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THIS DELIVERABLE HAS NOT YET BEEN APPROVED BY THE EC

Deliverable due date: M36 – November 2019

D4.14 Monitoring system of the effect of the electric fleet to district-level air quality, noise

WP4, Task 4.7 (Subtask 4.7.1)

Transition of EU cities towards a new concept of Smart Life and Economy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Project Acronym	mySMARTLife	
Project Title	**Transition of EU cities towards a new concept of Smart Life and Economy**	
Project Duration	1st December 2016 – 30th November 2021 (60 Months)	
Deliverable	D4.14 Monitoring system of the effect of the electric fleet to district-level air quality, noise	
Diss. Level	PU	
Status		Working
		Verified by other WPs
	■	Final version
Due date	30.11.2019	
Work Package	WP4	
Lead beneficiary	FVH	
Contributing beneficiary(ies)		
Task description	**Task 4.7: Sustainable Mobility and Electrical Mobility - SMART MOBILITY [VTT] (FVH, HEL, HEN, HMU, SAL, CAR)** With the large up-take of electric buses, the road-based mobility system in Helsinki becomes electric. Both the uptake and the monitoring of the charging infrastructures for this fleet, as well as demonstrations with all-electric fleet, are taken. **Subtask 4.7.1: Monitoring solutions (EV and charging point).** All results from EV and charging stations will be defined, deployed and monitored. VTT will define how all these data will be integrated, to measure the effect of the electric fleet to district-level air quality and noise. VTT will implement sensoring features into the EV fleet and chargers. FVH will place the data to the Urban Platform (Action 47) and subcontract required connectivity. VTT will implement EV and charging related analyses for the data. Definition, deployment and monitoring of the EV and recharging points. Investigation on the effect of the electric fleet to district-level air quality and noise. All results from EV and charging stations will be integrated, to measure the effect of the electric fleet to district-level air quality and noise.	

Date	Version	Author	Comment
17/10/2018	0.1	Timo Ruohomäki (FVH)	First draft
31/10/2018	0.2	Timo Ruohomäki (FVH)	Ready for review
21/11/2018	1.0	Timo Ruohomäki (FVH)	Final version ready for submission
21/10/2019	1.1	Timo Ruohomäki (FVH)	First draft of M36 final version
27/11/2019	1.2	Timo Ruohomäki (FVH)	Corrections after peer review

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Abbreviations and Acronyms

Acronym	Description
mySMARTLife	Transition of EU cities towards a new concept of Smart Life and Economy
OCPP	Open Charge Point Protocol
EV	Electric Vehicle

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1. Executive Summary

This deliverable provides an overview on past and future activities related to the monitoring system of EV and recharging points. Activities in the Helsinki pilot mostly focus on a single shared charging point that is currently being deployed in Hakaniemi.

As addition to the data collection from the charger, methods to monitor the impact of electrical vehicles in traffic flow have been studied and trials of data collection made. Some additional data requirements were identified since the current traffic counting systems were inadequate for the purpose. Co-operation with Helsinki Region Environmental Services (HSY) allowed the project to utilize the high-grade air quality monitoring system in Mäkelänkatu for the purpose. An environmental noise sensor was installed on the same site to allow the project to look for a correlation between emissions and noise.

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2. Introduction

2.1 Purpose and target group

This document intends to provide an overview of completed actions related to deliverable D4.14.

2.2 Contributions of partners

The following table depicts the main contributions from participant partners in the development of this deliverable.

Table 1: Contribution of partners

Participant short name	Contributions
FVH	Main author
VTT	Comments and suggestions on content
HEL	Peer review
CAR	Final review and comments

2.3 Relation to other activities in the project

The following table depicts the main relationship of this deliverable to other activities (or deliverables) developed within the mySMARTLife project and that should be considered along with this document for further understanding of its contents.

Table 2: Relation to other activities in the project

Deliverable Number	Contributions
D4.17	This deliverable builds on top of the actual charger deployment that is described in the deliverable D4.17
D4.11	The urban platform for IoT sensor data is utilized to collect observations.
D4.13	The open APIs of D4.13 are utilized by this action

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3. Introduction

In mySMARTLife, there are various indicators that are expected to be based on live data. For the development of the urban platform, this is a great opportunity to look at the entire data flow from sensors to the data visualization. In this particular deliverable there are no dashboards or public displays of data as part of the deliverable, but the technical concepts described here are generic and mostly shared with other tasks, e.g. D4.11 *Lighthouse-specific IoT service, backend and sensing systems in use* and D4.13 *Open data and open APIs to the building-level energy savings potential*. This deliverable then focuses on the connection to server, server systems and other measuring devices.

