SCOREwater

Smart City Observatories implement REsilient Water Management

DELIVERABLE D3.3

INTEGRATION AND CONNECTION OF SENSORS AND ALGORITHMS TO THE SCOREWATER PLATFORM INCLUDING PROCESSING, STORAGE AND TRANSFORMATION OF DATA TO OPEN API'S

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REVISION HISTORY

Version	Reason for changes	Name	Date
1	Original release to EU	Bas Vanmeulebrouk	2020-11-07
2	Minor modifications following the review comments in PR1 (Feb 2021). Minor changes, including update on results from the extended time of delivery.	Bas Vanmeulebrouk	2021-08-30
3	Addressing the comments of the external reviewer following the review meeting 23 June 2022. The following has been updated: • Updated references to new Smart Data Model Github repository (FIWARE references) • Fixed broken links to data portals of Barcelona (section 2.2) and Gothenburg (section 2.3) • Section 2.2, updated to explain when lab data will be added to the platform • Section 2.2.1, updated to discuss COD and flow properties in WaterQualityObserved data model • Section 2.2.1, updated to clarify the situation, and rephrasing previous statement "still on-going" • Section 2.3.1, updated to explain what was done to harmonize cumulative values • Section 2.3.2, updated to explain what input (which has been provided by now) was needed	Bas Vanmeulebrouk	2022-07-07

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ABBREVIATIONS

Abbreviation	Definition
API	Application Programming Interface
CKAN	Comprehensive Kerbal Archive Network
COD	Chemical Oxygen Demand
ETL	Extract, Transform, Load
FIWARE	Future Internet WARE
FTP	File Transfer Protocol
JSON	JavaScript Object Notation
ICT	Information and Communications Technology
IoT	Internet of Things
MQTT	Message Queuing Telemetry Transport
NGSI	Next Generation Service Interface
OCI	Open Container Initiative
REST	Representational state transfer
SDG	Sustainable Development Goals
SME	Small and Medium-sized Enterprise
TSS	Total Suspended Solids
VWC	Volumetric Water Content

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PROJECT ABSTRACT

SCOREwater focuses on enhancing the resilience of cities against climate change and urbanization by enabling a water smart society that fulfils SDGs 3, 6, 11, 12 and 13 and secures future ecosystem services. We introduce digital services to improve management of wastewater, stormwater and flooding events. These services are provided by an adaptive digital platform, developed and verified by relevant stakeholders (communities, municipalities, businesses, and civil society) in iterative collaboration with developers, thus tailoring to stakeholders' needs. Existing technical platforms and services (e.g. FIWARE, CKAN) are extended to the water domain by integrating relevant standards, ontologies and vocabularies, and provide an interoperable open-source platform for smart water management. Emerging digital technologies such as IoT, Artificial Intelligence, and Big Data is used to provide accurate real-time predictions and refined information.

We implement three large-scale, cross-cutting innovation demonstrators and enable transfer and upscale by providing harmonized data and services. We initiate a new domain "sewage sociology" mining biomarkers of community-wide lifestyle habits from sewage. We develop new water monitoring techniques and data-adaptive storm water treatment and apply to water resource protection and legal compliance for construction projects. We enhance resilience against flooding by sensing and hydrological modelling coupled to urban water engineering. We will identify best practices for developing and using the digital services, thus addressing water stakeholders beyond the project partners. The project will also develop technologies to increase public engagement in water management.

Moreover, SCOREwater will deliver an innovation ecosystem driven by the financial savings in both maintenance and operation of water systems that are offered using the SCOREwater digital services, providing new business opportunities for water and ICT SMEs.

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EXECUTIVE SUMMARY

This deliverable builds upon the information provided in D3.1 and D3.2. This document describes the progress on the connection and integration of sensors in the three cities (Amersfoort, Barcelona and Gothenburg). In each city sensors have been connected to the SCOREwater Platform.

Connectors have been developed to collect, store and provide the data from these sensors in the SCOREwater Platform. Connecting data sources is also an ongoing process. Until now the focus was on getting all components of the platform up and running and test the whole flow from the origin of the data (sensor) to the provisioning of the API. The coming period will focus on finetuning, extending and documenting all the different steps.

