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D1.2 Monitoring and Implementation Roadmap

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1. Executive Summary

Roadmaps for monitoring networks are valuable tools for city authorities and interested stakeholders, offering a structured framework to prepare the planned installation, track progress and assess the suitability of the setup. They support the implementation by providing a process design with clearly outlined objectives, key milestones, necessary deployment and maintenance stages, and specific requirements that must be fulfilled to achieve the intended goals. They help identify challenges early, optimize resource allocation, and adapt strategies as needed. Roadmaps can be flexibly adjusted to suit the planning of a new monitoring network or the expansion of existing ones. This adaptability ensures they remain relevant to varying contexts and evolving requirements, providing stakeholders with a versatile tool to address specific needs and achieve desired outcomes efficiently.

In the Net4Cities project, the goal is to learn from project-tailored roadmaps and city-tailored implementation plans to identify best practices and insights, with the end goal of designing a standardized roadmap that can serve as a practical guidance tool. This standardized roadmap will be made publicly available through the Net4Cities Studio, ensuring cohesive scalability of project findings and results.

Here, we report about the Net4Cities-specific monitoring and implementation roadmaps that are based on identified key policy needs and focused on monitoring and implementation plans that outline the concrete monitoring setups for advancements of existing monitoring networks.

Relevant stakeholders were identified in the partner cities such as administrations, port and airport authorities, and scoping workshops with stakeholders were held (Apr-Dec 2024) in all the Net4Cities partner cities. The stakeholders expressed their interest in Net4Cities and the advancements in monitoring infrastructure that is planned. For most cities, the existing monitoring infrastructure is already quite extensive, and their focus is to complement current monitoring with additional techniques that address the new and emerging pollutants (air quality) and extend the noise and traffic monitoring network. For air quality measurements of ultrafine particles (UFP), lung-deposited surface area (LDSA), ammonia (NH_3), volatile organic compounds (VOC) and greenhouse gases and PM_{10} filter analysis for source attribution are foreseen.

The Net4Cities monitoring sites were selected with local stakeholders. They conform to Net4Cities' research goals of measuring new and emerging pollutants from transport sources (e.g., traffic, ports, airports), and for options where the requirements of Net4Cities were met, also integrate preferences and interests of the partner cities. An overview of the Net4Cities sites is given in Table 1 below. Some sites still need to be further defined (TBD) or confirmed (TBC).

The instrumentation is deployed at the Net4Cities' sites following installation procedures that maximize comparability between cities. Instrumentation for air quality includes Airmodus CPCs for UFP measurements, OLS devices manufactured by Naneos GmbH for LDSA, passive samplers for NH_3, canister sampling for VOC and greenhouse gasses, and filter samplers for PM_{10}. The Cirrus Quantum outdoor noise monitor and Telraam traffic count monitor are the instruments for noise and traffic monitoring that will be installed together.

Table 1: All Net4Cities monitoring sites, their classification, and which instruments will be installed there.

Net4Cities site	Net4Cities classification	Air quality	Noise	Traffic
BE_ANT_TR1	Urban-traffic	YES	YES	YES
BE_ANT_TR2	Urban-traffic	NO	YES	YES
BE_ANT_UB1	Urban-background	YES	NO	NO
BE_ANT_PO1	Port	YES	YES	YES
BE_ANT_AP1	Airport	YES	NO	NO
ES_BAR_TR1	Urban-traffic	YES	TBD	TBD
ES_BAR_TR2	Urban-traffic	NO	TBD	TBD
ES_BAR_RL1	Railway	NO	TBD	TBD
ES_BAR_AP1	Airport	YES	NO	NO
ES_BAR_PO1	Port	YES	NO	NO
DE_BER_TR1	Urban-traffic	YES	YES	YES
DE_BER_TR2	Urban-traffic	YES	YES	YES
DE_BER_TR3	Urban-traffic	NO	YES	TBD
DE_BER_AP1	Airport	YES	NO	NO
DE_DUS_TR1	Urban-traffic	YES	YES	YES
DE_DUS_TR2	Urban-traffic	YES	YES	YES
DE_DUS_UB1	Urban-background	NO	YES	YES
DE_DUS_AP1	Airport	YES	NO	NO
GR_HER_TR1	Urban-traffic	YES	YES	YES
GR_HER_TR2	Urban-traffic	NO	YES	YES
GR_HER_TR3	Urban-traffic	NO	YES	YES
GR_HER_RB1	Regional background	YES	NO	NO
GR_HER_PO1	Port	YES	NO	NO
CY_LIM_TR1	Urban-traffic	YES	NO	NO
CY_LIM_TR2	Urban-traffic	NO	YES	YES
CY_LIM_TR3	Urban-traffic	NO	TBD	TBD
CY_LIM_TR4	Urban-traffic	NO	TBD	TBD
CY_LIM_RB1	Regional background	YES	YES	YES
CY_LIM_PO1	Port	YES	YES	YES
NO_OSL_TR1	Urban-traffic	YES	TBC	TBC
NO_OSL_TR2	Urban-traffic	TBC	TBC	TBC
NO_OSL_PO1	Port	TBC	TBC	TBC
NL_ROT_TR1	Urban-traffic	YES	YES	YES
NL_ROT_TR2	Urban-traffic	YES	YES	YES
NL_ROT_TR3	Urban-traffic	YES	YES	YES
NL_ROT_PO1	Port	YES	NO	NO
UK_SOU_TR1	Urban-traffic	NO	YES	YES
UK_SOU_TR2	Urban-traffic	NO	YES	YES
UK_SOU_TR3	Urban-traffic	NO	YES	YES
UK_SOU_PO1	Port	YES	NO	NO
GE_TBI_TR1	Urban-traffic	YES	YES	TBC
GE_TBI_TR2	Urban-traffic	YES	YES	TBC
GE_TBI_TR3	Urban-traffic	YES	YES	TBC
CH_ZUR_TR1	Urban-traffic	YES	YES	YES
CH_ZUR_TR2	Urban-traffic	YES	TBC	TBC
CH_ZUR_TR3	Urban-traffic	YES	TBC	TBC
CH_ZUR_AP1	Airport	YES	NO	NO

The implementation plans for air quality, noise and traffic include information on the timeline of the delivery and installation of instruments and the start of the monitoring, the standard operating procedures, the QA/QC procedures for the different instruments and the logging of interventions during the monitoring. An overview table with the delivery and installation dates, and the starting date for the monitoring is given below.

Table 2: Planned delivery and installation dates of Net4Cities instrumentation.

	Delivery of instruments and installation	Monitoring at all sites
Air quality	February-March 2025	From April 2025
Noise and traffic	January-June 2025 (sequential over the partner cities)	From July 2025

This deliverable provides the Net4Cities specific monitoring and implementation roadmaps for air quality, noise and traffic. Important outcomes are:

- The **selection of the sites** to include in Net4Cities for monitoring air quality and/or noise and traffic after consultation with stakeholders.
- **Labeling of sites** (unique) for further (data) communication.
- Consolidated information about the **existing monitoring infrastructure** at the Net4Cities sites and existing monitoring stations in the partner cities.
- Consolidated information on the **advancements of the monitoring infrastructure** in partner cities by Net4Cities.
- Descriptions of the instrumentation and **specifications for the installation requirements for different instruments** to align between the partner cities.
- Descriptions of **operating and QA/QC procedures** for the different instruments to align between the partner cities.
- **Timeline** of the main phases of the monitoring and implementation plans, including the installation and testing, and the operational phase when instruments are fully operational.

The main outcome of this work is a **streamlined approach for air quality, noise and traffic monitoring** at all Net4Cities sites according to the roadmaps.

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2. Objective

Air pollution and noise monitoring require careful planning to ensure that the location of measurements, the technologies applied, and the proposed timelines meet the specific needs of cities and their stakeholders. This planning process involves drafting monitoring and implementation roadmaps (WP1). In the Net4Cities project, this planning starts with scoping workshops held with local stakeholders in the participating cities between April and December 2024. These workshops aim to identify optimal locations for advancements in monitoring air pollution (WP2) noise and traffic (WP3) following standardized guidelines. The **outcome** of these **scoping workshops** is the **monitoring and implementation roadmaps** for advanced noise and air pollution monitoring networks, specifically in the Net4Cities project partner cities.

Based on the experience gained through the implementation of these Net4Cities-specific roadmaps, broader monitoring and implementation roadmaps will be available to other cities as part of the Net4Cities which is a web-based application to support the full chain from the design of monitoring networks to health impact studies. These roadmaps will provide an overview of key milestones and stages for monitoring and implementation and can serve as examples for the broader user community in terms of key steps to consider if they are to do a similar implementation. The Net4Cities-specific monitoring and implementation roadmaps are reported in this deliverable. These are based on identified key policy needs and focused on monitoring and implementation plans that outline the concrete monitoring setups.

These monitoring and implementation plans include:

- The determination of locations for air and noise pollution monitoring instrumentation and traffic count sensors.
- Materials and methods of deployments, including descriptions of technologies used, QA/QC procedures, and data management strategies.
- A timeline for the installation and continued use of this new instrumentation.

Alongside the logistics focus of the scoping workshops, local policy needs and challenges were discussed among participants. The summary outcome of those includes:

- An assessment of potential linkages of these measurements to noise and air pollution action plans, as well as sustainable mobility and climate change mitigation plans, including synergies across the areas.
- Identification of further policy needs. The idea is to list main air quality, traffic, and noise-related policy issues and use them as the basis for the determination of targeted campaigns, ideally identifying synergies and/or commonalities across the partner cities.

This deliverable provides an overview of the Net4Cities partner cities through a short geographical description, the policy challenges, and the roadmap for the advancements of existing monitoring infrastructure by Net4Cities (Chapter 3). An overview of the existing monitoring sites at the pilot cities is described in Chapter 4. Chapter 5 highlights the selection and labeling of the Net4Cities monitoring sites where advancements in air quality, noise and traffic monitoring will be made by the techniques listed in Chapter 6. The implementation plans for air quality (Chapter 7), noise (Chapter 8) and traffic (Chapter 9) include the timing for preparatory and deployment tasks and an overview of operating procedures, QA/QC and intervention logging for air quality, noise and traffic monitoring. Based on the work defined in the Net4Cities monitoring and implementation roadmap (this deliverable) transferrable monitoring and implementation roadmaps will be compiled and made available as part of the Net4Cities studio for the broader user community.

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3. Introduction of the partner cities

3.1 Short descriptions

The eleven partner cities are distributed over Europe (Figure 1). The cities are situated in different climate zones, some are at the sea and others are inland. The cities also differ in size and population. The following text provides a short description of the Net4Cities partner cities and their policy challenges concerning air quality, noise and traffic.

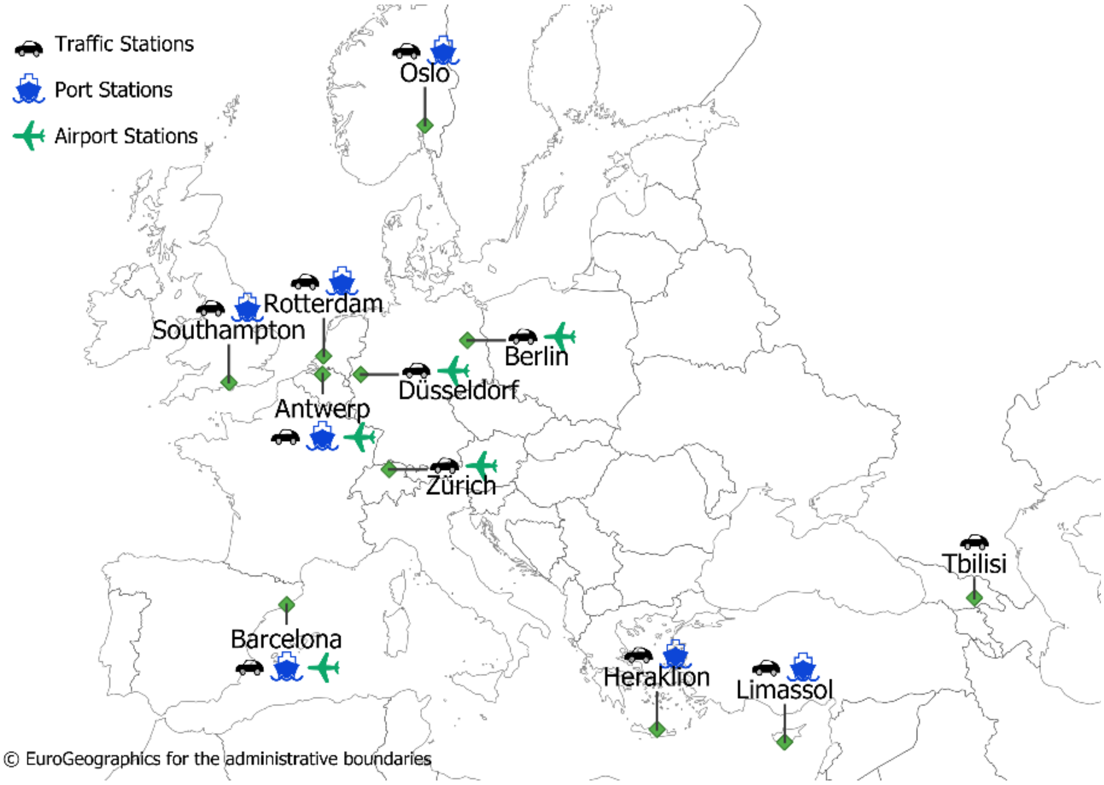

Figure 1: Map of the Net4Cities partner cities in Europe.

Antwerp (ANT) - Western Europe - Metropolitan[1]

Antwerp is the second largest city in Belgium (pop. 529,417) with a maritime climate. The port of Antwerp is the 2nd largest seaport in Europe. Brussels International Airport, located only 30 km from Antwerp, is the main airport serving Flanders, incl. the Antwerp region. Policy challenges concerning air quality are raised from the combination of dense population, high traffic volume (large share of diesel cars and freight traffic), port, and industrial activities. Transport

[1] Classification according to the classification of urban areas in OECD (Organization for Economic Co-operation and Development) countries as:

- Large metropolitan areas if they have a population of 1.5 million or more.
- Metropolitan areas if their population is between 500 000 and 1.5 million.
- Medium-size urban areas if their population is between 200 000 and 500 000.
- Small urban areas if their population is between 50 000 and 200 000.

emissions contribute strongly to the air quality in the city, and a low emission zone (LEZ) was introduced in 2017.

Barcelona (BAR) - Southern Europe, Mediterranean - Large Metropolitan

Barcelona is the second-largest city in Spain, located on the country's north-eastern coast (pop. 1.6 million; 3.2 million metro area). The growth in the diesel vehicle fleet and the resulting rise in traffic volume are the main sources of air and noise pollution in the city. These challenges have prompted policy responses in Barcelona, leading to a series of implemented measures to mitigate air pollution, such as the introduction of LEZs.

Berlin (BER) - Central Europe - Large Metropolitan

Berlin (pop. 3.7 million; 6.1 million metro area) is an economic hub in Germany and Europe with an oceanic climate and continental influence. Given its unique history, Berlin's transportation infrastructure has developed heterogeneously across the city, leading to imbalances in transportation capabilities. Combined with its spatial extent, it has a large fleet of diesel trucks and cars that contribute to high levels of urban air and noise pollution alongside a large public transportation network.

Düsseldorf (DUS) - Central Europe - Metropolitan

Düsseldorf (pop. 632,000; 10.2 million Rhine-Ruhr metro region) has an oceanic climate due to the relief-related opening towards the North Sea. Düsseldorf is a trade fair city and home to many stock exchange-listed companies and has several ports on the Rhine. The airport is an intercontinental hub and the third largest in Germany. Energy production, industry, and transport are the main causes of air pollution. As traffic is a major source of pollution, Düsseldorf wants to establish an "environmentally sensitive traffic management system" that collects environmental and traffic information and controls traffic in the city. In 2019 the goal of becoming climate neutral by 2035 was adopted.

Heraklion (HER) - Southern Europe, Mediterranean - Medium

Heraklion (pop. 174,000) is the largest city in Crete and has a Mediterranean climate. It has a port and an airport in the vicinity. The port has frequent domestic and international traffic serving international ports; the activities increase exponentially during the tourist season (approx. 8 months). During that period, Heraklion airport was the 2nd most frequently used in Greece, after Athens. Heraklion experiences significant air pollution episodes during spring and fall due to dust episodes, during winter due to domestic heating, and year-round due to traffic during peak morning and afternoon hours. Pollution is most pronounced during summer when population and traffic peak in Heraklion. PM pollution levels represent a concern, especially from non-exhaust emissions.

Limassol (LIM) - Southern Europe, Mediterranean - Small

Limassol (pop. 154,000) is a port city located on the south coast of Cyprus, the second biggest urban area of the island, and hosts the island's principal port lying 40 km west of the largest industrial area and fossil fuel power plants. Limassol is the most polluted city in Cyprus, frequently exceeding the legislated standards regarding PM, with the problem becoming enhanced during winter due to biomass combustion for residential heating under low inversions.

Oslo (OSL)- Northern Europe - Large Metropolitan

Oslo metropolitan area (pop. 1,600,000) has a Nordic humid continental climate. The city of Oslo has a port with frequent domestic and international traffic serving international ports and a dense of rail-network that includes trains and trams. Oslo experiences significant air pollution episodes in winter associated with thermal inversions. Even though around 50% of the fleet composition in Oslo is electric, PM pollution levels still represent a concern especially associated with non-exhaust emissions, exacerbated by the biomass combustion for residential heating.

Rotterdam (ROT)- Western Europe - Metropolitan

Rotterdam (pop. 660,000) has a maritime climate and hosts Europe's largest port and a big industrial area. Rotterdam is a logistical hub with seagoing and inland shipping, rail links, substantial road transport, and a small airport. Dense population, high traffic volume and shipping emissions contribute to poor air quality. The city will implement a Zero Emission Zone (ZEZ) for medium and heavy-duty vehicles to achieve emission-free city logistics in 2025. However, the impact of non-exhaust emissions remains a concern. The recent introduction of new shipping fuels may increase heavy metal ship emissions. Further needs are a better understanding of PNC from shipping and industrial sources to improve PNC emission database and modelling capacity.

Southampton (SOU)- Western Europe - Medium

Southampton is a port city (pop. 269,781) in the southern coast of the United Kingdom with an oceanic climate. The city is bounded by motorways to the north and west and the river Test estuary to the south. Southampton experiences high PM pollution levels during winter periods due to adverse meteorological conditions and increases in residential wood combustion. Combustion emissions from shipping, ports, and traffic contribute to the pollution burden in selected areas. Southampton Airport is adjacent to the city boundary, with its flight path directly overhead.

Tbilisi (TBI)- Eastern Europe - Large Metropolitan

Tbilisi is the capital of Georgia (pop. 1.5 million) and its largest city, located in the South Caucasus on the Kura River and has a humid subtropical climate with substantial continental and semi-arid influences. Historically, the main polluters of the air were factories, but today the increasing number of light vehicles, especially older models, is the main source of pollution. Current policies seek to strengthen public transport by expanding the network of compressed natural gas (CNG) buses.

Zurich (ZUR)- Central Europe - Medium

Zürich (pop. 427,000) is a business hub in northern Switzerland with a temperate climate. Zurich has an international airport (~31.5 million passengers in 2019); the Zurich Airport administration is making efforts to minimize their environmental and health impact through modifications in flight routes, fuels used, and ground support equipment and practices. For road traffic, efforts are being made to shift towards low or zero local emission options and to reduce noise pollution through shifts to electric or alternative fuels or Euro 6(d) vehicles, improving and subsidizing the public transport options, reducing speed limits to 30km/h to improve traffic flow, and increased application of automated traffic steering and control systems.