This deliverable intends to provide the city of Helsinki capabilities to monitor the environmental impact of traffic in real-time. The work has been done in co-operation with other monitoring projects, mostly focused on air quality such as the Helsinki Air Quality Testbed. The actions are naturally focusing on limited areas because of the resources available, but the concepts are created in a way that makes them easy to replicate and scale up. The quality of data has been another key requirement when planning the activities. While in general the citizen science is seen as a vital method in increasing co-creation and participation, the indicators related to this deliverable will require reliable data and measurements that can be repeated. This has led us to not only look for data models to improve semantic interoperability but also to find ways to describe the quality of data, sensor calibration details and sensor metadata in general. Outside the scope of this project, those methods can be extended to the citizen science initiatives, building the bridge between “professional” and “amateur” observations and empowering the citizens to participate in air quality monitoring.

The technical approach taken in this deliverable follows the same approach in other platform initiatives, being distributed and decoupled. To make the code contributions re-usable, functions are being deployed as micro-services whenever appropriate. To maintain the level of innovativeness, new technologies and concepts are tested in the process of setting up the sensing system when possible. To improve semantic interoperability, international standards, with the emphasis on standards from the W3C, ISO and IEC are followed and implemented. The ISO TC211 –framework provides relevant although not mandatory practises for not only defining geometries but also handling the sensors and their observations. While the use cases on this deliverable may not be directly inherited from the requirements of the INSPIRE –directive, it is in general a good practise to create and process data streams in a way that the spatial awareness is maintained. The traffic data has a link to the ISO TC211 –requirements through the Noise ADE –extension of CityGML that is used to provide environmental noise simulations based on the traffic system of the city. It is expected that such work is going to be done in parallel to this project in Helsinki and the capabilities built as part of the project will support such future initiatives as well.

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4. Shared Charging Point

The shared charging point is a key initiative in the electrification of city logistics as part of the mySMARTLife project. Expected indicators and data sets related to the vehicle charging events have been defined (see deliverable D4.17 for details). Because of the common data model in the project is based on ISO 80000 –ontologies, new indicators and observed properties can be added later on and the data model is not fixed to any pre-defined schema. While the Open Charging Point Protocol (OCPP) defines most of the expected properties, some additions may be required.

In the mySMARTLife Urban Platform concept most sensor properties are originally data points on a proprietary API. As an example, an energy meter may have a M-bus or Modbus –connection and the Modbus data points are made available on specific API, that exposes the tags and values. A connector in the Urban Platform will then select the required data points and generate a SensorThings data stream, embedding the missing metadata and location information. After this approach, the data stream can be utilized from northbound SensorThings API as a result of common or spatial search queries. In the future such observations can also be made available on the WFS API of Geoserver for related city object.

The following figure illustrates the SensorThings API data model:

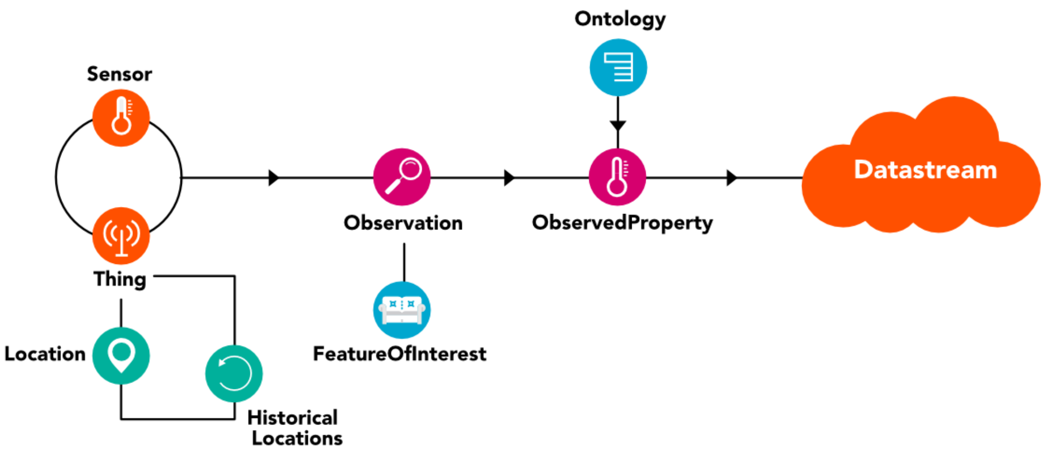

Figure 1: SensorThings API

In this model, the Thing-object would contain the metadata and location of the charging point and the Sensor-objects would each provide specific properties. Observations would mostly contain the timestamp of the moment when observation was made. The ObservedProperty would define the observation using linked data approach. In case of Helsinki, the definition would refer to the related concept in UCUM –service at the Finnish National Ontology FINTO. The UCUM –ontology is practically the same than ISO

