SYNCHRONICITY

GA no:	732240
Action full title:	SynchroniCity: Delivering an IoT enabled Digital Single Market for Europe and Beyond
Call/Topic:	Large Scale Pilots
Type of action:	Innovation Action (IA)
Starting date of action:	01.01.2017
Project duration:	36 months
Project end date:	31.12.2019
Deliverable number:	D4.5
Deliverable title:	Technical Validation of the SME projects
Document version:	Ver1.0
WP number:	WP4
Lead beneficiary:	9-UC
Main author(s):	Laura Rodríguez de Lope, Luis Díez, Johnny Choque, Luis Muñoz (UC)
Internal reviewers:	Susannah Stearman (FCC), Martin Brynskov (AU)
Type of deliverable:	R
Dissemination level:	PU
Delivery date from Annex 1:	M34
Actual delivery date:	15.01.2020 (M37)

Co-funded by the European Union

This deliverable is part of a project that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 732240.

Co-funded by

Executive Summary

In the SynchroniCity project, Work Package (WP) 5 opens the framework components and services, developed in WP2 and WP3, to SMEs through an Open Call. During the 6 months of the piloting phase, the SynchroniCity framework has been made available to the different pilots participating in the Open Call, with the aim of integrating their solutions and testing the framework's replicability.

Within this context, WP4 has focused on the technical validation of the Open Call pilots' integration and replication, developing a methodology that has been applied during the 6 months of the piloting phase to assist the pilots in the integration of their solutions with the framework and in the deployment of new SynchroniCity instances. The follow up and review of the pilots has been undertaken through the analysis of periodic reports from the pilot groups with the corresponding feedback in an iterative process.

In particular, the Minimum Interoperability Mechanisms (MiM) Validator tool, presented in D4.2, carried out periodic checks against the reported endpoints, validating both the APIs and data models. An instance of this service has been configured with the endpoints and access data provided by the pilots for both, core pilot cities and new ones, to execute the validation process against the corresponding SynchroniCity frameworks.

In the final stage and after the M6 report was provided by the pilots groups, an exhaustive validation has been carried out to report upon the use of the pilots' corresponding SynchroniCity interfaces. This includes reporting upon data set creation, data set consumption, alignment with SynchroniCity data models and, in the case of new deployment cities, the assessment of the MiM in the new framework instances in the corresponding Reference Zone (RZ).

In summary, this document provides a detailed description of the validation process completed alongside the SynchroniCity Open Call and the results of running such assessment. Nevertheless, through the overall results and KPIs, the reader, with not necessarily a technical profile, will have a quick view of the pilots' contribution to the SynchroniCity ecosystem.

With the overall results and KPIs detailed, the readers can engage with an overview of the pilots' contribution to the SynchroniCity ecosystem and growing the future market.

Abbreviations

API	Application Programming Interface
AWS	Amazon Web Services
CB	Context Broker
D	Deliverable
ETSI	European Telecommunications Standard Institute
GSMA	GSM Association IoT Big Data Project
IdM	Identity Manager
IoT	Internet of Things
KPI	Key Performance Indicator
LoRa	Long Range modulation
M	Month
MiM	Minimum Interoperability Mechanisms
NGSI	Next Generation Service Interface
NGSI-LD	NGSI Linking Data
OAUTH2	Open Authorization 2
REST	Representational State Transfer
RFC	Request for Comments
RZ	Reference Zone
SME	Small and medium-sized enterprises
STH	Short Time Historic
TCM	TMForum Catalogue Management
URL	Uniform Resource Locator
WAN	Wide Area Network
WiFi	Wireless Fidelity
WP	Work Package

Contents

1 Introduction 10
2 Validation Process 11
2.1 SynchroniCity MIMs 13
2.2 Validation and visualization tools 15
3 SynchroniCity Core Pilot Cities update 17
3.1 Porto's Reference Zone MiMs validation 18
3.1.1 Endpoints, interfaces and core components 18
3.1.2 Data models and available data sets 18
3.2 Santander's Reference Zone MiMs validation 19
3.2.1 Endpoints, interfaces and core components 19
3.2.2 Data models and available data sets 20
3.3 Antwerp's Reference Zone MiMs validation 21
3.3.1 Endpoints, interfaces and core components 21
3.3.2 Data models and available data sets 21
3.4 Eindhoven's Reference Zone MiMs validation 22
3.4.1 Endpoints, interfaces and core components 22
3.4.2 Data models and available data sets 22
3.5 Helsinki's Reference Zone MiMs validation 23
3.5.1 Endpoints, interfaces and components 23
3.5.2 Data models and available data sets 23
3.6 Manchester's Reference Zone MiMs validation 24
3.6.1 Endpoints, interfaces and core components 24
3.6.2 Data models and available data sets 24
3.7 Milan's Reference Zone MiMs validation 25
3.7.1 Endpoints, interfaces and core components 25
3.7.2 Data models and available data sets 25
3.8 Carouge's Reference Zone MiMs validation 26
3.8.1 Endpoints, interfaces and core components 26
3.8.2 Data models and available data sets 27
4 Pilot's validation outcomes 27
4.1 Active Travel Insights 28
4.1.1 Endpoints and interfaces used 28
4.1.2 Generated datasets 28
4.1.3 Consumed datasets 29
4.2 ASAP-VALUE : A Standards-based Approach to enhancing VALUE from city data lake. 29
4.2.1 Endpoints and interfaces used 29
4.2.2 Generated datasets 30

4.2.3 Consumed datasets 31
4.3 Autonomous Hub for Cyclist 31
4.3.1 Endpoints and interfaces used 31
4.3.2 Generated datasets 33
4.3.3 Consumed datasets 34
4.4 AAQM - Autonomous Real-Time Field Service Solution for Public Real Estate Air Quality Management 36
4.4.1 Endpoints and interfaces used 36
4.4.2 Generated datasets 36
4.4.3 Consumed datasets 37
4.5 BlueAlpaca 37
4.5.1 Endpoints and interfaces used 37
4.5.2 Generated datasets 38
4.5.3 Consumed datasets 38
4.6 Clean Air School Districts (CASD) 38
4.6.1 Endpoints and interfaces used 38
4.6.2 Generated datasets 39
4.6.3 Consumed datasets 39
4.7 Encouraging Cycling through use of Crowdsourced Data-Driven Insights 40
4.7.1 Endpoints and interfaces used 40
4.7.2 Generated datasets 41
4.7.3 Consumed datasets 41
4.8 Kimap-City 41
4.8.1 Endpoints and interfaces used 41
4.8.2 Generated datasets 42
4.8.3 Consumed datasets 42
4.9 Kissmybike 43
4.9.1 Endpoints and interfaces used 43
4.9.2 Generated datasets 43
4.9.3 Consumed datasets 44
4.10 LINC 44
4.10.1 Endpoints and interfaces used 44
4.10.2 Generated datasets 45
4.10.3 Consumed datasets 45
4.11 Neighbourly: A Smart City Platform 45
4.11.1 Endpoints and interfaces used 45
4.11.2 Generated datasets 47
4.11.3 Consumed datasets 47

4.12 NoiseAbility 47
4.12.1 Endpoints and interfaces used 47
4.12.2 Generated datasets 48
4.12.3 Consumed datasets 49
4.13 Quamtra: Smart Waste Management 49
4.13.1 Endpoints and interfaces used 49
4.13.2 Generated datasets 50
4.13.3 Consumed datasets 50
4.14 RainBrain, the smart blue-green roof 51
4.14.1 Endpoints and interfaces used 51
4.14.2 Generated datasets 51
4.14.3 Consumed datasets 52
4.15 Real-time traffic data with energy savings on street lights 53
4.15.1 Endpoints and interfaces used 53
4.15.2 Generated datasets 53
4.15.3 Consumed datasets 53
4.16 SmartImpact 54
4.16.1 Endpoints and interfaces used 54
4.16.2 Generated datasets 54
4.16.3 Consumed datasets 55
5 Overall Validation Results and Conclusions 56
5.1 SynchroniCity Impact 59
5.1.1 New instances deployed 59
5.1.2 IoT devices and communication technologies covered by pilots deployments 60
5.2 Metrics & KPIs 61
5.3 SynchroniCity Framework Perception 63
REFERENCES 64
ANNEX I – Technical Reports Templates 65
M2 Technical report tamplate 65
M4 Technical report tamplate 70
M6 Final Report – Technical Environment 80
ANNEX II – Seongnam's MiMs validation 82
Endpoints, interfaces and core components 82
Data models and available data sets 82

List of Figures

Figure 1. Technical validation iterative process 11
Figure 2. SynchroniCIty MiMs validator components 16
Figure 3. Snapshot of the web page showing the validation status 16
Figure 4. Data sets created and generated per pilot (logarithmic scale) 57
Figure 5. Number of piloting cities per pilot 57
Figure 6. Pilots level of integration 59
Figure 7. Interfaces implemented in new cities 60
Figure 8. Communication technologies employed by pilots in their deployments 61

List of Tables

Table 1. Colour code showing technical validation results 12
Table 2. SynchroniCity datamodels as for November of 2019. Last column indicates modification in the data model during the SynchoniCity open call 15
Table 3. Colour code showing validated component result/status 18
Table 4. Porto's deployed components (Synchronicity Architecture) 18
Table 5. Evolution of the Porto's data model validation. The table depicts the status before and after the Open Call piloting phase, as well as the increase between them. 19
Table 6. Santander's deployed components (Synchronicity Architecture) 20
Table 7. Evolution of the Santander's data model validation. The table depicts the status before and after the Open Call piloting phase, as well as the increase between them. 20
Table 8. Antwerp's deployed components (Synchronicity Architecture) 21
Table 9. Evolution of the Antwerp's data model validation. The table depicts the status before and after the Open Call piloting phase, as well as the increase between them. 22
Table 10. Eindhoven's deployed components (Synchronicity Architecture) 22
Table 11. Evolution of the Eindhoven's data model validation. The table depicts the status before and after the Open Call piloting phase, as well as the increase between them. 23
Table 12. Helsinki's deployed components (Synchronicity Architecture) 23
Table 13. Evolution of the Helsinki's data model validation. The table depicts the status before and after the Open Call piloting phase, as well as the increase between them. 24
Table 14. Manchester's deployed components (Synchronicity Architecture) 24
Table 15. Evolution of the Manchester's data model validation. The table depicts the status before and after the Open Call piloting phase, as well as the increase between them. 25
Table 16. Milan's deployed components (Synchronicity Architecture) 25
Table 17. Evolution of the Milan's data model validation. The table depicts the status before and after the Open Call piloting phase, as well as the increase between them. 26
Table 18. Carouge's deployed components (Synchronicity Architecture) 27
Table 19. Evolution of the Carouge's data model validation. The table depicts the status before and after the Open Call piloting phase, as well as the increase between them. 27
Table 20. Endpoints managed by Active Travel Insights 28
Table 21. Active Travel Insights list of NGSI context entities generated 28
Table 22. Active Travel Insights list of consumed NGSI context entities 29
Table 23. Core pilot cities' endpoints managed by ASAP-Value 29
Table 24. New pilot cities' endpoints managed by ASAP-Value 30
Table 25. ASAP-Value list of NGSI context entities generated 31
Table 26. ASAP-Value list of consumed NGSI context entities 31
Table 27. Core pilot cities' endpoints managed by Autonomous Hub for Cyclist 32
Table 28. New pilot cities' endpoints managed by Autonomous Hub for Cyclist 33
Table 29. Autonomous Hub list of NGSI context entities generated 34
Table 30. Autonomous Hub list of consumed NGSI context entities 35
Table 31Core pilot cities' endpoints managed by by AAQM 36
Table 32. Results the validation of new pilot cities' endpoints managed by AAQM 36
Table 33. AAQM list of NGSI context entities generated 37
Table 34. AAQM list of consumed NGSI context entities 37
Table 35. Endpoints managed by BlueAlpaca 38
Table 36. BlueAlpaca list of consumed NGSI context entities 38
Table 37. Endpoints managed by CASD 39
Table 38. CASD list of NGSI context entities generated 39
Table 39. CASD list of consumed NGSI context entities 40
Table 40. Core pilot cities' endpoints managed by by AAQM 40
Table 41. Results the validation of new pilot cities' endpoints managed by Encouraging Cycling 40
Table 42. Encouraging Cycling list of NGSI context entities generated 41
Table 43. Endpoints managed by Kimap-City 42
Table 44. Kimap-City list of NGSI context entities generated 42
Table 45. Kimap-City list of consumed NGSI context entities 43

Table 46. Endpoints managed by Kissmybike 43
Table 47. Kissmybike list of NGSI context entities generated 43
Table 48. Kissmybike list of consumed NGSI context entities 44
Table 49. Endpoints managed by LINC 44
Table 50. LINC list of NGSI context entities generated 45
Table 51. Results the validation of new pilot cities' endpoints managed by Neighbourly 47
Table 52. Neighbourly list of NGSI context entities generated 47
Table 53. Core pilot cities' endpoints managed by NoiseAbility 48
Table 54. Results the validation of new pilot cities' endpoints managed by NoiseAbility 48
Table 55. Core pilot cities' endpoints managed by Quamtra 49
Table 56. Results the validation of new pilot cities' endpoints managed by Quamtra 50
Table 57. Quamtra list of NGSI context entities generated 50
Table 58. Quamtra list of consumed NGSI context entities 51
Table 59. Endpoints managed by RainBrain 51
Table 60. RainBrain list of NGSI context entities generated 52
Table 61. RainBrain list of consumed NGSI context entities 52
Table 62. Endpoints managed by Real-time traffic 53
Table 63. Real-time traffic list of NGSI context entities generated 53
Table 64. Core pilot cities' endpoints managed by SmartImpact 54
Table 65. Results the validation of new pilot cities' endpoints managed by SmartImpact 54
Table 66. SmartImpact list of NGSI context entities generated 55
Table 67. SmartImpact list of consumed NGSI context entities 56
Table 68. Overall pilots classification 58
Table 69. SynchroniCity interfaces implemented in the new cities 59
Table 70. Number of IoT devices deployed in the piloting cities 60
Table 71. Technical validation KPIs 61
Table 72. KPIs global values 62
Table 73. KPIs values per RZ 63
Table 74. Seongnam's deployed components (Synchronicity Architecture) 82
Table 75. Evolution of the Seongnam's data model validation. The table depicts the status before and after the Open Call piloting phase, as well as the increment between them. 82

1 Introduction

Work Package (WP) 4 is responsible for validating the outcomes of SynchroniCity in terms of architecture, deployments, services, pilots and users. In this sense, Task 4.4 focuses on the technical results achieved by the SynchroniCity Open Call pilots.

The technical validation of the SynchroniCity architecture and data models adopted in each core city, carried out within WP2, and atomic services, in WP3, was presented in D4.3 [1]. The integration of the Open Call pilots with these SynchroniCity components, together with their replicability in several cities, and the evolution of the framework in those piloting cities are the aims of the validation task T4.4. The results of this validation are presented alongside this deliverable. The quality of the solutions adopted by the pilots is beyond the scope of this document, however the pilot descriptions, key results and more detail about the pilot process can be found in D5.6 [2].

With this in mind, the objective of *D4.5* is to present the process and tools used to validate the technical outcomes of the SynchroniCity Open Call pilots, as well as the outcomes themselves, and in doing so provides the reader with an overall status of the cities after the Open Call execution.

Section 2 presents, the iterative approach followed for the pilots' technical validation. This section details the components included in the technical validation:

- SynchroniCity interfaces (NGSI, Historical data Access and OAuth APIs)
- SynchroniCity data models,

and the tools and mechanisms employed for the assessment of these components. The initial tool, described in D4.3, has been evolved to support all the MiMs and integrated with the SynchroniCity GitLab, to include all new updates on data models. The new features of the SynchroniCity MiMs validation tool are detailed in this section.