3.2 Policy challenges and action plans at the cities

Relevant stakeholders were identified in the partner cities such as administrations, port and airport authorities, and scoping workshops with stakeholders were held (Apr-Dec 2024). Feedback forms were completed during these workshops. An overview of the stakeholders in the different cities is given in Table 3. In an internal version of this document, this table includes the main stakeholder feedback reflecting policy challenges. Since these discussions with the city partners were not cleared to be shared publicly and include politically relevant priorities, this information is not included here in the public deliverable.

In general, the city authorities[2] expressed their interest in Net4Cities and the advancements in monitoring infrastructure that is planned. In some cities where air quality, noise or traffic monitoring is lacking or insufficient, there is great interest in expanding the infrastructure to collect air quality, noise and traffic data. For most cities, the existing monitoring infrastructure is already quite extensive, and their main focus is to complement current monitoring with additional techniques that address the new and emerging pollutants and/or updates to the monitoring infrastructure that will prepare them for the revised Ambient Air Quality Directive (AAQD) requirements, or to focus additional measurements (targeted campaigns) at sites of special interest (construction works, shipping emissions).

Table 3: Overview of main issues identified in stakeholder workshops.

City	Stakeholder(s)	Field
ANT	City of Antwerp, Flemish Environment Agency, Environment Department, Port of Antwerp,	Air quality
ANT	City of Antwerp, Flemish Environment Agency, Departement Omgeving, Port of Antwerp,	Noise
BAR	Barcelona city council, Generalitat de Catalunya – regional government, Public Health Agency of Barcelona, Port and Airport authority (meeting at later date, Sept 2024)	Air quality, noise, traffic
BER	Berlin Senate Department for Mobility, Transport, Climate Protection and the Environment; Noise department, Emissions department	Noise
BER	Senate Department for Mobility, Transport, Climate Protection and the Environment; Air quality measurements and monitoring,	Air quality
DUS	City Düsseldorf, Düsseldorf Airport, State Agency for Nature, Environment and Consumer Protection (LANUV)	Air quality
DUS	City Düsseldorf, Düsseldorf Airport, LANUV, Lohmeyer Consulting Engineers	Air quality, noise
DUS	City Düsseldorf, Düsseldorf Airport, LANUV	Noise, traffic
DUS	City Düsseldorf, Düsseldorf Airport, LANUV	Noise
HER	Region of Crete, Directorate of environment and spatial planning, Heraklion Port Authority	Air quality, noise, traffic
LIM	Department of Labour Inspection, Limassol Port Authority, Limassol municipality	Air quality, noise, traffic
OSL	Oslo Municipality, Fjellinjen	Air quality, noise, traffic
ROT	City of Rotterdam (policy officer AQ), Province of South-Holland (policy officer AQ), Port of Rotterdam (program manager environmental policy)	Air quality, traffic
SOU	City of Southampton (Air Quality Officer and Transport Policy Team Leader)	Air quality, noise, traffic
TBI	Head of Environmental Pollution Monitoring Service, Head of the Laboratory of the National Environment Agency (NEA)	Air quality, noise, traffic
ZUR	Zurich City (Head of AQ measurements), EMPA (Acoustics/Noise control), Zurich Region (Deputy AQ monitoring), EMPA (National AQ monitoring network), EMPA (atmospheric modelling & remote sensing)	Air quality, noise, traffic

[2] While we refer here to city authorities for simplicity, the stakeholders ranged from city authorities to environmental agencies/ministries, port and/or airport authorities, and varied from city to city depending on the local governance structures.

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3.3 Roadmap for advancement of the monitoring networks

The Net4Cities roadmap for advancing monitoring networks incorporates co-creation with city partners to address (local) policy challenges effectively. It focuses on delivering tailored products and outcomes that maximize relevance, impact, and uptake by the stakeholders. To support this, Net4Cities developed a framework with city liaisons to facilitate scoping workshops and ensure direct harmonized communication between the stakeholders and Net4Cities across all partner cities.

The information from scoping workshops is used by the Net4Cities consortium to advance and expand monitoring networks and generate new knowledge on transport-related pollution. The monitoring and implementation plans are developed accordingly.

The measurement data are centralized in the Net4Cities data hub where data will be further processed. Results and recommendations to support local, regional, and national Zero Pollution strategies will then be published as part of the Net4Cities Studio products. While most of the data processing and feedback to the stakeholders are covered in other work packages of Net4Cities (WP4-6), certain aspects, such as recommendations on the site selection, the installation and deployment of instruments, as well as continued engagement with the stakeholders throughout are included in the monitoring and implementation roadmap (WP1).

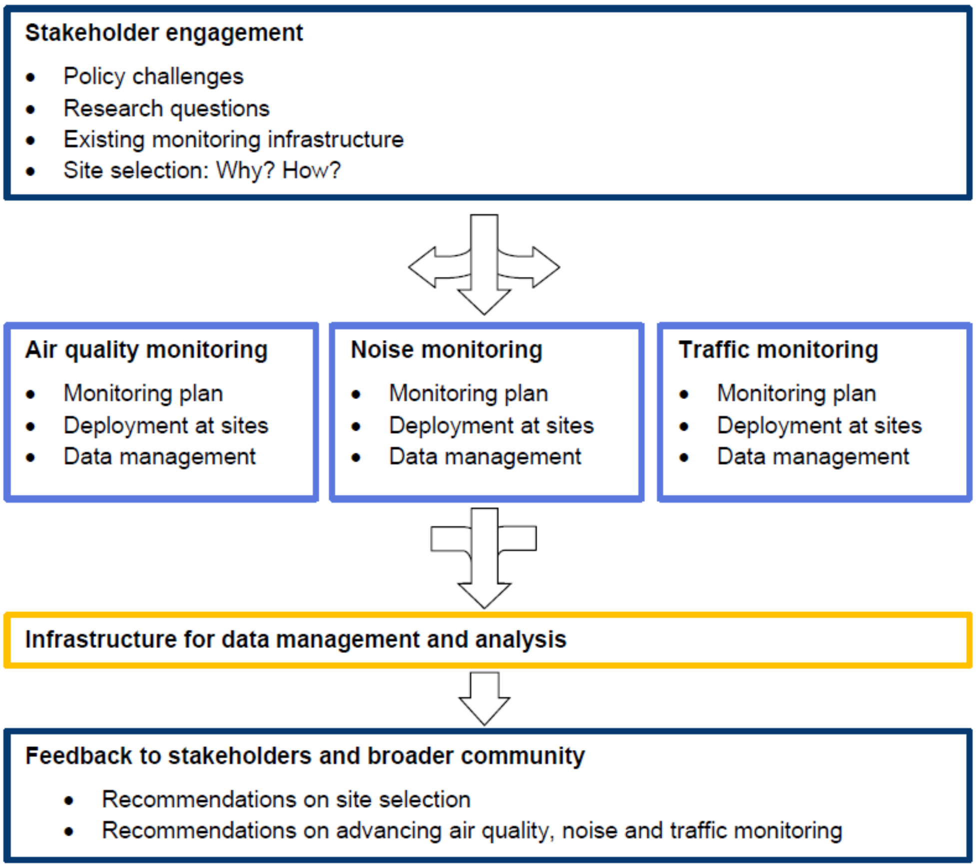

Figure 2: Overview of the topics that are included in the monitoring and implementation roadmaps.

The monitoring and implementation roadmaps will be available as part of the Net4Cities studio. These roadmaps provide an overview of key milestones and stages for monitoring and implementation and can serve as examples for the broader user community in terms of key steps to consider if they are to do a similar implementation (see Annex A). They will include recommendations on potential critical issues that need to be addressed when planning a new or expansion of a monitoring network, such as site selection, site requirements, and operating procedures including QA/QC. These roadmaps can offer guidance for continued monitoring beyond Net4Cities or for setting-up future monitoring campaigns.

The Net4Cities roadmaps for air quality, noise and traffic monitoring and implementation are described below and different types of schematic representations are presented. Details on the respective monitoring plans are provided in Chapters 7-9.

For the implementation of the monitoring in the Net4Cities partner cities, the main phases[3] are similar for air quality, noise and traffic: (1) the site and instrument selection phase, (2) the installation and testing phase, (3) the operational or deployment phase, and (4) the after-deployment phase. However, due to domain-specific needs, the tasks within each phase may vary, and the duration of certain phases can differ accordingly.

3.3.1 Roadmap for air quality

The roadmap for air quality monitoring (Figure 3, for bigger size see Annex C) includes actions for stakeholder engagement, monitoring installation and deployment and data management. Performing those actions ensures that project milestones are met, and that air quality monitoring is implemented and streamlined in the Net4Cities partner cities, and developed as a function of the stakeholder needs to tackle current policy challenges.

The air quality monitoring instruments can be divided into on-line and off-line instruments. On-line instruments provide continuous, real-time measurements. Off-line monitoring involves sampling and posterior analysis, typically an off-site lab analysis. Off-line measurements cannot be provided in real-time. The decision of the instrumentation for Net4Cities was mostly decided in the project design, and therefore not emphasized here. Decisions on instrument configurations were made (see for example 6.1.2.1 for the UFP monitoring).

[3] See Annex B for more details of the different phases.

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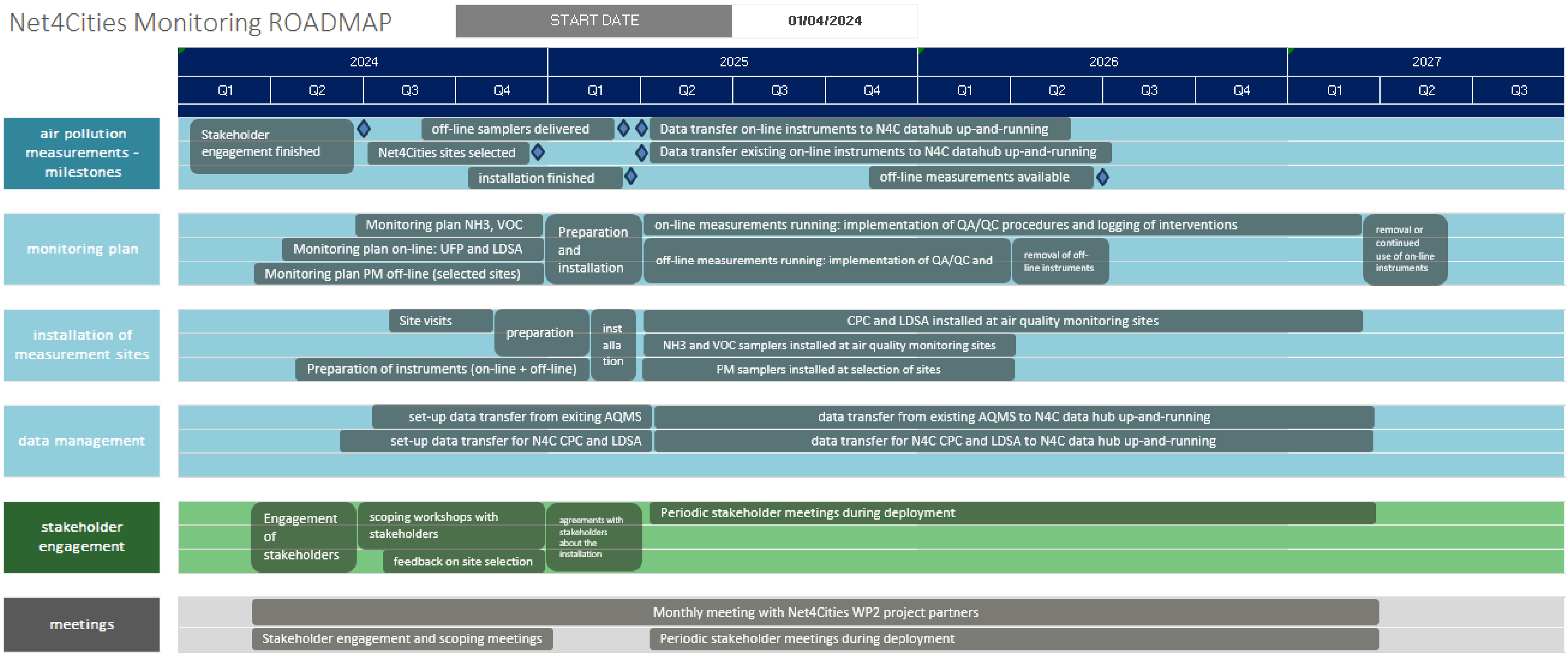


Figure 3: Net4Cities air quality monitoring roadmap.

3.3.2 Roadmap for noise and traffic

Objective

The Net4Cities noise monitoring network aims to collect information about the noise levels at different sites in cities where traffic is the predominant noise source. In addition to the noise terminals, traffic counters will also be installed. The analysis of the noise levels alongside the traffic information will provide insight into the acoustic situation, identifying the main causes, the worst time intervals, etc., which will help in taking actions to mitigate the noise. All the information, registered in each of the terminals installed in 11 cities participating in the project, will be stored in the project data hub. This data will be available to feed noise calculation models for creating detailed noise maps and for further analysis or correlations with other air quality pollutants.

Phases

The deployment of the noise and traffic monitoring network can be divided into three phases described below: (1) site and instrument **selection phase**, (2) **installation and testing phase**, and (3) **operational phase** when sensors are tested and deployed to perform measurements over a period of time.

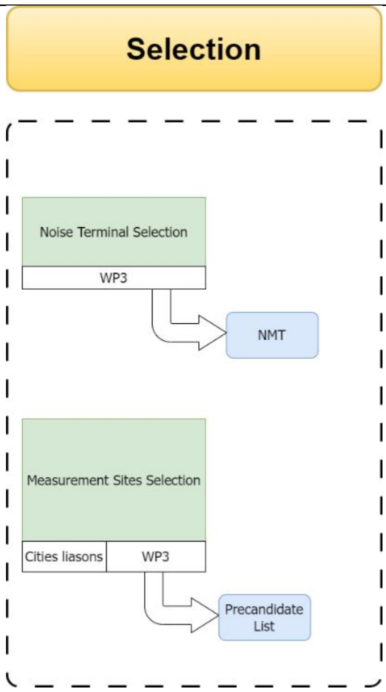
During the **selection phase**, the noise monitoring terminals, and the sites for their installation in each city are selected through parallel processes. The noise terminal was selected from the results of market research. The one that suits the requirements of the project best (time register, frequency analysis, precision, integration time) was chosen. The sites were selected as part of the scoping workshops with the cities. Locations of interest to the cities were identified, ensuring they met both the acoustic requirements (traffic noise needs to be the predominant source, with a preference for continuous traffic flow) and the technical requirements for noise terminals (power supply, sufficient data network coverage, and no obstacles for installing the physical device) and for Telraam traffic count devices, that requires a clear field of view, and both sensors need a power supply.

The **installation phase** consists of the tasks of installing the noise sensor alongside the Telraam traffic sensor. A technical visit to the site confirms suitability for both noise and traffic sensors. The Telraam installation requires power connection and registering the unique device in the Telraam system by scanning a QR-code (see further instructions for details). Installing the NMT includes a technical visit(s) to ensure the site meets the requirements and to plan the installation, setting up and registering the NMT in the system (off-site) and installing the device (on-site), and implementing the application to integrate the noise data into the data hub.

In the **final testing and characterization phase**, an application will be implemented to integrate the measurements results and valuable auxiliary data, as the one from the System Integrity Check (SIC) at each site into the data hub. The data from the System Integrity Check (SIC) along with noise data itself will be evaluated to confirm the reliability of the results in each location. Finally, if no issues are detected the values will be used to acoustically characterize the site. More details on the noise monitoring plans, including the timing for different cities, a description of the noise monitor, and applicable operating and QA/QC procedures, are provided in Chapters 6 and 8.

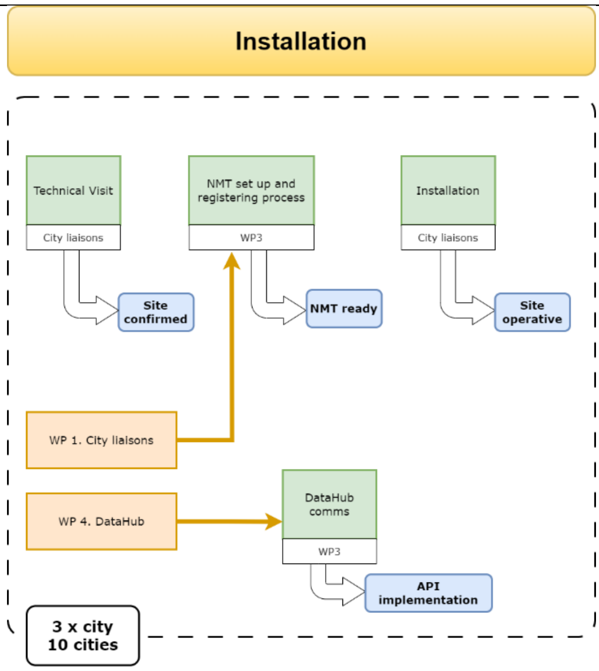
Phase 1: Selection

By end 2024



Phase 2: Installation

Finished by end 06/2025



Phase 3: Operational
All instruments online from 1 July 2025

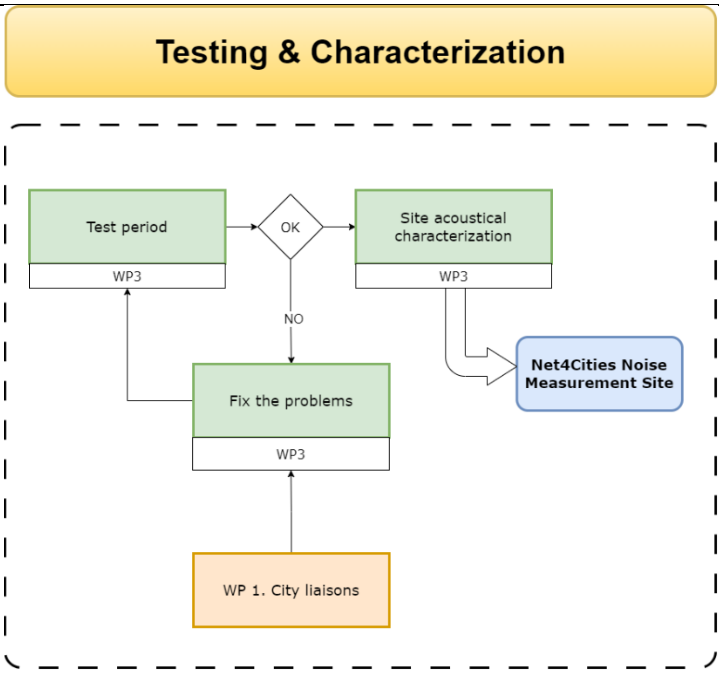


Figure 4: Phases in the deployment of the noise monitoring network.

In the **deployment phase**, the noise network will start operating, providing noise data to the data hub for further use in Net4Cities (Figure 5).

The tasks during the usual operation of the network will involve ensuring that:

- The terminals are measuring correctly, and the registered data is reliable and representative of the acoustic situation (SIC and outlier detection). The transfer process of data from the Cirrus cloud storage and loading process in the Net4Cities data hub works correctly and no data are missing.
- The information needed for further tasks in Net4Cities is available.