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80000, but because of copyright restrictions the ISO 80000-contents cannot be published directly. Both the ISO and IEC have declined to provide the project such a license.

Other usages for ontologies are currently evaluated. As an example, structuring the CityKEYS as a hierarchical ontology might become useful when in the future project indicators are to be calculated automatically.

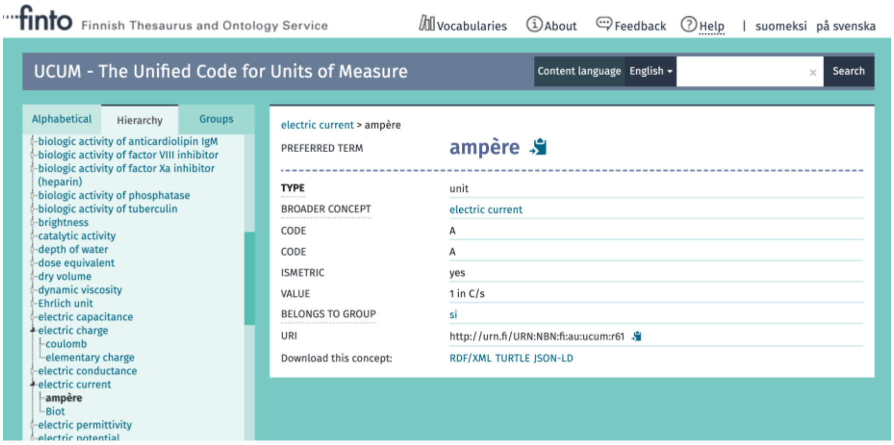

Figure 2: Definition of unit ampére in FINTO

5. Sensor Measurements

5.1 Mäkelänkatu Measuring Station

The Mäkelänkatu Measuring Station is a permanent operation managed by mySMARTLife partner HSY. The station monitors the environmental impact of traffic with various methods and high-grade, calibrated instruments. The station is located by one of the major streets, thus providing an opportunity to monitor traffic in higher volumes and various methods. The station is installed into two cargo containers, providing mounting places and power to new sensors with small effort and no additional permits. Some of the sensors may end up collecting personal data based on the new GDPR definition and because of that terms and conditions are displayed on the wall of the station.

5.2 Environmental Noise

Environmental noise is one of the major impacts of traffic and also one of the impacts where Electrical Vehicles are expected to cause major improvement. As part of the mySMARTLife –project, ten low power measuring stations are installed permanently around the city to collect readings on different types of locations. For Helsinki this is a major step and new innovation, since noise emissions have not yet been

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measured constantly. The new information will also help the city to adjust the noise simulations that have multiple uses from transportation to land use planning.

The noise sensors were purchased in late 2017 in order to be thoroughly tested. Getting installation permits has been more challenging than expected, but the locations mostly confirmed and the last sensors will be installed in early 2019 to be ready before the actual monitoring phase of the project will start in 1.1.2020. The first noise monitoring station was installed in Korkeasaari Zoo in January 2018 and has operated without interruptions or technical problems ever since. The location has a little traffic so it will act as a reference point on measurements.

The following picture illustrates the noise measurement instrument installed in Mäkelänkatu measuring station:

Figure 3: Noise Sensor in Mäkelänkatu

The environmental noise measurement has provided new, detailed information on traffic patterns that can be used when analyzing other types of observations made on the same location to identify the correlation between traffic and the emissions. The observations are collected with 1 Hertz frequency for future analytical purposes.