The ingestion of data in the Platform uses the FIWARE-principles and architecture (software, data models and API´s). The sensor data is transformed to match (FIWARE) data models and standard APIs. These APIs will be listed in the market place with different plans and policies (subscription models and security and privacy measures).

Each city has their own instance of the platform, which will be available only for the participants in the SCOREwater project at this moment. Their feedback and test results will be used to further improve the connections to real time sensors and the ingestion of data into the SCOREwater platform. In the next phase the Platform will be made available for external parties too.

Examples of the implementation progress are described in this deliverable.

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1. INTRODUCTION

This deliverable is about the integration and connection of sensors and algorithms to the SCOREwater Platform. It includes the processing, storage and transformation of data to Open API's.

This demonstrator is an important part of the development of the SCOREwater Platform, since it focuses on the harmonization and provisioning of heterogeneous data sources. This process is a prerequisite for creating algorithms, applications and new solutions.

Paragraph 1.1 describes some generic characteristics of the SCOREwater Platform. More details can be found in Deliverable 3.1 and 3.2. Paragraph 1.2 describes the implementation in the three cities and the connections/integrations that are currently available.

1.1. SCOREWATER PLATFORM

The SCOREwater Platform is based on the FIWARE-architecture. It uses open-source software components from the FIWARE catalogue, and follows the open data models and open API's. These three aspects (software, data models and API's) are strongly related.

To harmonize and standardize data sources, the following steps are needed:

1. Ingest (bring data into the SCOREwater platform)
2. Process (store the data in a time series/spatial database, with index and metadata)
3. Deliver (create API's to provide access to the metadata and data and deliver the API's to end users)

These three steps are shown in the scheme below.