The technical validation outcomes have been divided into two complementary branches:

- **Core pilot cities' status update:** Section 3 lists an update of the SynchroniCity reference components (MiMs) deployed in each core pilot city, detailing the validation result. This analysis also checks the SynchroniCity compliant data sets available in each city instance and compares them with the status before the Open Call. This way, the reader can have a quick view of the core cities evolution during the piloting phase.
- **Open Call Pilots validation:** Section 4 focuses on the assessment of each one of the Open Call pilot by analysing the SynchroniCity compliant data sets created and consumed, and the interfaces used for the integration of the solution with each piloting city. In cases where the pilot brought new cities, the framework components of these new cities are also validated.

Finally, Section 5, presents the overall technical results of the Open Call. An assessment of the degree of integration of the pilots and new cities with SynchroniCity framework is undertaken. Furthermore, the impact of the Open Call through the technical KPIs, already defined in D4.2 [3] and D4.3, is detailed to summarize the technical outcomes of the Open Call. This section also presents the perception of the pilots' experience in using the SynchroniCity framework, providing valuable conclusions about the future steps to reach the Digital Single Market. This deliverable closes this way the technical validation work of the SynchroniCity framework.

2 Validation Process

The objective of the technical validation is gathering measurable information about how pilot services use the SynchroniCity framework and MiMs. In particular, the focus has been set on the items listed below:

1. **Integration with the SynchroniCity framework:** Pilots' services consume and/or creates data sets by a pilot service or data source and stores them within SynchroniCity instances, through the corresponding interfaces.
2. **SynchroniCity data models compliance:** New datasets should comply with any of the defined SynchroniCity datamodels or, when applicable, promote new ones according SynchroniCity mechanisms.
3. **Atomic services:** Pilots were encouraged to isolate SynchroniCity related functionalities to create atomic services, that could be afterwards deployed and reused by others. During the technical validation we asked pilots about this matter to foster reusability.
4. **Replicability:** Pilots must demonstrate the replicability of their solution replicating their solution in at least 2 cities.
5. **New instances:** Some pilots develop their services in new cities and deploy a new instance of the SynchroniCity there. For the technical validation, we required information about such instances including the deployed technical components.

The technical validation has been undertaken over the whole pilot period based on an iterative approach by means of periodic reports, as indicated in Figure 111. The iterative approach allows detection of deviations with respect to the working plan and provided feedback to the pilot groups with enough time to react and reach the objectives prior to deadline.

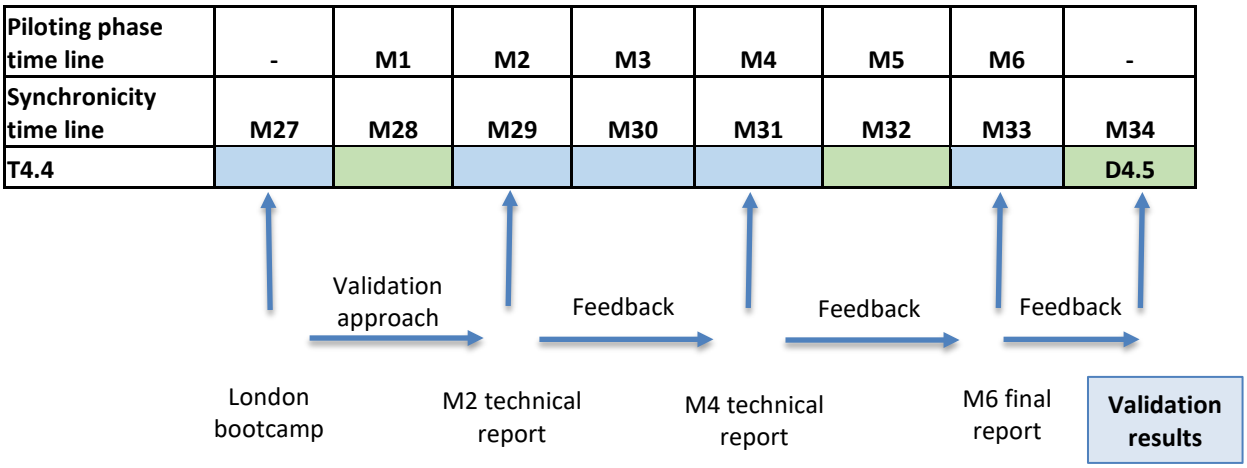

Figure 1. Technical validation iterative process

The main technical validation milestones during the pilot lifetime are undertaken by means of periodic reports and a first meeting to inform pilots about the validation approach to be followed, as indicated below:

- **London bootcamp (M0):** During the London Bootcamp, before the piloting phase started, the WP4 team met individually with all the pilot groups to inform them about how the technical validation of their solutions would be undertaken and to outline what information would be requested in the different reports during the pilot lifetime.
- **Technical report month 2 (M2)**: After the first two months, the first technical report was requested with information about the integration with the SynchroniCity instances. It included datasets which were planned to beconsumed and created, as well as the deployment of new SynchroniCity instances.
- **Technical report month 4 (M4)**: In the second technical report, pilots were asked to describe the technical development of their solution, and its deployment in all or some of the concerned cities.
- **Report month 6 (M6)**: in the final report, pilots were asked to provide technical information concerning the replication and exploitation of the service, including deployment and the integration in all their piloting cities.

The templates of the different reports are available in ANNEX I.

After the evaluation of each of the reports, pilots were provided with feedback about the different issues detected and about missing information with the objective pilots could improve their solutions and subsequent reports. After the M6 final report, and the corresponding technical validation of the pilots' results, it was decided together with WP5 to provide some final feedback to the piloters with the remaining issues highlighted and then give them some extra time to solve the issues, before conducting an additional technical validation round. The outcomes of this final technical validation are detailed in Section 4.

Following the Open Call criteria to determine the requirements to be considered technically validated, a minimum level of integration with the SynchroniCity framework was needed. This meant pilots needed to demonstrate replicability of their solution in at least 2 pilot cities, which included:

- Interaction of the solution with SynchroniCity endpoints
- Datasets consumed and/or generated must follow a minimum level of compliance with SynchroniCity data models

According to this criterion, pilots have been evaluated following the colour code presented in Table 1.

	Pilot technically validated. Replicability of the solution demonstrated in all the piloting cities: - Integration of the solution with SynchroniCity endpoints. - Data sets consumed/ generated following a minimum level of compliance with SynchroniCity data models.
	Pilot technically validated. Replicability of the solution demonstrated in at least two pilot cities but not in all of them, missing one or more pilot city: - Integration of the solution with SynchroniCity endpoints. - Data sets consumed/ generated following a minimum level of compliance with SynchroniCity data models.
	Pilot not technically validated. Replicability of the solution not demonstrated in at least two cities, missing: - Integration of the solution with SynchroniCity endpoints. - Data sets consumed/ generated following a minimum level of compliance with SynchroniCity data models.

Table 1. Colour code showing technical validation results

In order to formally evaluate the integration of the pilots with the SynchroniCity framework, we have carried out a technical validation similar to that reported in D4.3. In the validation process we assessed that pilots have used the SynchroniCity MIMs provided by the cities, as well as that new SynchroniCity instances deployed by the pilots are compliant with the SynchroniCity MIMs. In the following we briefly describe the SynchroniCity MIMs, and the validation tools employed to perform the systematic technical validation. A detailed description of the SynchroniCity framework components that are validated and the structure of the validator tools can be found in D4.3- Section 2.

2.1 SynchroniCity MIMs

The SynchroniCity MIMs can be divided into interfaces and data models. The interfaces validated are:

- **SynchroniCity NGSI context information API**: Based on the NGSI standard [4] and being adapted to include the ETSI NGSI-LD standard [5].
- **SynchroniCity Historical data access API:** An evolution of the FIWARE STH-COMET and defined to fulfil the requirements of the NGSI-LD short-term historical data.
- **SynchroniCity Security API (Identity management):** Based on the broadly adopted oAuth2.0 standard described in the RFC 6749 [6], which presents four different authorization flows.

While the data marketplace is an important functionality of the SynchroniCity framework, it has not yet been adopted to a common set of interfaces to be exposed. For that reason, the presence of the data marketplace is not part of the systematic validation.

The SynchroniCity data models have been defined in Task 2.2 in the context of the SynchroniCity Architecture. This work was reflected on D2.3 [7] and D4.3, and now has been updated, with new inclusions and modifications proposed by the Open Call pilots, in the data models section on the SynchroniCity GitLab[1]. Table 2 provides a summary of the SynchroniCity data models indicating, in the last column whether they have been updated or newly created during the open call. For each one it is also defined the application area, formal name of the data model, definition source and its status:

- **Approved**: The data model has been officially adopted by SynchroniCity and can be used.
- **Under Discussion**: The data model is under discussion. SynchroniCity partners and external stakeholders can suggest changes or extensions. The data model could be used but cannot be considered stable.

Area	Data Model Name	Source	Status	Change
Environment	AirQualityObserved	GSMA[2]	Approved	
	NoiseLevelObserved	FIWARE[3]	Approved	Updated
Point Of Interest	PointOfInterest	GSMA	Approved	Updated

1 https://gitlab.com/synchronicity-iot/synchronicity-data-models
2 https://github.com/GSMADeveloper/NGSI-LD-Entities
3 https://github.com/FIWARE/data-models

	Beach	FIWARE	Approved	
	Museum	FIWARE	Approved	
	Store	SynchroniCity	Approved	Updated
Transportation	BikeHireDockingStation	FIWARE	Approved	
	TrafficFlowObserved	FIWARE	Approved	
	EVChargingStation	SynchroniCity	Approved	
	CrowdFlowObserved	SynchroniCity	Approved	
	Vehicle	FIWARE	Approved	
	CarSharingStation	SynchroniCity	Approved	
	RestrictedTrafficArea	SynchroniCity	Approved	Updated
	Road	FIWARE	Approved	
	RoadSegment	FIWARE	Approved	
Weather	WeatherObserved	GSMA	Approved	Updated
	WeatherForecast	GSMA	Approved	Updated
Urban Mobility	GtfsAgency	SynchroniCity	Approved	Updated
	GtfsStop	SynchroniCity	Approved	Updated
	GtfsStation	SynchroniCity	Approved	Updated
	GtfsAccessPoint	SynchroniCity	Approved	Updated
	GtfsRoute	SynchroniCity	Approved	Updated
	GtfsTrip	SynchroniCity	Approved	Updated
	GtfsShape	SynchroniCity	Approved	Updated
	GtfsStopTime	SynchroniCity	Approved	Updated
	GtfsService	SynchroniCity	Approved	Updated
	GtfsCalendarRule	SynchroniCity	Approved	Updated
	GtfsCalendarDateRule	SynchroniCity	Approved	Updated
	GtfsFrequency	SynchroniCity	Approved	Updated
	GtfsTransferRule	SynchroniCity	Approved	Updated

	ArrivalEstimation	SynchroniCity	Approved	Updated
	GtfsTransitFeedFile	SynchroniCity	Approved	Updated
	PublicTransportRoute	SynchroniCity	Approved	
	PublicTransportStop	SynchroniCity	Approved	
Parking	ParkingSpot	FIWARE	Approved	
	OffStreetParking	FIWARE	Approved	
	OnStreetParking	FIWARE	Approved	
Parks & Gardens	Garden	FIWARE	Approved	
	GreenspaceRecord	FIWARE	Approved	
Waste Management	WasteContainer	FIWARE	Approved	
	WasteMeasurement	SynchroniCity	Under Discusiion	New
	WasteContainerModel	FIWARE	Approved	
Device	Device	FIWARE	Approved	
Queue Monitor	QueueMonitor	SynchroniCity	Approved	New
Energy	ThreePhaseMultiCircuitAcMeasurement	SynchroniCity	Approved	New
	GreenEnergyGenerator	SynchroniCity	Approved	New
	GreenEnergyMeasurement	SynchroniCity	Approved	New

Table 2. SynchroniCity datamodels as for November of 2019. Last column indicates modification in the data model during the SynchoniCity open call

2.2 Validation and visualization tools

The technical validation of pilots makes use of the SynchroniCity MIM validator, whose functionality was reported in D4.3-Section2.2.1. In addition, the validator exposes a REST interface with which the validation output can be obtained. The process to deploy and configure the service is described in the SynchroniCity GITLab[4], and validator API is fully described in a Swagger page[5] from which it can be used.

The main instance of the SynchroniCity MiMs validator is permanently running and it performs daily validation of the different SynchroniCity instances, checking the compliance of the interfaces and

[4] https://gitlab.com/synchronicity-iot/rz-instance-validator/tree/master#synchronicity-mim-validator
[5] https://framework-validator.synchronicity-iot.smartsantander.eu/api-docs/

data models with SynchroniCity MiMs. Figure 2 represents the main interfaces and components of the MiMs validation tool.

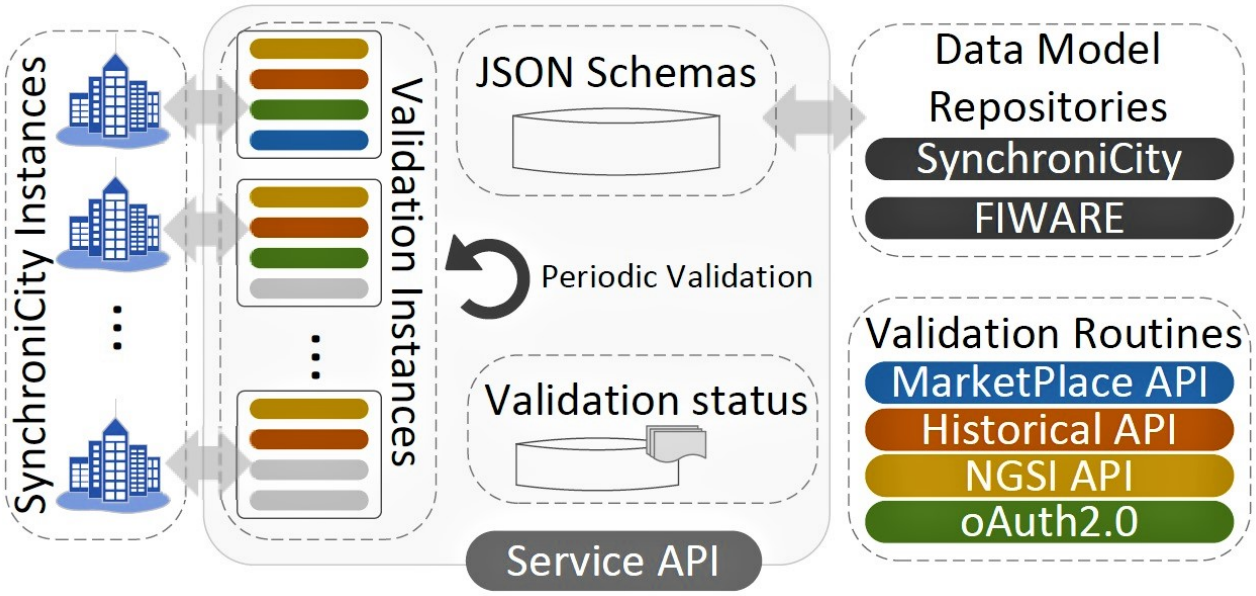

Figure 2. SynchroniCIty MiMs validator components

In addition to this, we have developed a web page[6] to reveal a summarized version of the validation status. Figure 3 shows a snapshot of this web page, where we show the types of entities present in each city, the current status of the data models' validation, total number of entities of each type and total number of entities per city. The objective of this web page is to provide the overall information of the validation status of the cities, while the more detailed reports of such validation can be retrieved from the validator API.

Figure 3. Snapshot of the web page showing the validation status

[6] https://validation.services.synchronicity-iot.eu/table/

Although the functionality of the validator has not been changed, its implementation has been adapted according to modifications in the deployment of the SynchroniCity instances and the way new instances have been deployed. In particular, to ensure data isolation some cities have exposed multiple endpoints for different city services, pilots and/or types of entities. Other cities, however, have accomplished data isolation by exploiting the service/servicePath concepts of the NGSI interfaces. According to that, the validator has been re-structured to use the concept of service as a validation element, instead of the endpoint used in previous versions. As a consequence, each service is identified with a 4-tuple as follows:

- **Name:** Name of the city in which the service is deployed. It corresponds to the SynchroniCity instance.
- **Endpoint:** This is the URL where the API is deployed. It is worth noting that different URLs can be mapped over the same service, although such configuration is internal and hidden to external users.
- **Service:** It is the name of the city service provided by the NGSI utilities. This utility isolates data using different databases.
- **Service path:** This feature allows the usage of different paths within a service, such as a folder tree. Thus, this is a virtual data isolation, rather than physical isolation.