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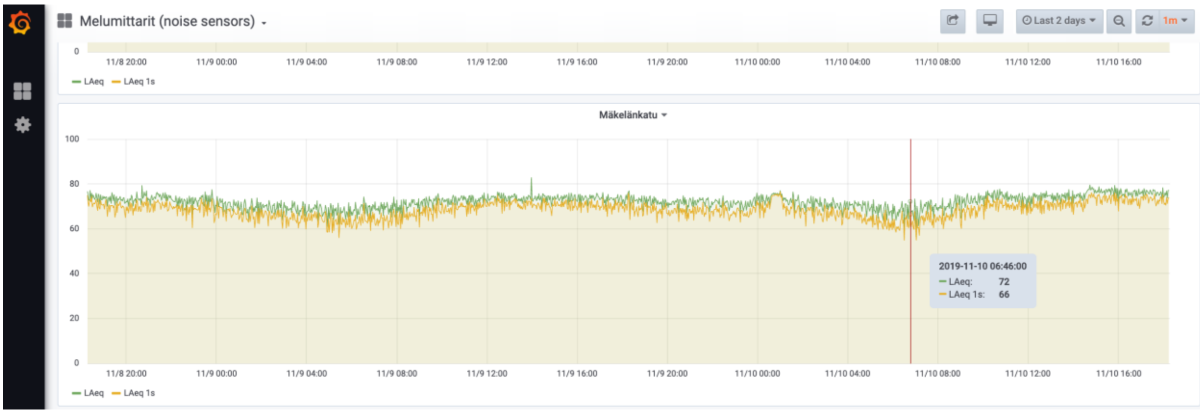

Figure 4: Noise Emissions in Mäkelänkatu

5.3 Sporametri Moving Sensor

Some of the observations required in monitoring the environmental impact of specific types of traffic are very local. The airborne particles are only observed on permanent stations, but some emission gases like NO,NO_2 may have very specific locations and it is not known how as an example the buildings by the streets have an impact on the levels of measured gases. Because of this, one of the sensing pilots in mySMARTLife is made with moving sensors with the goal to provide a heat map of the density of most common traffic-related gas emissions. For research purposes such data set is also interesting because it can be used to improve the analysis of pollution models since it can provide additional information to the earlier observations made on few permanent stations off the streets.

Such measurements are technically challenging. The sensor device must be capable of making observations frequently so that fast moving sensor base keeps the grid of observations small enough. When the data has raised interest among the researchers, the quality of sensor and data must be high enough to meet the expectations, together with a correct process of calibration and comparison between other sensors. When looking for a moving object that would allow the sensors being installed at about 4,0 meters from the street level and moving frequently on the busiest streets, the platform was chosen to be the tram system operated by the city of Helsinki public transport department HKL.

Based on these requirements, a request for tender was submitted to three professional companies providing sensor equipment and related services. The only company that responded and met the specific technical requirements was the Finnish company Aeromon Ltd. They have provided sensing services using drones to observe SOx emissions of shipping industry and methane emissions from landfills.

The operational lifetime of the selected gas sensors is expected to be about two months. The actual pilot begun with a two-week calibration phase when all the sensors are mounted on the Mäkelänkatu Measuring Station. Their observed values are compared with each other and also with other sensing devices at the station. When the performance and calibration factors are identified, the sensors will be

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mounted on trams where they operate full time for about two months. The last phase in the process is re-calibration at the station where for two weeks the sensors again are compared with others to see any signs of degradation of sensitivity.

Figure 5: Aeromon Sensor on Sporametri

The measurement run started in late 2018 and continued until June 2019. A second run will be made later in the monitoring phase to identify changes over time. The datasets will also be cleaned and published for future research use.

