long-term, large-scale environmental measurements globally. New datasets required to better understand health impacts of UFP.
- **Health Impact:** Ultrafine particles can deposit deep in the alveoli and potentially cross into the blood-stream (Figure 2). LDSA recognized as a highly effective metric for nanoparticle toxicology[1,2]
- **Levels:** LDSA hourly averages <15 µm²/cm³ are considered low and >40 µm²/cm³ are considered high (no consensus), episodic peaks can exceed 200 µm²/cm³ [3,4]. PNC <1,000 pt/cm³ are considered low, with concentrations >10,000 pt/cm³ considered high[5].

naneos OLS – setup and initial results

- Use diffusion charging principle as in the naneos Partector instruments.
- Measuring only LDSA, not size distribution or PNC, but ~20 co-located with CPCs.
- Initial quality checks indicate excellent performance. High data availability (>95%) across all sites. **For more – see Fierz et al. poster 5C**
- Initial results exhibit heterogeneity amongst cities, but similar concentrations between site-types with transport-related emissions.



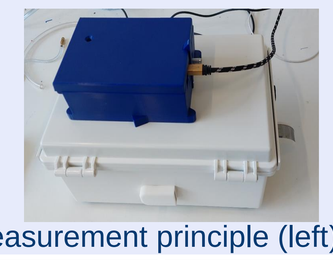


Figure 3. naneos OLS (right) and diffusion charging measurement principle (left).

Airmodus CPCs – setup and initial results

- **A30 / A20 CPC**; stainless steel inlet tubing (at some sites available combined gas inlets used); PermaPure 12'' Nafion dryer + pump; cyclone (~2.5µm cutoff); RHTP Module (<40% RH).
- **Condensation fluid**: Propylene Glycol (at select locations Butanol). Tests for ACTRiS compliance ongoing.
- **IoT Datalogger** with LTE/Wifi connection. 1Hz timeseries data.
- Substantial technical issues encountered due to hardware failure (e.g., faulty laser driver), dirty environments (reduced flow and clogged instruments), and poor LTE connection.
- Missing data due to technical challenges, logistical issues in installation, and data transfer issues.

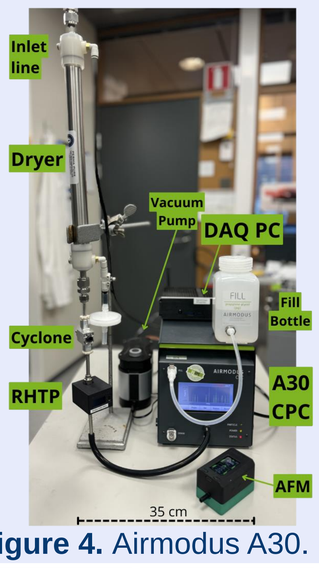


Figure 4. Airmodus A30.