Based on this multi-parameter configuration, the validation is able to adapt the validation flow to the different approaches followed by the cities. A detailed description of the validation features for each of the configurations can be found in D4.3-Section 2.2.1.

3 SynchroniCity Core Pilot Cities update

This section updates the D4.3 validation process carried out together with the core pilot cities in M27, before starting the Open Call piloting phase. This part of the validation process shows the evolution of the core pilot cities during the Open Call piloting phase, one by one, in terms of available interfaces and data sets.

The validation of new cities with SynchroniCity instances will be carried out in the corresponding pilot validation, in Section 4 of this document, following the same procedure as core pilot cities.

Following the same validation schema as in D4.3, an instance of the SynchroniCity MiM validator tool, described in Section 2.2, has been deployed and configured according to cities instructions to execute the corresponding validation process.

For each city (RZ), the interfaces and data sets have been requested for validation.

The online validation process, mentioned in Section 2.2, returns detailed results of the status of the different APIs and the datasets found on each configured SynchroniCity framework instance. These results point to what is SynchroniCity compliant and what is not, detailing exactly what is failing. Presented in this document is the status of each RZ both summarised and colour coded for Interfaces validation (Table 3):

	The component/Interface satisfactorily passed the corresponding validation process, with few minor remarks (if any).
	The component/Interface is mandatory and is present/reachable but failed the corresponding validation process because of required functionalities mismatched and/or not SynchroniCity compliant. In any case, these reported issues are feasible to be rectified.

	This component/interface is mandatory and is not present or not compliant at all with SynchroniCity specifications
	The component/interface is not mandatory and has not been validated because it is not reachable, not deployed, specific credentials that are needed that have not been provided, etc.

Table 3. Colour code showing validated component result/status

The results from the last validation conducted on each Reference Zone are shown in the next subsections.

For the provided endpoints, Table 3 colour codes are used to comment on each RZ's status. When "Auth. Required" column is marked as "Yes", an OAuth token is required, and the SynchroniCity Security Layer was also validated.

In each data set validation, a comparison table is provided, showing the status before the deployment of the Open Call pilots (D4.3), the validation results after the piloting phase and the increase to available datasets. The "Total" column represents the total number of entities from each SynchroniCity data model available in the SynchroniCity instance, while the "Valid" column shows how many of them are fully compliant with the corresponding approved schema.

3.1 Porto's Reference Zone MiMs validation

3.1.1 Endpoints, interfaces and core components

PORTO's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	https://broker.fiware.urbanplatform.portodigital.pt	Orion Context Broker endpoint	NO	NGSI Interface: NGSIv2
Identity Management	http://idm.urbanplatform.portodigital.pt/	IdM Keyrock	YES	OAuth 2.0 (Supported)
Historical Data	https://ql.urbanplatform.portodigital.pt/	QuantumLeap REST API implementation	NO	SynchroniCity Historical API
	https://history-data.fiware.urbanplatform.portodigital.pt/	STH-Comet REST API endpoint	NO	SynchroniCity Historical API

Table 4. Porto's deployed components (Synchronicity Architecture)

3.1.2 Data models and available data sets

PORTO's Reference Zone data model validation						
Data Set	**Before Open Call pilots**		**After Open Call pilots**		**Increase**	
	Total	Valid	Total	Valid	Total	Valid
AirQualityObserved	5	5	5	5	0	0
ArrivalEstimation	8	0	-	-	-8	0
CrowdFlowObserved	-	-	30	30	30	30

Device	191	155	305	177	114	22
GtfsAgency	1	1	1	1	0	0
GtfsCalendarDateRule	-	-	28	28	28	28
GtfsCalendarRule	15	15	18	18	3	3
GtfsRoute	73	73	73	73	0	0
GtfsService	15	15	18	18	3	3
GtfsStop	2468	2468	2579	2463	111	-5
GtfsTransitFeedFile	1	1	2	0	1	-1
NoiseLevelObserved	15	13	15	15	0	2
OffStreetParking	1	1	1	1	0	0
PointOfInterest	3062	2696	3062	3015	0	319
ThreePhaseMultiCircuitAcMeasurement	-	-	4	0	4	0
TrafficFlowObserved	115	115	389	124	274	9
Vehicle	246	0	-	-	-246	0
WasteContainer	-	-	207	0	207	0
WasteContainerModel	-	-	153	153	153	153
WasteMeasurement	-	-	1	0	1	0
WeatherForecast	131	131	132	131	1	0
WeatherObserved	17	12	12	8	-5	-4

Table 5. Evolution of the Porto's data model validation. The table depicts the status before and after the Open Call piloting phase, as well as the increase between them.

3.2 Santander's Reference Zone MiMs validation

3.2.1 Endpoints, interfaces and core components

SANTANDER's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	https://context.san.synchronicity-iot.eu	Orion Context Broker endpoint	YES	NGSI Interface: NGSIv2
Identity Management	https://auth.san.synchronicity-iot.eu	IdM Keyrock	YES	OAuth 2.0
Historical Data	https://historical.san.synchronicity-iot.eu	QuantumLeap REST API implementation	YES	SynchroniCity Historical API

Marketplace	https://marketplace.san.synchronicity-iot.eu	SynchroniCity Marketplace	YES	TCM

Table 6. Santander's deployed components (Synchronicity Architecture)

3.2.2 Data models and available data sets

Santander's Reference Zone data model validation						
Data Set	**Before Open Call pilots**		**After Open Call pilots**		**Increase**	
	Total	Valid	Total	Valid	Total	Valid
AirQualityObserved	77	77	109	104	32	27
ArrivalEstimation	25	25	25	0	0	-25
Beach	13	13	13	13	0	0
BikeHireDockingStation	16	16	19	19	3	3
Device	325	325	325	325	0	0
GreenEnergyGenerator	-	-	2	0	2	0
GreenEnergyMeasurement	-	-	2	0	2	0
GreenspaceRecord	18	18	18	18	0	0
GtfsTransitFeedFile	2	2	2	0	0	-2
Museum	10	10	10	10	0	0
NoiseLevelObserved	16	16	26	26	10	10
OffStreetParking	-	-	2	2	2	2
OnStreetParking	23	23	23	23	0	0
ParkingSpot	323	323	324	324	1	1
PointOfInterest	214	214	214	214	0	0
PublicTransportRoute	32	32	32	32	0	0
PublicTransportStop	449	449	521	449	72	0
Store	2170	2170	2170	0	0	-2170
TrafficFlowObserved	311	311	311	311	0	0
Vehicle	92	92	105	105	13	13
WeatherForecast	6	6	6	6	0	0
WeatherObserved	207	207	210	210	3	3
WasteMeasurement	-	-	3	0	3	0

Table 7. Evolution of the Santander's data model validation. The table depicts the status before and after the Open Call piloting phase, as well as the increase between them.

3.3 Antwerp's Reference Zone MiMs validation

3.3.1 Endpoints, interfaces and core components

ANTWERP's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	https://ext-api-gw-p.antwerpen.be/digipolis/sbascactivetravelis/v1	Orion Context Broker endpoint	YES	NGSI Interface: NGSIv2
	https://ext-api-gw-p.antwerpen.be/digipolis/sbascencouragingcyc/v1	Orion Context Broker endpoint	YES	NGSI Interface: NGSIv2
	https://ext-api-gw-p.antwerpen.be/digipolis/sbasckissmybike/v1	Orion Context Broker endpoint	YES	NGSI Interface: NGSIv2
	https://ext-api-gw-p.antwerpen.be/digipolis/sbascrainbrain/v1	Orion Context Broker endpoint	YES	NGSI Interface: NGSIv2
	https://ext-api-gw-p.antwerpen.be/digipolis/sbascstreetlights/v1	Orion Context Broker endpoint	YES	NGSI Interface: NGSIv2
Identity Management	https://ext-api-gw-p.antwerpen.be/sirus/orion-consumer-api-a/v2/oauth2	WSO2	YES	OAuth 2.0
Historical Data	https://ext-api-gw-p.antwerpen.be/digipolis/sctravelinsightsh/v1	STH-Comet REST API endpoint	YES	SynchroniCity Historical API
	https://ext-api-gw-p.antwerpen.be/digipolis/scencouragingcych/v1	STH-Comet REST API endpoint	YES	SynchroniCity Historical API
	https://ext-api-gw-p.antwerpen.be/digipolis/sckissmybikeh/v1	STH-Comet REST API endpoint	YES	SynchroniCity Historical API
	https://ext-api-gw-p.antwerpen.be/digipolis/scrainbrainh/v1	STH-Comet REST API endpoint	YES	SynchroniCity Historical API
	https://ext-api-gw-p.antwerpen.be/digipolis/streetlightsh/v1	STH-Comet REST API endpoint	YES	SynchroniCity Historical API
Marketplace	https://ext-api-store.antwerpen.be	Kong Marketplace	YES	n.a.

Table 8. Antwerp's deployed components (Synchronicity Architecture)

3.3.2 Data models and available data sets

Antwerp's Reference Zone data model validation

Data Set	Before Open Call pilots		After Open Call pilots		Increase	
	Total	Valid	Total	Valid	Total	Valid
AirQualityObserved	12	0	32	10	20	10
BikeHireDockingStation	-	-	106	0	106	0
CrowdFlowObserved	-	-	16	0	16	0
Device	-	-	292	0	292	0
Garden	-	-	11	6	11	6
GreenspaceRecord	-	-	22858	15838	22858	15838
ParkingSpot	-	-	313		313	
TrafficFlowObserved	-	-	184	14	184	14
Vehicle	-	-	32	32	32	32
WasteContainer	159	62	162	73	3	11
WeatherForecast	-	-	2838	796	2838	796
WeatherObserved	-	-	22152	13944	22152	13944

Table 9. Evolution of the Antwerp's data model validation. The table depicts the status before and after the Open Call piloting phase, as well as the increase between them.

3.4 Eindhoven's Reference Zone MiMs validation

3.4.1 Endpoints, interfaces and core components

EINDHOVEN's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	http://mycity.techlab.atos.net/orion/v2	Orion Context Broker endpoint	NO	NGSI Interface: NGSIv2
Identity Management				
Historical Data				

Table 10. Eindhoven's deployed components (Synchronicity Architecture)

3.4.2 Data models and available data sets

EINDHOVEN's Reference Zone data model validation			
Data Set	**Before Open Call pilots**	**After Open Call pilots**	**Increase**

	Total	Valid	Total	Valid	Total	Valid
AirQualityObserved	35	35	-	-	-35	-35
Device	-	_	32	0	32	0
Garden	-	_	8	8	8	8
GreenspaceRecord	-	_	44213	44213	44213	44213
NoiseLevelObserved	_	_	16	0	16	0
WeatherForecast	-	_	800	224	800	224
WeatherObserved	-	_	23306	23306	23306	23306

Table 11. Evolution of the Eindhoven's data model validation. The table depicts the status before and after the Open Call piloting phase, as well as the increase between them.

3.5 Helsinki's Reference Zone MiMs validation

3.5.1 Endpoints, interfaces and components

HELSINKI's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	https://ngsi.fvh.fi/v2	Orion Context Broker endpoint (read)	NO	NGSI Interface: NGSIv2
	https://synchronicity.cs.hut.fi/orion/v2/	Orion Context Broker endpoint (write)	NO	NGSI Interface: NGSIv2
Identity Management				
Historical Data				

Table 12. Helsinki's deployed components (Synchronicity Architecture)

3.5.2 Data models and available data sets

HELSINKI's Reference Zone data model validation						
Data Set	**Before Open Call pilots**		**After Open Call pilots**		**Increase**	
	Total	Valid	Total	Valid	Total	Valid
BikeHireDockingStation	347	347	472	472	125	125
AirQualityObserved	52	41	168	115	116	74
NoiseLevelObserved	7	7	14	14	7	7
WeatherObserved	14	14	14	14	0	0
TrafficFlowObserved	_	_	146	0	146	0

CrowdFlowObserved	-	-	16	0	16	0

Table 13. Evolution of the Helsinki's data model validation. The table depicts the status before and after the Open Call piloting phase, as well as the increase between them.

3.6 Manchester's Reference Zone MiMs validation

3.6.1 Endpoints, interfaces and core components

MANCHESTER's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	https://broker.iot-data-marketplace.com	Orion Context Broker endpoint	YES	NGSI Interface: NGSIv2
Identity Management	https://auth.iot-data-marketplace.com	IdM Keyrock	YES	OAuth 2.0
Historical Data	https://historical.iot-data-marketplace.com	Proprietary	YES	SynchroniCity Historical API
Marketplace	https://iot-data-marketplace.com/	SynchroniCity Marketplace	YES	TCM

Table 14. Manchester's deployed components (Synchronicity Architecture)

3.6.2 Data models and available data sets

MANCHESTER's Reference Zone data model validation						
Data Set	**Before Open Call pilots**		**After Open Call pilots**		**Increase**	
	Total	Valid	Total	Valid	Total	Valid
AirQualityObserved	3	3	70	2	67	-1
Beach	-	-	13	0	13	0
BikeHireDockingStation	1	1	12	12	11	11
CrowdFlowObserved	40	40	53	0	13	-40
Museum	-	-	10	0	10	0
NoiseLevelObserved	6	0	16	0	10	0
OffStreetParking	80	9	28	28	-52	19
OnStreetParking	464	464	41	41	-423	-423
ParkingSpot	-	-	119	0	119	0
TrafficFlowObserved	12	12	503	4	491	-8
Vehicle	-	-	20	0	20	0

WeatherForecast	-	-	116	0	116	0
WeatherObserved	6	6	18	0	12	-6
WasteMeasurement	-	-	1	0	1	0

Table 15. Evolution of the Manchester's data model validation. The table depicts the status before and after the Open Call piloting phase, as well as the increase between them.

3.7 Milan's Reference Zone MiMs validation

3.7.1 Endpoints, interfaces and core components

MILAN's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	https://api.comune.milano.it/synchronicity/context/1.0	Orion Context Broker endpoint	YES	NGSI Interface: NGSIv2
Identity Management	https://api.comune.milano.it/token	WSO2	YES	OAuth 2.0
Historical Data	https://api.comune.milano.it/synchronicity/comet/1.0	STH-Comet REST API endpoint	YES	SynchroniCity Historical API
	https://api.comune.milano.it/synchronicity/historical/1.0	SynchroniCity Historical data API (on top of comet)	YES	SynchroniCity Historical API
Marketplace	https://apisp.comune.milano.it/store/	WSO2 based	YES	n.a.

Table 16. Milan's deployed components (Synchronicity Architecture)

3.7.2 Data models and available data sets

MILAN's Reference Zone data model validation						
Data Set	**Before Open Call pilots**		**After Open Call pilots**		**Increase**	
	Total	Valid	Total	Valid	Total	Valid
AirQualityObserved	852	852	426	426	-426	-426
BikeHireDockingStation	767	767	867	867	100	100
CarSharingStation	113	113	113	113	0	0
Device	-	-	3	0	3	0
EVChargingStation	63	63	63	63	0	0
Garden	1064	1064	1064	1064	0	0
GtfsAgency	4	4	2	2	-2	-2

GtfsCalendarRule	1414	1414	707	707	-707	-707
GtfsFrequency	1414	1414	707	707	-707	-707
GtfsRoute	582	582	291	291	-291	-291
GtfsService	1414	1414	707	707	-707	-707
GtfsShape	582	582	291	291	-291	-291
GtfsStation	6886	6886	3443	3443	-3443	-3443
GtfsStop	10618	10618	5309	0	-5309	-10618
GtfsStopTime	71356	71356	35678	35678	-35678	-35678
GtfsTransitFeedFile	4	0	2	0	-2	0
GtfsTrip	1414	1414	707	707	-707	-707
OffStreetParking	74	74	74	74	0	0
OnStreetParking	-	-	175	73	175	73
ParkingSpot	-	-	211	210	211	210
PointOfInterest	75999	75999	75546	75546	-453	-453
PublicTransportStop	-	-	62	62	62	62
QueueMonitor	-	-	75	75	75	75
RestrictedTrafficArea	177	177	177	177	0	0
Road	4331	4331	4331	4331	0	0
ThreePhaseMultiCircuitAcMeasurement	-	-	3	0	3	0
Vehicle	2	0	16	16	14	16
WeatherObserved	4253	4253	2124	2124	-2129	-2129

Table 17. Evolution of the Milan's data model validation. The table depicts the status before and after the Open Call piloting phase, as well as the increase between them.