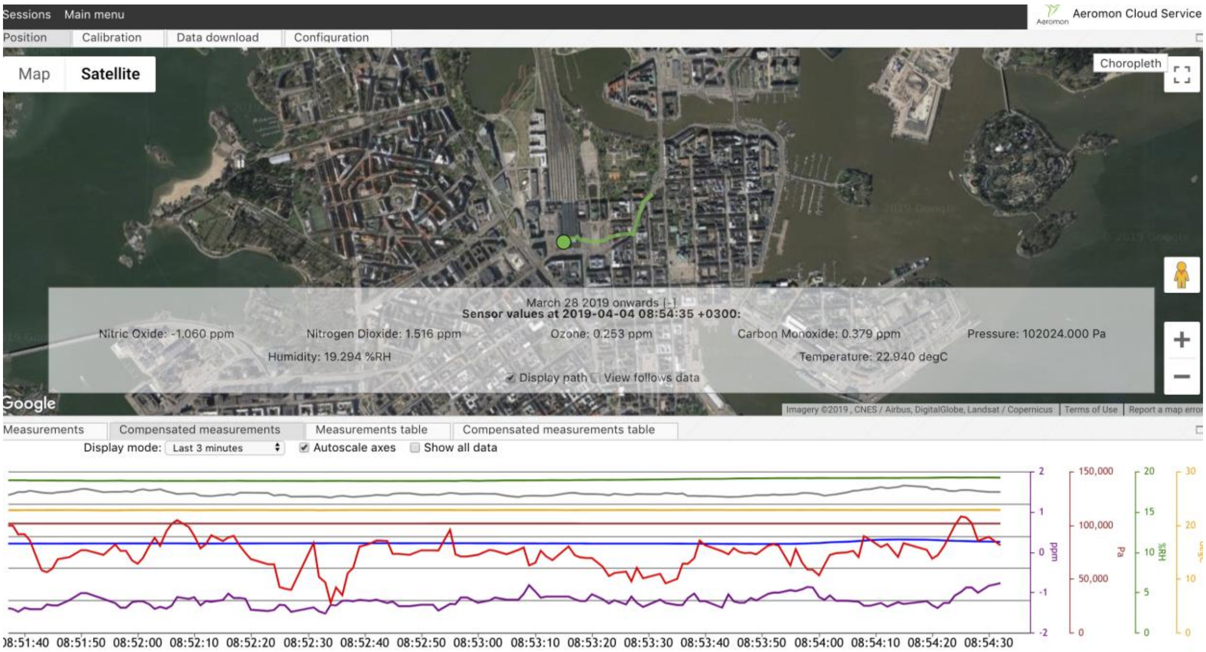

Figure 6: Sporametri Live Data Dashboard

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5.4 Traffic Counting and Classification

The new sensing systems together with existing sensors at the Mäkelänkatu station provide an extensive combination of observations to measure the environmental effect of traffic and to identify any trends that can be identified during the last phase of the project. In Helsinki there is currently only limited information available on the volumes and categories of traffic. Naturally there is a strong correlation between traffic volumes and the traffic-related emissions. Because of this, an additional pilot is going to be made as part of mySMARTLife to count and analyse traffic using a specific edge software running on a surveillance camera.

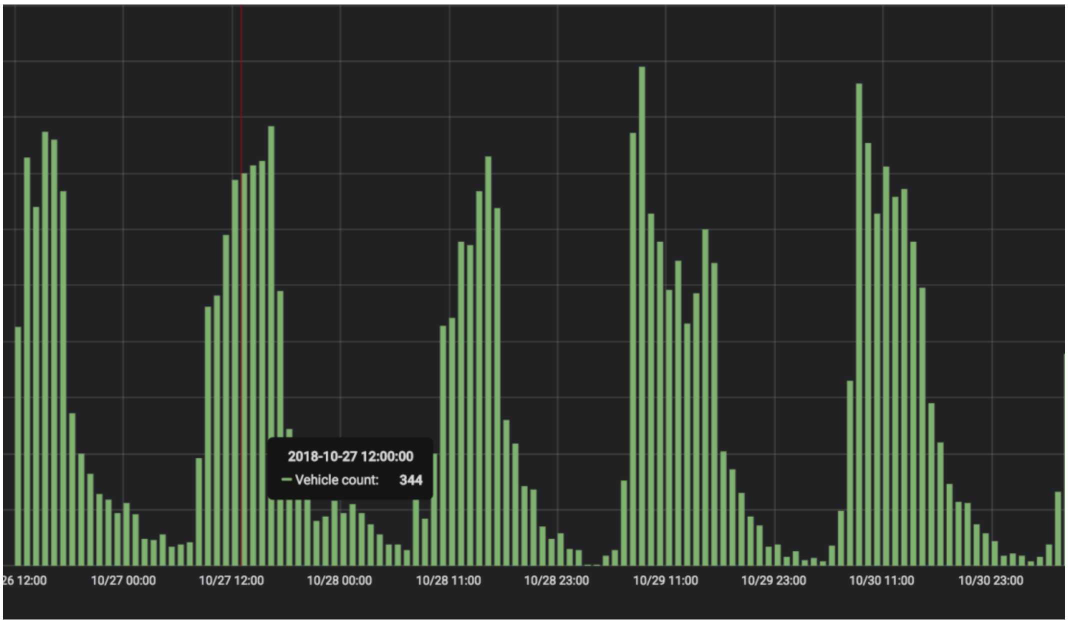

Figure 7: Live Vehicle Counting in Mäkelänkatu

5.5 Protocols and Data Models

The project has decided to utilize data models with proper spatial capabilities throughout the project. The primary protocol and data model for inbound data streams is the SensorThings API from Open Geospatial Consortium, OGC. As addition of being versatile and compact, the protocol implements all the relevant ISO TC211 -standards on both spatial and measurement related topics. This will make it easier for the whole data infrastructure to be able to provide data for INSPIRE –services. The data sets will be created on TimeseriesML –format and stored automatically with relevant metadata to the CKAN system.