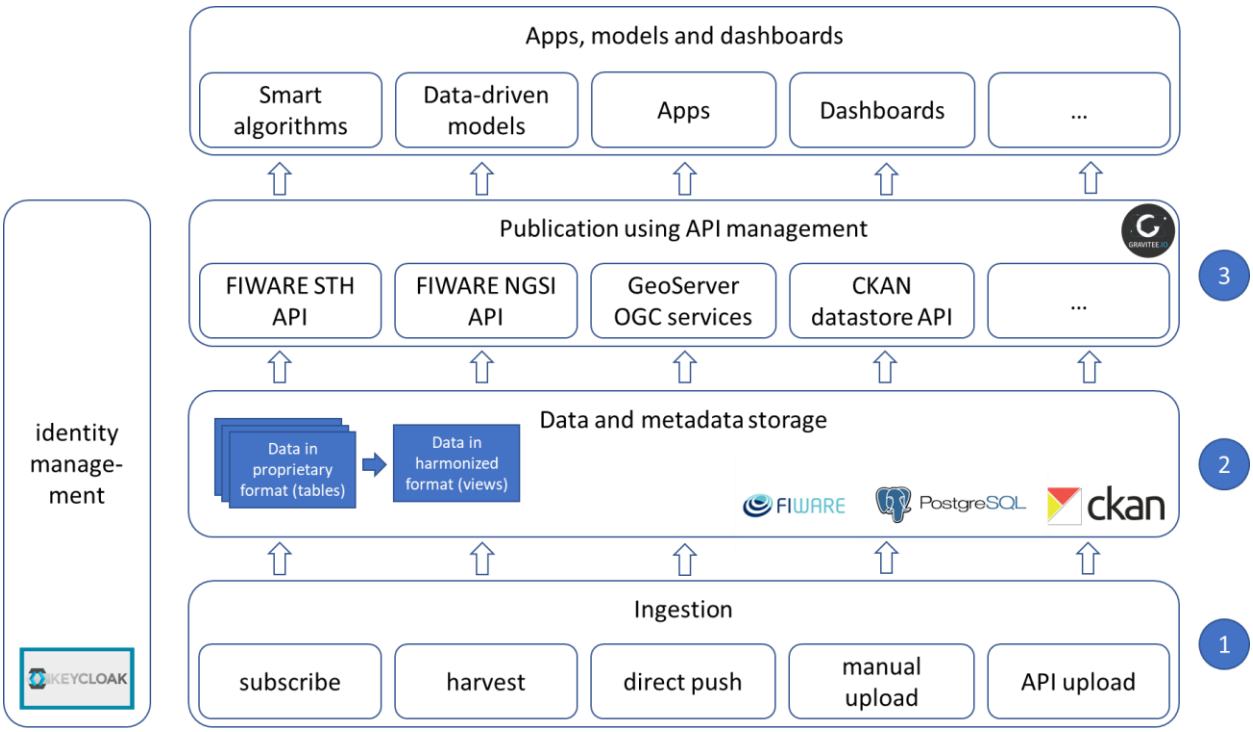

Figure 1. The SCOREwater Platform with generic process to ingest, process, deliver and publish data.

For the ingestion of data into the SCOREwater Platform the following methods are used:

1. Subscriptions
    a. 3rd party context brokers
    b. Queues (a. o. MQTT)

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2. Direct push to the platform by IoT agents
    a. REST services to post proprietary data to the SCOREwater platform
    b. FTP
    c. AWS S3 buckets
3. Periodically harvest 3rd party metadata (if linking to data at the source is feasible)
4. Periodically harvest 3rd party data sets (if linking to data at the source is not feasible)
5. Upload via API or manual upload

Ingested data is stored in the platform. The data is stored in proprietary format and selected in harmonized views. This allows us to modify the harmonization without modifying the raw data.

2. PROGRESS IN CITIES

This chapter focuses on the progress of the integration of data sources and sensor deployments in the three cities.

The generic process for all cities is that sensor data (with a proprietary format) is stored within the SCOREwater Platform. A harmonized view is created and the data is published to the FIWARE Context Broker (alerts) and to API's (Open API, CKAN data store API, GeoServer OGC API's) to make them available for use in data driven models. Additional security measures are added to prevent unauthorized access.

Some information is not being uploaded to the SCOREwater platform to prevent unauthorized access to sensitive data or insight in specific sensor locations (e.g. sensor locations in Barcelona).

2.1. AMERSFOORT

To publish data, Amersfoort uses its CKAN based open data platform (amersfoort.dataplatform.nl) for SCOREwater purposes as well. The SCOREwater datasets in this open data platform are marked with a separate tag. Table 1 lists the data sources connected for Amersfoort within the frame of the project. Other data sources listed in the grant agreement are available in the Amersfoort open data portal.

Table 1 Amersfoort data sources in the SCOREwater platform

Amersfoort data sources		
Teneo Soil Moisture sensor	Meteorological data	Available
	Soil moisture data	Available
Measure your city	Meteorological data	Available
	Soil moisture data	Available
Arcadis	Sewerage information	Available

2.1.1. MEASURE YOUR CITY

Integration of data from the citizen science project "MeetJeStad" into the SCOREwater platform is operational. There is a harvester which periodically downloads meteorological information from the Measure your city website. This data is harmonized according to the FIWARE data model "Weather observed" (FIWARE, 2022d). Variables collected are temperature (degrees Celsius), relative humidity (percentage) and, depending on the type of sensor, illuminance (Lux). Data from the Measure Your City soil moisture sensors is connected to the SCOREwater platform as well. These data are mapped to the "GreenSpaceRecord" FIWARE data model (FIWARE, 2022b). This model contains a harmonized description of the conditions recorded on a particular area or point inside a greenspace (flower bed, garden, etc.), like soil temperature or soil moisture. The Measure your city soil moisture sensors measure soil moisture using conductivity. Calibration of the data is still under investigation.

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2.1.2. SOIL MOISTURE

As part of the SCOREwater project, the City of Amersfoort installed a soil moisture sensor network (D4.17) using Teneo sensors. There are multiple sensors at the same location at different depths. This sensor network delivers its data in a proprietary CSV-format to the SCOREwater platform through FTP. As soon as an FTP has been uploaded, it is picked up and processed. These data are mapped to the "GreenSpaceRecord" FIWARE data model (FIWARE, 2022,b). The Teneo soil moisture sensors measure soil moisture using Volumetric water content (VWC).