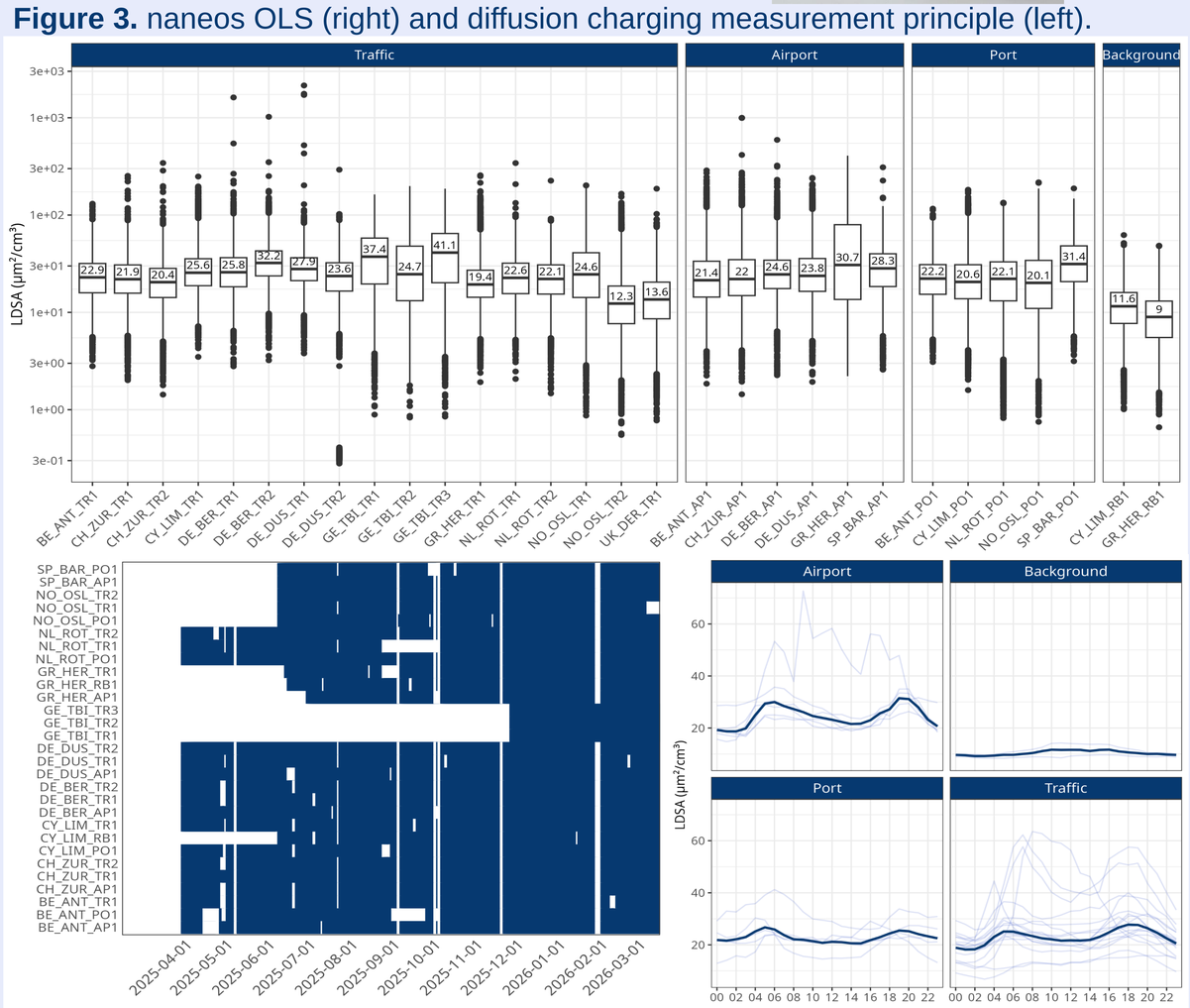


Figure 5. (top) Boxplots of hourly LDSA concentrations at all sites, (bottom-left) data availability at all sites, (bottom-right) diurnal plots of LDSA by site-type.