A maintenance plan has also been established to ensure the network operates correctly. This plan includes two types of actions:

- Corrective maintenance: Actions to resolve specific problems, such as power or communication breakdowns. If additional support is required, the manufacturer will be involved.
- Predictive maintenance: Scheduled actions, including:
    - Monthly: Carry out a technical visit, which includes a visual inspection to check the status of all the elements of the terminal.
    - Yearly: Replace old microphone windshields with new ones. Perform an acoustics check using an external acoustic calibrator to verify the integrity of the measurement chain.

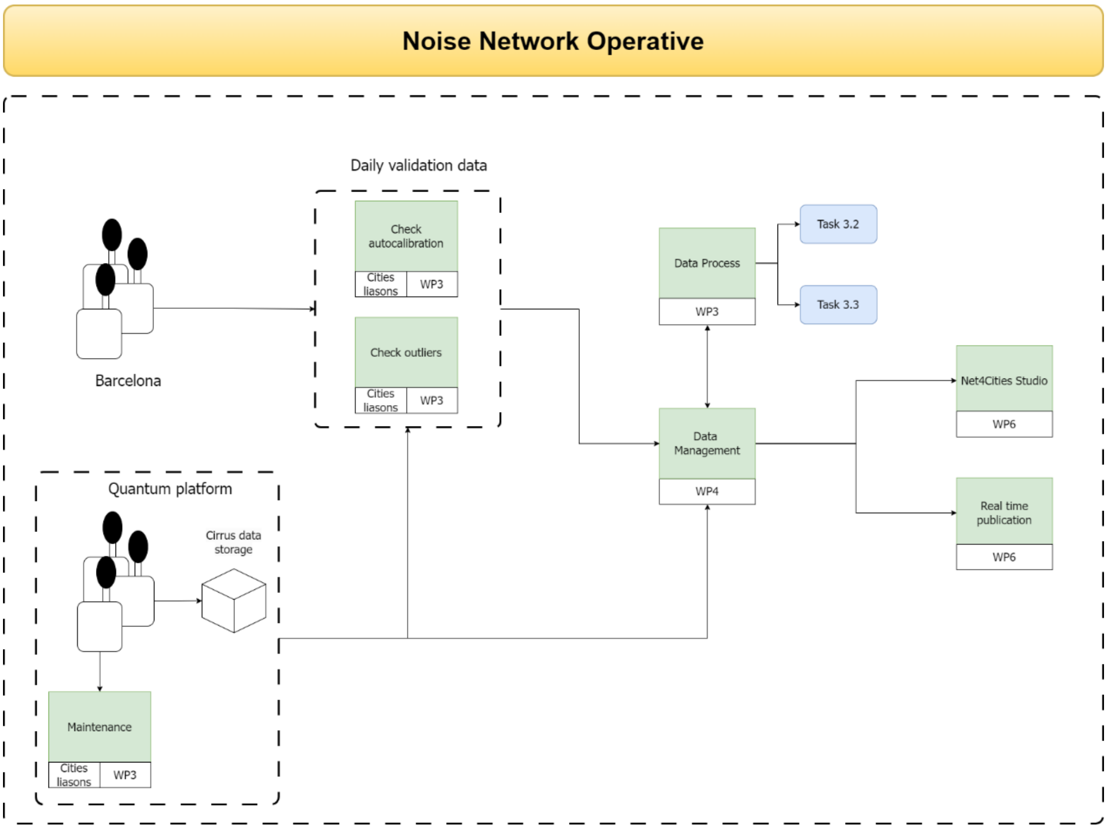


Figure 5: Deployment of noise monitoring: maintenance and data flow.

The exploitation of noise monitoring results involves analyzing the noise levels to:

- Get detailed knowledge of traffic noise by breaking down the contribution of each type of vehicle.
- Identify anomalies.
- Determine temporal patterns for soft sensing and dynamic mapping.
- Set up alarm triggers and identify high noise level events (noisy sources).
- Understand and enhance the application of CNOSSOS-EU. Add value to the results of the Strategic Noise Map.

The operational phase requires no specific action for the Telraam traffic sensors, as Telraam devices are designed to be "install and forget". Once installed, data will flow to the dashboard without the need for follow-up. The timeline for each phase aligns with the noise sensor timeline, as both sensors are installed simultaneously. As with the noise data, Telraam data is relayed to the data hub for tasks 3.2 and 3.3, as well as for generating specific indicators for the Net4Cities Studio. The Telraam network dashboard enables sensor monitoring during deployment. Two key aspects can be monitored:

- **Optimal placement** by setting and checking the region of interest.
- **Sensor logs**, including connectivity signals, device internal resets, and other diagnostics.

In case of malfunction, **corrective maintenance** is required. This involves addressing specific issues, such as power or communication breakdowns. If further action is needed, the manufacturer will be involved. The exploitation of traffic monitoring results involves analyzing the data to correlate traffic patterns with noise data (see section on noise) and potentially also air quality.

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4. Existing monitoring networks

4.1 Air quality

4.1.1 Overview of regulated pollutants

Regulated pollutants are collected in line with existing CEN methods (Table 4) and QA/QC procedures for regulated pollutants, as defined in the AAQD. Equivalent methods for $PM_{2.5}$ and PM_{10} are used in addition to reference methods (filter sampling) at some sites; these automated measuring systems for which equivalence to the reference method was demonstrated (standard EN 16450:2017[4]). For the methods used, a consistent relationship to the reference method. These pollutants are largely part of existing monitoring infrastructure, although in limited cases capacity or analyses will be added in the context of Net4Cities, most often for additional filter analysis. The established monitoring and associated data generated will be integrated into the monitoring capacity being added in Net4Cities to provide a more comprehensive analysis and evaluation of urban air pollution and the associated sources.

Table 4: Overview of regulated pollutants and reference measurement methods.

Pollutant	Instrument	Reference method
SO_2	UV fluorescence	EN 14212:2012
NO_2, NO	Chemiluminescence	EN 14211:2012
PM_{10}	Gravimetry	EN 12341:2023
$PM_{2.5}$	Gravimetry	EN 12341:2023
CO	Nondispersive infrared spectroscopy	EN 14626:2012
O_3	UV photometry	EN 14625:2012
benzene	Pumped or diffusive sampling, thermodesorption or solvent extraction, Gas Chromtography	EN 14662 – part 1 (2005), part 2 (2005), part 3 (2016), part 4 (2005), part 5 (2005)
Chemical composition $PM_{2.5}$ (background location) SO_4^{2-}, Na^+, NH_4^+, Ca^{2+}, elemental carbon (EC), NO_3^-, K^+, Cl^-, Mg^{2+}, organic carbon (OC)	Ion Chromatography, Thermal-Optical Method for Carbon Detection	EN 16913:2017, EN 16909:2017

[4] EN 16450:2017 'Ambient air – Automated measuring systems for the measurement of the concentration of particulate matter (PM_{10}; $PM_{2.5}$).

4.1.2 Overview of emerging pollutants

The technical report on air pollutants of emerging concern (Monforti-Ferrario et al., 2022) gives relevant information about four air pollutants not currently regulated by EU air quality legislation. The additional air pollutants addressed are ultrafine particles (UFP), black carbon (BC), ammonia (NH_3) and methane (CH_4), and the marker for biomass burning: levoglucosan, which, along with BC, is a component of particulate matter. The selection of these additional air pollutants is based on their health and environmental impacts together with the maturity and robustness of current measurement techniques. The air pollutants of emerging concern are covered in Net4Cities: UFP, BC, NH_3, and CH_4. Note that also the new AAQD (published 23/10/24) gives recommendations or requirements on measuring these pollutants at selected sites.

Ultrafine Particles are measured as particle number concentration (PNC) following CEN standard (EN16976:2024) for ultrafine particles down to 10 nm. Since UFP largely dominate particle number size distributions (PNSD), their number concentration can be estimated by measuring the total particle number concentration. Ultrafine particles with diameters ranging 50-100 nm are usually the most abundant in the air, except at traffic sites and airports where primary particles (10 – 25 nm) often dominate (Monforti-Ferrario et al., 2022, ACI Europe, 2018, Stacey et al., 2023).

Black carbon is a component of $PM_{2.5}$ emitted from carbon-containing combustion sources[5]. Transport is an important source of BC in Europe, accounting for about one-third of the BC emissions (Monforti-Ferrario et al., 2022 and reference therein). Diesel engines emit much more BC than petrol- or gas-fired engines, but most of this BC is captured by diesel-exhaust particle filters, when present. BC cannot be measured directly in air, and therefore related metrics are measured, including (i) elemental carbon (EC) and (ii) PM light absorption (equivalent BC, eBC). On-line BC measurement techniques (filter photometers) are linked to the light-absorbing properties of the particles. Light absorption coefficients can be used to calculate eBC concentrations by applying a conversion factor. The multi-wavelength AE33 state-of-the-art commercial instrument will be used in Net4Cities to distinguish BC from fossil fuel biomass combustion-derived BC.

Ammonia Recent studies have indicated increasing emissions of NH_3 from traffic in urban areas. However, data for NH_3, especially in urban areas, are scarce; a review by RI-URBANS[6] identified only six urban datasets of NH_3 in Europe. In Europe, the main source of ammonia is agriculture. However, traffic-related emissions of ammonia by both gasoline engines and diesel engines equipped with DeNox catalytic (or selective catalytic reduction, SCR) systems are currently largely underestimated (Monforti-Ferrario et al., 2022 and references therein). Ammonia can be measured by diffusive sampling, as described in the EN standard method for measuring gas-phase ammonia (EN 17346:2020): diffusive sampling (denuder), extraction, and determination of ammonium (NH4+) in solution. On-line methods include chemiluminescence (after thermal conversion to NO), cavity ring-down spectroscopy (CRDS) based monitors, and optical remote sensing techniques like Differential Optical Absorption Spectroscopy (DOAS) and Differential Absorption (LIDAR).

Methane, nitrous oxide (N_2O) and carbon dioxide (CO_2) are important greenhouse gasses. N_2O emitted from vehicles has increased dramatically in recent years. N_2O is, however, rarely measured in cities, airports, or ports, because online measuring devices are prohibitively

[5] https://www.eea.europa.eu/publications/status-of-black-carbon-monitoring

[6] https://riurbans.eu/wp-content/uploads/2022/10/RI-URBANS_D1_D1_1.pdf

expensive. Measurements with inert canisters offer an affordable alternative to online observations and will be done at the Net4Cities partner cities. These offline measurements can provide an overview of the concentrations of these pollutants (including different VOC compounds) at sites where online measurements are unavailable. Detailed information on VOC composition and greenhouse gasses (GHGs), such as N_2O and CH_4, in urban areas will advance the state-of-the-knowledge.

An overview of existing on-line monitoring infrastructure for UFP, BC and NH_3 in the Net4Cities partner cities (Table 5) shows a variety of instruments that are currently used, but also highlights the limited number of cities where emerging pollutants are currently actually measured. As a long-lived greenhouse gas, CH_4 is not typically included in air quality monitoring stations (AQMS).

Table 5: Overview of emerging pollutants and measurement methods in the existing infrastructure at some partner cities.

Pollutant	Instrument make/type	Method	City
UFP	EPC 3783, TSI	Water based	ANT
	SMPS 3938 + EPC 3783, TSI	Water based	ANT
	SMPS+C 5420-TR-CEN Grimm	Butanol Based	BER (airport)
	CPC 3750, TSI	Butanol Based	LIM
BC	AE33 aethalometer, Magee	PM light absorption, multi λ; loading correction	ANT, LIM, BER, OSL
NH_3	Picarro (G2509)	Cavity Down Ring Spectrometer	Not included in AQMS at any of the partner cities

In addition to these pollutants, **lung-deposited surface area (LDSA)** is measured in Net4Cities. Epidemiological studies show a stronger and more consistent association between the active surface area of particles deposited in the lungs and the impacts of PM exposure than PNC. LDSA has proven to be an effective metric for nanoparticle toxicology in multiple in-vivo and in-vitro studies (Schmid and Stoeger 2016). To provide more detailed information on the risk of health effects of UFP, UFP as lung-deposited surface area concentration (LDSA) is measured in parallel to the PNC across the cities.

4.1.3 AQMS at the partner cities

There are existing AQMS in the Net4Cities partner cities (Table 6). The number of AQMS in the cities ranges between 2 and 19. PM and NO_2 is monitored at most stations, whereas BC and UFP monitoring is limited to a smaller number of stations per city, if it exists at all.

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Table 6: Overview of existing AQMS at the partner cities. The table includes all AQMS site types in the city (e.g., urban background) and is not limited to transport-related sites. The number of AQMS where PM, NO2, BC and UFP are measured are given.

City	Number of AQMS	PM	NO_2	BC	UFP
Antwerp	19 + 1[a]	14+1[a]	17+1[a]	11+1[a]	1+1[a]
Barcelona	8 + 2[b] + 3[c]	11	11	1	0
Berlin	17	12	17	4	0+1[a]
Düsseldorf	18 + 1[a]	6	18	1	0
Heraklion	2 + 1[d]	1+1d	1	1+1d	1
Limassol	2 + 1[d]	2 + 1[d]	2 + 1[d]	2 + 1[d]	2 + 1[d]
Oslo	14	14	11	1	1
Rotterdam	15	10	11	7	1
Southampton	4 + 4[e]	1 + 4[e]	4 + 4[e]	0	0
Tbilisi	9	3	3	0	0
Zurich	6 + 1[a] + 10[f]	6 + 1[a]	6 + 1[a]	1[a]	10[f]

a AQMS in the airport region (not part of city network)
b mobile stations
c AQMS at the port
d regional background station at 40 km
e EarthSense Zephyr® monitors
f LDSA monitors in the Canton of Zurich

Overview maps of the existing AQMS at the partner cities are given in Annex D. AQMS are located at urban background, traffic and some at industrial locations. Some regional background stations are included. The context provided by these stations will be key for the subsequent analysis in Net4Cities.

4.2 Noise

The management and assessment of environmental noise strategies carried out up to now, in the cities of the project have been based on the realization of measurement campaigns but above all in the elaboration of strategic noise maps.

Strategic noise maps are a fundamental tool for managing noise because they provide insight into the acoustic situation, specifically in terms of people exposed and identifying the areas that are more problematic from a noise perspective. Strategic noise maps are elaborated mainly from calculations of the yearly average situation. In Europe, the calculation method used is CNOSSOS-EU as established in the EU Directive 2002/49/CE (see example in Figure 6).

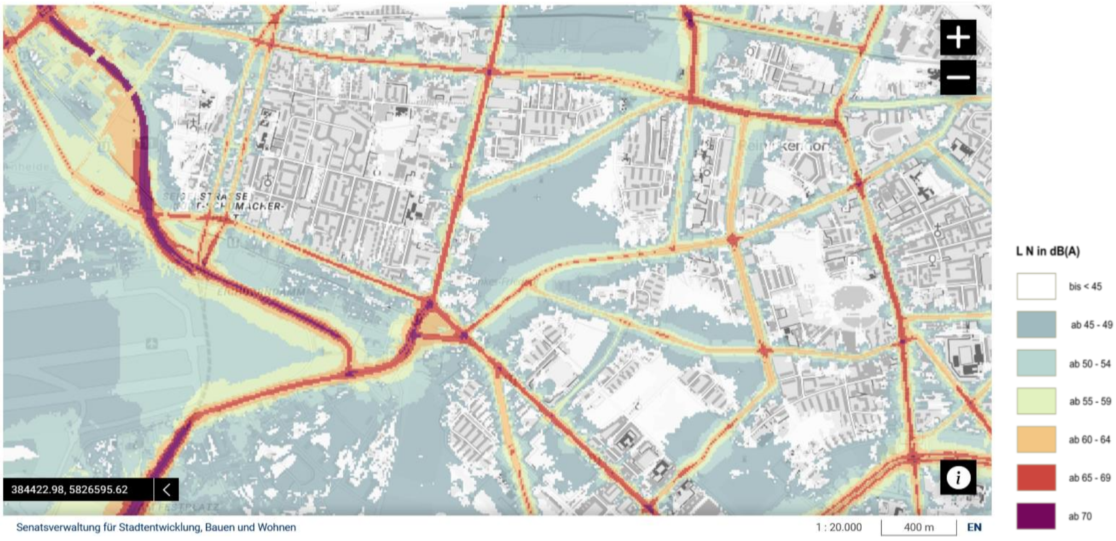

Figure 6. Example of strategic noise map. Berlin. 07.05.02 Index L_n (Night) Road Traffic

Such data are key points for determining the most appropriate initiatives and actions that should be considered during the drawing up process of the Action Plans. Thus, strategic maps play a vital role in the management of noise.

Regarding noise monitoring networks, their main feature is that they provide real-time information on the actual noise levels measured at their terminals. This data can help inform when immediate actions need to be taken or for managing noise sources whose operations can be noisy and cause disturbances (this could happen even if the yearly average noise level is low).

Many of the partner cities have noise monitoring networks near their airports, dedicated to managing and controlling the noise produced by the take-off and landing operations that affect the neighborhoods close to the airport (see example, Figure 7). Cities also conduct short-term measurement campaigns to determine the actual noise values that exist at specific points in the city that may be problematic.

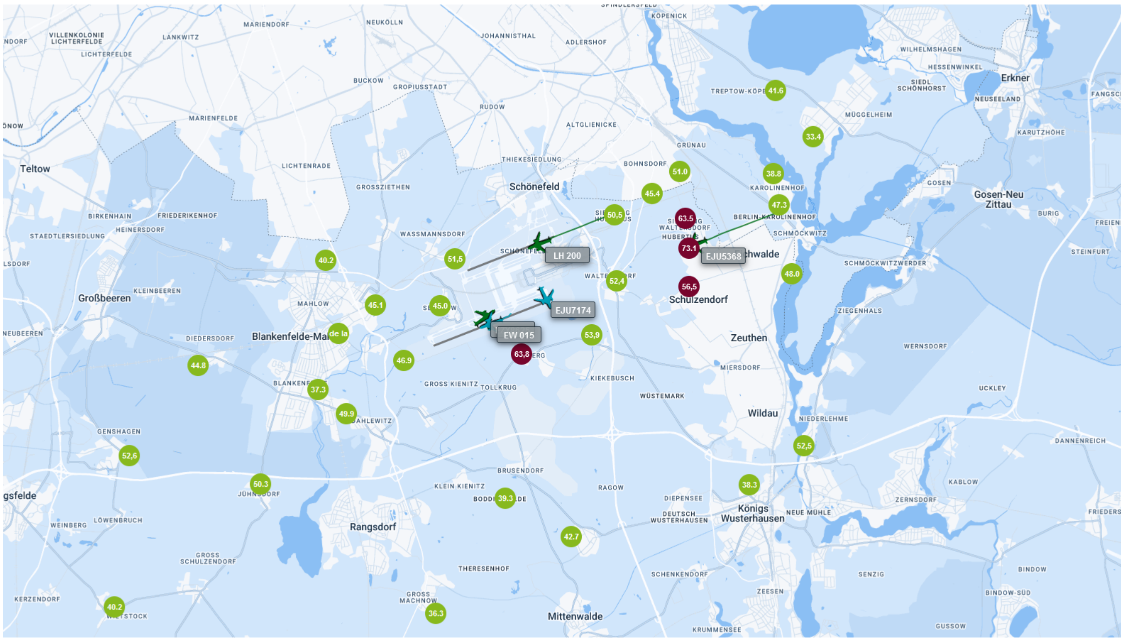

Figure 7. Noise Monitoring Network Berlin Airport

The following table summarize the situation in each city.