2.1.3. SEWERAGE INFORMATION

The City of Amersfoort provided an initial number of datasets in a readable proprietary format ("kikker"). These are static files that have been manually uploaded to the SCOREwater platform. There is no generic, international data model for this topic. The current data model (GWSW) is focused on The Netherlands.

SCOREwater partner Hydrologic has provided a direct link to the API's of their own platform, providing access to the City of Amersfoort sewerage timeseries (levels, discharges). The Hydrologic API's can be found via the SCOREwater platform since metadata describing the API's has been added. This metadata record contains information on how to obtain access.

2.1.4. ALERTS

Hydrologic has developed a Flood Early Warning data driven model. The model uses predicted rainfall to determine whether or not precipitation will lead to overflows in the sewage system. If this is the case, alerts will be sent out to persons subscribed. For this purpose, the "Alert" data model is used (FIWARE, 2022a).

2.2. BARCELONA

For Barcelona, a CKAN open data platform (https://catalogus-barcelona-scorewater.dataplatform.nl/) has been deployed. This platform can be used to a) upload datasets to and b) connect sensor datasets to. The main sensor to be connected for Barcelona is the s:can water quality sensor which has been installed in three locations in Barcelona. Uploading of lab information and other data sources is pending. The infrastructure to facilitate uploading these metadata and/or data for these datasets is in place and the staff working the case will be assisted in doing so within the frame of deliverable 3.6. For these datasets, metadata (including information on how to get access to the actual data) will be added to the SCOREwater platform. The technical infrastructure to create and maintain the metadata is available. Table 2 lists the Barcelona data sources to be connected within the frame of the project.

Table 2 Barcelona data sources in the SCOREwater platform

Barcelona data sources		
s::can	Water quality	Available
	Lab	Pending
	Socio economic	Pending
	Built environment	Pending
	Health status	Pending
	IRIS platform	Pending
	Serwernet	Pending

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2.2.1. S:CAN

The s::can sensors have been installed in three neighborhoods in Barcelona. They upload data to the SCOREwater platform about water quality. This data is harmonized to the FIWARE data model "WaterQualityObserved" (FIWARE, 2022c). The s::can sensors measure a lot of parameters, including flow and chemical oxygen demand (COD), which were not part of the WaterQualityObserved data model when this sensor was onboarded on the platform. COD has been added to the data model since then, and Civity and s::can raised an issue in the Smart Data Model Github repository proposing to add flow to the data model. This proposal has been approved.

2.3. GOTHENBURG

In Gothenburg the aim is to measure the quality of wastewater from construction sites, with variables like turbidity, flow, conductivity, pH and water level. Also additional sensors and data sources are connected and integrated with the SCOREwater platform. The following sensor datasets have been connected to the CKAN open data portal instance created for Gothenburg (https://catalogus-gothenburg-scorewater.dataplatform.nl/). Table 3 lists the data sources connected for Gothenburg within the frame of the project.

Table 3 Gothenburg data sources in the SCOREwater platform

Gothenburg data sources		
Swedish Hydro Solutions	Telecontrol.net water quality	Available[1]
	Ezecontrol water quality	Pending[2]
Talkpool	Water quality	Harmonization pending
Vatten I Goteborg	Meteorological data	Available
SMHI	Meteorological data	Available

2.3.1. WEATHER STATIONS

A harvester has been created for the Drakegatan weather station, which is located close to the construction site under investigation. The data is harmonized with the FIWARE data model "Weather observed" (FIWARE, 2022d). The data from the weather station shows the rainfall per day (precipitation). The weather station publishes the cumulative precipitation (with a from and a to timestamp, while the FIWARE data model only includes one timestamp without the option to include a from and a to timestamp. To align this cumulative precipitation with the data model and the other source of weather data, the cumulative values are converted to non-cumulative values by subtracting the cumulative value at timestamp t – 1 from the cumulative value at timestamp t. An alternative option was to propose a change to the WeatherObserved Smart Data Model, but that would mean the issue would be passed on to the actual users of the data (they would still have to come with a solution to combine data from different data sources). Similarly, data from SMHI (Swedish Meteorological and Hydrological Institute) is harvested from a weather station close to construction site.