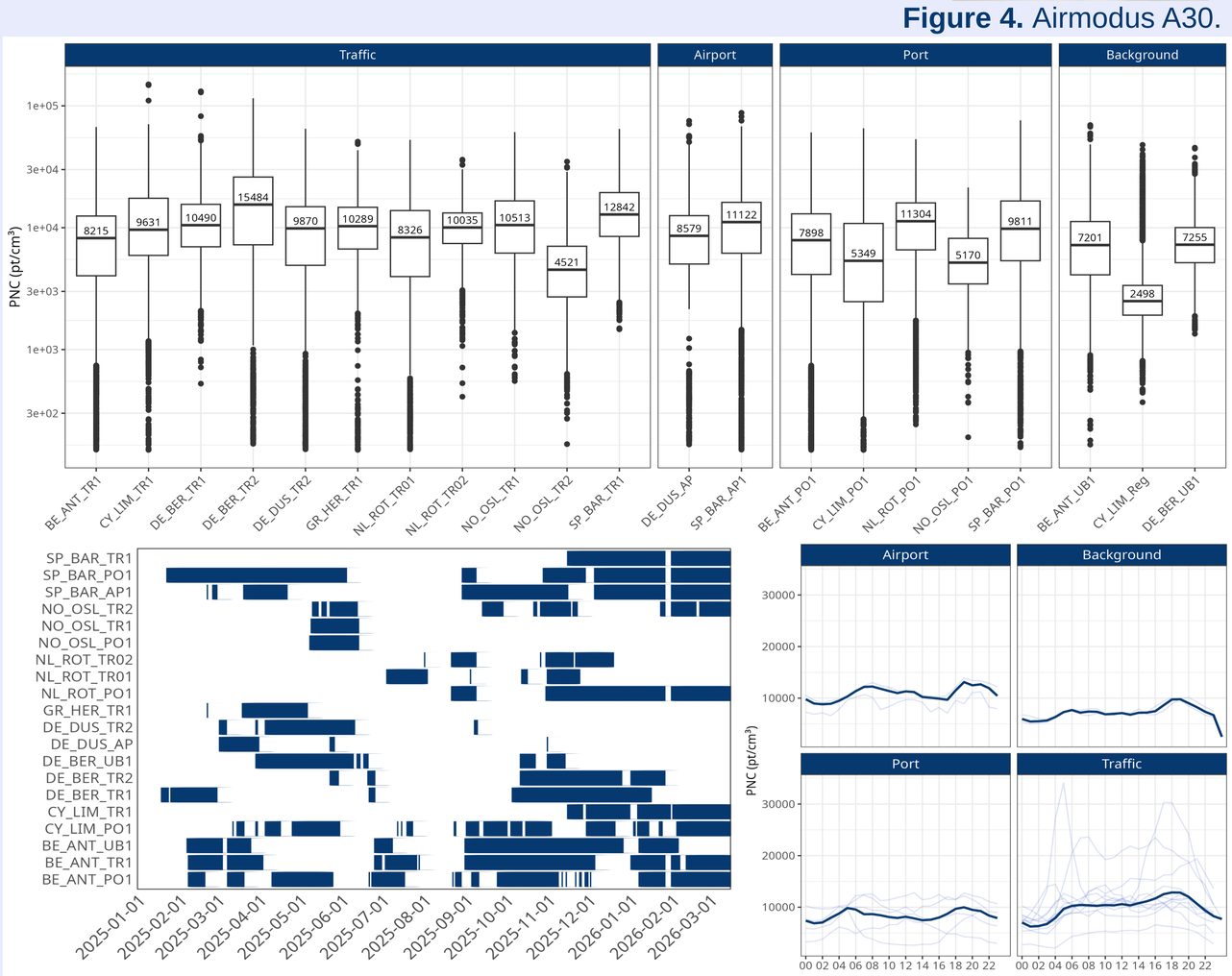


Figure 6. (top) Boxplots of hourly PNC at all sites, (bottom-left) data availability at all sites, (bottom-right) diurnal plots of PNC by site-type.

Next steps: The remaining 18 months of the project will focus on improving data quality, conducting detailed analysis across all sites, and providing policy-relevant recommendations on air pollution and transport policy to stakeholders. The Net4Cities Studio (currently under development) will host all project results, publications, and deliverables, and will serve as a platform for accessing open-access long-term datasets.

Co-funded by the European Union

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Department of Economic Affairs, Education and Research EAER
State Secretariat for Education, Research and Innovation SERI

UK Research and Innovation

Website LinkedIn BlueSky

1. Schmid and Stoeger, 2016. Journal of Aerosol Science, Volume 99, Pages 133-143, DOI: 10.1016/j.jaerosci.2015.12.006.
2. Kwon et al., 2020. Exp Mol Med 52, 318–328. DOI: 10.1038/s12276-020-0405-1
3. Edebeli et al., 2023. Int J Public Health 68:1605879. DOI: 10.3389/ijph.2023.1605879
4. Liu et al. (2023). Science of The Total Environment, Volume 898, 165466, DOI: 10.1016/j.scitotenv.2023.165466.
5. WHO, 2021. WHO global air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide.

RIFS