3.8 Carouge's Reference Zone MiMs validation

3.8.1 Endpoints, interfaces and core components

CAROUGE's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	https://orion.cityreport.org:5005	Orion Context Broker endpoint	YES	NGSI Interface: NGSIv2
Identity Management	https://keyrock.cityreport.org:443	WSO2	YES	OAuth 2.0

Historical Data	https://orion.cityreport.org:5005/v2/entities	Proprietary	YES	SynchroniCity Historical API

Table 18. Carouge's deployed components (Synchronicity Architecture)

3.8.2 Data models and available data sets

CAROUGE's Reference Zone data model validation						
Data Set	**Before Open Call pilots**		**After Open Call pilots**		**Increase**	
	Total	Valid	Total	Valid	Total	Valid
AirQualityObserved	12	12	306	302	294	290
Device	-	-	10	0	10	0
NoiseLevelObserved	-	-	908	0	908	0
OffStreetParking	25	24	51	46	26	22
OnStreetParking	16	16	32	32	16	16
ParkingSpot	1	0	3	0	2	0
ThreePhaseMultiCircuitAcMeasurement	-	-	5	0	5	0
TrafficFlowObserved	254	254	126	126	-128	-128
Vehicle	18	18	37	36	19	18
WasteContainer	-	-	4	0	4	0
WasteContainerModel	-	-	2	2	2	2

Table 19. Evolution of the Carouge's data model validation. The table depicts the status before and after the Open Call piloting phase, as well as the increase between them.

4 Pilot's validation outcomes

This section analyses the results of the pilots based on the information provided in their M6 final report, following the validation mechanisms described in section 2.

For each pilot, the following points are checked:

- **Endpoints** used for integrating the solution, paying special attention to the **new instances** deployed. The results of the endpoints' validation follow the same colors code as core pilot cities, exposed in Table 3.
- **Generated data sets** in each pilot city's SynchroniCity instance, checking the number of entities created for each data set and if they adopt SynchroniCity data models (valid entities).
- **Consumed data sets** in each pilot city's SynchroniCity instance, checking the number of entities consumed for each data set.

4.1 Active Travel Insights

4.1.1 Endpoints and interfaces used

City	Endpoint	Interoperability Points	Auth. Required	Reference standards / Specifications
ANTWERP	https://ext-api-gw-p.antwerpen.be/digipolis/sbascactivetravelis/v1	Context Information Management	YES	NGSI Interface: NGSIv2
HELSINKI	https://synchronicity.cs.hut.fi/orion/v2	Context Information Management	NO	NGSI Interface: NGSIv2
MANCHESTER	https://broker.iot-data-marketplace.com/v2	Context Information Management	YES	NGSI Interface: NGSIv2

Table 20. Endpoints managed by Active Travel Insights

4.1.2 Generated datasets

ANTWERP's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
TrafficFlowObserved	Vehicle count	170	0
CrowdFlowObserved	Crowd count	16	0
AirQualityObserved	Air quality data	1	0
HELSINKI's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
TrafficFlowObserved	Vehicle count	146	0
CrowdFlowObserved	Crowd count	16	0
MANCHESTER's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
TrafficFlowObserved	Vehicle count	239	4
CrowdFlowObserved	Crowd count	23	0
AirQualityObserved	Air quality data	2	2

Table 21. Active Travel Insights list of NGSI context entities generated

4.1.3 Consumed datasets

According to the information provided by the pilot in M6 report, Table 3 shows the datasets consumed by Active Travel Insights in the endpoints piloted, through the corresponding NGSI interface and according SynchroniCity defined data models.

HELSINKI's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
AirQualityObserved	Air quality condition	3*	111

Table 22. Active Travel Insights list of consumed NGSI context entities

4.2 ASAP-VALUE : A Standards-based Approach to enhancing VALUE from city data lake

The validation of ASAP-Value has follow a different process from the rest of the pilots. In their case, the new instances deployed are not SynchroniCity compliant to the current model as they are based in the most recent NGSI-LD interface [5] instead of NGSIv2 [4]. Nevertheless, it has been considered that NGSI-LD is the natural evolution of the SynchroniCity framework, and so it has been validated, not with the validation tool, used to validate NGSIv2 interfaces, but following a manual approach carried out by the technical validation team.

In the case of Carouge, however, the pilot makes use of an NGSIv2 endpoint, and the same validation mechanisms as the rest of pilots have been followed.

4.2.1 Endpoints and interfaces used

Core pilot cities' Interfaces used (endpoints integrated)

City	Endpoint	Interoperability Points	Auth. Required	Reference standards / Specifications
CAROUGE	https://orion.cityreport.org:5005/v2/	Context Information Management	YES	NGSI Interface: NGSIv2
	https://orion.cityreport.org:5005/v2/	Historical data	YES	SynchroniCity Historical API

Table 23. Core pilot cities' endpoints managed by ASAP-Value

New instances deployed validation

The new instances have been validated following the same approach as in the core pilot cities, detailed in section 3 of this document. The next table presents the results of the validation process, following the colour code of Table 3.

BORDEAUX's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	https://bordeaux.sensinov.com/ngsi-ld/v1/	Orion Context Broker endpoint	Yes	NGSI Interface: NGSI-LD
Identity Management	https://bordeaux.sensinov.com/login		Not accessible	oAuth2.0
Historical Data	https://bordeaux.sensinov.com/ngsi-ld/v1/	Historical data	Yes	Historical API
SEONGNAM's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	https://bordeaux.sensinov.com/ngsi-ld/v1/	Orion Context Broker endpoint	Yes	NGSI Interface: NGSI-LD
Identity Management	https://seongnam.sensinov.com/login		Not accessible	oAuth2.0
Historical Data	https://bordeaux.sensinov.com/ngsi-ld/v1/	Historical data	Yes	Historical API

Table 24. New pilot cities' endpoints managed by ASAP-Value

4.2.2 Generated datasets

CAROUGE's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
-	-	-	-
BORDEAUX's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
EVChargingStation	Public charging station supplying energy to electrical vehicles	3	3
SEONGNAM's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**

OffStreetParking	Off-street parking site	3	3
ParkingSpot	Individual parking spot/parking lot	460	460

Table 25. ASAP-Value list of NGSI context entities generated

4.2.3 Consumed datasets

According to the information provided by the pilot in M6 report, Table 26 shows the datasets consumed by AAQM in the endpoints piloted, through the corresponding NGSI interface and according SynchroniCity defined data models.

CAROUGE's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
OffStreetParking	Off-street parking site	*	51
OnStreetParking	On-street parking site	*	32
TrafficFlowObserved	Vehicle count	*	126
Vehicle	Real time tracking of the vehicles	*	37
BORDEAUX's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
EVChargingStation	Public charging station supplying energy to electrical vehicles	urn:ngsi-ld:EVChargingStation:<identifier>:ASAP-VALUE	3
SEONGNAM's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
OffStreetParking	Off-street parking site	urn:ngsi-ld:OffStreetParking:<identifier>:ASAP-VALUE	3
ParkingSpot	Individual parking spot/parking lot	urn:ngsi-ld:ParkingSpot:<identifier>:ASAP-VALUE	460

Table 26. ASAP-Value list of consumed NGSI context entities

4.3 Autonomous Hub for Cyclist

4.3.1 Endpoints and interfaces used

Core pilot cities' Interfaces used (endpoints integrated)

City	Endpoint	Interoperability Points	Auth. Required	Reference standards / Specifications

SANTANDER	https://context.san.synchronicity-iot.eu/v2	Context Information Management	YES	NGSI Interface: NGSIv2
	https://historical.san.synchronicity-iot.eu/	Marketplace	YES	Marketplace API

Table 27. Core pilot cities' endpoints managed by Autonomous Hub for Cyclist

New instances deployed validation

The new instances have been validated following the same approach as in the core pilot cities, detailed in section 3 of this document. The next table presents the results of the validation process, following the colour code of Table 3.

LA NUCIA's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	https://test.synchronicity.ridespark.com:1026/v2	Orion Context Broker endpoint	No	NGSI Interface: NGSIv2
Identity Management				
Historical Data	https://test.synchronicity.ridespark.com:8080	Historical Data	No	SynchroniCity Historical API
DONEGAL's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	https://test.synchronicity.ridespark.com:1026/v2/	Orion Context Broker endpoint	No	NGSI Interface: NGSIv2
Identity Management				
Historical Data	https://test.synchronicity.ridespark.com:8080	Historical Data	No	SynchroniCity Historical API
PALENCIA's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	https://test.synchronicity.ridespark.com:1026/v2	Orion Context Broker endpoint	No	NGSI Interface: NGSIv2
Identity Management				
Historical Data	https://test.synchronicity.ridespark.com:8080	Historical Data	No	SynchroniCity Historical API
BEZANA's Reference Zone SynchroniCity Framework INSTANCE				

Interfaces (Interoperability Points)	Endpoint	Description	Auth. Required	Reference standards / Specifications
Context Information Management	https://test.synchronicity.ridespark.com:1026/v2/	Orion Context Broker endpoint	No	NGSI Interface: NGSIv2
Identity Management				
Historical Data	https://test.synchronicity.ridespark.com:8080	Historical Data	No	SynchroniCity Historical API

Table 28. New pilot cities' endpoints managed by Autonomous Hub for Cyclist

4.3.2 Generated datasets

SANTANDER's data model validation			
Dataset	Description	Nº of Entities	
		Total	Valid
OffStreetParking	Off-street parking site	1	1
AirQualityObserved	Air quality condition	1	1
WeatherObserved	Weather conditions	1	1
GreenEnergyGenerator	Green energy device	1	0
GreenEnergyMeasurement	Snapshot measure of energy	1	0
BikeHireDockingStation	Bike hire docking station	1	1
LA NUCIA's data model validation			
Dataset	Description	Nº of Entities	
		Total	Valid
OffStreetParking	Off-street parking site	2	2
AirQualityObserved	Air quality condition	1	1
WeatherObserved	Weather conditions	1	1
BikeHireDockingStation	Bike hire docking station	1	1
DONEGAL's data model validation			
Dataset	Description	Nº of Entities	
		Total	Valid
OffStreetParking	Off-street parking site	1	1
AirQualityObserved	Air quality condition	1	1

WeatherObserved	Weather conditions	1	1
BikeHireDockingStation	Bike hire docking station	1	1
PALENCIA's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
OffStreetParking	Off-street parking site	1	1
AirQualityObserved	Air quality condition	1	1
WeatherObserved	Weather conditions	1	1
BEZANA's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
OffStreetParking	Off-street parking site	1	1
AirQualityObserved	Air quality condition	1	1
WeatherObserved	Weather conditions	1	1

Table 29. Autonomous Hub list of NGSI context entities generated

4.3.3 Consumed datasets

According to the information provided by the pilot in M6 report, Table 30 shows the datasets consumed by Autonomous Hub in the endpoints piloted, through the corresponding NGSI interface and according SynchroniCity defined data models.

SANTANDER's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
OffStreetParking	Off-street parking site	urn:ngsi-ld:OffStreetParking:santander:parking:*	1
AirQualityObserved	Air quality condition	urn:ngsi-ld:AirQualityObserved:santander:environment:*	1
WeatherObserved	Weather conditions	urn:ngsi-ld:WeatherObserved:santander:environment:*	1
GreenEnergyGenerator	Green energy device	urn:ngsi-ld:GreenEnergyGenerator:santander:greenenergy:*	1
GreenEnergyMeasurement	Snapshot measure of energy	urn:ngsi-ld:GreenEnergyMeasurement:santander:greenenergy:*	1
BikeHireDockingStation	Bike hire docking station	urn:ngsi-ld:BikeHireDockingStation:santander:transportation:*	1
LA NUCIA's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
OffStreetParking	Off-street parking site	urn:ngsi-ld:OffStreetParking:lanucia:parking:*	2

AirQualityObserved	Air quality condition	urn:ngsi-ld:AirQualityObserved:lanucia:enviroment:*	1
WeatherObserved	Weather conditions	urn:ngsi-ld:WeatherObserved:lanucia:enviroment:*	1
BikeHireDockingStation	Bike hire docking station	urn:ngsi-ld:BikeHireDockingStation:lanucia:transportation:*	1
DONEGAL's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
OffStreetParking	Off-street parking site	urn:ngsi-ld:OffStreetParking:donegal:parking:*	1
AirQualityObserved	Air quality condition	urn:ngsi-ld:AirQualityObserved:donegal:environment:*	1
WeatherObserved	Weather conditions	urn:ngsi-ld:WeatherObserved:donegal:enviroment:*	1
BikeHireDockingStation	Bike hire docking station	urn:ngsi-ld:BikeHireDockingStation:donegal:transportation:*	1
PALENCIA's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
OffStreetParking	Off-street parking site	urn:ngsi-ld:OffStreetParking:palencia:parking:*	1
AirQualityObserved	Air quality condition	urn:ngsi-ld:AirQualityObserved:palencia:environment:*	1
WeatherObserved	Weather conditions	urn:ngsi-ld:WeatherObserved:palencia:enviroment:*	1
BEZANA's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
OffStreetParking	Off-street parking site	urn:ngsi-ld:OffStreetParking:bezana:parking:*	1
AirQualityObserved	Air quality condition	urn:ngsi-ld:AirQualityObserved:bezana:enviroment:*	1
WeatherObserved	Weather conditions	urn:ngsi-ld:WeatherObserved:bezana:enviroment:*	1

Table 30. Autonomous Hub list of consumed NGSI context entities

4.4 AAQM - Autonomous Real-Time Field Service Solution for Public Real Estate Air Quality Management

4.4.1 Endpoints and interfaces used

Core pilot cities' Interfaces used (endpoints integrated)

City	Endpoint	Interoperability Points	Auth. Required	Reference standards / Specifications
HELSINKI	https://synchronicity.cs.hut.fi/orion/v2	Context Information Management	NO	NGSI Interface: NGSIv2
SANTANDER	https://context.san.synchronicity-iot.eu/v2	Context Information Management	YES	NGSI Interface: NGSIv2
	https://marketplace.san.synchronicity-iot.eu	Marketplace	YES	Marketplace API

Table 31Core pilot cities' endpoints managed by by AAQM

New instances deployed validation

The new instance has been validated following the same approach as in the core pilot cities, detailed in section 3 of this document. The next table presents the results of the validation process, following the colour code of Table 3.

TAMPERE's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	https://test.synchronicity.ridespark.com:1026/v2	Orion Context Broker endpoint	YES	NGSI Interface: NGSIv2
Identity Management	https://accounts.tampere.apinf.cloud/oauth2/password	IdM Keyrock	YES	OAuth 2.0
Historical Data				

Table 32. Results the validation of new pilot cities' endpoints managed by AAQM

4.4.2 Generated datasets

HELSINKI's data model validation		
Dataset	**Description**	**Nº of Entities**

		Total	Valid
AirQualityObserved	Air quality condition	111	76
SANTANDER's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
AirQualityObserved	Air quality condition	28	23
TAMPERE's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
AirQualityObserved	Air quality condition	53	51

Table 33. AAQM list of NGSI context entities generated

4.4.3 Consumed datasets

According to the information provided by the pilot in M6 report, Table 34 shows the datasets consumed by AAQM in the endpoints piloted, through the corresponding NGSI interface and according SynchroniCity defined data models.

