CREATE-IoT

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CROSS FERTILISATION THROUGH ALIGNMENT, SYNCHRONISATION AND EXCHANGES FOR IoT

H2020 – CREATE-IoT Project

Deliverable 01.12

EU IoT value chain integration framework

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PP	Restricted to other programme participants (including the Commission Services)	
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Summary						
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DoW	Proposal of framework (with proper KPIs to allow measurement) to foster links among EU communities of IoT users and providers, Member States' and related initiatives and evaluation of the results achieved during the project within this framework.					
Comments						

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1.00	27-06-2020	SINTEF	Final version released.

Table of contents

1. EXECUTIVE SUMMARY

1.1 Publishable summary

This document represents a conceptual effort by CREATE-IoT partners to provide a structure (framework) allowing to understand, influence and monitor how the EU IoT value chain can grow mature by integrating and better orchestrating the multi-sided efforts that currently take place and will be taking place in the future in terms of IoT innovation and IoT market development across the EU.

The structure of proposed EU IoT value chain integration framework stems from the family of horizontal KPIs for evaluation of the IoT LSPs developed in a collaborative effort between CREATE-IoT and the LSPs, as presented in deliverable D02.03. However, the value chain integration effort presented in D01.12 generalizes the concepts and scope in order to capture performance at EU value chain level, which cannot be seen just as the collection of performances of individual LSPs.

Section 3 of this document provides context and motivation for the proposed integration framework. Then, Section 4 introduces the proposed EU IoT value chain integration framework that considers four main dimensions: (1) IoT technology and standards, (2) Business opportunities and social impacts, (3) Ecosystem openness and value chain involvement, and (4) IoT acceptance, accessibility and compliance. Each of this dimensions is broken down in relevant indicators. Section 4 also provides an analysis of the family of stakeholders that come into play in the IoT innovation and market take-up processes.

This deliverable does not stop at just proposing the framework, but it also provides an analysis of how our project CREATE-IoT has contributed to each dimension of the framework. As Section 5 shows, CREATE-IoT has generated multiple contributions towards the integration of the EU IoT value chain during the project lifetime along each dimension of the framework. We show how CREATE-IoT has generated a valuable footprint on the EU's IoT ecosystem thanks to a rich variety of coordination and support activities carried out, with special emphasis in the second half of the project.

To help complete the picture, Section 6 provides a preliminary analysis of identified contributions from three finalized LSPs at the time of elaborating this deliverable (AUTOPILOT, MONICA and SYNCRONICITY).

Section 7 closes the deliverable with the main takeaways and conclusions of our analysis.

1.2 Non-publishable information

The document is public.

2. INTRODUCTION

2.1 Purpose and target group

This deliverable proposes an IoT value chain integration framework as a methodological tool and structure that allows to capture a comprehensive understanding of the many different factors influencing IoT development and deployment across the IoT value chain. The framework presented has been thought as a tool for analysis, understanding and monitoring of the good (or bad) performance of the EU's IoT value chain in the future as it progresses towards maturity and market consolidation.

The proposed framework can be seen as a standalone tool, but we have devoted some effort to map how our project CREATE-IoT has generated contributions within it. We also present a preliminary analysis of contributions coming from LSPs.

2.2 Contributions of partners

GRAD: Editor, conceptual design, contributions on almost all sections

SINTEF: Conceptual design, analysis of AUTOPILOT, final revision

ATOS: Analysis of SYNCRONICITY

AL: Contributions on the compliance dimension (WP5).

BLU-SL: Content shaping, contributions on the ecosystem dimension and SME engagement

LINKS: Analysis and contributions related to MONICA

MI: Content shaping, contributions on compliance dimension

AS: Content shaping and contributions in the dimensions of standardization (WP6 activities) and legal compliance (WP5 activities).

2.3 Relations to other activities in the project

This deliverable takes stock from the activity and results coming from almost every work package of the project. WPs. According to the framework and indicators proposed in Section 4 we have scanned the bulk of the work developed by the project and identified how our project has provided direct or indirect contributions towards the integration of actors and initiatives in the EU IoT value chain.