Table 7: Overview of existing noise monitoring networks at the partner cities.

City	Existing Noise Networks	Noise source	Comments
Antwerp	1[(a)]	Airport	17 noise monitoring terminals
Barcelona	1	Airport	Made up of 8 noise monitoring terminals
	1	Urban	Made up of 71 noise monitoring terminals (see picture below)
	1	Leisure noise	Made up of 69 noise monitoring terminals
	1	General purposes	Made up of 10 noise monitoring terminals
Berlin	1	Airport	Made up of 15 noise monitoring terminals
Düsseldorf	1	Airport	
Heraklion	1		
Limassol	0		Specific dedicated campaign
Oslo	0		Specific dedicated campaign
Rotterdam	1	Airport	
Southhampton	0		Specific dedicated campaign
Tiblisi	0		Specific dedicated campaign
Zurich	0		Specific dedicated campaign

(a) Noise monitoring near Brussels Airport.

Barcelona is particularly notable because there is a specific network for monitoring the noise from the airport, and additionally, there are three other networks to manage noise in the city, monitoring levels of traffic (with 71 terminals), leisure activities (69 terminals), and another for general purposes (assistance complaints, etc.), totaling 150 terminals. The following picture shows the locations of these terminals in the city (Figure 8).

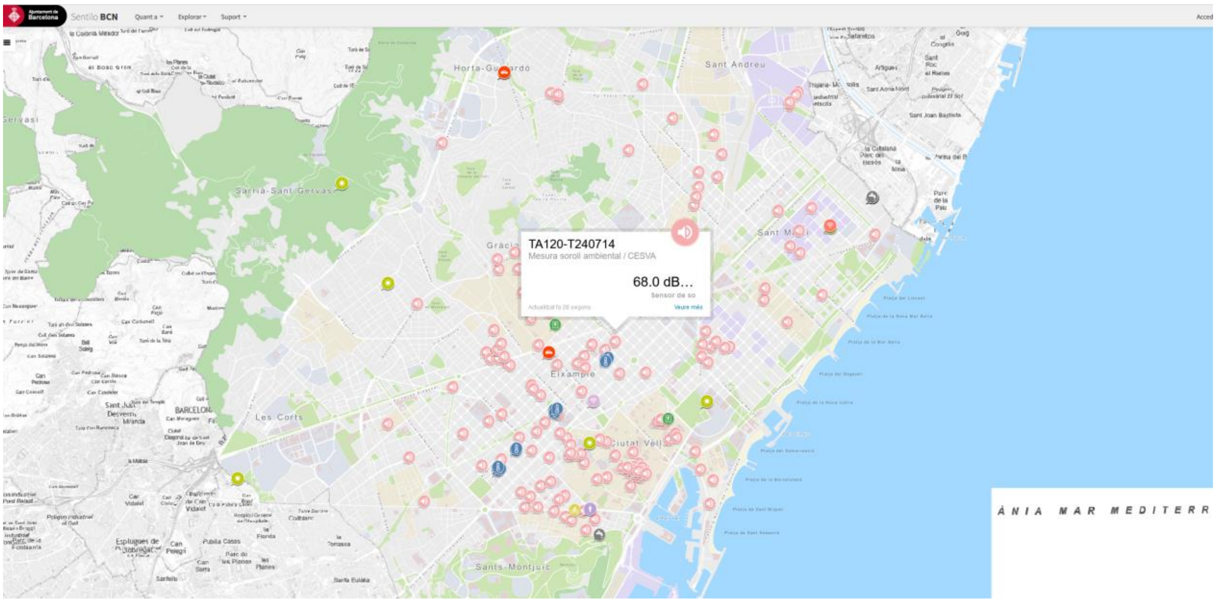

Figure 8. Urban noise monitors in Barcelona. Pink points are noise monitoring terminals.

4.3 Traffic

A variety of sources exist for traffic count data in urban areas. Many of these are not publicly available, and some are behind substantial paywalls. For the purposes of this deliverable, we will acknowledge these sources but will not attempt to summarize them here. We may pursue integration of a limited number of such traffic count sources in agreement with the cities, if an added value for analyses exists.

Telraam is a citizen science platform that enables individuals and communities to monitor traffic flows in their neighborhoods using small, affordable sensor devices. The Telraam sensors, typically mounted on windows overlooking streets, collect detailed data about various forms of mobility, including cars, pedestrians, bicycles, and heavy vehicles.

The vast majority of the existing Telraam sensor network are indoor sensor (placed on the inside of windows facing the street). Apart from the vast majority of indoor Telraam sensors, there are currently about 30 outdoor Telraam sensors active too, mostly in Belgium. It's this new outdoor sensor which will be deployed in this project as well (see further), co-located with the noise measurements. The collected data of both sensors is the same and is accessible via an online platform (www.telraam.net) and an API (www.telraam-api.net), making it easy for users to analyze traffic patterns, assess the impact of infrastructure changes, and advocate for safer, more sustainable streets.

The data from Telraam devices includes hourly or daily counts of traffic segmented by type (e.g., cars, bicycles, pedestrians) and provides historical trends to identify patterns or anomalies. Interactive maps display the monitored streets and aggregate traffic flow, enabling users to compare data across locations or over time. The platform also includes filtering options to examine specific time frames or types of mobility. This granular, localized traffic data is valuable for city planners, policymakers, and grassroots organizations seeking evidence-based insights into urban mobility challenges. An overview of existing Telraam traffic monitoring networks in the partner cities is given in Table 8 (maps are shown in Annex Table E-1).

Table 8: Overview of existing Telraam traffic monitoring networks in the partner cities.

City	Estimated # sensors	Comments
Antwerp	Historical: +/- 100 Live: +/- 30	Various Telraam sensors of the previous generation are active from various previous projects and most sensors are currently offline.
Barcelona	Historical: +/- 30 Live: +/- 3	Sensors of the old generation have been deployed for WeCount project (www.wecount.net)
Berlin	Historical: +/- 150 Live: +/- 100	Actively maintained Telraam network by a local NGO (ADFC).
Düsseldorf	1	Single test device from a private user.
Heraklion	1	Single test device from a private user.
Limassol	0	/
Oslo	Historical: 5 Live: 0	Part of a small pilot project run by NILU.
Rotterdam	Historical: 3 Live: 0	Several test devices from a private user (all offline).
Southhampton	0	/
Tiblisi	0	/
Zurich	Historical: 5 Live: 2	Trial projects ongoing with the city (outside of scope of Net4Cities). It is possible that more sensors will be added in the course of these trails.

All data of historical and currently live sensors are freely accessible via the Telraam API: www.telraam-api.net.

5. Selection of Net4Cities monitoring sites

5.1 Selection of the Net4Cities monitoring sites

The Net4Cities monitoring sites were selected in collaboration with local stakeholders. They conform to Net4Cities' research goals of measuring new and emerging pollutants from transport sources (e.g., traffic, ports, airports), and for options where the requirements of Net4Cities were met, also integrate preferences and interests of the partner cities. Where possible and of interest, air pollution, noise and traffic monitoring locations were co-located.

5.2 Labeling of the Net4Cities monitoring sites

Selected monitoring locations are labeled according to a N4C format: XX_YYY_ZZZ where:

- XX = county code (e.g., BE for Belgium)
- YYY = city (e.g., ANT for Antwerp)
- ZZZ = classification of a site (e.g., TR (traffic), UB (urban background), PO (port) or AP (airport)) followed by a number (e.g., TR1, TR2)

As an example, site BE_ANT_TR1 is a monitoring site at a traffic location in Antwerp, Belgium.

5.3 Overview of the Net4Cities monitoring sites

The core Net4Cities monitoring sites are classified as urban traffic, port, or airport sites, with a few additional urban or regional background sites included for reference (Table 9). Where possible and of interest, air pollution, noise and traffic monitoring were co-located.

Table 9: Overview of selected N4C monitoring sites for air quality, noise and traffic.

Net4Cities site	Net4Cities classification	Air quality	Noise	Traffic
BE_ANT_TR1	Urban-traffic	YES	YES	YES
BE_ANT_TR2	Urban-traffic	NO	YES	YES
BE_ANT_UB1	Urban-background	YES	NO	NO
BE_ANT_PO1	Port	YES	YES	YES
BE_ANT_AP1	Airport	YES	NO	NO
ES_BAR_TR1	Urban-traffic	YES	TBD	TBD
ES_BAR_TR2	Urban-traffic	NO	TBD	TBD
ES_BAR_RL1	Railway	NO	TBD	TBD
ES_BAR_AP1	Airport	YES	NO	NO
ES_BAR_PO1	Port	YES	NO	NO
DE_BER_TR1	Urban-traffic	YES	YES	YES
DE_BER_TR2	Urban-traffic	YES	YES	YES
DE_BER_TR3	Urban-traffic	NO	YES	TBD
DE_BER_AP1	Airport	YES	NO	NO
DE_DUS_TR1	Urban-traffic	YES	YES	YES
DE_DUS_TR2	Urban-traffic	YES	YES	YES
DE_DUS_UB1	Urban-background	NO	YES	YES
DE_DUS_AP1	Airport	YES	NO	NO
GR_HER_TR1	Urban-traffic	YES	YES	YES
GR_HER_TR2	Urban-traffic	NO	YES	YES
GR_HER_TR3	Urban-traffic	NO	YES	YES
GR_HER_RB1	Regional background	YES	NO	NO
GR_HER_PO1	Port	YES	NO	NO
CY_LIM_TR1	Urban-traffic	YES	NO	NO
CY_LIM_TR2	Urban-traffic	NO	YES	YES
CY_LIM_TR3	Urban-traffic	NO	TBD	TBD
CY_LIM_TR4	Urban-traffic	NO	TBD	TBD
CY_LIM_RB1	Regional background	YES	YES	YES
CY_LIM_PO1	Port	YES	YES	YES
NO_OSL_TR1	Urban-traffic	YES	TBC	TBC
NO_OSL_TR2	Urban-traffic	TBC	TBC	TBC
NO_OSL_PO1	Port	TBC	TBC	TBC
NL_ROT_TR1	Urban-traffic	YES	YES	YES
NL_ROT_TR2	Urban-traffic	YES	YES	YES
NL_ROT_TR3	Urban-traffic	YES	YES	YES
NL_ROT_PO1	Port	YES	NO	NO
UK_SOU_TR1	Urban-traffic	NO	YES	YES
UK_SOU_TR2	Urban-traffic	NO	YES	YES
UK_SOU_TR3	Urban-traffic	NO	YES	YES
UK_SOU_PO1	Port	YES	NO	NO
GE_TBI_TR1	Urban-traffic	YES	YES	TBC
GE_TBI_TR2	Urban-traffic	YES	YES	TBC
GE_TBI_TR3	Urban-traffic	YES	YES	TBC
CH_ZUR_TR1	Urban-traffic	YES	YES	YES
CH_ZUR_TR2	Urban-traffic	YES	TBC	TBC
CH_ZUR_TR3	Urban-traffic	YES	TBC	TBC
CH_ZUR_AP1	Airport	YES	NO	NO

Legend:
YES = present; for air quality at least one air pollutant is measured with Net4Cities on- or off-line instruments.
NO = not present; for air quality no additional air quality monitoring with net4Cities instruments. TBD (to be defined): site needs to be defined/selected. TBC (to be confirmed): site is selected but need final confirmation (to be confirmed)

At most of the selected sites, existing monitoring infrastructure is available for air quality. An overview of existing on-line and off-line air quality monitoring for a large selection of pollutants is provided in Annex Table D-1. Near real-time monitoring data of the existing on-line infrastructure will be available in the Net4Cities Studio.

An overview of the location of sites per city is shown in Annex D (Figures D-1/11).

5.4 Considerations and constrains for the monitoring sites

5.4.1 Air quality

The advancements in air quality monitoring are made in almost all cases at existing AQMS, and constraints regarding these sites are applicable (see Directives 2015/1480 and 2008/50/EC).

Therefore, the remaining constraints are related mainly to practical issues and are e.g., installation (space inside the station or attachment for outside deployment) and position of sampling inlet (unrestricted airflow around sampling inlet and not influencing other sampling). These can be pollutant specific and are further defined in the respective guidelines for measurements.

5.4.2 Noise

The NMTs, which will measure continuously, will be located at sites where traffic is the predominant noise source so other variables will be negligible and can be ignored, following the recommendations established in the annex C of the UNE ISO 1996-2:2020.

To select the noise terminal sites, the following recommendations have been considered:

- The predominant noise source is traffic[7]. Because the NMT cannot distinguish between sources, levels from traffic must be higher than the rest of the sources (residual) by 10 or more dB. In cases where noise events will be detected the recommendations of point 3 of annex C of UNE ISO 1996-2:2020 must be observed.
- The microphone (which is not detachable from the NMT cabinet) will be installed at a height prescribed in the 2002/49/CE Directive and Annex I.
- The sites must be free of obstacles that can reflect or screen the sound. At sites where noise reflections may occur, an arm or extension pole may be necessary to reduce their impact.

Minimal distances to reduce the effect of reflections in the installation of a noise monitor in a facade.

- Regarding reflections, in case any obstacle exists close to the microphone and any corrections may be needed, it will be determined following the corrections indicated in Annex B of UNE ISO 1996-2:2020.
- Evaluate the existing air quality monitoring network to determine if it is possible to share the facilities of any of the already existing stations.
- At AQMS, noise and vibrations from the station itself may occur and must be also reduced by locating the microphone far away from the noisiest AQ instrument (especially the air-

[7] There is an exception, in Barcelona one of the NMTs will register noise from railway to detect freight train contributions.

cooling compressor), and if needed, plan for mechanical isolation of the NMT away from the structure, to ensure that the noise levels are not contaminated especially during nighttime.

- In case NMTs are not installed in the AQMS, a pole or other (existing) infrastructure must be considered (e.g., lamp posts) to install them.
- In all cases a continuous power supply is needed.
- Access to reception for mobile data coverage is needed. NMT includes a router and a SIM CARD but it is necessary to be sure that there is enough 4G coverage at the site.
- In all the NMT sites where the predominant source of noise is from vehicle traffic an outdoor traffic counter (Telraam) must be installed so that traffic and noise data can be correlated.

5.4.3 Traffic

While there are some Telraam sensors (mainly indoor, citizen science Telraam deployments) existing in a number of the partner cities (see previous chapter), none of the sites selected for noise and traffic monitoring include existing Telraam installations. Therefore, sensors will be installed on site. The traffic counters used here are outdoor Telraam units. For placement of the Telraam devices at the sites, the requirements are as follows:

- The device should be facing outward perpendicular to the street. Ideally at the first floor level or higher, with a minimum elevation of 3 meters above ground level for clear visibility.
- The street should be between 3 and 15 meters away from the sensor placement. Narrow streets or those too close to the window may prevent the device from properly identifying larger vehicles, such as vans or trucks.
- View and Field of Vision:
    - An unobstructed view of the street is essential, free from significant obstructions like trees, shrubs, or stationary vehicles.
    - Avoid placing the device near busy junctions or traffic lights where vehicles may stop for extended periods.
- Power Source: Telraam requires 12V DC (barrel jack) or a classic 5V USB-C. A power outlet is needed at all monitoring stations.
- Connectivity: The Telraam S2 uses built-in cellular connectivity (LTE-M or NB-IoT) for data transmission, eliminating the need for a Wi-Fi connection.

These requirements ensure the device can reliably monitor and classify traffic, including vehicles, bicycles, and pedestrians, while maintaining user convenience and privacy. For more details, you can refer to the installation guidelines on Telraam FAQ[8].

6. Advancement of monitoring networks across partner cities

Net4Cities is providing advancements and expansions to the monitoring capacity for air quality, noise and traffic across partner cities. The instrumentation is deployed at the Net4Cities' sites following installation procedures that maximize comparability between cities. An overview of the instrumentation as well as specifications and details on the actual set-up at the Net4Cities'

[8] https://telraam.helpspace-docs.io/article/256/technical-requirements-for-telraam-installation-a-detailed-guide

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sites is described in this chapter. An overview of the advancements in air quality monitoring at the different sites is given in Annex Table D-2.

The procedures and scripts that are developed to introduce the data from the on-line air quality, noise and traffic measurements to the Net4Cities data hub are treated in WP4 of Net4Cities (see D4.1 and D4.2). A continuous and real-time data flow from sensors to the data hub will be implemented. The off-line air quality data will be introduced on the data hub as analyses are completed.

6.1 Overview of the air quality measurements

6.1.1 Short description of the instruments

Ultrafine Particles will be measured as Particle Number Concentration (PNC) following CEN standard (EN16976:2024) for PNC down to 10 nm, using a Condensation Particle Counter (CPC) from Airmodus (model A30 or A20). This project involves the development of a comprehensive measurement setup based on the latest CEN standards, with specific adjustments for enhanced functionality. The system includes stainless steel inlet tubing, a 12-inch long Nafion dryer (Permapure), a mini cyclone designed by Airmodus, and the RHTP module for monitoring inlet relative humidity (RH), temperature (T), and pressure (P). These variables are logged continuously at a frequency of 1 Hz, ensuring comprehensive data collection.

The A30 CPC features a sample flow of 0.2 L through its optics and a bypass flow of 1.3 L/min, resulting in a laminar flow to prevent particle losses. A limited number of stations are equipped with the A20 bCPC, which is an ACTRIS-compliant instrument, but the majority will have the A30 CPC installed. A key distinction from the CEN standard is that the A30 CPC employs propylene glycol at various sites instead of the CEN-compliant butanol. This project aims to investigate the long-term performance of propylene glycol in contrast to butanol. According to CEN standards, other working fluids may be acceptable if their equivalence to butanol is established, highlighting the necessity for long-term equivalence studies. The comparison of propylene glycol and butanol is currently ongoing. Initial results on the performance of propylene glycol were already published and showed good equivalence (Wlasits et al., 2024). The A30 CPC utilizing propylene glycol offers exceptionally low consumption, requiring only 0.5 liters for a full year of measurements, and features an extensive measurement range of up to 500,000 particles per cm^3. In contrast, typical butanol-based CPCs consume over 12 liters annually and smaller measurement range. This enhanced measurement capability enables us to monitor concentrations in high-emission areas, commonly referred to as hot spots, particularly near airports, ports, and heavily polluted urban environments.

The use of butanol in air quality monitoring stations can be complicated due to its cross-reactivity with benzene monitors. Consequently, butanol-based CPCs necessitate an additional, costly vaporization stage in their exhaust systems. Furthermore, commercially available vaporizers are not typically designed for continuous operation.

Airmodus provides an IoT logger for seamless data transmission to the Net4Cities data hub. This logger facilitates full remote control of the CPC and ensures continuous live data transfer. For regular checks on inlet flow, the Airmodus flow meter (AFM) can be utilized. A schematic of the complete system is presented in Figure 9.

This project not only advances our understanding of CPC performance using different working fluids but also contributes valuable insights to the field of air quality monitoring.