HELSINKI's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
WeatherObserved	Weather conditions	*	14

Table 34. AAQM list of consumed NGSI context entities

4.5 BlueAlpaca

4.5.1 Endpoints and interfaces used

City	Endpoint	Interoperability Points	Auth. Required	Reference standards / Specifications
MILAN	https://api.comune.milano.it/synchronicity/context/1.0/v2/	Context Information Management	YES	NGSI Interface: NGSIv2
SANTANDER	https://context.san.synchronicity-iot.eu/v2	Context Information Management	YES	NGSI Interface: NGSIv2
	https://marketplace.san.synchronicity-iot.eu	Marketplace	YES	Marketplace API
HELSINKI	https://synchronicity.cs.hut.fi/orion/v2	Context Information Management	NO	NGSI Interface: NGSIv2

ANTWERP	https://ext-api-gw-p.antwerpen.be/digipolis/cutlera/v1	Context Information Management	YES	NGSI Interface: NGSIv2

Table 35. Endpoints managed by BlueAlpaca

4.5.2 Generated datasets

No datasets generated.

4.5.3 Consumed datasets

According to the information provided by the pilot in M6 report, Table 36 shows the datasets consumed by BlueAlpaca in the endpoints piloted, through the corresponding NGSI interface and according SynchroniCity defined data models.

MILAN's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
QueueMonitor	Single queue line for a single service	urn:ngsi-ld:QueueMonitor:Milan:PublicOffice:API:*	25
SANTANDER's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
BikeHireDockingStation	Bike hire docking station	urn:ngsi-ld:BikeHireDockingStation:santander:transport:bikeDockStation:*	17
HELSINKI's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
BikeHireDockingStation	Bike hire docking station	*	472
AirQualityObserved	Air quality condition	*	111
ANTWERP's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
AirQualityObserved	Air quality condition	AirQualityObserved:VMM:*	9
WeatherObserved	Weather conditions	WeatherObserved:IMDC:*	11

Table 36. BlueAlpaca list of consumed NGSI context entities

4.6 Clean Air School Districts (CASD)

4.6.1 Endpoints and interfaces used

City	Endpoint	Interoperability Points	Auth. Required	Reference standards / Specifications

ANTWERP	https://ext-api-gw-p.antwerpen.be/digipolis/aovmma/v1/	Context Information Management	YES	NGSI Interface: NGSIv2
CAROUGE	https://orion.cityreport.org:5005/v2	Context Information Management	YES	NGSI Interface: NGSIv2
HELSINKI	https://synchronicity.cs.hut.fi/orion/v2	Context Information Management	NO	NGSI Interface: NGSIv2

Table 37. Endpoints managed by CASD

4.6.2 Generated datasets

ANTWERP's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
AirQualityObserved	Air quality condition	10	10
CAROUGE's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
AirQualityObserved	Air quality condition	46	46
HELSINKI's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
AirQualityObserved	Air quality condition	3	3

Table 38. CASD list of NGSI context entities generated

4.6.3 Consumed datasets

According to the information provided by the pilot in M6 report, Table 39 shows the datasets consumed by CASD in the endpoints piloted, through the corresponding NGSI interface and according SynchroniCity defined data models.

ANTWERP's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
AirQualityObserved	Air quality condition	AirQualityObserved:VMM:*	9
CAROUGE's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
AirQualityObserved	Air quality condition	urn:ngsi-ld:AirQualityObserved:carouge:environment:fixed:*	92

HELSINKI's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
AirQualityObserved	Air quality condition	Not defined (all entities)	111

Table 39. CASD list of consumed NGSI context entities

4.7 Encouraging Cycling through use of Crowdsourced Data-Driven Insights

4.7.1 Endpoints and interfaces used

Core pilot cities' Interfaces used (endpoints integrated)

City	Endpoint	Interoperability Points	Auth. Required	Reference standards / Specifications
MANCHESTER	https://broker.iot-data-marketplace.com/v2/entities	Context Information Management	YES	NGSI Interface: NGSIv2
ANTWERP	https://ext-api-gw-p.antwerpen.be/digipolis/sbascencouragingcyc/v1	Context Information Management	YES	NGSI Interface: NGSIv2

Table 40. Core pilot cities' endpoints managed by by AAQM

New instances deployed validation

The new instance has been validated following the same approach as in the core pilot cities, detailed in section 3 of this document. The next table presents the results of the validation process, following the colour code of Table 3.

DUBLIN's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	https://broker.iot-data-marketplace.com/v2/entities	Orion Context Broker endpoint	YES	NGSI Interface: NGSIv2
Identity Management	https://auth.iot-data-marketplace.com/oauth2	IdM Keyrock	YES	OAuth 2.0
Historical Data				
Marketplace	https://iot-data-marketplace.com/#/offering?catalogueId=802	SynchroniCity Marketplace	YES	TCM

Table 41. Results the validation of new pilot cities' endpoints managed by Encouraging Cycling

4.7.2 Generated datasets

DUBLIN's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
BikeHireDockingStation	Bike hire docking station	12	12
WeatherObserved	Observation of weather conditions at a certain place and time.	17	0
TrafficFlowObserved	Vehicle count	264	0
WeatherForecast	Harmonised description of a Weather Forecast.	115	115
MANCHESTER's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
BikeHireDockingStation	Bike hire docking station	12	12
WeatherObserved	Observation of weather conditions at a certain place and time.	17	0
TrafficFlowObserved	Vehicle count	264	0
WeatherForecast	Harmonised description of a Weather Forecast.	115	115
ANTWERP's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
BikeHireDockingStation	Bike hire docking station	106	0
TrafficFlowObserved	Vehicle count	9	9

Table 42. Encouraging Cycling list of NGSI context entities generated

4.7.3 Consumed datasets

No datasets consumed.

4.8 Kimap-City

4.8.1 Endpoints and interfaces used

City	Endpoint	Interoperability Points	Auth. Required	Reference standards / Specifications
SANTANDER	https://context.san.synchronicity-iot.eu/v2	Context Information Management	YES	NGSI Interface: NGSIv2
	https://marketplace.san.synchronicity-iot.eu	Marketplace	YES	Marketplace API

PORTO	https://broker.fiware.urbanplatform.portodigital.pt/v2	Context Information Management	NO	NGSI Interface: NGSIv2
MILAN	https://api.comune.milano.it/synchronicity/context/1.0	Context Information Management	YES	NGSI Interface: NGSIv2

Table 43. Endpoints managed by Kimap-City

4.8.2 Generated datasets

SANTANDER's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
PublicTransportStop	Model for public transport stop	72	0
PORTO's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
GtfsStop	GTFS stop with location_type 0	116	116
MILAN's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
PublicTransportStop	Model for public transport stop	62	0

Table 44. Kimap-City list of NGSI context entities generated

4.8.3 Consumed datasets

According to the information provided by the pilot in M6 report, Table 45 shows the datasets consumed by Kimap-City in the endpoints piloted, through the corresponding NGSI interface and according SynchroniCity defined data models.

SANTANDER's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
PublicTransportStop	Model for public transport stop	Not defined (all entities)	449
PORTO's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
GtfsStop	GTFS stop with location_type 0	urn:ngsi-ld:GtfsStop:porto:bus:stcp:*	2579
MILAN's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**

PublicTransportStop	Model for public transport stop	urn:ngsi-ld:PublicTransportStop:Milan:UrbanMobility:Kimap:*	62

Table 45. Kimap-City list of consumed NGSI context entities

4.9 Kissmybike

4.9.1 Endpoints and interfaces used

City	Endpoint	Interoperability Points	Auth. Required	Reference standards / Specifications
MILAN	https://api.comune.milano.it/synchronicity/context/1.0/v2	Context Information Management	YES	NGSI Interface: NGSIv2
ANTWERP	https://ext-api-gw-p.antwerpen.be/digipolis/sbasckissmybike/v1	Context Information Management	YES	NGSI Interface: NGSIv2
SANTANDER	https://context.san.synchronicity-iot.eu/v2	Context Information Management	YES	NGSI Interface: NGSIv2
	https://marketplace.san.synchronicity-iot.eu	Marketplace	YES	Marketplace API

Table 46. Endpoints managed by Kissmybike

4.9.2 Generated datasets

MILAN's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
Vehicle	Real time tracking of the vehicles	16	16
ANTWERP's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
Vehicle	Real time tracking of the vehicles	16	16
SANTANDER's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
Vehicle	Real time tracking of the vehicles	12	12

Table 47. Kissmybike list of NGSI context entities generated

4.9.3 Consumed datasets

According to the information provided by the pilot in M6 report, Table 48 shows the datasets consumed by Kissmybike in the endpoints piloted, through the corresponding NGSI interface and according SynchroniCity defined data models.

MILAN's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
BikeHireDockingStation	Bike hire docking station	urn:ngsi-ld:BikeHireDockingStation:Milan:BikeSharing:GeoJson:*	288
Road	Contextual description of a road	urn:ngsi-ld:Road:Milan:StreetNames:Csv:*	4325
ANTWERP's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
---	---	---	---
SANTANDER's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
BikeHireDockingStation	Bike hire docking station	urn:ngsi-ld:BikeHireDockingStation:santander:transport:bikeDockStation:*	17

Table 48. Kissmybike list of consumed NGSI context entities

4.10 LINC

4.10.1 Endpoints and interfaces used

City	Endpoint	Interoperability Points	Auth. Required	Reference standards / Specifications
PORTO	https://broker.fiware.urbanplatform.portodigital.pt/v2	Context Information Management	NO	NGSI Interface: NGSIv2
MILAN	https://api.comune.milano.it/synchronicity/context/1.0/v2	Context Information Management	YES	NGSI Interface: NGSIv2
	https://api.comune.milano.it:443/synchronicity/historical/1.0	Historical Data	YES	SynchroniCity Historical API
CAROUGE	https://orion.cityreport.org:5005	Context Information Management	YES	NGSI Interface: NGSIv2

Table 49. Endpoints managed by LINC

4.10.2 Generated datasets

PORTO's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
ThreePhaseMultiCircuitAcMeasurement	Measurement from an electrical sub-metering system	4	0
Device	Apparatus intended to accomplish a particular task	4	0
MILAN's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
ThreePhaseMultiCircuitAcMeasurement	Measurement from an electrical sub-metering system	3	0
Device	Apparatus intended to accomplish a particular task	3	0
CAROUGE's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
ThreePhaseAcMultiCircuitMeasurement	Measurement from an electrical sub-metering system	8	0
Device	Apparatus intended to accomplish a particular task	5	0

Table 50. LINC list of NGSI context entities generated

4.10.3 Consumed datasets

No datasets consumed.

4.11 Neighbourly: A Smart City Platform

4.11.1 Endpoints and interfaces used

Core pilot cities' Interfaces used (endpoints integrated)

This pilot has deploy a new instance based on Amazon Web Services (AWS) for both new city and core pilot cities. SynchroniCity interfaces provided by the core cities have not been used, but the ones deployed in the new instance. For this reason the AWS SynchroniCity instance deployed by the pilot for Manchester, Porto and Santander has been validated as a new instance.

New instances deployed validation

The new instances have been validated following the same approach as in the core pilot cities, detailed in section 3 of this document.The following table presents the results of the validation process.

MANCHESTER's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	http://ec2-18-185-130-23.eu-central-1.compute.amazonaws.com:1026/v2	Orion Context Broker endpoint	No	NGSI Interface: NGSIv2
Identity Management				
Historical Data	http://ec2-18-185-130-23.eu-central-1.compute.amazonaws.com:8080	Historical Data	No	SynchroniCity Historical API
PORTO's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	http://ec2-18-185-130-23.eu-central-1.compute.amazonaws.com:1026/v2	Orion Context Broker endpoint	No	NGSI Interface: NGSIv2
Identity Management				
Historical Data	http://ec2-18-185-130-23.eu-central-1.compute.amazonaws.com:8080	Historical Data	No	SynchroniCity Historical API
SANTANDER's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	http://ec2-18-185-130-23.eu-central-1.compute.amazonaws.com:1026/v2	Orion Context Broker endpoint	No	NGSI Interface: NGSIv2
Identity Management				
Historical Data	http://ec2-18-185-130-23.eu-central-1.compute.amazonaws.com:8080	Historical Data	No	SynchroniCity Historical API
Market place	https://marketplace.san.synchronicity-iot.eu	Marketplace	YES	Marketplace API
HERNING's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	http://ec2-18-185-130-23.eu-central-1.compute.amazonaws.com:1026/v2	Orion Context Broker endpoint	No	NGSI Interface: NGSIv2

Identity Management				
Historical Data	http://ec2-18-185-130-23.eu-central-1.compute.amazonaws.com:8080	Historical Data	No	SynchroniCity Historical API

Table 51. Results the validation of new pilot cities' endpoints managed by Neighbourly

4.11.2 Generated datasets

MANCHESTER's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
AirQualityObserved	Air quality condition	1	1
WasteMeasurement	A waste measurement	1	0
PORTO's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
AirQualityObserved	Air quality condition	1	1
WasteMeasurement	A waste measurement	1	0
SANTANDER's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
AirQualityObserved	Air quality condition	4	4
WasteMeasurement	A waste measurement	3	0
HERNING's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
AirQualityObserved	Air quality condition	4	4
WasteMeasurement	A waste measurement	2	0

Table 52. Neighbourly list of NGSI context entities generated

4.11.3 Consumed datasets

No datasets consumed.

4.12 NoiseAbility

4.12.1 Endpoints and interfaces used

Core pilot cities' Interfaces used (endpoints integrated)

City	Endpoint	Interoperability Points	Auth. Required	Reference standards / Specifications
EINDHOVEN	https://orion.my-city.org/noiseability/v2	Context Information Management	NO	NGSI Interface: NGSIv2

Table 53. Core pilot cities' endpoints managed by NoiseAbility

New instances deployed validation

The new instance has been validated following the same approach as in the core pilot cities, detailed in section 3 of this document.The following table presents the results of the validation process.

BILBAO's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	http://synchronicity.bilbao.usmart.io:1026/v2	Orion Context Broker endpoint	No	NGSI Interface: NGSIv2
Identity Management				
Historical Data	http://Bilbao-Load-Balancer-264410326.eu-west-1.elb.amazonaws.com/8080	Historical data	No	SynchroniCity Historical API
EDINBURG's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	http://ec2-18-185-130-23.eu-central-1.compute.amazonaws.com:1026/v2	Orion Context Broker endpoint	No	NGSI Interface: NGSIv2
Identity Management				
Historical Data	http://edi-sync-lb-1271070260.eu-west-1.elb.amazonaws.com/8080	Historical data	No	SynchroniCity Historical API

Table 54. Results the validation of new pilot cities' endpoints managed by NoiseAbility

4.12.2 Generated datasets

EINDHOVEN's data model validation		
Dataset	**Description**	**Nº of Entities**

		Total	Valid
NoiseLevelObserved	Noise pressure levels	8	0
BILBAO's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
NoiseLevelObserved	Noise pressure levels	5	5
EDINBURG's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
NoiseLevelObserved	Noise pressure levels	6	6

Table 1. NoiseAbility list of NGSI context entities generated

4.12.3 Consumed datasets

No datasets consumed.

4.13 Quamtra: Smart Waste Management

4.13.1 Endpoints and interfaces used

Core pilot cities' Interfaces used (endpoints integrated)

City	Endpoint	Interoperability Points	Auth. Required	Reference standards / Specifications
PORTO	https://broker.fiware.urbanplatform.portodigital.pt/v2	Context Information Management	NO	NGSI Interface: NGSIv2
CAROUGE	https://orion.cityreport.org	Context Information Management	YES	NGSI Interface: NGSIv2

Table 55. Core pilot cities' endpoints managed by Quamtra

New instances deployed validation

The new instance has been validated following the same approach as in the core pilot cities, detailed in section 3 of this document.The following table presents the results of the validation process.