Summary of inputs from WPs:

- WP01 provides important an important source of activities and results developed especially during the second half of the project, where an intense reach out activity of workshops and exchanges with external actors was developed. We highlight the most relevant ones:
    - D01.04 - Common methodology and KPIs for design, testing and validation
    - D01.06 - Workshop on evaluation of IoT FA based on common methodologies and KPIs
    - D01.07 - Pan-European workshop with national initiatives for digitising industry across the EU
    - D01.08 - Coordination Event: Common event with the IoT projects addressing security for supporting the common activities
    - D01.09 - Public-Private Partnerships collaborative event

- D01.10 - IoT large-scale pilots' event with national and regional initiatives
- WP02 provides the basis for the set of KPIs considered, work developed with LSPs and external stakeholders to support business models, sustainability and exploitation strategy, as well as the support provided to SMEs and the work to generate engagement of the SME community:
  - D02.03 - Common methodologies and KPIs for design, testing and validation
  - D02.04 - Best Practice Guide and SME/Start-up toolkit
  - D02.05 - Business and sustainability models for large-scale IoT scenarios
  - D02.06 - Workshop on sustainability
  - D02.07 - Workshop on exploitation strategy
- WP3 provides interesting contributions along multiple activity streams: the work devoted to IoT and Arts integration, its work to support user acceptance and the work supporting SME involvement with LSPs:
  - D03.01 - Methodology for integrating ICT and Art
  - D03.03 - Workshops on user acceptance
  - D03.04 - Workshop on SME involvement with LSPs
  - D03.05 - List of the IoT Community of Artists
- WP4 served as the seed for the work presented in this deliverable, as it initiated the efforts to reach out the IoT LSP community in search for gain a better understanding of the links of IoT towards other communities and parts of the digital landscape in the context of the EU digital economy
  - D04.01 - IoT as a key pillar of EU digital economy
  - D04.03 - EU research and innovation activities overall plan
- WP05 has been the go-to source for all the aspects related to trust, social perception and legal/regulatory compliance. We highlight the following key deliverables:
  - D05.02 - IoT Policy Framework Evaluation & Final IoT Policy Framework
  - D05.03 - IoT Data Value Chain Model
  - D05.04 - IoT Data Value Chain Model Evaluation & Final IoT Data Value Chain Model
  - D05.06 - Legal IoT Framework Evaluation & Final Legal IoT Framework
  - D05.08 - IoT Policy Framework Common Event
  - D05.09 - IoT Data Value Chain Model Common Event
- WP06 has provided the necessary inputs along the standardisation and interoperability dimension. From the wide range of results generated by WP06 we highlight the following as the most relevant:
  - D06.02 - Recommendations for commonalities and interoperability profiles of IoT platforms
  - D06.03 - Assessment of convergence and interoperability in LSP platforms
  - D06.06 - Assessment of convergence and interoperability in LSP platforms
  - D06.08 - Interoperability Framework Workshop
  - D06.09 - Workshop on LSPs use cases: integration and standardisation alignment
  - D06.10 - Workshop on IoT standardisation activities
  - D06.11 - Workshop on common IoT standardisation framework
- Finally, from WP07 we highlight the impact and contribution of its communication and dissemination activities to help enlarge the community of IoT stakeholders that have become aware of and engaged with the work and activities of the IoT LSP Programme.

3. Motivation for an IoT value chain integration framework at European level

3.1 Problem statement

The global economy is amid an undeniable digital transformation process. Despite varying adoption rates and depths depending on the economic sector or geography, plenty of evidence shows that businesses, value chains, public services and our societies at large are becoming increasingly digital[1][2]. The digital transformation brings along important benefits and advantages for the transformed business or sector in the form of optimization of operating costs, better decision making, added value, or facilitated regulatory compliance, just to name a few.

The EU's economy is no exception to this trend, and important digital transformation efforts are underway in many relevant verticals such as industrial manufacturing, agriculture, healthcare/well-being, road transport, smart cities and public services in general. The importance of digital technologies has proven critical during the global COVID-19 crisis, as many professional, administrative and personal activities could maintain continuity through digital channels and tools.

However, digital transformation is not about the adoption of *one* specific technology but a complete universe of technology components and services with many interdependencies that can only render their purpose and provide value when working together. Digital technology is, in fact, an ecosystem in itself, with its own value chain(s), internal and external stakeholders, and is subject to relevant external factors (such as regulation). Under this setting, a number of barriers exist that may block or hamper how digital technology becomes available and is adopted. This makes the process of digital transformation a *complex problem* whose solution calls for an orchestrated (framework-based) approach that considers the whole digital value, and all possible stakeholders and external factors involved.