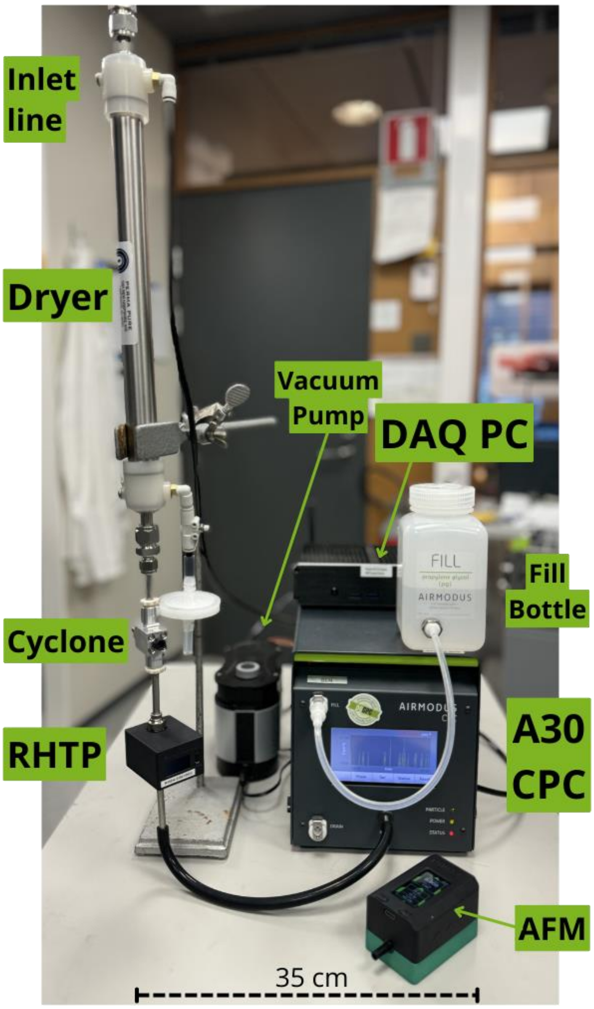

Figure 9. UFP measurement system including Airmodus A30 CPC.

Lung-deposited surface area LDSA monitoring will be done using devices manufactured by Naneos GmbH (OLS instrument). LDSA instruments will be deployed in all 11 Net4Cities partner cities at three locations.

The instruments use diffusion charging to measure LDSA, are very small and versatile in deployment, and measure UFP between 20 – 350 nm. The devices measure the total surface area of particles per volume of air [$\mu m^2/cm^3$] of particles smaller than 350 nm. Parameters measured include lung-deposited surface area, auxiliary data such as device temperature, relative humidity in device, air pressure, and internal signals (corona high voltage, electrometer offset and gain, among others). Data are automatically transmitted to a cloud-based server, through which data will be integrated into the Net4Cities data hub.

Figure 1010 shows the device installed on a lamp post and the Naneos Partector 2 that will be used for regular performance checks (comparison with the fixed LDSA monitor).

Figure 10: Naneos LDSA monitor mounted on a lamppost (left). Naneos Partector 2 Monitor (right).

Black carbon will be measured in Net4Cities with a multiwavelength filter photometer commercialized as AE-33 by Magee Sci. The instrument will be used in Net4Cities to apportion fossil fuel from biomass combustion-derived BC. No new instruments will be installed as part of the Net4Cities project.

The measurement principle of the Aethalometer is based on the attenuation of a light beam though a filter tape on which the aerosol is collected over time. The filter tape automatically advances when the attenuation reaches a certain threshold. The attenuation is a function of composition of the particle load and the wavelength. The instruments used can have different size-selective inlets and can use different mass absorption coefficient (MAC) values to convert light absorption coefficient to BC concentrations (see also RI-URBANS, 2024). The threshold for filter tape advance can also be different between the cities. The absorption coefficient will be calculated from the attenuation and instrument specific parameters (type of filter tape) and will be converted to BC concentrations using the mass absorption cross section (MAC). The BC concentration is often referred to as eBC (equivalent black carbon), meaning the BC mass concentrations measured using an optical method, correspond not only to black carbon but to other light absorbing particulate components, such as dust and specific organics. eBC corresponds to the BC concentration determined at 880 nm using the MAC.

The AE33 is preferred because of its filter loading correction by performing sampling on two filter spots at a different flow; corrected and uncorrected results are reported. It has been demonstrated that aerosol derived from the combustion of liquid and solid fuels exhibit specific wavelength dependence with respect to light absorption, which can be used, in combination with the aethalometer-measured absorption coefficient, to derive their individual mass in an aerosol sample (Sandradewi et al., 2008). It is typically assumed that liquid fuel is associated with fossil fuel combustion from traffic while solid fuel with biomass combustion.

Ammonia As no reference method exists for the continuous measurement of NH_3, passive samplers are considered the current standard (EN 17346:2020). Measurements are taken through the absorption of NH_3 to the sampler that is impregnated with oxalic acid. The samples are then analysed in the laboratory using photometry. Following EN 17346:2020, this method produces measurements of NH_3 with an uncertainty of ± 10%. The current standard allows different acids for ammonia collection and NILU selected oxalic acid based on previous experiences and performed a comparison. NH_3 passive samplers from NILU are used in Net4Cities to create new knowledge on NH_3 concentration and its relationship with traffic emissions, vehicle fleet composition and seasonality in urban areas. The passive sampler (Figure 11) is a circular plastic container (1.2 cm height and 2.5 cm diameter). The sampler has a metal pre-filter (grid) with a Teflon pre-filter inside, for protection against turbulence in the front of the sampler, as well as an impregnated Whatman Grade 40 filter for absorption of gases.

Figure 11: Passive sampler for the measurement of NH_3, provided by NILU.

The passive sampler measurements will be complemented with (1) mobile on-line measurements at different times of the year in and around Düsseldorf, to get insights on spatial distribution and the urban contribution to total NH_3, and (2) with stationary on-line measurements in Antwerp to get insights into daily patterns. On-line measurements will be performed using cavity-ringdown. EU legislation does not describe a reference method for the on-line measurement of NH_3. As part of the RI-URBANS project, recommendations on measurement methods, sampling and QC of ammonia measurements are currently being prepared but no final version is available (RI-URBANS, 2024 (b)).

Nitrous oxide, methane, carbon dioxide, carbon monoxide, and volatile organic compounds In Net4Cities, air samples will be collected monthly at one traffic location in each of the cities over one year. Sampling will be done by the local partners, using SilcoCan canisters, provided by FZJ. These canisters will sample over the course of one hour and are equipped with a capillary to reduce the flow and an impregnated filter to destroy O_3 (Figure 12).

Figure 12: SilcoCan canister sampler with capillary filter and ozone filter attached.

The collected canister samples are analyzed in a central laboratory (FZJ) using cavity-ring-down-spectroscopy for N_2O, CO_2, and CH_4 In addition, selected VOCs are measured using GC/MS. The gas chromatographic method detects hydrocarbons with a chain length of 2 to 12 carbon atoms, as well as oxygenated compounds such as alcohols and ketones. The VOC measurement system has been part of the quality assurance within the WMO observation network for VOC.

Filter analysis for exhaust/non-exhaust attribution Net4Cities will collect integrated (filter) samples at daily resolution from traffic sites at 5 cities and analyze them for trace metals linked to exhaust (V, Ni, Mn, Cu, Fe) and non-exhaust emissions such as tyre (Zn), brake (Sb, Cu), pavement (Si, Ca, Fe and Al) or rail emissions (Mn, Cr, Cu, Sb, Ba and Zn), as well as bulk carbon and water-soluble ions (SO4= NO3-, Na+, K+, NH4+, Cl-, Ca+2, Mg+2) following harmonized protocols. The same filters will also be used for the analysis of ions, wood burning tracers, and EC/OC analysis. The sum of all the components above allows for identifying and quantifying these sources over the entire PM mass. The chemical speciation dataset will serve as input for offline source apportionment (SA) for exhaust and non-exhaust attribution and validation of operational, online SA methods (see source apportionment methods).

The sampling of the filters is done by the local partners and analysis is done by the Cyprus Institute (CyI). A harmonized sampling and analysis method will be used in the cities which means:

- Quartz fiber filters will be used for sampling.
- Sampling duration of 24h per filter.
- Sampling with a PM_{10} preclassifier and an airflow of 2 m^3/h or higher.
- ICP-MS will be used for trace metal analysis.

Sampling frequency will be 1 filter every 3 days over one year or equivalent, to result in a total of ca. 100 samples. Filter samples are stored at -20°C after sampling and sent to the lab for analysis every three months. Field blanks will be available throughout the sampling period.

In addition, because these markers exist in trace concentrations, only recently has continuous monitoring with an adequately low detection limit been commercialized that can detect the markers (xACT). This instrumentation is state-of-the-art and not yet widely implemented. The xACT technique will be used in Limassol and Heraklion to provide information on trace species in real-time.

6.1.2 Description and specification of the installation plans

The instrument configuration for new instrumentation at air quality monitoring is identical at all the sites, except for the UFP monitoring. Specifications of the monitoring systems and installation details per monitoring site are described in this section.

6.1.2.1 Specifications of the UFP monitoring

This project involves the installation and configuration of Airmodus Condensation Particle Counters (CPC) across partner cities, each of which is selected from a range of options tailored to their specific monitoring requirements. The standard configuration utilizes a dedicated stainless steel inlet line measuring 2 meters in length with an inner diameter of 4mm. For stations incorporating a combined measurement line for particulate matter (PM) monitoring, including a $PM_{2.5}$ inlet hat and sampling manifold, the individual CPC inlet line will not be installed; instead, the combined inlet line serves both PM and CPC measurements.

Regardless of the configuration, all setups included a 12” Nafion dryer, a mini-cyclone, and an RHTP Module, which were interconnected using conductive Tycon tubing to ensure consistent and accurate performance. It is crucial for the inlet line to maintain a laminar flow, and the entire section must be conductive to minimize particle losses to the walls of the tubing. The default inlet line was characterized in the Airmodus laboratory to identify size-dependent losses, with results anticipated to be reported during the project's progress.

For stations requiring outdoor housing for ultrafine particle (UFP) measurements, the system will include a sampling line designed to meet operational requirements. The European standard EN16976:2024 mandates that CPC installations be placed in temperature-controlled environments, maintaining a range of 20-30 °C with permissible fluctuations of ± 2 °C over a 24-hour period. This temperature stability is particularly challenging for outdoor enclosures, necessitating active cooling solutions for the housing. The measurement system is equipped with comprehensive diagnostic signals to facilitate data filtering based on environmental conditions, thus enhancing the reliability and accuracy of the collected data.

Table 10: Configuration of Airmodus UFP instruments in Net4Cities installed across partner cities.

Configuration	ANT	BAR	BER	DUS	HER	LIM	OSL	ROT	SOU	TBI
Number of sites	3	3	2	3	1	1	3	3	2	3
Working fluid (a)	pg	pg	pg	pg	pg	b	b	pg	pg	pg
CPC model	A30	A30	A30	A30	A30	A20	A20	A30	A30	A30
Inlet system (b)			C							C
Own housing (c)				2x					1x	
Data acquisition (d)					OD		OD			

(a) pg: propylene glycol, b: butanol
(b): Airmodus provides full inlet system including entire pipeline. Some stations are using combined manifold and those are marked as C (combined). All installations include a Nafion dryer, a cyclone and RHTP Module even if the inlet line is combined with other equipment.
(c) Some units are not placed in the AQMS but have a separate outdoor housing; this is indicated with x; details are described in text; all other systems are installed inside AQMS.
(d) Airmodus provides LTE-based IoT logger that allows full online remote control and data transfer. Some stations are using their DAQ system; marked as OD (own data-acquisition).

6.1.2.2 Specifications of the LDSA monitoring

The LDSA monitor is a compact weatherproof housing equipped with a heated inlet to prevent condensation within the instrument. The housing measures approximately 20 cm x 15 cm x 30 cm and weighs around 3.5 kg (including the built-in instruments). The devices require a 230 V power source and must be connected to a power source using the provided cable. The cables are (if not specified differently) 5 m long and come with a plug that matches the country-specific socket.

The devices are installed outside without any additional housing or container. It is recommended to mount them at a height of 2.5 to 3 meters to prevent possible ground effects and vandalism. Once installed and plugged in, the devices will start autonomously and begin continuous measurement. In case of a power outage, the devices will restart once the power is back on. The data is continuously transmitted to a cloud using a built-in SIM card, from which it can be retrieved and transferred to the Net4Cities data hub. During the duration of the project, three different measures are taken to ensure high data quality:

a) Housekeeping data is sent alongside the LDSA data. It will allow the manufacturer to detect quality deterioration if it would appear. Housekeeping data will not be broadcast to the Net4Cities data hub.
b) Regular co-location measurements using a provided handheld LDSA measurement device (Naneos Partector 2). All co-location measurements follow the same protocol, and the data from the co-location measurements will be analyzed by ZHAW. If any drift is detected, the local partners will be contacted with further information. It is recommended to do co-location measurements at least once every three months.
c) All devices will be sent back to the manufacturer mid-campaign (between 12 and 18 months after deployment) for a general service. The shipping costs will be paid by ZHAW. Local partners will be contacted in time with further information.

6.1.2.3 Specifications of the VOC & GHG monitoring

The VOC and GHG sampling will be done with canisters. Sampling takes about an hour and is designed to capture a representative composition of volatile organic compounds and the concentrations of greenhouse gases in the air. No local sources should be sampled that are not representative of the location, e.g., emissions from chemical containers, rubbish containers, petrol stations or the measurement container (e.g., the CPCs if the working fluid is butanol). It is suggested that the site should be examined for possible localized hotspots prior to sampling.

6.1.2.4 Specifications of the NH_3 monitoring

The NH_3 passive samplers provided by NILU are simple in structure and therefore are easy and flexible to deploy. Each sampling site shall be equipped with a round-shaped protective cover with clips, for easy sampler installation and removal. The cover comes with a mounting bracket and necessary screws. It is essential to position this lid so that the sampler does not get wet. As the sampler's vertical position above ground has been shown to influence NH_3 sampling results, all samplers should be installed at the same height for the sake of comparability between sites across all partner cities. A height of ca. 2 m is recommended for all sites. It is expected that each site is protected from vandalism. The sampling period is one month.

Samplers are delivered in an airtight box, together with a registration form. After the sampling period ends, the sampler must be immediately placed back in the box, ensuring it is closed and cannot absorb more gas from the air. It is crucial to close the storage box carefully to avoid leaks, which could contaminate the sampler. If the box is not properly closed upon receipt, this will affect the analysis.

Field blank samples must be taken. At least one field blank sample per measurement period per measurement project is required. The number of field blank samples is typically determined by the Operations Manager at NILU for inorganic analysis during project registration.

No maintenance is needed for the NH_3 passive samplers once installed. They must only be replaced once a month and sent off to the laboratory for analysis. If storage time before sample analysis is expected to last long, it is recommended to keep the samplers cooled in a refrigerator.

6.1.2.5 Specification of the PM speciation sampling

Sampling shall be performed using a PM_{10} sampler complying with the requirements of EN 12341. The sampler will be placed next to the AQMS or on the roof. This can be different at different sites and will be function of practical considerations. The sampler inlet is situated about 1.5 m above the closest horizontal surface; this means that sampling will take place between 1.5 m and 4 m above ground. In most cities (Limassol, Berlin) samplers will be placed on the roof of the AQMS.

6.2 Overview of the noise measurements

6.2.1 Description of the Noise Monitoring Terminal

The noise monitor selected is the Quantum Outdoor, manufactured by Cirrus plc (Figure 13).

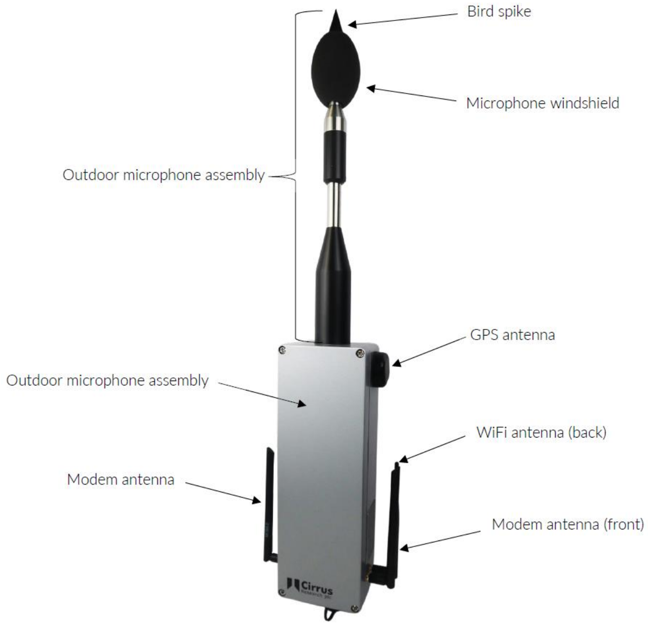

Figure 13: The Cirrus Quantum outdoor noise monitor.

Quantum outdoor device is a noise monitor ideal for long-term unattended noise monitoring applications. Thanks to its cloud connection, Quantum Outdoor offers a complete monitoring solution by offering all the benefits of remote 24/7 noise monitoring.

Its main characteristics are:

Standards:

- Class 1 environmental noise monitor – meets all applicable international noise measurement standards including IEC 61672-1:2013
- IEC 61260:1995 & ANSI S1.11-2004 1:1 octave and 1:3 octave band filters Class 1 or Class 2

Technical characteristics:

- **Microphone:** ½" MK:224 pre-polarized free-field electret
- **Microphone preamplifier:** MV:920
- **Measurement range:** 20 to 140dB RMS in a single range
- **Noise floor:** <19dB(A) Class 1
- **Frequency weightings RMS:** A, C, & Z measured simultaneously
- **Peak:** A, C, & Z measured simultaneously
- **Frequency analysis 1:1 octave bands:** 31.5 Hz to 16k Hz
- **Frequency analysis 1:3 octave bands:** 6.3 Hz to 20 kHz
- **Time weightings:** Simultaneous Fast, Slow and Impulse
- **Time history:** User selectable 10 ms, 100 ms, 500ms, 1 sec
- **Live data view Noise at work:** (L_{AF}, L_{Aeq} & L_{CPeak})
- **Live data view Environmental:** (L_{AF} & L_{Aeq})

- **Live data view Custom:** (L_{Aeq}, L_{Ceq}, L_{AFMax}, L_{ASMax},
- L_{CPeak} & L_{ZPeak})
- **Live data rate:** 1 sec
- **Stored values:** L_{Aeq}, L_{Ceq}, L_{Zeq}, C-A, L_{AE}, L_{EX8}, L_{AFMax},
- L_{ASMax}, L_{CPeak}, L_{ZPeak}, L_{AF1}, L_{AF5}, L_{AF10},
- L_{AF50}, L_{AF95}, L_{AF99}, L_{AeqT1} & L_{AeqT2}
- 1:1 octave bands: 31.5 Hz to 16 kHz.
- 1:3 octave bands: 6.3 Hz to 20 kHz.
- **Frequency Analysis Time history** of 1:1 & 1:3 octave bands
- **Audio quality**: Standard (16bit/16kHz) High (24bit/48kHz)
- **System Integrity Check (SIC)**: Three frequency single level charge injection
- 500Hz, 4kHz and 8kHz.

General characteristics:

- **Dimensions:** 200 x 850 x 122mm (7.8 x 33.5 x 4.8")
- **Weight:** 5 kg
- **Power:** PoE IEEE 802.3af-2003 37V – 57V DC 12V –
- 18V DC 1.5A
- **Power consumption:** < 8w
- **Network connections:** 4G with 3G fallback factory fitted with
- industrial multi-network SIM/ Ethernet/ Dual-band WiFi (2.4GHz and5GHz)/ Bluetooth®
- **Case material:** Metal - aluminium
- **Mounting BK:** 901 wall mounting kit
- Pole mount (standard option)
- **Temperature Operating**: -10 °C to +50 °C
- **Temperature Storage:** -20 °C to +60 °C
- **Humidity:** Up to 95% RH non-condensing
- Environmental IP65
- Electromagnetic performance EN 61000-6-3:2007+A1:2011
- EN 61000-6-1:2007

The detailed dimensions of the terminal and its components are given in Figure 14.