CALATAYUD's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	http://ocb-swm-calatayud.quamtra.com/v2	Orion Context Broker endpoint	YES	NGSI Interface: NGSIv2

Identity Management	https://ocb-swm.wtelecom.es/oauth2/token	IdM Keyrock	YES	OAuth 2.0
Historical Data				

Table 56. Results the validation of new pilot cities' endpoints managed by Quamtra

4.13.2 Generated datasets

PORTO's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
WasteContainer	Waste Containers	206	0
WasteContainerModel	Static properties of waste container	153	153
Device	Apparatus intended to accomplish a particular task	108	0
CALATAYUD's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
WasteContainer	Waste Containers	93	0
WasteContainerModel	Static properties of waste container	93	93
Device	Apparatus intended to accomplish a particular task	113	0
CAROUGE's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
WasteContainer	Waste Containers	1	0
WasteContainerModel	Static properties of waste container	1	1

Table 57. Quamtra list of NGSI context entities generated

4.13.3 Consumed datasets

According to the information provided by the pilot in M6 report, Table 58 shows the datasets consumed by Quamtra in the endpoints piloted, through the corresponding NGSI interface and according to the SynchroniCity defined data models.

PORTO's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
WasteContainer	Waste Containers	wastecontainer:*	206
WasteContainerModel	Static properties of waste container	wastecontainermodel:*	153

Device	Apparatus intended to accomplish a particular task	device:wt:*	108
CALATAYUD's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
WasteContainer	Waste Containers	wastecontainer:*	93
WasteContainerModel	Static properties of waste container	wastecontainermodel:*	93
Device	Apparatus intended to accomplish a particular task	device:wt:*	113
CAROUGE's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
WasteContainer	Waste Containers	wastecontainer:*	1
WasteContainerModel	Static properties of waste container	wastecontainermodel:*	1

Table 58. Quamtra list of consumed NGSI context entities

4.14 RainBrain, the smart blue-green roof

4.14.1 Endpoints and interfaces used

City	Endpoint	Interoperability Points	Auth. Required	Reference standards / Specifications
ANTWERP	https://ext-api-gw-p.antwerpen.be/digipolis/asbascrainbrain/v2	Context Information Management	YES	NGSI Interface: NGSIv2
EINDHOVEN	http://orion.my-city.org/rainbrain/v2	Context Information Management	YES	NGSI Interface: NGSIv2

Table 59. Endpoints managed by RainBrain

4.14.2 Generated datasets

ANTWERP's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
Garden	Distinguishable planned space for plants and other forms of nature	7	6
GreenspaceRecord	Description of the conditions recorded on a greenspace	30500	26961
Device	Apparatus intended to accomplish a particular task	24	0

WeatherObserved	Observation of weather conditions at a certain place and time.	37000	32310
WeatherForecast	Harmonised description of a Weather Forecast.	2684	836
EINDHOVEN's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
Garden	Distinguishable planned space for plants and other forms of nature	4	4
GreenspaceRecord	Description of the conditions recorded on a greenspace	22504	22504
Device	Apparatus intended to accomplish a particular task	16	0
WeatherObserved	Observation of weather conditions at a certain place and time.	11860	11860
WeatherForecast	Harmonised description of a Weather Forecast.	528	408

Table 60. RainBrain list of NGSI context entities generated

4.14.3 Consumed datasets

According to the information provided by the pilot in M6 report, Table 61 shows the datasets consumed by RainBrain in the endpoints piloted, through the corresponding NGSI interface and according SynchroniCity defined data models.

ANTWERP's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
Garden	Distinguishable planned space for plants and other forms of nature	Not defined (all entities)	7
GreenspaceRecord	Description of the conditions recorded on a greenspace	Not defined (all entities)	500
WeatherForecast	Harmonised description of a Weather Forecast.	Not defined (all entities)	500
EINDHOVEN's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
Garden	Distinguishable planned space for plants and other forms of nature	Not defined (all entities)	4
GreenspaceRecord	Description of the conditions recorded on a greenspace	Not defined (all entities)	500
WeatherForecast	Harmonised description of a Weather Forecast.	Not defined (all entities)	336

Table 61. RainBrain list of consumed NGSI context entities

4.15 Real-time traffic data with energy savings on street lights

4.15.1 Endpoints and interfaces used

City	Endpoint	Interoperability Points	Auth. Required	Reference standards / Specifications
ANTWERP	https://ext-api-gw-p.antwerpen.be/digipolis/asbascstreetlights/v1	Context Information Management	YES	NGSI Interface: NGSIv2
	https://ext-api-gw-p.antwerpen.be/digipolis/astreetlightsh/v1	Historical Data	NO	SynchroniCity Historical API
PORTO	https://broker.fiware.urbanplatform.portodigital.pt/v2	Context Information Management	NO	NGSI Interface: NGSIv2
	http://history-data.urbanplatform.portodigital.pt/v2	Historical Data	NO	SynchroniCity Historical API

Table 62. Endpoints managed by Real-time traffic

4.15.2 Generated datasets

ANTWERP's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
TrafficFlowObserved	Observation of traffic flow conditions at a certain place and time.	5	5
PORTO's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
TrafficFlowObserved	Observation of traffic flow conditions at a certain place and time.	6	6

Table 63. Real-time traffic list of NGSI context entities generated

4.15.3 Consumed datasets

No datasets consumed.

4.16 SmartImpact

4.16.1 Endpoints and interfaces used

Core pilot cities' Interfaces used (endpoints integrated)

City	Endpoint	Interoperability Points	Auth. Required	Reference standards / Specifications
SANTANDER	https://context.san.synchronicity-iot.eu	Context Information Management	YES	NGSI Interface: NGSIv2
	https://marketplace.san.synchronicity-iot.eu	Marketplace	YES	Marketplace API
CAROUGE	'https://orion.cityreport.org:5005	Context Information Management	YES	NGSI Interface: NGSIv2

Table 64. Core pilot cities' endpoints managed by SmartImpact

New instances deployed validation

The new instance has been validated following the same approach as in the core pilot cities, exposed in section 3 of this document. The following table presents the results of the validation process.

NOVISAD's Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	https://cb.synchronicity.dunavnet.eu	Context Information Management	YES	NGSI Interface: NGSIv2
Identity Management	https://idm.synchronicity.dunavnet.eu/oauth2/token	IdM Keyrock	n.a.	oAuth 2.0
Historical Data	https://hd.synchronicity.dunavnet.eu	Historical Data	YES	SynchroniCity Historical API
Marketplace	https://mp.synchronicity.dunavnet.eu	Marketplace	YES	Marketplace API

Table 65. Results the validation of new pilot cities' endpoints managed by SmartImpact

4.16.2 Generated datasets

NOVISAD's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
AirQualityObserved	Air quality condition	4	4

NoiseLevelObserved	Noise pressure levels	10	10
SANTANDER's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
AirQualityObserved	Air quality condition	2	2
NoiseLevelObserved	Noise pressure levels	10	10
CAROUGE's data model validation			
Dataset	**Description**	**Nº of Entities**	
		Total	**Valid**
AirQualityObserved	Air quality condition	92	91
NoiseLevelObserved	Noise pressure levels	453	0

Table 66. SmartImpact list of NGSI context entities generated

4.16.3 Consumed datasets

According to the information provided by the pilot in M6 report, Table 67 shows the datasets consumed by SmartImpact in the endpoints piloted, through the corresponding NGSI interface and according SynchroniCity defined data models.

NOVISAD's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
AirQualityObserved	Air quality condition	urn:ngsi-ld:AirQualityObserved:novisad:environment:fixed:*	4
NoiseLevelObserved	Noise pressure levels	urn:ngsi-ld:NoiseLevelObserved:novisad:environment:fixed:*	10
SANTANDER's data model validation			
Dataset	**Description**	**ID pattern**	**Consumed entities**
AirQualityObserved	Air quality condition	urn:ngsi-ld:AirQualityObserved:santander:environment:mobile:*	77
NoiseLevelObserved	Noise pressure levels	urn:ngsi-ld:NoiseLevelObserved:santander:environment:fixed:*	16
TrafficFlowObserved	Observation of traffic flow conditions at a certain place and time.	urn:ngsi-ld:TrafficFlowObserved:santander:traffic:flow:*	311
CAROUGE's data model validation			

Dataset	Description	ID pattern	Consumed entities
AirQualityObserved	Air quality condition	urn:ngsi-ld:AirQualityObserved:carouge:environment:fixed:*	92
NoiseLevelObserved	Noise pressure levels	Not defined (all entities)	453

Table 67. SmartImpact list of consumed NGSI context entities

5 Overall Validation Results and Conclusions

From the tables presented in Section 4 , we can conclude that all pilots fulfill the minimum level of integration defined in Section 2, and so **all of them are technically validated**.

Even though all of them are technically approved, there are differing levels of integration with the SynchroniCity framework. Three different levels have been defined:

- **Minimum integration**: Fulfils Open Call minimum integration criteria. They generate data sets in at least 2 pilot cities, but the performance of the solution doesn't have a strong dependency on SynchroniCity framework.
- **Medium integration**: The performance of the solution depends on SynchroniCIty framework, as it consumes data from at least 2 cities.
- **High integration**: The pilot has brought new cities to SyncroniCity, deploying in them new SynchroniCIty instances. The performance of the solution depends on SynchroniCIty framework, as it consumes data from at least 2 cities.

In the following, the overall results of the pilots are analysed, in order to show their level of integration with SynchroniCity. Figure 4 represents (in logarithmic scale) the number of entities created and consumed by each one of the pilot groups. On the 'Y' axis, pilots that only create entities are represented, while on the 'X' axis is the pilot that only consumes data. Most of the pilots, represented in the high- right area of the graph, create and consume data sets.

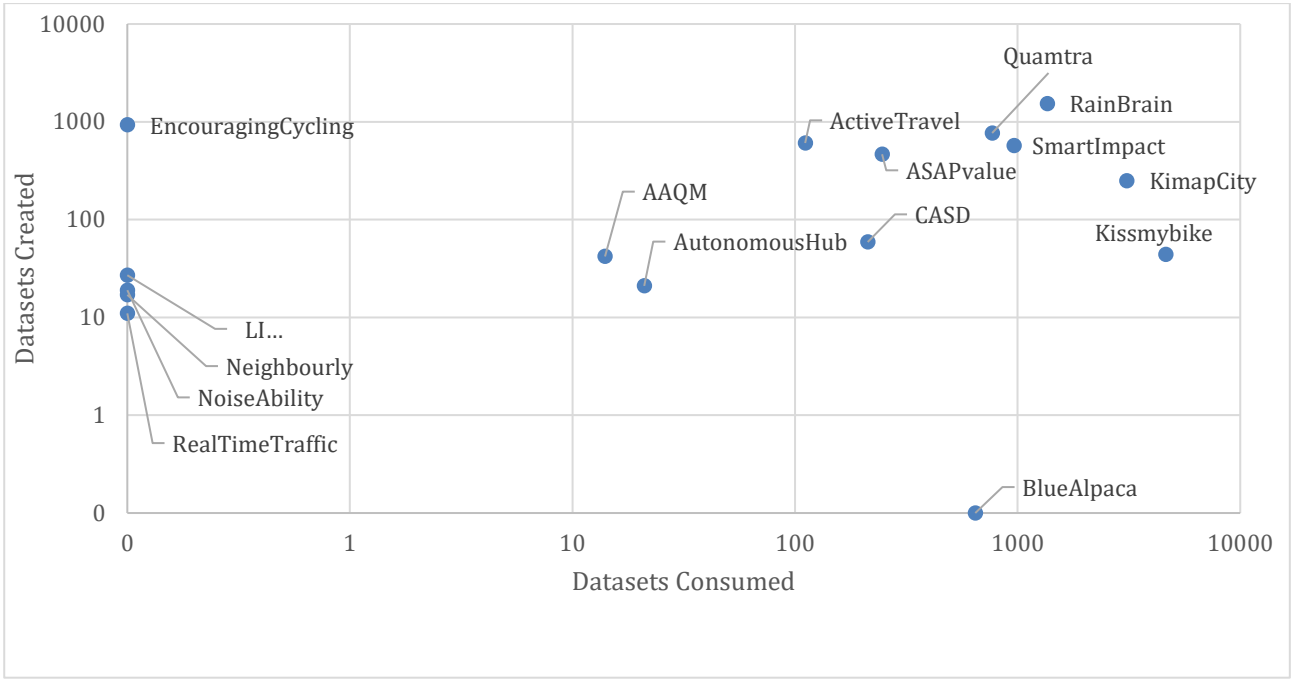

Figure 4. Data sets created and generated per pilot (logarithmic scale)

Figure 5 represents the number of cities where each pilot group has deployed their solution. It shows that most of the pilot groups have deployed their solution in at least 3 cities, and half of them have deployed SynchroniCity instances in new cities.

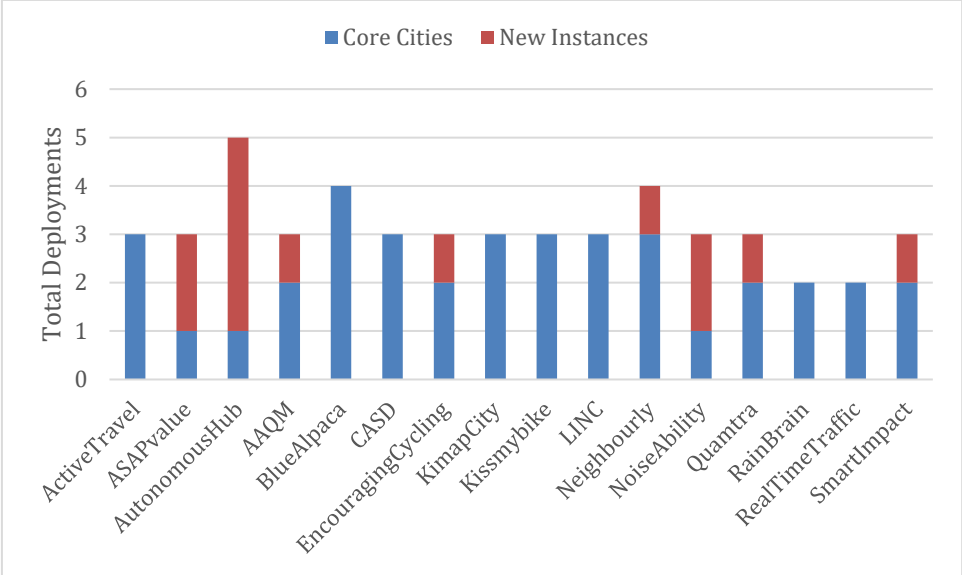

Figure 5. Number of piloting cities per pilot

Using to the integration levels and the figures presented above, the following clasification can be extracted (see Table 68).

#	Pilot	Comments	Integration level
1	Active Travel Insights	• Generates and consumes data	Medium
2	ASAP-VALUE : A Standards-based APproach to enhancing VALUE from city data lake	• Generates data in 2 of 3 instances • Consumes data • New SynchroniCity instances created	Medium
3	Autonomous Hub for Cyclist	• Generates and consumes data • New SynchroniCity instances created	High
4	AAQM - Autonomous Real-Time Field Service Solution for Public Real Estate Air Quality Management	• Generates data • Consumes data in 1 of 3 instance • New SynchroniCity instance created	Medium
5	BlueAlpaca	• Consumes data	Medium
6	Clean Air School Districts (CASD)	• Generates and consumes data	Medium
7	Encouraging Cycling through use of Crowdsourced Data-Driven Insights	• Generates data	Minimum
8	Kimap-City	• Generates and consumes data	Medium
9	Kissmybike	• Generates and consumes data	Medium
10	Linc	• Generates data	Minimum
11	Neighbourly™ : A Smart City Platform	• Generates data • New SynchroniCity instance created	Minimum
12	NoiseAbility	• Generates data • New SynchroniCity instance created	Minimum
13	Quamtra: Smart Waste Management	• Generates and consumes data • New SynchroniCity instance created	High
14	RainBrain, the smart blue-green roof	• Generates and consumes data	Medium
15	Real-time traffic data with energy savings on street lights	• Generates data	Minimum
16	SmartImpact	• Generates and consumes data • New SynchroniCity instance created	High

Table 68. Overall pilots classification

As a summary, 3 of the 16 pilots have achieved a high level of integration with SynchroniCity, with strong dependencies on the framework, creating and consuming data sets, and creating SynchroniCity instances for new cities. 8 pilots reached a medium integration level, where there were also strong dependencies on the framework, generating and consuming data. Finally, 5 pilots had a minimum integration level, generating new data sets following SincroniCity data models in at least two piloting cities, but not consuming data. Figure 6 represents the overall results on the integration level of the diferent solutions.