We can identify a number of barriers:

- Intrinsic to the IoT value chain
    - Technology readiness
    - Technology interoperability
    - Reliability
    - Business development and sustainability
- Extrinsic to the IoT value chain
    - Regulatory landscape and compliance
    - Trust and social perception
    - Social impact
    - Investment capacity
    - Lack of coordination at ecosystem level

An orchestration effort is required if the EU wants to succeed in its digital transformation process, and in particular, in having a vibrant IoT ecosystem able to overcome the barriers unlocking its potential and thus bring growth and sustainability to our economy and society.

3.2 Proposed solution: a framework to orchestrate efforts towards a successful digital transformation of the EU

CREATE-IoT proposes an IoT value chain integration framework as the right tool to support, orchestrate, and monitor efforts towards the digital transformation of the EU's economy, and in particular, to help orchestrate and monitor the performance of the EU's IoT value chain considered as a whole.

Among the many technology components involved in the digital economy, the Internet of Things is arguably a pivotal one. IoT, in itself, is a blend of technology components that involve sensors and actuators, connectivity technology, data storage, service provision, dynamic applications and processes at business or personal level. The IoT interfaces with, or often embeds other key technologies for digital transformation such as data analytics, big data or artificial intelligence. In addition, the IoT provides a number of cross-cutting functions that go beyond the pure technological dimension such as trustworthiness, safety, security or reliability. Some of these functions allow to accommodate restrictions coming from the external constraints such as regulatory frameworks or solution acceptability (required by external stakeholders such as regulators, industry verticals or customers).

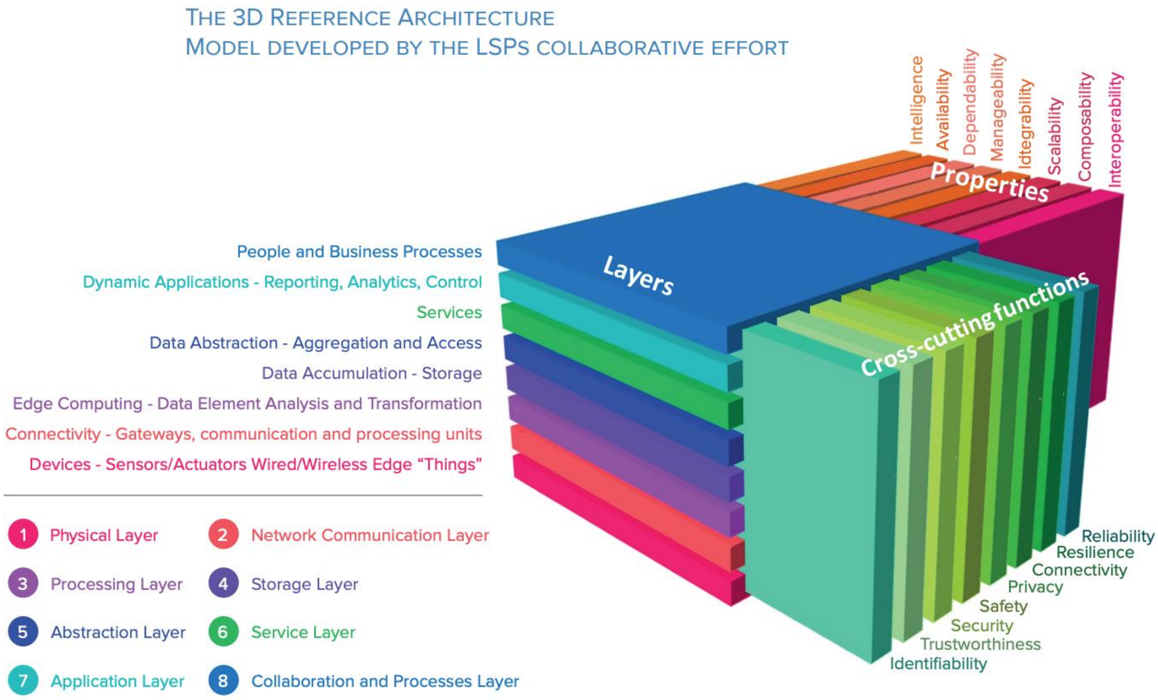

Figure 1: The 3D Reference Architecture Model

Such complexity is adequately embedded into the 3D Reference Architecture model that has been developed by the IoT European Large-Scale Pilots Programme community as presented in deliverable D06.03 and depicted in Figure 1.

Considering the pivotal role of the IoT within the digital transformation process, and taking inspiration from the 3D model above, in the next section of this document we introduce our proposed IoT Value Chain Integration Framework as the adequate tool to orchestrate research, innovation and deployment efforts of IoT and digital technologies in the EU.