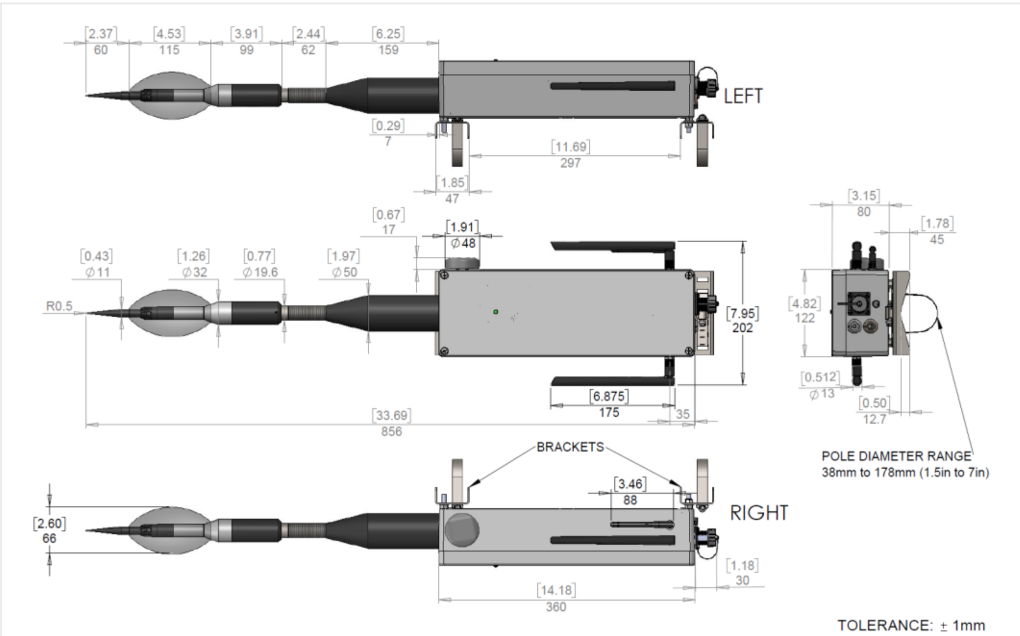

Figure 14: NMT dimensions.

6.2.2 Specifications of the noise measurements

In Net4Cities the planned noise measurements can be classified into two main groups:

- **Continuous monitoring.** In these measurements the NMTs will measure the noise level continuously, registering a value each second[9]. These values will be post-processed to obtain the noise indicators of interest following the process indicated in the UNE ISO 1996-2:2020.

- **Events.** At specific sites, the NMT will be set up to detect the noise due to a single vehicle passing by the NMT (also considered an "event"). For the event set-up, the noise level will be registered with a higher time resolution (lower integration time, around 10 ms). The information on these events along with the traffic data will be correlated to determine the contribution of each kind of vehicle in the total traffic noise.

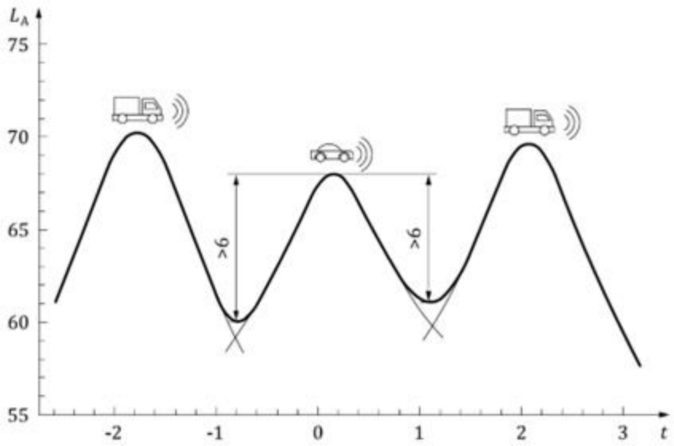

Figure 15: illustration of required signal-to-noise ratio for individual vehicle passages (ISO 11819-1:2023).

In both cases to evaluate the noise, the following indicators will be measured either in broadband measurements, which will give information on the acoustic energy of the 20 – 20.000 Hz frequency band as in 1/3 octave bands, which results will allow for more detailed insight of the noise sources that are contributing to the environmental noise measured.

L_{Aeq}: The A-weighted equivalent continuous sound pressure level, stated in ISO 1996-1:2016. It represents the level that would have had the fluctuating noise measured if it had been steady. It is the basis for obtaining[10] L_{day}, $L_{evening}$, L_{night}, L_{den} which are the preferred noise indicators to evaluate environmental noise.

Besides the normative, these indicators are also stated in the Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise and are the basis for the exposure evaluation.

[9] The integration time may change (increase) according to the traffic information interval.
[10] The process is indicated in UNE-ISO 1996-2:2020.

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L_N: percentile/statistical, shows the noise level exceedance for N% of the measurement period (ISO 1996-1:2016). Their analysis provides important knowledge about the noise source behavior, e.g. L_{95}, the level exceeded for 95% of the measurement time may be interpreted as an indicator of background noise levels while L_{10} and L_1 may be associated with the vehicle pass events.

L_{AFMAX}: Shows the maximum value reached during the interval considering a FAST time-weighting, and a A frequency-weighting (ISO 1996-1:2016). Its value will be analyzed along with L_{10} and L_1 to evaluate the contribution of the events to the overall values.

L_{AFmin}: Show the minimum value reached during the interval considering a FAST time-weighting, and a A frequency-weighting (ISO 1996-1:2016). Its value will be analyzed along with L_{95} to evaluate the background level.

6.3 Overview of the traffic measurements

6.3.1 Short description of the instrument

In Net4Cities, 3 outdoor Telraam sensors are generally planned per pilot city.

An example of the Telraam module is shown in Figure 16. The instrument has the option to be installed with a solar panel due to low power consumption. In Net4Cities, instruments will be installed using mains power and details on power connection are given in Figure 17. We refer to the Telraam installation manual (constantly updated) available **here**[11].

Figure 16: Telraam module (in this picture installed with solar panel)

[11] https://drive.google.com/file/d/1BhIiWr_1h8s6LMuU3Knz73damgmlhbRY/view

Figure 17: details of the Telraam power connection.

6.3.2 Specifications of the traffic measurements

The Telraam data structure is as follows:

- **Traffic Counts**: Organized by segments (unique road identifiers), time intervals (15-minute increments), and user categories (pedestrians, bicycles, cars, heavy vehicles).
- **Timestamps**: Each data point includes precise timestamps for temporal analysis.
- **Location Metadata**: Geographical coordinates or segment IDs to associate data with specific streets or road sections.

Available API Endpoints:

- **Traffic Data Retrieval**: APIs provide endpoints to query historical or near-real-time traffic data for specified segments or time ranges.
- **Device Status**: Endpoints monitor sensor activity and report on data collection reliability or gaps.
- **Summary Statistics**: Pre-processed aggregates like median speeds, busiest hours, or modal split ratios.

Query Parameters:

- Filters for the mode of transportation, date ranges, or geographical segments.
- Options for granularity, such as raw counts vs. aggregated statistics.

Output Formats:

- Data is typically delivered in machine-readable formats like JSON or CSV for integration with analytics tools.

7. Implementation plan for air quality

The implementation plan for air quality is described here and includes information on the time-line of the air quality monitoring, the standard operating procedures, the QA/QC procedures and the logging of interventions during instrument deployment.

7.1 Timeline of the air quality monitoring

There are five phases in the timeline for air quality monitoring: (1) the preparation (selection) phase, (2) the installation phase, (3) the test phase, (4) the monitoring phase, and (5) the post-deployment phase.

Most of the preparatory work for air quality monitoring with on-line instruments will be carried out by the end of 2024, and the off-line monitoring by March 2025 (Table 11). The installation of the on-line instruments will take place between January and early March 2025. After installation, a test phase is foreseen (February-March 2025) to have everything up-and-running by 1 April 2025. At that time, the off-line sampling will also start, and all the necessary equipment for the offline sampling will be shipped to the project partners by March 2025. SOPs, QA/QC and logging procedures are provided by the end of 2024.

Table 11: Overview of activities related to preparation/installation of instruments.

Activity preparation /installation	Pollutant	Responsible	Timing (by day/month/year)
Delivery of instrumentation			
Delivery Airmodus CPC	UFP	Airmodus	7/03/2025
Delivery LDSA devices	LDSA	ZHAW	1/02/2025
Samplers for ammonia measurements sent to partners	NH_3	NILU	1/03/2025
Equipment for canister sampling send to partner	VOCs/GHG	FZJ	1/03/2025
Installation at the Net4Cities sites			
Installation Airmodus CPC	UFP	Local partner with Airmodus	14/03/2025
Installation LDSA devices	LDSA	Local partners	14/03/2025
Installation of passive sampler holder	NH_3	Local partners	5/03/2025
Installation or selection of existing PM10 filter sampler	PM speciation	Selected local partners	1/04/2025
Data transfer			
Evaluation LDSA and UFP data (check if everything is working and data transmitted to data hub)		Airmodus, ZHAW, NILU in collaboration with local partners	1/04/2025
UFP and LDSA measurements available on-line		Airmodus, ZHAW, NILU	1/04/2025
SOPs, QA/QC and logbook			

SOPs for air quality instrument/samplers available	UFP, LDSA, NH3, VOC, PM speciation	Airmodus, ZHAW, NILU, FZJ, CYL	1/01/2025
QA/QC protocol for air quality instrument/samplers available	UFP, LDSA, NH3, VOC, PM speciation	Airmodus, ZHAW, NILU FZJ, CYL	1/01/2025
Logbook for different instruments available	UFP, LDSA, NH3, VOC, PM speciation	Airmodus, ZHAW, NILU FZJ, CYL	1/01/2025

The Net4Cities air quality monitoring will be online at the latest by the end of March and as of 1 April 2025 will be online and measuring (Table 12). Within Net4Cities, the on-line air quality monitoring will be deployed for a minimum of two years (until 31/3/2027). For the off-line monitoring, a monitoring period of one year is foreseen (until 31/3/2026). For UFP and LDSA monitoring, the monitoring phase can be extended beyond the end of the project. The proposed timeline is in line with MS2.2 of the project proposal.

Table 12: Timeline of instrument deployment at the N4C monitoring sites for air quality.

Activity*	Time	Comment
ALL CITIES		
On-line monitoring of UFP	1/4/2025 – 31/3/2027+	UFP monitoring can be extended beyond the end of Net4Cities[12]
On-line monitoring of LDSA	1/4/2025 – 31/3/2027+	LDSA monitoring can be extended beyond the end of Net4Cities[13]
On-line monitoring data (existing measurement transferred to Net4Cities data hub)	1/4/2025 – 31/3/2027+	
Passive sampling for ammonia	From 2/04/2025 for 1 year	monthly sampling**
Canister sampling for VOCs & GHG	From 2/04/2025 for 1 year	1 sample per month**
SELECTED CITIES		
Filter sampling for source apportionment (PM speciation) in ANT, BER, HER, LIM, TBI	1/4/2025 – 31/3/2026	1 filter sampled every 3 days
BC for source apportionment	1/4/2025 – 31/3/2026	Existing instruments

* for details on the installation at the sampling sites, see §6.1.2
** for details see §7.1.1

The after-deployment phase includes the removal of instruments from the monitoring sites and the delivery of instruments to the respective project partners. This will be done up to 3 months

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[12] Partner cities will have the option of purchasing the Airmodus CPCs after the end of the monitoring period at reduced cost (accounting for depreciation).
[13] LDSA devices will be transferred to the partner cities at no cost at the end of the planned measurement period.

after the ending of the monitoring. The after-deployment phase also includes the reporting of final log-files with interventions and events, and other actions that are needed from project partners with respect to the air quality measurements that took place in the partner cities.

7.1.1 Detailed timeline passive and canister sampling

The off-line measurements will start on 1/4/2025 and continue until 31/03/2026 for one year. The on-line measurements will be also operational in that period. The sampling across partner cities will be done simultaneously, as far as this is practically feasible. Dates of sampling and sampler changes are coordinated over the different cities. Table 13 gives the overview of dates on which the passive samplers will be changed at the different cities, and the dates when canister samples are taken. This will be done on the first Wednesday of the month. Ammonia is sampled over 4 or 5 weeks (average concentration). The sampling of canisters will be done on the same dates between 8-9 am (local time) to capture peak traffic hours (hourly average concentration). In case of rain, canister sampling will be shifted to the following day with dry weather, between 8 and 9 local time.

Table 13: Dates for changes of the passive samplers and canister sampling

Sample	Canister sampling	PS sampling Start date	PS sampling Stop date	PS sampling #days
0*	2025/03/05 8am-9am	--	--	--
1	2025/04/02 8am-9am	02/04/2025	07/05/2025	35
2	2025/05/07 8am-9am	07/05/2025	04/06/2025	28
3	2025/06/04 8am-9am	04/06/2025	02/07/2025	28
4	2025/07/02 8am-9am	02/07/2025	06/08/2025	35
5	2025/08/06 8am-9am	06/08/2025	03/09/2025	28
6	2025/09/03 8am-9am	03/09/2025	01/10/2025	28
7	2025/10/01 8am-9am	01/10/2025	05/11/2025	35
8	2025/11/05 8am-9am	05/11/2025	03/12/2025	28
9	2025/12/03 8am-9am	03/12/2025	07/01/2026	35
10	2026/01/07 8am-9am	07/01/2026	04/02/2026	28
11	2026/02/04 8am-9am	04/02/2026	04/03/2025	28
12	2026/03/04 8am-9am	04/03/2025	1/04/2025	28

* First measurement is considered as a test measurement

7.1.2 Detailed timeline for filter sampling for analysis and source apportionment at selected cities

At a selection of traffic sites in the cities of Berlin, Tbilisi, Heraklion, Limassol and Antwerp, PM10 will be sampled on filters. The quartz fiber filters will be analyzed with ICP-MS for the following elements: Na, Ca, Mg, K, Al, Fe, Ti, V, Ni, Sc, Se, Mo, As, Sb, Sn, Cd, Cs, La, Cr, Mn, Co, Cu, Sr, Ag, Pb. The filter sampling will be conducted from 1/4/2025 until 31/3/2026 for one year, with a sampling frequency of one filter every three days (122 filters per site in total).

Filters are analyzed in batches every three months. All results are expected to be available by the end of May 2026.

7.2 Installation, operating and QA/QC procedures

Installation, operating and QA/QC procedures are internal documents that are available for the project partners. For on-line monitoring (UFP, LDSA) and off-line samplings (NH3, VOC and PM_{10}):

- UFP: https://syncandshare.desy.de/index.php/s/P9QgwrzAwQZe9F4
- LDSA: https://syncandshare.desy.de/index.php/s/3cNGdimASHP4X8H
- NH3 with passive samplers: https://syncandshare.desy.de/index.php/s/Yx3WZLD-NFbdt5o4
- VOC with canister method: https://syncandshare.desy.de/index.php/s/3GbPWomp5LoWpAQ
- Filter PM_{10} sampling for speciation: https://syncandshare.desy.de/index.php/s/Nza8iteBoQGMQer

7.3 Logging of interventions

Interventions are logged in a digital form, containing the following fields:

- City (selection form dropdown menu)
- N4C site (selection from dropdown menu)
- Instrument/sampler (selection from dropdown menu)
- Date of intervention
- Hour of intervention (UTC)
- Intervention (selection from a dropdown menu, including corrective and preventive maintenance)
- Description for further details on the intervention
- Remarks for additional information.

8. Implementation plan for noise

This section includes:

- The timeline for the deployment of the noise monitoring network over the ten cities.
- The procedure to install the terminals in each location and start sending data to the Cirrus Cloud.
- The operating procedure.
- The procedure to introduce data into the Net4Cities data hub.

8.1 Timeline of the noise monitoring deployment

In the project 30 noise terminals will be installed in 10 different cities (all partner cities except Barcelona). To facilitate the installation process, and to solve all the issues that may come up during installation, the process will be done sequentially.

The manufacturer, Cirrus plc, will provide at least, 6 NMTs per month, so the installation will be done in, at least, two cities at the same time.

The main factor considered in ranking the order of installation was the simplicity of installation. Sites where the NMT will be co-located, sharing facilities with an existing AQ station, were prioritized because:

- The NMT could likely be mounted on the safety banister of the station's roof, with no further actions or extension masts needed.
- A power supply is already available.

The installation process is set to begin in January, and the tentative timeline for the entire process is shown in Table 12. Still, it may be subject to changes due to cities requirements.

Table 14: Overview of the tentative plan for installing noise monitoring at the partner cities.

City	Start by week 2025 (estimated installation time of 4 weeks)
Antwerp	15/01/2025
Barcelona	15/01/2025
Berlin	15/01/2025
Heraklion	03/02/2025
Oslo	03/02/2025
Rotterdam	03/03/2025
Düsseldorf	03/03/2025
Southhampton	07/04/2025
Zurich	07/04/2025
Tbilisi	05/05/2025
Limassol	05/05/2025

8.2 Installation of NTMs in each site

Cirrus will send the NMT directly to the person(s) responsible for the installation in each city. The installation process is divided into three different stages:

8.2.1 Pre-installation stage (previous to receive the NMT)

The person(s) responsible for the installation will visit the sites to evaluate and prepare it, looking at:

- Look for the best place to install the NMT at the site. In the case that the installation will be on top of the roof it will be necessary to find a place far away from the noisiest AQ staff, and above all the compressor (air-cooling).
- How to get power supply for the NMT (what components are needed, if it is necessary access to the inside of the station the way to do it, etc.).
- How to fix/hang the NMT, whether it is possible to fix it to the safety banister on the top of the roof using the steel straps that are provided with the NMT, or if it will be necessary any kind of adaptor.
- Check that the site has enough mobile coverage.

8.2.2 Setting up the NMT

Once the NMT has been received, the person(s) responsible will:

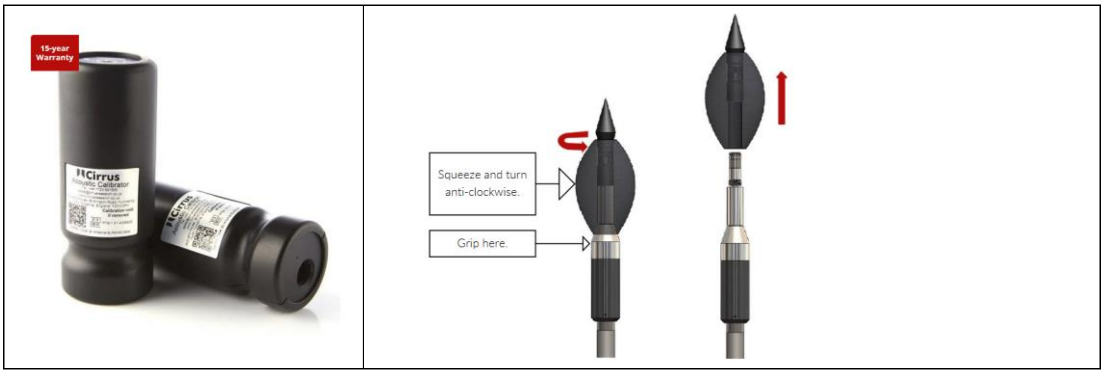
- Unbox the NMT and check that everything has arrived correctly. Video #1
- Connect and plug the different elements (antennas mainly). Video #2
- Registering the NMT on the Cirrus Cloud. Video #3
- Linking to the application. Video #4

Now the NMT is ready to be installed in the site.