[1] Due to a migration of the SHS platform part of this work has to be re-done.
[2] Due to a migration of the SHS platform, this work has been postponed to wait for the new platform

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2.3.2. TALKPOOL

The Talkpool infrastructure is used to connect data from the IVL Turbinator sensors and other water quality sensors to the SCOREwater platform. To be able to ingest information from the Talkpool infrastructure, a so-called MQTT listener has been developed to collect the sensor data about water quality. This listener checks for updates from the sensors and then ingests the data in the SCOREwater platform. This data is transformed to the FIWARE data model "Water quality observed". At the time of writing of the original deliverable, work on the mapping of the raw data to the harmonized Smart Data Model was still ongoing. To convert raw data from the sensor to actual water quality observations, scale and offset factors were needed. These have been provided and applied by now, but the delay did cause issues in WP4.

A connection to the Swedish Hydro Solution sensors has been established. This connection needs further work though since Swedish Hydro Solutions has updated their platform. The connection must be migrated to this new platform before the old version is being deprecated.

2.3.3. OTHER SENSORS

To test the connection to/with other sensors, an existing project in Uppsala (Sweden) to measure water quality, is connected to the SCOREwater platform. The data from these sensors is retrieved through a subscription with a 3rd party Context Broker and stored in the SCOREwater platform. The FIWARE "Water quality observed" data model has been applied. Variables collected are conductivity and temperature.

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3. LESSONS LEARNED

This chapter provides some lessons learned from the integrations and connections.

Based on the results, some feedback on the data models is provided in the table below. This feedback is collected from developers at Civity working on the SCOREwater platform and input from SCOREwater partner connecting their sensors and data to the platform.

Table 4 Feedback on FIWARE data models

Data model	Observations
Water quality observed	Fits rather well with the data collected
Air quality observed	Fits rather well with the data collected
Weather observed	Some weather stations provide more information, not everything can be included in the standard FIWARE data model. Not necessarily bad since other stations do not provide this information.
"sewer information"	Missing models and information systems
Alerting	Fits rather well with the data collected

Besides the feedback on the data models, the integration of sensor data in the SCOREwater platform, gives additional challenges. From a technical perspective sub-optimal choices are made, due to previously made choices, lack of data and integration options. The consequence is that more custom connectors, translators and ingestion methods are being developed. More customization than previously was expected is needed to bring the data into the SCOREwater platform and convert proprietary data to a harmonized data (model). To maintain the platform in the future, ongoing focus on standardization of all components, models, connections, API´s, etc. is needed.

4. REFERENCES

FIWARE. (2022a, 07 06). *Alert data model*. Retrieved from Smart Data Models: https://github.com/smart-data-models/dataModel.Alert/tree/master/Alert

FIWARE. (2022b, 07 06). *GreenSpaceRecord*. Retrieved from Smart Data Models: https://github.com/smart-data-models/dataModel.ParksAndGardens/tree/master/GreenspaceRecord

FIWARE. (2022c, 07 06). *WaterQualityObserved*. Retrieved from Smart Data Models: https://github.com/smart-data-models/dataModel.WaterQuality/tree/master/WaterQualityObserved

FIWARE. (2022d, 07 06). *WeatherObserved*. Retrieved from Smart Data Models: https://github.com/smart-data-models/dataModel.Weather/tree/master/WeatherObserved

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ANNEX 1 – STOCKTAKING

A final Annex of stocktaking was included in all Deliverables of SCOREwater produced after the first half-year of the project. It provides an easy follow-up of how the work leading up to the Deliverable has addressed and contributed to four important project aspects:

1. Strategic Objectives
2. Project KPI
3. Ethical aspects
4. Risk management

STRATEGIC OBJECTIVES

Table 5 lists those strategic objectives of SCOREwater that are relevant for this Deliverable and gives a brief explanation on the specific contribution of this Deliverable.

Table 5. Stocktaking on Deliverable's contribution to reaching the SCOREwater strategic objectives.