4. Proposal for an EU IoT value chain Integration framework

4.1 Purpose and Objectives

The IoT value chain integration framework introduced in this section must be understood as a methodological tool and structure that allows to capture a comprehensive understanding of the many different factors influencing IoT development and deployment across the IoT value chain, and measure the status or performance across the value chain and its environment.

The purpose of the proposed integration framework is multiple:

- Capture all the different relevant dimensions involved along the IoT research, innovation, deployment and adoption phases
- Capture the interests of the different stakeholders communities engaged around the IoT
- Serve as a tool to facilitate synergies, integrate efforts, and consolidate achievements among the EU's IoT value chain stakeholders
- Serve as a tool measuring how well the EU's IoT ecosystem is doing in terms of technology development, adoption and impact.
- Serve as a tool for decision making

4.2 Proposed IoT value chain integration framework: dimensions, indicators and metrics

CREATE-IoT has supported the IoT European Large-Scale Pilots Programme in the development of a common methodology and in the design of horizontal KPIs to measure the LSPs impact on the overall programme. Horizontal refers to the horizontal impacts of the Programme across all focus areas. The horizontal KPIs are measuring the contribution of the LSPs participating in the programme to the achievement of the strategic impacts of the programme and underlining their cumulated value added. They have been developed on the basis of an iterative process led by CREATE-IoT in collaboration with the LSPs and presented initially in deliverable D02.03.

Figure 2: Horizontal KPIs developed by CREATE-IoT and the LSPs

Now, the purpose and scope of this deliverable D01.12 goes beyond the pure LSP project or IoT application. Indeed the goal here is to capture an integrated understanding of the whole IoT value chain at EU level, which is more complex than a collection of individual projects or applications. However, the structure and methodology behind the horizontal KPIs depicted in Figure 2 are very sound basis. Therefore, we have used the horizontal KPIs as starting point and reworked them by projecting them into a wider scope as the IoT Value Chain represents. This has required some adaptations and additions in the selection of the considered dimensions and KPIs. The result is shown in Table 1.

Table 1: Dimensions considered in the proposed IoT value chain integration framework

Dimension	Subdomains considered (Indicators)
1. IoT Technology and Standards	1.1. Progress towards IoT standardisation 1.2. Progress towards IoT platform/device interoperability 1.3. IoT platform openness 1.4. Open IoT data sets availability 1.5. IoT market-readiness
2. Business Opportunities and Social Impacts	2.1. Adoption of IoT-based business models 2.2. IoT-based business volume 2.3. Social impact of IoT 2.4. Social perception of IoT
3. Ecosystem openness and Value Chain involvement	3.1. IoT ecosystem diversity 3.2. SME share in the ecosystem 3.3. IoT demonstration
4. Acceptance, accessibility and compliance	4.1. User trust 4.2. User satisfaction 4.3. Regulatory compliance/readiness

Table 2 provides details on the scope of each indicator and the metrics that can be used for evaluation. This structure will be used in Section 5 to report how CREATE-IoT has contributed along each dimension and in Section 6 to provide a sample of contributions to the framework from individual LSPs.

Table 2: IoT value chain integration framework with proposed metrics

KPIs	Definition	Metric
Dimension 1: IoT Technology and Standards		
1.1 IoT standardisation	Progress in IoT pre-normative and standardization achievements	Number of relevant standard/pre-normative contributions
1.2 IoT platform/device interoperability	Progress towards IoT interoperability of platforms and devices	Number of interoperable IoT implementations available
1.3 IoT platform openness	Level of adoption of open IoT platforms	Ratio open/proprietary IoT platforms available
1.4 Open IoT data sets availability	Availability of open IoT data sets	Ratio of open data sets
1.5 IoT market-readiness	IoT-based products and services available in the market	Number of IoT products and services available
Dimension 2: Business Opportunities and Social Impacts		