8.2.3 Installing the NMT at the site

In this last stage, the NMT will be installed at the monitoring location. The steps are:

- Fix/hang the NMT, with the necessary elements considered in the previous technical visit.
- Plug in the power supply.
- Check that the NMT is sending information to the Cirrus Cloud.
- Check the level, using the external calibrator provided together with the NMT.



- Take pictures of the installation and including pictures from the "point of view" of the microphone.
- Fill out the installation report.

The installation is now finished.

8.3 Operating procedures

Once the terminals are switched on and set up, the noise network will work unattended, the terminals will measure continuously and send the data to the cloud/datahub without requiring any operator action. Unless an issue is noted, no intervention will be needed.

To ensure that the noise levels measured are correct, is planned to perform a daily check of the status of each NMT in terms of:

- SIC[14] values.
- Communications status.
- Outliers.

In case any issue is detected corrective actions, as was mentioned before will be needed.

[14] Quantum NMT carries out an auto check four times per day, at three different frequencies 500 Hz, 4 kHz and 8 kHz

9. Implementation plan for traffic

The Telraam outdoor installation plans align with the noise sensor installation plan. So, the timeline is similar.

As with noise, Telraam will ship the devices directly to the responsible person(s) of each partner city. As with the noise sensors, site visits by the responsible person(s) are required to [1] verify the suitability of the location (see earlier sections for requirements and [2] confirm power supply.

These site visits can be combined with site visits for noise sensors.

Mechanical installation is simple (see earlier section).

Registration of the sensor to allow data to be sent to the Telraam platform requires the preparatory, prior to installation:

1. Creation of the Net4Cities Telraam dashboard by Telraam team
2. Creation of a Telraam account by the responsible for each partner city
3. Assign administration rights to these accounts

Once installed on site, the responsible person (with Telraam admin access), scans the QR-code on the sensor and registers the device, using this step-by-step guide: https://telraam.helpspace-docs.io/article/72/step-5-location

Telraam sensors are “install and forget” and do not require any specific operating procedures. Possible issues due to external factors are:

- Loss of power - issues with power supply.
- Loss/limited connectivity – in case of network operator failures.
- Vandalism - it is expected the devices in monitoring stations are not accessible to unauthorized personnel.

Devices auto-recover when power and connectivity are reinstated. Proper operation of the devices can be monitored via the Telraam dashboard. In case of malfunction, contact Telraam team.

Data for the devices can be retrieved via the API following the same protocol as described for the existing sensors (see previous section).

10. Conclusions

This deliverable provides the Net4Cities specific monitoring and implementation roadmaps for air quality, noise and traffic. Important outcomes are:

- The **selection of the sites** to include in Net4Cities for monitoring air quality and/or noise and traffic after consultation with stakeholders.
- **Labeling of sites** (unique) for further (data) communication.
- Consolidated information about the **existing monitoring infrastructure** at the Net4Cities sites and existing monitoring stations in the partner cities.
- Consolidated information on the **advancements of the monitoring infrastructure** in partner cities by Net4Cities.
- Descriptions of the instrumentation and **specifications for the installation requirements for different instruments** to align between the partner cities.
- Descriptions of **operating and QA/QC procedures** for the different instruments to align between the partner cities.
- **Timeline** of the main phases of the monitoring and implementation plans, including the installation and testing, and the operational phase when instruments are fully operational.

The main outcome of this work is a **streamlined approach for air quality, noise and traffic monitoring** at all Net4Cities sites according to the roadmaps.

The deliverable provides a critical reference for the air quality monitoring (WP2) and noise and traffic monitoring (WP3) work of Net4Cities, specifically for the air quality, noise and traffic data collection. The procedures and timings included in this report provide information on how and when the monitoring networks will be installed and operated. If any changes to site information is required prior to installation, this deliverable will be updated accordingly so that a comprehensive overview is available for the project and interested parties. The data collected through the monitoring outlined here are transferred to the Net4Cities data hub (WP4) and will be critical for the outputs shared in the Net4Cities Studio (WP6). On-going discussions with the partner city stakeholders will support a smooth implementation and joint reflection with inform best-practices and lessons learned from the execution of the roadmaps. These will be integrated into general roadmaps that will be provided to stakeholders and the broader community with key milestones and stages for monitoring and implementation to serve as examples in terms of key steps to consider if they are to do a similar implementation.

Acronyms

Table 15. Table of acronyms.

Acronym	Meaning
AAQD	Ambient Air Quality Directive
AFM	Airmodus flow meter
AQMS	Air Quality monitoring station
BC	Black carbon
CH_4	Methane
CRDS	Cavity ring-down Spectroscopy
CO	Carbon monoxide
CO_2	Carbon dioxide
EC	Elemental carbon
GHG	Greenhouse gas
LDSA	Lung-deposited surface area
MAC	Mass Absorption Coefficient
N4C	Net4Cities
NMT	Noise Monitoring Terminal
NH_3	Ammonia
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
O_3	Ozone
OC	Organic carbon
PC	Policy challenges
PM	Particulate matter
PNC	Particle number concentration
SA	Source apportionment
SIC	System Integrity Check
UFP	Ultrafine Particles
QA/QC	Quality Assurance/ Quality Control
SO_2	Sulphur dioxide
VOC	Volatile Organic Compounds

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Annex A

Key elements of the roadmap:

1. **Goals and Objectives**: defining monitoring and prioritization targets aligned with policy needs
2. **Timeline**
3. **Step-by-Step Framework**: guidance for deploying instruments and implementing/expanding monitoring networks
4. **Best Practices**: reflecting the lessons learned from Net4Cities experience
5. **Adaptability Measures**: potential tailoring approaches and aspects to consider for varying city requirements and infrastructure
6. **Performance Metrics**: criteria for evaluating progress and impact
7. **Stakeholder Roles**: responsibilities/roles that need to be defined/established and stakeholders that need to be involved in the process (e.g. local authorities, industries, etc.).

Annex B

For the implementation of the monitoring in the Net4Cities partner cities, the main phases[15] are similar for air quality, noise and traffic: (1) the site and instrument selection phase, (2) the installation and testing phase, (3) the operational or deployment phase, and (4) the post-deployment phase.

The phases that are defined in this deliverable are:

- **Site and instrument selection phase** (= preparation phase)
  - Note that this phase also includes the stakeholder engagement where policy challenges and research questions are defined and resulting in monitoring requirements that will feed into a monitoring plan.
  - The monitoring plan includes site and instrument selection; this also includes site visits to consider practical issues and definition of instrument configuration.
  - This phase also includes the preparation of QA/QC procedures and SOPs.

- **Installation and testing phase**
  - This phase includes the effective installation and testing of the instruments.
  - Effective installation can be ready in a few hours or days but this phase also includes some preparational work prior to installation on site.
  - Testing can include a close follow up of certain instrumental parameters and results to be sure everything is working; it can also include checks related to data transmission.
  - In some cases, the 'testing' part of this phase has no predefined timing and/or can overlap with the deployment phase; the main thing is that a certain time is foreseen between the effective installation and when the instruments are expected to provide correct data.

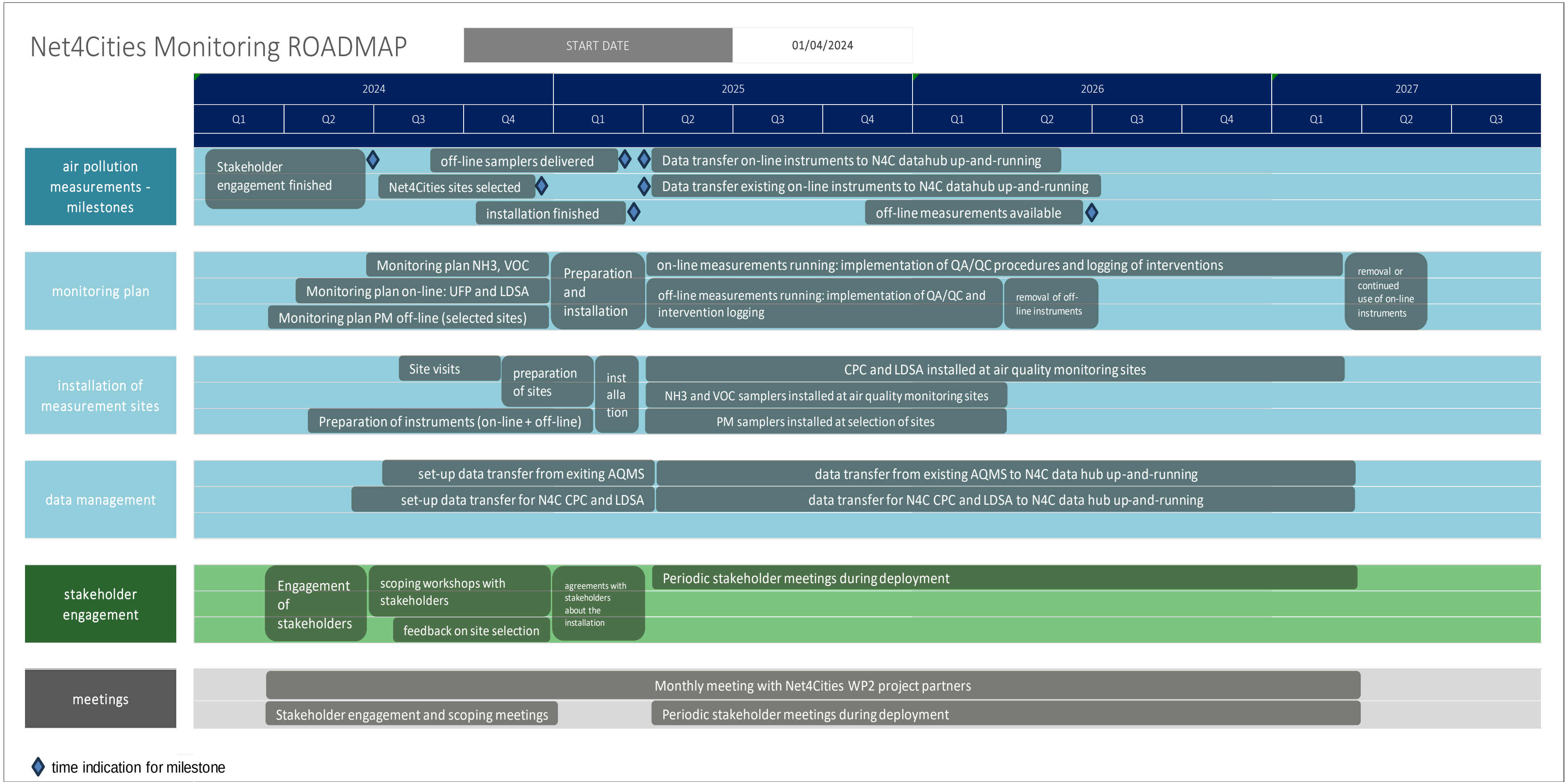
- **Operational phase = Deployment phase**
  - This phase is a major part of the roadmap and includes the data collection that is expected in the project.
  - The deployment phase includes the execution of QA/QC procedures that were defined in the first phase.
  - The deployment phase also includes data management.

- **AfterPost-deployment phase**
  - Depending on the next steps this phase can include:
    - De-installation of all equipment.
    - Continuation of the measurements after the project.

[15] See Annex B for more details of the different phases.

Annex C

Net4Cities air quality monitoring roadmap.



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Annex D

Figure D-1: Existing air quality monitoring stations with (○) and without (○) Net4Cities advancements in Antwerp (BE_ANT_AP1 not shown).

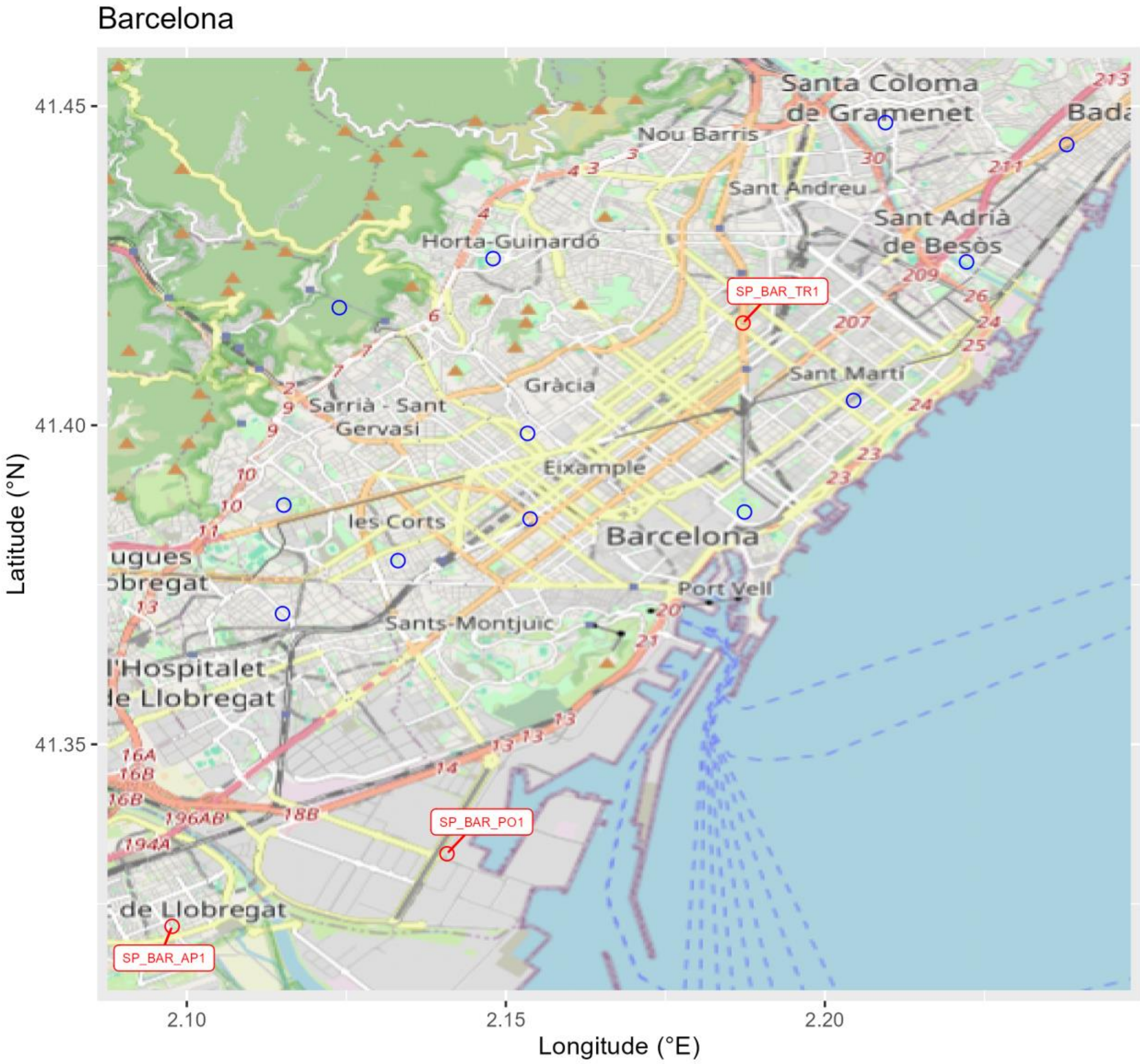

Figure D-2: Existing air quality monitoring stations with (○) and without (○) Net4Cities advancements in Barcelona.

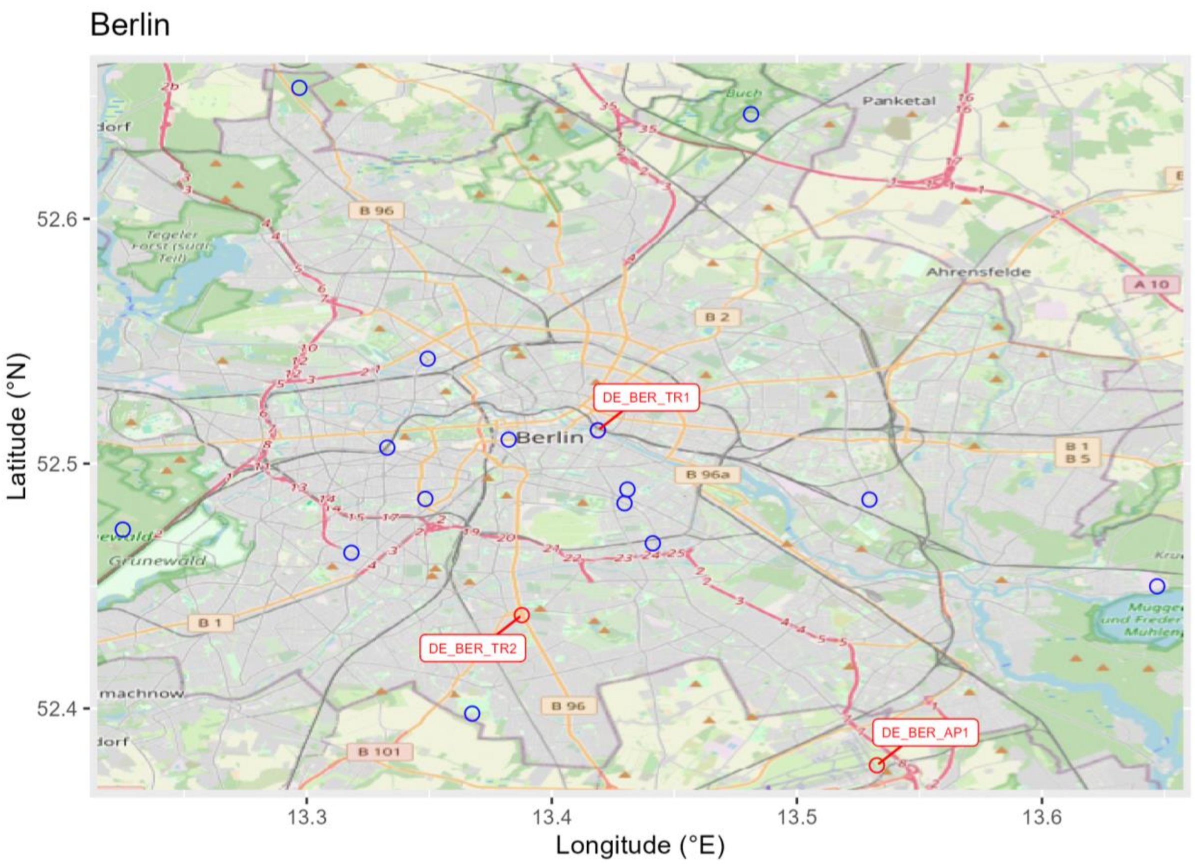

Figure D-3: Existing air quality monitoring stations with (○) and without (○) Net4Cities advancements in Berlin.