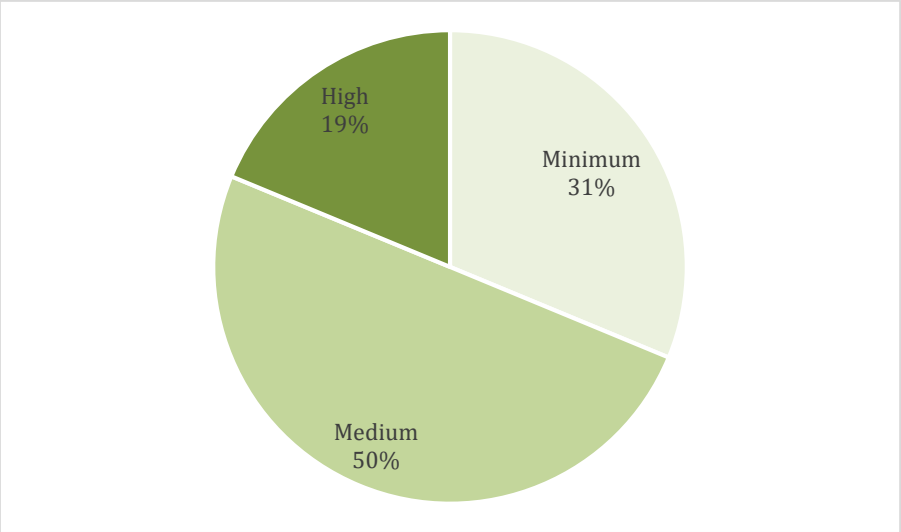

Figure 6. Pilots level of integration

5.1 SynchroniCity Impact

5.1.1 New instances deployed

From the tables exposed in Section 4, we can conclude that the open call pilots brought 13 new cities to SynchroniCity, however the level of integration differs from one to another: the context broker with an NGSI interface, as a mandatory component, has been implemented in all the new cities and historical data have been also adopted by most of them. This not the case of the security framework and marketplace, that have been adopted by a reduced number of cities. However, It has to be remarked that the city of Novisad has implemented all the SynchroniCity interfaces.

City	Interfaces			
	NGSI	Historical	Security	Marketplace
Bezana	√	√	-	-
Bilbao	√	-	-	-
Bordeaux	√	√	-	-
Calatayud	√	-	√	-
Donegal	√	√	-	-
Dublin	√	-	√	√
Edinburgh	√	-	-	-
Herning	√	√	-	-
La Nucía	√	√	-	-
Novisad	√	√	√	√
Palencia	√	√	-	-
Seongnam	√	√	-	-
Tampere	√	-	√	-

Table 69. SynchroniCity interfaces implemented in the new cities

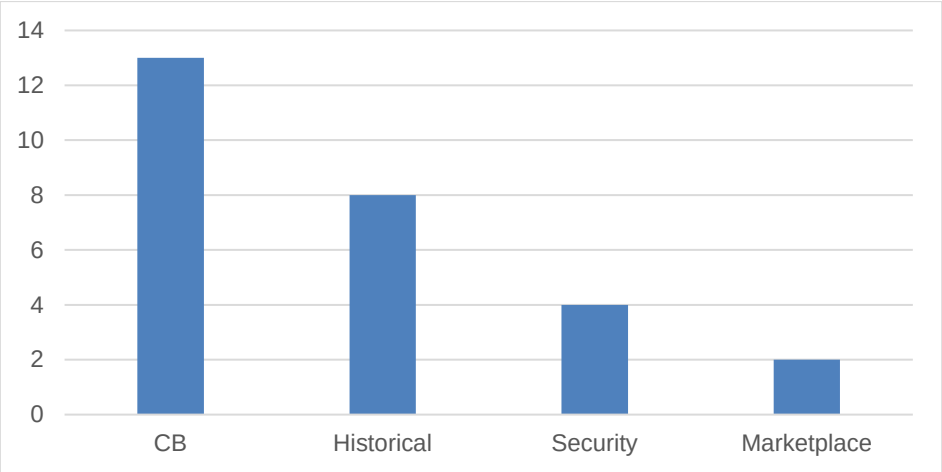

Figure 7. Interfaces implemented in new cities

5.1.2 IoT devices and communication technologies covered by pilots deployments

Only 3 of the 16 pilots did not physically deploy hardware devices in their piloting cities, the other 13 pilots have installed hardware IoT devices in the piloting cities. These carry out the context data sets' creation required for the implementation of their solutions. This means an increase in the number of IoT devices in the IoT infrastructure of piloting cities. The number of devices installed in the different cities, according to M6 reports, is shown in Table 70.

City	# IoT Devices
Bezana	15
Bilbao	5
Calatayud	100
Donegal	15
Dublin	200
Edinburgh	6
La Nucía	15
Novisad	76
Palencia	15
Tampere	25

City	#IoT Devices
Porto	175
Santander	90
Antwerp	442
Carouge	199
Eindhoven	11
Helsinki	37
Manchester	216
Milan	52
TOTAL	**1694**

Table 70. Number of IoT devices deployed in the piloting cities

The physical deployments have covered different access communication technologies for their integration qith the framework. Most of them have used cellular technologies (2G/3G/4G), followed by LoRaWAN, but other technologies like WiFi, SigFox or ZigBee have algo been employed for the intration of the deployments. Figure 8 shows their distribution.

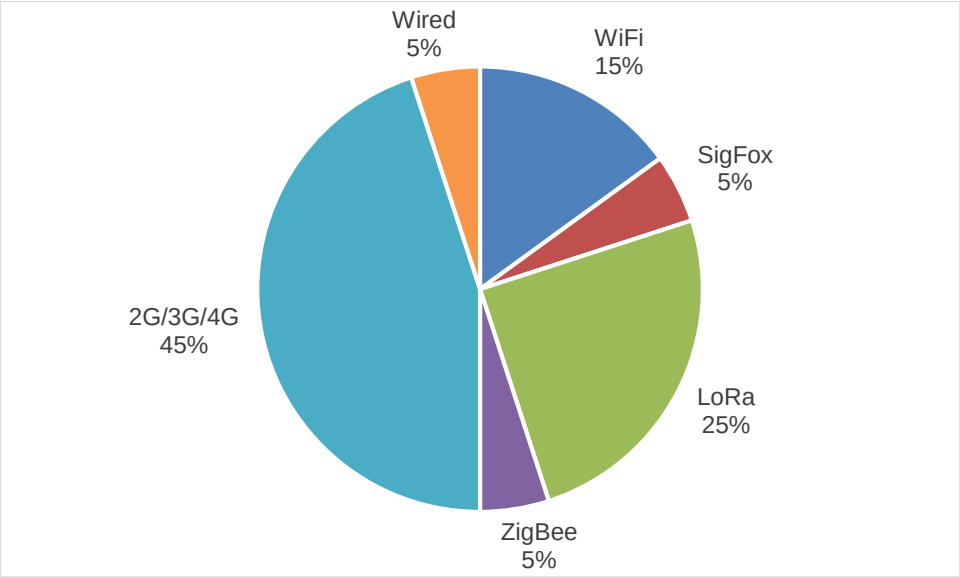

Figure 8. Communication technologies employed by pilots in their deployments

5.2 Metrics & KPIs

The purpose of this section is to measure the technical metrics of the Open Call pilots and compare them with the ones provided by the core pilot cities, reported in D4.3, to show the final technical validation KPIs of the SynchroniCity project

The technical validation KPIs presented in this document, have been previously introduced in D4.2 and D4.3. Table 71 summarizes all of them.

#	KPI	Description	Indicator unit	Measurement
1	SynchroniCity data sets	Number of available different types of data sets according to SynchroniCity data models	#	Total and per RZ
2	Data sets shared	Number of data sets that are shared by 2 or more RZs	#	Total
3	Entities	Number of available entities (through NGSI interface)	#	Total and per RZ
4	SynchroniCity cities	Number of cities with a NGSI interface exposing data sets according to SynchroniCity data models	#	Total
5	Atomic services	Number of Atomic Services implemented	#	Total

Table 71. Technical validation KPIs

Based on the validation results presented in sections 3 and 4, we can convey that the 21 piloting cities have an open NGSI interface to expose SynchroniCity data sets. These RZs expose 43 different types of data sets according to SynchroniCity data models, where 30 of them are at least common to 2 RZs. This leads to a total number of 159 data sets and 236589 entities full compliant with SynchroniCity data models. The effort of the core RZs and the success of the Open Call can be seen in almost doubling of the data sets available, and number of data sets shared by 2 or more cities. Complete results are presented in Table 72.

#	KPI	Description	Before Open Call	After Open Call	Increase
1	SynchroniCity data sets	Number of available different types of data sets according to SynchroniCity data models	38	**43**	5
		Number of available data sets according to SynchroniCity data models, including those duplicated in several RZs	80	**159**	79
2	Data sets shared	Number of data sets that are shared by 2 or more RZs	16	**30**	14
3	Entities	Number of available entities (including partial validated entities)	195646	**267056**	71410
		Number of available entities (full SynchroniCity compliant)	194778	**236589**	41811
4	SynchroniCity cities	Number of cities with a NGSI interface exposing data sets according SynchroniCity data models	8	**21**	13
5	Atomic Services	Number of atomic services implemented	8	**8**	0

Table 72. KPIs global values

Table 73 shows how entities and data sets are distributed among the 21 piloting cities.

#	1	3	
KPI	SynchroniCity data sets	Entities	
		Fully compliant	Total
Porto	20	6260	7035
Santander	23	2191	4472
Antwerp	12	30713	48996
Carouge	11	544	1484
Eindhoven	6	67751	68375
Helsinki	6	615	830
Manchester	14	87	1020
Milan	28	127754	133174
Bezana	3	3	3
Bilbao	1	5	5
Bordeaux	1	3	3
Calatayud	3	93	299
Donegal	4	4	4
Dublin	11	20	805
Edinburgh	1	6	6
Herning	2	4	6
La Nucía	4	5	5
Novisad	2	14	14
Palencia	3	3	3

Seongnam	2	463	463
Tampere	2	51	54

Table 73. KPIs values per RZ

5.3 SynchroniCity Framework Perception

Open Call pilots have been asked to provide their impressions on working with SynchroniCity framework. The following conclusions are based on the perception that the pilot groups had using the SynchroniCity framework while integrating their solutions:

- Most of the pilot groups describe the integration with the SynchroniCity framework as easy and smooth. They state that having standardized data models, and a standardized API for pushing and pulling data simplified things greatly and saved a lot of time. Also, they have expressed their interest in an automatic tool to validate data models.

- The main issue reported by piloters has been the lack of uniformity in the authentication and authorization process. Most of them have dealt with different choices for the Identity Manager in the piloting cities making it not possible to build a completely city-agnostic solution. For this reason, several pilot groups have stated the necesity to unify the way stakeholders are authorized on the platform.

- Another issue reported on the integration of the pilots with the SynchroniCity framework was the lack of readiness of SynchroniCity instances and the slow response of some RZs, bringing delays to their working plan. Despite the delays suffered, once data was available, the online documentation, on how to set up a new instance and work with real time or historical data, was well valued.

- Although no pilot group has made use of the atomic services, some of them, have stated interest in their usage. Due to lack of time during the piloting phase, they were not able to exploit the offered atomic services in their solutions, but currently are surveying the possibility of including some of them, such as the Grafana or Parking Estimator atomic services. Furthermore, they state they are interested in building new ones or to contribute to extending the existing ones.

These conclusions extracted from the pilot groups and their technical experience in experimenting with SynchroniCity components, validate the framework and provide valuable information for the next steps to be taken in the path to the Digital Single Market.

REFERENCES

1. SYNCHRONICITY CONSORTIUM, «D4.3 – TECHNICAL VALIDATION (PHASE II)», 2019.
2. SynchroniCity Consortium, «D5.6 – Report on the selected SME projects delivery and lessons learnt», 2019.
3. SynchroniCity Consortium, «D4.2 – Technical Validation (Phase I)», 2018.
4. ETSI GS CIM 004 V1.1.1 (2018-04) «Context Information Management (CIM); Application Programming Interface (API)», 2018
5. ETSI GS CIM 009 V1.1.1 (2019-01) « Context Information Management (CIM); NGSI-LD API », 2019
6. IETF OAuth Working Group, «The OAuth 2.0 Authorization Framework, RFC6749», 2012. Available online: https://tools.ietf.org/html/rfc6749
7. SynchroniCity Consortium, «D2.3 – Catalogue of OASC Shared Data Models for Smart City domains », 2019.
8.
9. «Data Catalog Vocabulary (DCAT) – revised edition», W3C First Public Working Draft 08 May 2018 [Online]. Available: https://www.w3.org/TR/vocab-dcat-2/
10. Digitransit Journey planner. [Online]. Available: https://digitransit.fi/en/
11. https://docbox.etsi.org/ISG/CIM/Open/ISG_CIM_NGSI-LD_API_Draft_for_public_review.pdf
12. FIWARE Data Models [Online]. Avaliable: https://www.fiware.org/developers/data-models/
13. FIWARE NGSI APIv2 Walkthrough [Online]. Available: https://fiware-orion.readthedocs.io/en/master/user/walkthrough_apiv2/index.html
14. FIWARE Sort Term Historic (STH) Comet component [Online]. Available: https://fiware-sth-comet.readthedocs.io/en/latest/
15. FIWARE Identity Manager (IdM) KeyRock enabler [Online]. Available: [https://catalogue-server.fiware.org/enablers/identity-management-keyrock]
16. OMA Next Generation Services Interface for Context Management V1.0 [Online]. Avaliable: http://www.openmobilealliance.org/release/NGSI/V1_0-20120529-A/OMA-TS-NGSI_Context_Management-V1_0-20120529-A.pdf
17. SynchroniCity Consortium, «D2.1.1 – Reference Architecture for IoT Enabled Smart Cities (V1) », 2017.
18. SynchroniCity Consortium, «D2.2 – Data Models Guidelines», 2017.
19. Synchronicity Consortium, «D2.4 – Basic data marketplace enablers», 2018.
20. SynchroniCity Consortium, «D2.10 – Reference Architecture for IoT Enabled Smart Cities (V2)», 2018.
21. Synchronicity Consortium, «D2.8 Report on Basic Reference Zones platform deployment and operational plan», 2018.
22. SynchroniCity Consortium, «D4.1 – Validation Methodology Description», 2017.
23. Synchronicity Consortium, Marketplace API [Online]. Available: https://synchronicityiot.docs.apiary.io/#reference/marketplace-api
24. SynchroniCity Data models [Online]. Avaliable: https://gitlab.com/synchronicity-iot/synchronicity-data-models
25. SynchroniCity Consortium, Data Storage API - Historical data access [Online]. Available: [https://synchronicityiot.docs.apiary.io/#reference/data-storage-api-historical/get-historical-data]
26. SynchroniCity Consortium, Security API [Online]. Available:

https://synchronicityiot.docs.apiary.io/#reference/security-api
27. SynchroniCity Consortium, SynchroniCity Data Models Validator (SC_DMV) and Reference Zone's Instance Validator tool [Online]. Available: https://gitlab.com/synchronicity-iot/rz-instance-validator
28. WSO2 Inc. Identity Server [Online]. Available: https://wso2.com/identity-and-access-management

ANNEX I – Technical Reports Templates

M2 Technical report tamplate

SynchroniCity Pilot Technical Report (M2)
Pilot Title:
Date Submitted:
SME Pilot Lead Name and Organisation:
SME Pilot Group Partners:
Pilot Cities:
Name of the Journey Mentor:

Remember:

- This report should be focused ONLY on technical achievements and/or strategies related to the integration with existing Synchronicity frameworks and/or the deployment of new ones.
- At this stage, it is only required to the pilots to have integrated with only one of the involved cities. On each table you will find a Tested/Planned (T/P) column to reflect if the corresponding row has already been Tested (T) with the corresponding SynchroniCity Framework of if it is the (planned (P)) way to be done in the pilot replication.
- Submit by emailing helpdesk@synchronicity-iot.eu stating that you have finalised the document. Include as attachments any other additional documentation that you consider important.
- If you have any questions please contact your journey mentor or the helpdesk.