Project goal	Contribution by this Deliverable
SO1: Deploy and demonstrate a smart water management approach, which is people-centred, inclusive, interoperable, flexible and safe.	**The deliverable uses open-source software and open standards which are not controlled by Big Tech to deliver water related information to both professionals and the general public.**
SO2: Harmonize and improve interoperability opportunities in the water sector by enhancing and adopting water/ICT open standards, ecosystems, vocabularies and ontologies.	**The deliverable uses open standards and open data models and applies those to water related information thus investigating what does work and identifying potential issues.**
SO5: Identify and mitigate key barriers to implementation of smart, resilient water management	**The deliverable delivers water related information to both professionals and the general public.**
The SCOREwater platform will be based on existing open source software components, standards and data models.	This deliverable describes the connection and integration with sensors from the three cities that are processed, stored and provisioned through the SCOREwater platform.
Identify existing systems and applications, and provide a functional and technical analysis of these systems and applications, including relevant standards, connections and data.	Deliverable 3.1 and 3.2 describe software solutions for the SCOREwater platform. This deliverable describes the implementation of integrations and connectors for the SCOREwater Platform, based upon these software choices.
A prerequisite of the project is to base the SCOREwater platform on FIWARE	The implementation of connectors and integrations uses FIWARE data models (if available), Open API´s and software components.

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PROJECT KPI

Table 6 lists the project KPI that are relevant for this Deliverable and gives a brief explanation on the specific contribution of this Deliverable[3].

Table 6. Stocktaking on Deliverable's contribution to SCOREwater project KPI's.

Project KPI	Contribution by this deliverable
KPI2: Number of input data-sources connected and consumed	14 (data sources connected)
KPI7: Number of experiences related to ICT standardization and testbed standardized	5 (FIWARE Smart data models)
KPI9: Number of Open Data Catalogues in the Data Market	3 (one for each case)
KPI21: Cross-domain integration with other Open Data Catalogues	2 (SMHI and Vatten i Goteborg)
Open source software by default	This deliverable uses FIWARE open source components, models and standards for connecting and integrating sensor data in the SCOREwater platform (when available). The availability of these standardized data streams (open API´s) contributes to multiple KPI's. In upcoming updates of this document this information and results will be added.
FIWARE as prerequisite	This deliverable uses selected FIWARE components (software, models and API´s) for connecting and integrating data in the SCOREwater platform.

[3] D3.2, D3.3 and D3.4 are tightly linked. The reported KPI numbers are the cumulative effort of all three deliverables. Thus the same values are reported in all three deliverables' annexes.

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ETHICAL ASPECTS

Table 7 lists the project's Ethical aspects and gives a brief explanation on the specific treatment in the work leading up to this Deliverable. Ethical aspects are not relevant for all Deliverables. Table 7 indicates "N/A" for aspects that are irrelevant for this Deliverable.

Table 7. Stocktaking on Deliverable's treatment of Ethical aspects.

Ethical aspect	Treatment in the work on this Deliverable
Justification of ethics data used in project	N/A
Procedures and criteria for identifying research participants	N/A
Informed consent procedures	N/A
Informed consent procedure in case of legal guardians	N/A
Filing of ethics committee's opinions/approval	N/A
Technical and organizational measures taken to safeguard data subjects' rights and freedoms	In accordance with D9.2 where applicable
Implemented security measures to prevent unauthorized access to ethics data	In accordance with D9.2 where applicable
Describe anonymization techniques	In accordance with D9.2 where applicable
Interaction with the SCOREwater Ethics Advisor	N/A

RISK MANAGEMENT

Table 8 lists the risks, from the project's risk log, that have been identified as relevant for the work on this Deliverable and gives a brief explanation on the specific treatment in the work leading up to this Deliverable.

Table 8. Stocktaking on Deliverable's treatment of Risks.

Associated risk	Treatment in the work on this Deliverable
Technical immaturity of FIWARE components	Usage of alternative open source tools for harvesting, connecting and integrating sensor data in the SCOREwater platform. For the technical software components limitations have not yet appeared. Close collaboration with other EU-funded projects and the FIWARE-foundation further limits this risk.
Missing of incomplete standards and data models	Collaboration with other EU-funded projects, FIWARE-foundation and other standardization bodies to develop open standards and data models.

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