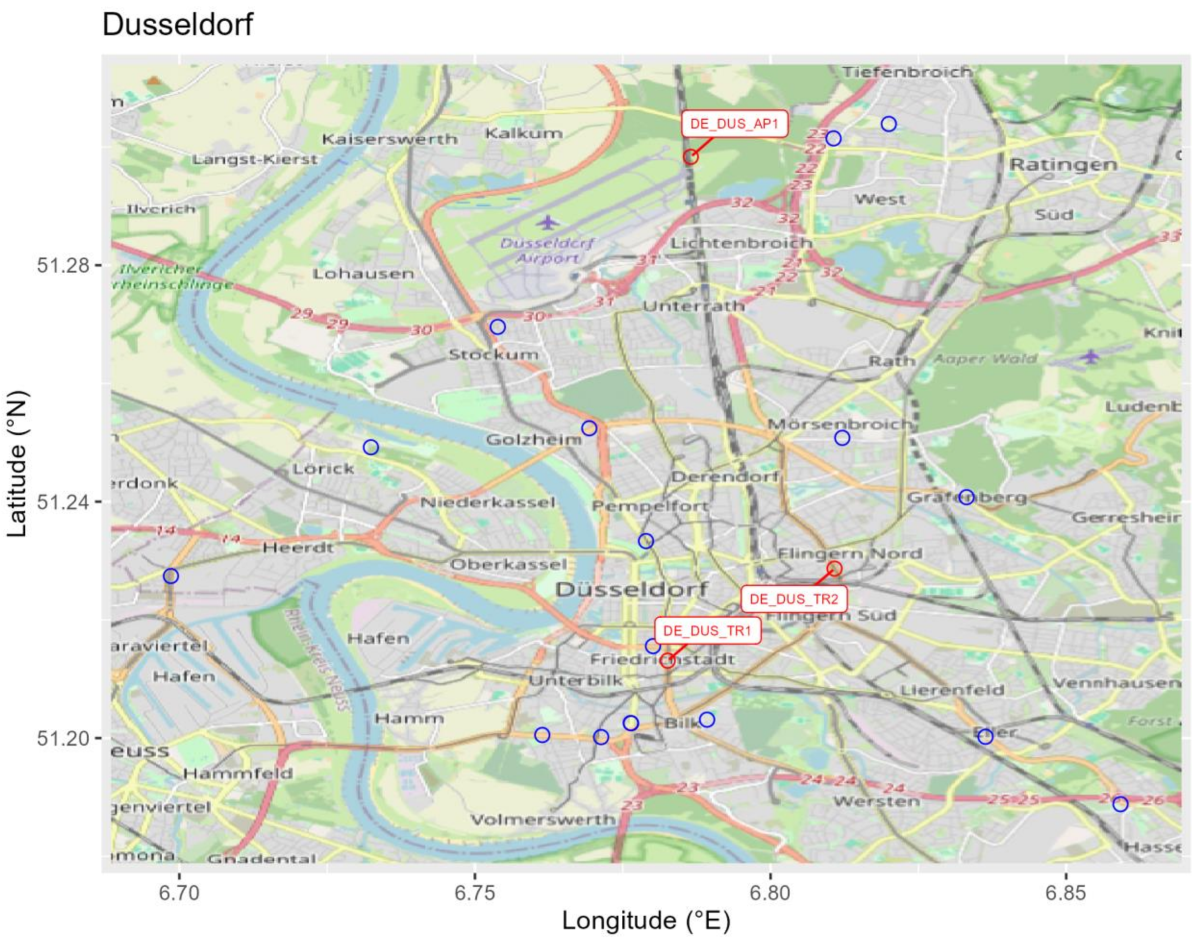

Figure D-4: Existing air quality monitoring stations with (○) and without (○) Net4Cities advancements in Dusseldorf.

Figure D-5: Existing air quality monitoring stations with (○) and without (○) Net4Cities advancements in Heraklion (Regional background site not shown).

Figure D-6: Existing air quality monitoring stations with (○) and without (○) Net4Cities advancements in Limassol.

Figure D-7: Existing air quality monitoring stations with (○) and without (○) Net4Cities advancements in Oslo.

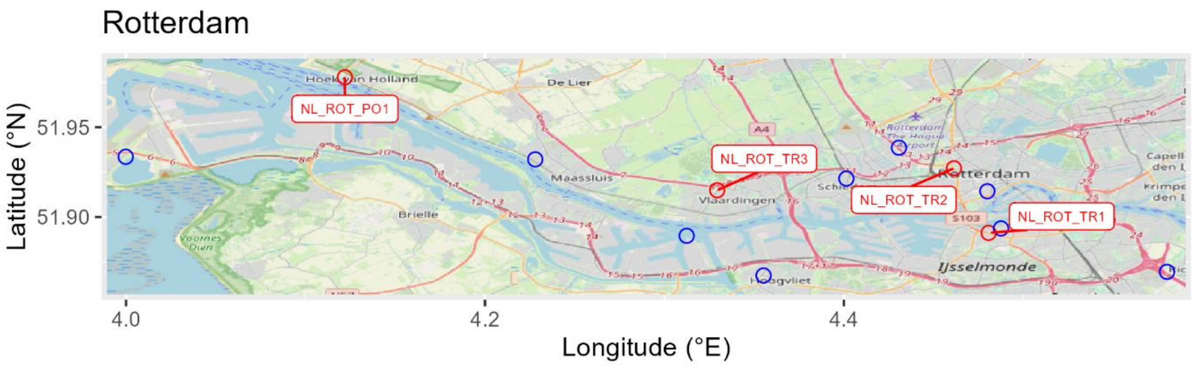

Figure D-8: Existing air quality monitoring stations with (○) and without (○) Net4Cities advancements in Rotterdam.

Figure D-9: Existing air quality monitoring stations with (○) and without (○) Net4Cities advancements in Southampton. At the new stations the Zephyr air quality monitor will be installed to provide air quality data for regulatory pollutants.

Figure D-10: Existing air quality monitoring stations with (○) and without (○) N4C advancements in Tbilisi.

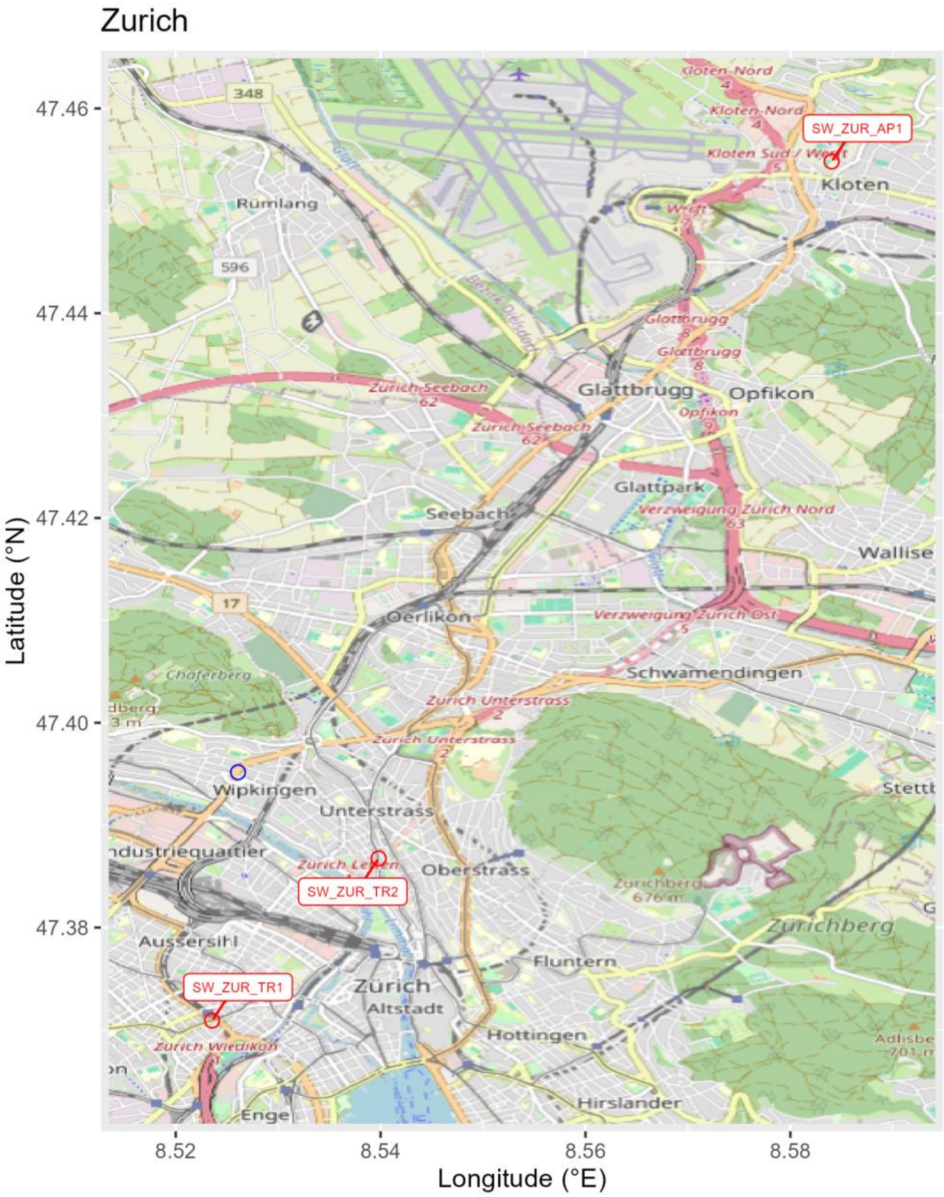

Figure D-11: Existing air quality monitoring stations with (○) and without (○) Net4Cities advancements in Zurich.

Table D-1: Overview of existing infrastructure at the Net4Cities sites.

	Existing instrumentation for air quality								for noise	for traffic
N4C site	SO2	CO	O3	NOx	PM2.5	PM10	BC	PM comp.		
BE_ANT_UB1	NO	NO	YES	YES	YES	YES	YES	NO	NO	NO
BE_ANT_TR1	NO	NO	NO	YES	YES	YES	YES	NO	NO	NO
BE_ANT_PO1	NO	NO	NO	YES	YES	YES	NO	NO	NO	NO
BE_ANT_AP1	NO	NO	NO	YES	YES	YES	YES	NO	NO	NO
BE_ANT_TR2	NO	NO	NO	YES	YES	YES	YES	NO	NO	NO
ES_BAR_TR1								NO	NO	NO
ES_BAR_PO1								NO	NO	NO
ES_BAR_AP1								NO	NO	NO
DE_BER_TR1	NO	YES	YES	YES	YES	YES	YES	NO	NO	NO
DE_BER_TR2	NO	NO	NO	YES	YES	YES	NO	NO	NO	NO
DE_BER_AP1	NO	YES	YES	YES	YES	YES	NO	NO	NO	NO
DE_DUS_TR1	NO	NO	NO	YES	YES	YES	NO	NO	NO	NO
DE_DUS_TR2	NO	NO	NO	YES	NO	YES	NO	NO	NO	NO
DE_DUS_AP1	NO	NO	NO	YES	NO	YES	NO	NO	NO	NO
GR_HER_RB1	NO	YES	YES	YES	YES	YES	YES	NO	NO	NO
GR_HER_TR1	YES	YES	YES	YES	YES	YES	YES	YES	NO	NO
GR_HER_PO1	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CY_LIM_RB1	YES	YES	YES	YES	YES	YES	YES	NO	NO	NO
CY_LIM_TR1	YES	YES	YES	YES			YES	NO	NO	NO
CY_LIM_PO1	YES	YES	YES	YES	YES	YES	YES	YES	NO	NO
NO_OSL_TR1	NO	NO	NO	YES	NO	YES	NO	NO	NO	NO
NO_OSL_TR2	NO	YES	NO	YES	NO	YES	NO	NO	NO	NO
NO_OSL_PO1	NO	NO	NO	YES	NO	YES	NO	NO	NO	NO
NL_ROT_TR1	NO	NO	NO	YES	YES	YES	YES	NO	NO	NO
NL_ROT_TR2	NO	NO	YES	YES	YES	YES	YES	NO	NO	NO
NL_ROT_TR3	NO	NO	YES	YES	YES	YES	NO	NO	NO	NO
NL_ROT_PO1	YES	NO	YES	YES	YES	YES	YES	NO	NO	NO
UK_SOU_PO1	NO	NO	YES*	YES*	NO	NO	NO	NO	NO	NO
UK_SOU_TR1	NO	NO	YES*	YES*	NO	NO	NO	NO	NO	NO
UK_SOU_TR2	NO	NO	YES*	YES*	NO	NO	NO	NO	NO	NO
UK_SOU_TR3	NO	NO	YES*	YES*	NO	NO	NO	NO	NO	NO
GE_TBI_TR1	YES	YES	YES	YES	YES	YES	NO	NO	NO	NO
GE_TBI_TR2	YES	NO	NO	YES	YES	YES	NO	NO	NO	NO
GE_TBI_TR3	YES	YES	YES	YES	YES	YES	NO	NO	NO	NO
CH_ZUR_TR1	YES	YES	YES	YES	YES	YES	NO	NO	NO	NO
CH_ZUR_TR2	YES	YES	YES	YES	YES	YES	NO	NO	NO	NO
CH_ZUR_AP1	NO	NO	NO	YES	YES	YES	YES	NO	NO	NO

* measured with Zephyr system.

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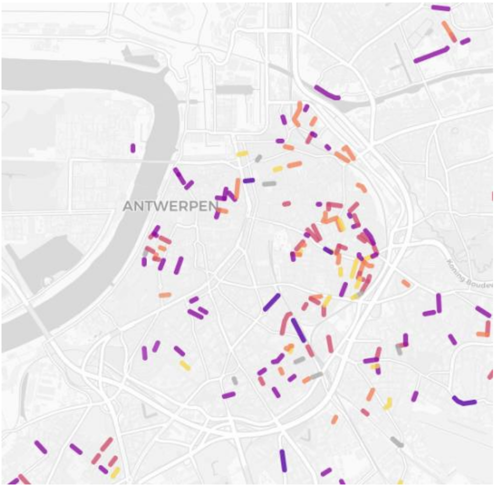
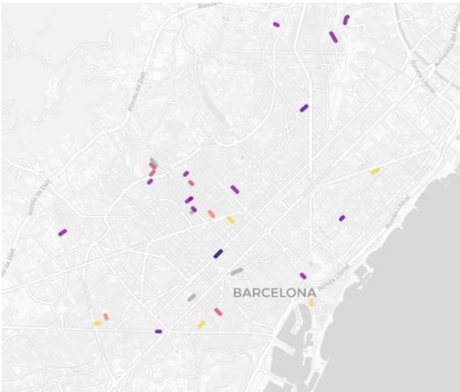
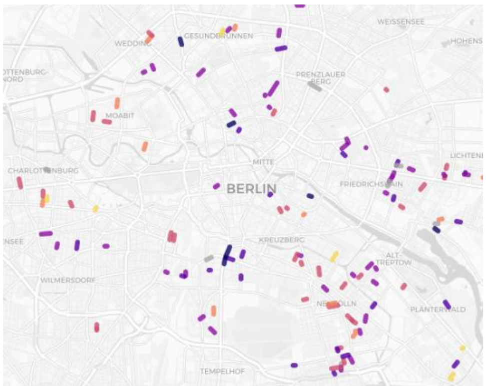
Table D-2: Overview of advancements in air quality monitoring infrastructure at the Net4Cities sites.

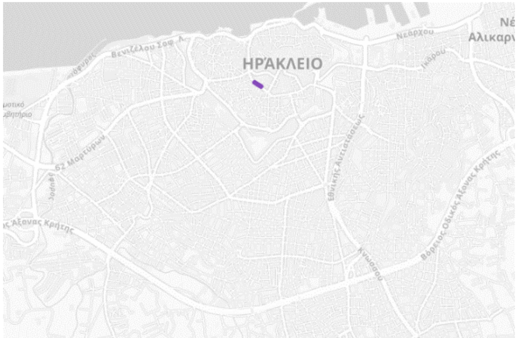
	on-line instruments		off-line instruments		
Unique Name	LDSA	UFP	NH3	VOC	Aerosol Filters
BE_ANT_UB1	YES	YES	YES	NO	NO
BE_ANT_TR1	YES	YES	YES	YES	YES
BE_ANT_PO1	YES	YES	YES	NO	NO
BE_ANT_AP1	?	NO	YES	NO	NO
BE_ANT_TR2	NO	NO	NO	NO	NO
ES_BAR_TR1	YES	YES			
ES_BAR_PO1	YES	YES			
ES_BAR_AP1	YES	YES			
DE_BER_TR1	YES	YES	YES	YES	YES
DE_BER_TR2	YES	YES	YES	NO	NO
DE_BER_AP1	YES	YES	YES	NO	NO
DE_DUS_TR1	YES	YES	YES	YES	YES
DE_DUS_TR2	YES	YES	YES	NO	YES
DE_DUS_AP1	YES	YES	YES	NO	NO
GR_HER_REG	YES	YES	YES	YES	YES
GR_HER_TR1	YES	YES	YES	YES	YES
GR_HER_PO1	YES	YES	NO	NO	NO
CY_LIM_RB1	YES	YES	YES	NO	YES
CY_LIM_TR1	YES	YES	YES	YES	YES
CY_LIM_PO1	YES	YES	YES	NO	NO
NO_OSL_TR1	YES	YES	YES	YES	
NO_OSL_TR2	YES	YES	YES	NO	
NO_OSL_PO1	YES	YES	YES	NO	
NL_ROT_TR1	YES	YES	YES	YES	NO
NL_ROT_TR2	YES	YES	YES	YES	NO
NL_ROT_TR3	NO	NO	NO	NO	NO
NL_ROT_PO1	YES	YES	YES	YES	NO
UK_SOU_NR1	NO	NO	NO	NO	NO
UK_SOU_NR2	NO	NO	NO	NO	NO
UK_SOU_LR1	NO	NO	NO	NO	NO
UK_SOU_LR2	NO	NO	NO	NO	NO
UK_SOU_PO1	YES	YES	NO	NO	NO
UK_SOU_TR1	NO	NO	NO	NO	NO
UK_SOU_TR2	NO	NO	NO	NO	NO
UK_SOU_TR3	NO	NO	NO	NO	NO
GE_TBI_TR1	YES	YES	YES	YES/TBD	YES/TBD
GE_TBI_TR2	YES	YES	YES	YES/TBD	YES/TBD
GE_TBI_TR3	YES	YES	YES	YES/TBD	YES/TBD
CH_ZUR_TR1	YES	YES	NO	NO	NO
CH_ZUR_TR2	YES	YES	NO	NO	NO
CH_ZUR_AP1	YES	YES	NO	NO	NO

Note: the advancements of air quality in Southampton with the on- and off-line instruments in Southampton is limited to one UFP and LDSA monitor at the port site. At other sites, the Zephyr air quality monitor will be installed. This is a unique situation for Southampton compared to the other cities.

Annex E

Table E-1: Overview of existing Telraam traffic monitoring networks at the partner cities.

City	Estimated # sensors	Comments
Antwerp	Historical: +/- 100 Live: +/- 30	Various Telraam sensors of the previous generation active form various previous projects; most sensors currently offline 
Barcelona	Historical: +/- 30 Live: +/- 3	Sensors of the old generation, in context of WeCount project (www.wecount.net) 
Berlin	Historical: +/- 150 Live: +/- 100	Actively maintained Telraam network, by local NGO (ADFC) 

Düsseldorf	1	Single test device from a private user 
Heraklion	1	Single test device from a private user 
Limassol	0	/
Oslo	Historical: 5 Live: 0	Part of a small pilot project run by NILU 
Rotterdam	Historical: 3 Live: 0	Several test devices from a private user (all offline)

		
Southhampton	0	/
Tiblisi	0	/
Zurich	Historical: 5 Live: 2	Trial projects ongoing with the city (outside of scope of Net4Cities). Possible more sensors will be added in the course of the project.