Both the environmental monitoring and traffic counting pilots involve legacy data standards that are widely used and must be taken into account. In environmental monitoring the sensors have limited, often-proprietary protocols supported. While some open options such as Ultralight 2.0 may be available, those might not support all the elements the vendor's own protocol does. Therefore, protocol conversion in the

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Urban Platform is mandatory and at that point the data can be complemented if vital attributes such as location information or sensor metadata is missing.

As addition to protocol conversion, the sensor data stream may require also mathematical correction. Some environmental sensor values need to be corrected on the cross-effect of observed properties. In mySMARTLife, this is mostly out of the scope since we are using data streams that are already prepared and corrected on other platforms.

The following figure illustrates the planned Urban Platform concept to manage the data stream in a microservice:

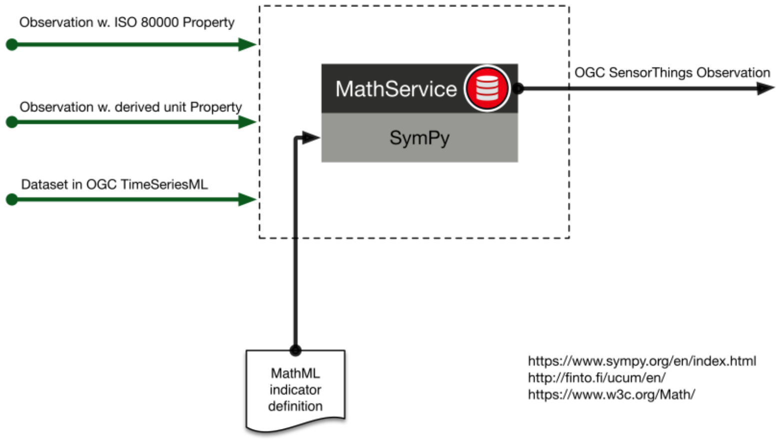

Figure 8: Sensor Datastream Preparation

A micro-service will be created for each purpose being able to both convert the protocol and to add possible mathematical correction functions into it. In order to make the service generic, the correction function is defined in the form of MathML, which is a W3C standard for defining mathematical functions as both visual representation and functionally. In general, the figure above also illustrates the method to provide live indicators that are calculated from sensor values and/or CKAN datasets. The MathML or similar function would define how the indicator is calculated. The linked data approach will be studied later on since it might be useful to have the CityKEYS indicators also as an ontology with definitions and formulas.

The MathML function can also provide more complex data aggregation function. As an example, to get the daily Sound Exposure value for noise $L_{Aeq(7-22)}$ (A-weighted noise level, equalised, observed from 7:00 to 22:00) according to IEC 801-21-23, a time integral function needs to be applied on the data stream on daily basis. The function to get the daily value is the following (Bernard 1992):

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$$L_{Aeq} = 10\log\left(\frac{1}{T}\int_0^T \frac{p^2(t)}{p_0^2}\,dt\right)$$

The approach to use Python mathematical libraries to define more complex data processing needs makes the Urban Platform more capable and flexible on handling sensor data without the need to hard code every use case on the platform.

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6. Conclusions

At the moment, the conclusions of the previous work are limited since the final stage of being able to connect to the charging station and monitor actual charging events has not yet been possible. However, it is expected that no major issues other than typical connectivity and interoperability adjustments will be needed. This deliverable is not related to private car chargers. The City of Hamburg has completed the first version of service that is capable of monitoring the chargers using the standard OCPP -protocol. In Helsinki, the charger infrastructure is managed by a few commercial operators, so being able to monitor the stations would require an access to their services and there may be commercial reasons to not grant it. This is to be seen.

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7. References

Bernard, P. (1992). *L_{eq},SEL,WHAT?,WHY?,WHEN?*, Brüel&Kjaer Application Notes. Online https://www.bksv.com/media/doc/bo0051.pdf

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