GENERAL ASPECTS

1. **Provide an overview of the technical progress of your pilot towards the objectives according to your workplan, including milestones and achievements.**
   This general overview should show the integration of the pilot software/platform with the Synchronicity framework.

2. **When applies, explain and justify what has changed in your technical deployment process compared to your initial workplan and any foreseen deviations to report.**

3. **Describe the experience of integrating your solution into the SynchroniCity framework, indicating barriers and problems found and solutions adopted, if any. Cover the following aspects:**

   - **Access to data (availability and homogeneity of the required datasets):**

   - **Integration into SynchroniCity APIs (use of the different Sync. APIs, mainly Context data access and historical data):**

4. **Explain if you have used any existing Atomic Services in your pilot or if your pilot has created new Atomic Services. Which ones?**

5. **Enumerate and describe any new data model (or modification of existing ones) proposed within Synchronicity framework.**

6. **If in your pilot there is a New Pilot City, what are the actions that the city has taken to implement the SynchroniCity framework and your solution? Describe also the experience of integrating the SynchroniCity framework from the city perspective (thoughts, barriers, advantages).**

DATA SETS

1. Data consumed (Context Information) in each Pilot City from SynchroniCity instances

List ONLY those datasets retrieved from SynchroniCity frameworks through the corresponding NGSI

CITY	Synchronicity Data Model	Attributes	T/P
City 1:			
City 2:			

2. Data consumed (Historical) in each Pilot City from SynchroniCity instances

List ONLY those datasets retrieved from SynchroniCity frameworks through the corresponding SynchoniCity Historical API

CITY	Data type	Attributes	T/P
City 1:			
City 2:			

3. Data (new Context Information) generated in each Pilot City in SynchroniCity instances.

List ONLY those datasets updated to SynchroniCity frameworks through the corresponding NGSI API. Include the used data type (for new datamodels include the proposed new data type), the attributes updated and the final usage of this info (internal use for the pilot, open to 3rd parties exploitation…)

CITY	Data Model	Attributes	Data Usage	T/P
City 1:				
City 2:				

NEW SYNCHRONICITY INSTANCES

If in your pilot you have deploy a new SynchroniCity instance, please provide the following information:

1. Endpoints, interfaces and components

Should show the different deployed SynchroniCity Interfaces, a short description of what they provide, how to access them and what are the supported APIs/protocols.

SynchroniCity instance / City 1: ***Name***

Interfaces	Endpoint	Description	Exposed APIs	T/P
Context Information Management				
Identity Management				
IoT Management				
Historical Data				

SynchroniCity instance /City 2: ***Name***

Interfaces	Endpoint	Description	Exposed APIs	T/P
Context Information Management				
Identity Management				
IoT Management				
Historical Data				

2. Available SynchroniCity Data Models

List ONLY those data models offered by or proposed within SynchroniCity framework, managed through the corresponding NGSI API

SynchroniCity instance / City 1: ***Name***

Data Model	Description	Included relevant attributes	Number of entities	T/P

SynchroniCity instance / City 2: ***Name***

Data Model	Description	Included relevant attributes	Number of entities	T/P

3. Available SynchroniCity Historical Information

List ONLY those data managed through the corresponding SynchroniCity Historical API

SynchroniCity instance / City 1: ***Name***

Data Model (type)	Description	Attributes	T/P

SynchroniCity instance / City 2: ***Name***

Data Model (type)	Description	Attributes	T/P

You are welcome to include other documentation that you have produced and is relevant for the technical validation of your pilot.

M4 Technical report tamplate

SynchroniCity Pilot Technical Report (M4)
Pilot Title:
Date Submitted:
SME Pilot Lead Name and Organisation:
SME Pilot Group Partners:
Pilot Cities:
Name of the Journey Mentor:

Remember:

- This report should be focused **only** on technical achievements and/or strategies related to the integration with existing Synchronicity frameworks and/or the deployment of new ones.
- At this stage (month 4), pilots are required **to demonstrate** integration with SynchroniCity framework and solution replicability. This means, that, for those pilots providing data, they should demonstrate they are able to create & update entities in, at least, two different Sync. instances. Pilots capturing data should demonstrate they consume datasets from, at least, two Sync. instances. Endpoints, data models and entity ID patterns provided within this doc would be used by WP4 to check the reported integration.
- For **new IoT deployments** (new sensors deployed) an additional technical annex **can** be provided, including the technical description of the deployed devices (implemented/supported technologies, etc.) plus the location (GPS/UTM) of the deployment. This extra annex can complement the info required in this text.
- Submit by emailing helpdesk@synchronicity-iot.eu stating that you have finalised the document. Include as attachments any other additional documentation that you consider important.
- If you have any questions, please contact your journey mentor or the helpdesk.

INSTRUCTIONS

The objective of this report is to get an actual overview of the deployment status, SynchroniCity integration achievements and replication capabilities of your final application. It is divided in three sections, related to the IoT deployments feeding your app; the SynchroniCity instance/s, interfaces and data models managed; and the data exploitation done by your final app. We require specific and concrete information from these three levels, so we are providing a set of tables to quickly collect this from your side. Please, stick to these tables and consider that the provided info will be used to validate your reported achievements and deployment plans. Ensure that all of the endpoints and credentials provided are enough to get access to the achievements reported.

DATA GENERATION of NEW IoT Deployments

Each table here represents an IoT Deployment used to feed your final app. It would also include new IoT sensors/devices deployed and/or any other new information source that finally generate new SynchroniCity compliant entities (or new attribute/s on existing ones). For new IoT deployments, provide a technical summary with the tech. capabilities of the new deployed devices (in the included box of this section).

1. **Deployment Name: name given by the pilot to this new IoT deployment**
2. **Type of Source: e.g. Noise Sensors, data base link, ckan**
3. **Device Location: For fixed sensors use GPS/UTM format. For mobile sensors specify the area where they're deployed. This is not applicable for other information source e.g. ckan**
4. **Nº of sources deployed/used: num. of this kind of devices/sources deployed**
5. **Data Captured: e.g. Noise level**
6. **Data Model (Sync) to be used: Sync. data model to be used to capture the data provided. E.g. NoiseLevelObserved**
7. **Sync. Instance to be stored: name of the Sync. compliant instance where this dataset will be stored (this would link with next section on the doc)**
8. **IoT Deployment Network Technology: final technology used to connect the deployment to the backbone. E.g. LoRa, SigFox, 3G, WiFi, mesh networks, etc.**
9. **IoT Agent / Data Injector used: if any existing FIWARE IoT agent or a new data injector developed by the pilot is used to update data through the NGSI interface**
10. **Deployment ready (Date): data when this deployment was done or when it is planned it would be finalised.**

SYNCRONICITY Integrated Instances and Managed Datasets

Each table represents integration with one SynchroniCity instance (existing or new one). Use a copy of this table to report each of the instances you report integration with. The table is structured following this schema:

7. **SynchroniCity Instance (name). Provide the name to identify it (if it is a new one) or the RZ providing it.**
    a. **Production dates: date when integration with this instance is ready (you start to read/write data on it) [*In case integration has not been achieved yet, provide the expected date*]. This date sets when WP4 can access this to check created and/or read datasets and validate this integration.**
    b. **Endpoints: report here the endpoints (either, it is a new instance or an existing one) for all the components you are using/providing (or plan to) [NGSI API;**

Historical API; Marketplace; and, if you are using any OAUTH protocol, the IdM -or similar- where credentials can be obtained]. The minimum required component to get Sync. compliant is the NGSI API. Don't forget to provide also required credentials so WP4 team can access these endpoints.

8. **Context Management: report here the SynchroniCity compliant datasets you are consuming and/or generating (ONLY CONTEXT INFORMATION). [*In case integration has not been achieved yet, provide the datasets that would be consumed/generated*]**
    a. **Type/Data Model: points out the Sync. compliant data model. If it is still under discussion, also include it and remark this.**
    b. **ID: id pattern used to identify the entities managed by your pilot (either, created, or consumed). E.g "urn:ngsi-ld:NoiseLevelObserved:*:PilotX:*"**
    c. **Attributes: the list of attributes of this data type consumed/generated. (Create as many rows as you need to report all types and attributes consumed)**
9. **Historical Datasets: report here the SynchroniCity Historical datasets you are consuming and/or generating (in this case, only if the data can be retrieved using the Sync. API).**
    a. **Type/Data Model: points out the Sync. compliant data model. If it is still under discussion, also include it and remark this.**
    b. **ID: id pattern used to identify the entities managed by your pilot (either, created, or consumed). E.g "urn:ngsi-ld:NoiseLevelObserved:*:PilotX:*"**
    c. **Attributes: the list of attributes of this type consumed/generated**
10. **MarketPlace: if you have created or purchased any offer in this instance's MP, list them here.**

DATA EXPLOITATION (Applications)

This table represents the application layer of your pilot. It provides information about how to download/access the final app deployed to check it. The table is structured following this schema:

1. **Application Name: represent the name of the app and how it is distributed (web user interface, Android app, iOS app, etc.) This info should be enough to either access it and/or download and install it.**
2. **Data Consumed: this represents the MINIMUM datasets required to provide the basic functionalities of the app:**
    a. **Datasets (Sync): type (Sync. data model) and source (Sync. instance) providing this data.**
    b. **Datasets (Other not Sync. compliant): type (type of info) and source (e.g. city CKAN service) providing this data.**
3. **Atomic Services: if your app uses one of the Sync. provided atomic service or if your pilot provides a new one, list them here. Point also de instance (endpoint) to access and check it.**
4. **Date & City: date when the app would be deployed in the city**

DATA GENERATION of NEW IoT Deployments

City 1 (Name)

Deployment Name	
Type of Source	
Device Location	
Nº of sources deployed/used	
Data Captured	
Data Type (Sync) to be used	
Sync. Instance to be stored	
IoT Deployment Network Technology	
IoT Agent / Data Injector used	
Deployment ready (Date)	

Deployment Name	
Type of Source	
Device Location	
Nº of sources deployed/used	
Data Captured	
Data Type (Sync) to be used	
Sync. Instance to be stored	
IoT Deployment Network Technology	
IoT Agent / Data Injector used	
Deployment ready (Date)	

City 2 (Name)

Deployment Name	
Type of Source	
Device Location	
Nº of sources deployed/used	
Data Captured	
Data Type (Sync) to be used	
Sync. Instance to be stored	
IoT Deployment Network Technology	
IoT Agent / Data Injector used	

Deployment ready (Date)	

Technical capabilities summary of the deployed devices (ONLY for new ones)

SYNCRONICITY Integrated Instances and Managed Datasets

Synchronicity Instance 1

Synchronicity Instance (Name)				
Production/Deployment Date				
Endpoints	**NGSI (Context Info)**			
	Historical Data Access			
	Marketplace			
	Uses OAUTH?	**Yes/No**	**IdM**	
DATA SETS CONSUMED (Context Management)				
TYPE/Data Model				
ID				
Attributes				
TYPE/Data Model				
ID				
Attributes				
DATA SETS GENERATED (Context Management)				
TYPE/Data Model				
ID				
Attributes				
TYPE/Data Model				
ID				
Attributes				

DATA SETS CONSUMED (Historical Data Sets)	
TYPE/Data Model	
ID	
Attributes	

TYPE/Data Model	
ID	
Attributes	

DATA SETS GENERATED (Historical Data Sets)	
TYPE/Data Model	
ID	
Attributes	

TYPE/Data Model	
ID	
Attributes	

MARKETPLACE	
Offer 1	
Offer 2	

DATA EXPLOITATION (Applications)

Application Name			
Platform (Android, Web, iOS…)			
Access (endpoint / market)			
Data Consumed			
Dataset (Sync) consumed	Set 1	Type (Sync)	
		Source	
	Set 2	Type (Sync)	
		Source	
Dataset (NOT Sync) consumed	Set 1	Type	
		Source	
	Set 2	Type	
		Source	
Atomic Services			
Sync. Atomic Service		Name	
		Instance	
		Deployment Date	
New Atomic Service		Name	
		Instance	
		Deployment Date	
		Functionality	
		Dataset consumed	
		Dataset produced	
Application ready (Date)			
City			

COMMENTS (Technical Issues):

Please, enumerate (and shortly describe) any technical issue you have found (if any) during your SynchroniCity framework deployment, SynchroniCity integration (with any of the existing Sync. instances) and/or solution/app replicability.

You are welcome to include other documentation that you have produced and is relevant for the technical validation of your pilot.

M6 Final Report – Technical Environment

1. **Hardware IoT deployments**
   Create a new table for each deployment.

City of deployment	
Type of device	
Number of deployed devices	
Synchronicity instance used to store generated data	
Data type (s)/Data model(s)	
Communication technology (e.g. SigFox, LoRa, 3G, wired, etc.)	

2. **Data consumed and created in each Pilot City (fill in one table per city).**
   Create a new table for each city or instance. Add rows where necessary to indicate more than one dataset.

SynchroniCity instance (name)	
Endpoints (indicate URLs used/deployed)	
NGSI API	
Historical API	
Oauth 2.0 API	
Marketplace (where your offers are)	
Context Data sets consumed (NGSI)	
Type/Data Model	
ID pattern	
Context Data sets created (NGSI)	
Type/Data Model	

ID Pattern	
Context Data sets consumed (historical)	
Type/Data Model	
ID Pattern	
Context Data sets consumed (historical)	
Type/Data Model	
ID Pattern	

3. **If in your pilot you have performed hardware deployment. Explain the experiences of deploying the hardware devices in the different cities.**

4. **Explain the experience of integrating your solution into the SynchroniCity framework, indicating barriers and problems found and solutions adopted, if any.**
   At least the following points should be covered: access to data, integration with APIs.

5. **If in your pilot there are New Pilot Cities. What are the actions that the city has taken to implement the SynchroniCity framework and your solution?**
   Describe also the experience of integrating the SynchroniCity framework from the city perspective (thoughts, barriers, advantages).
6. **Explain if you have used any existing Atomic Services in your pilot project or if your pilot project has created new Atomic Services. Which ones?**

ANNEX II – Seongnam's MiMs validation

The following results have been provided by Seongnam Reference Zone. This RZ has carried out its own validation, therefore the validation process undertaken by WP4 for the other RZs has not been applied.

Endpoints, interfaces and core components

Seongnam's Non- Reference Zone SynchroniCity Framework INSTANCE				
Interfaces (Interoperability Points)	**Endpoint**	**Description**	**Auth. Required**	**Reference standards / Specifications**
Context Information Management	https://203.253.128.164:1026/v2/entities/parkingLot_1	Orion Context Broker endpoint	No	NGSI Interface: NGSIv2
oneM2M Platform	http://203.253.128.164:7579/sync_parking/yt_lot_1	oneM2M based platform	No	oneM2M
Agnostic Data Mapping Proxy	https://github.com/ramnathteja/megabox	oneM2M interworking proxy entity	No	oneM2M, NGSIv2
Marketplace	http://125.138.177.86:8040/	oneM2M Extention	No	oneM2M

Table 74. Seongnam's deployed components (Synchronicity Architecture)

Data models and available data sets

Seongnam's Non-Reference Zone data model validation						
Data Set	**Before Open Call pilots**		**After Open Call pilots**		**Increment**	
	Total	Valid	Total	Valid	Total	Valid
OffStreetParking	2	2	4	4	2	2
ParkingSpot	231	231	678	678	447	447
BusStop	4	4	4	4	-	-
Intra_bus	96	96	96	96	-	-
Inter_bus	105	105	105	105	-	-
Metro	2	2	2	2	-	-

Table 75. Evolution of the Seongnam's data model validation. The table depicts the status before and after the Open Call piloting phase, as well as the increment between them.