KPIs	Definition	Metric
2.1 Adoption of IoT-based business models	IoT-based business models in use	Number of IoT-based business models
2.2 IoT-based business volume	Estimated size of the IoT market	Aggregated business volume of the IoT market (products and services)
2.3 Social impact of IoT	IoT-induced improvements in quality of life, social welfare, environmental protection, and other socially relevant issues	Qualitative measurements of positive social impacts induced by IoT
2.4 Social perception	Perceived value, improvement of quality of life and social welfare thanks to the IoT	Qualitative measurements from specific studies, surveys
Dimension 3: Ecosystem openness and Value Chain Involvement		
3.1 IoT ecosystem diversity	Degree of representativeness of the different stakeholder groups in the ecosystem	Number of stakeholder categories with significant participation in the ecosystem
3.2 SME share in the ecosystem	Number of SMEs engaged in the IoT ecosystem	Ratio of SMEs vs. total ecosystem members
3.3 IoT demonstration	Progress in IoT pilots and demonstrators as accelerators of IoT take-up	Number of pilot sites with IoT implementations open to stakeholders and visitors
Dimension 4: Acceptance, Accessibility and Compliance		
4.1 User trust	Degree of trust of users (pilots or market) in relation to data protection and privacy	Qualitative scale (0%: very low / 100%: very high)
4.2 User satisfaction	Level of satisfaction of users (pilots or market)	Likert scale for user satisfaction
4.3 Regulatory compliance/readiness	Perceived readiness of regulatory framework required for IoT deployment or compliance of the IoT product/service to current regulation	Qualitative measurement (0%: not ready at all/ 100%: completely ready)

4.3 Stakeholder Analysis

The proposed framework is intended to capture the evolution and performance of the IoT value chain and also the effect of external forces affecting the value chain itself. Therefore, it considers a wide range of stakeholders from both within and outside the IoT value chain. Each stakeholder may be affected by (or have an influence on) one or several dimensions of the framework presented above. Next we provide an overview of the key stakeholders and their footprint on the proposed framework.

The **ICT/IoT research and innovation community** is composed of universities, RTOs, competence centres, innovation-performing companies, end-users and any other actor taking an active role in the IoT innovation process, including pilots or demonstrators. We include here all the actors involved in standardization efforts. Digital Innovation Hubs are expected to play an important role across the whole value chain as innovation facilitators.

ICT/IoT technology providers and OEMs are an essential link in the IoT value chain as they enable technological replicability and scalability. We consider IoT platform providers as part of this group. Their footprint extends mainly over dimensions 1, 2 and 3 of our framework.

IoT service providers are the actors in the value chain that transform IoT technology into value for the end-user in the form of an IoT-based service. They have stakes across most of our proposed framework, as they may benefit from standardization and interoperability and their services require market readiness for success (dimension 1), they need a sound business model to generate revenue from (dimension 2), are an important piece of the ecosystem (especially if they are SMEs, dimension 3), and are the main interface towards users (dimension 4).

IoT end-users, at the end of the value chain, hold the casting vote regarding the market readiness of an IoT service or solution. When end-users perceive benefits from what the value chain offers, then they will buy in and the market will develop positively. IoT end-users are also crucial during the innovation phase, as co-developers, testers or early-validators. Many profiles of IoT end-users exist, depending on the vertical and IoT application, but for any of them it will be essential to secure their trust and product or service acceptance.

Public authorities and policy makers and regulators play an essential roles in this framework. Public administrations in their role of IoT buyers or IoT infrastructure orchestrators/regulators have a decisive role in the adequate development of some IoT verticals such as smart cities/territories, healthcare and wellbeing or mobility and transport (including autonomous vehicles), just to name a few. Policy makers can also be crucial as favourable policies have the potential to foster IoT innovation and market take-up, whereas unfavourable policies may hamper innovation and take-up. Regulation is an essential piece of the puzzle as well, given the important implications of legal compliance and regulatory compliance both in the innovation and the market development phases.

Investors play a key role in the development of the current and future IoT market. Lack of investors in the ecosystem is a clear condition locking market development (dimension 3).

Civil society must be necessarily considered in the equation. No technology can be successful unless it is accepted, or at least tolerated, by citizens. The introduction of innovative technologies such as the IoT may generate socioeconomic impacts that need be tracked. In addition, the massive adoption of IoT technology may also bring undesired consequences for users or citizens, which in turn, may influence societal acceptance (dimensions 2 and 4).

5. ACHIEVEMENTS DURING CREATE-IOT

This Section provides a detailed walkthrough of how CREATE-IoT has contributed along each dimension of the framework presented in Section 4.

5.1 IoT Technology and Standards

5.1.1 Progress towards IoT standardisation

Standardization in the context of IoT plays an important role as it has also been underlined in the context of the CREATE-IoT project. Partners of the CREATE-IoT project had already previously contributed to the field with T6.2 "*Pre-normative and standardisation activities*" focusing on the contribution from the LSPs and CREATE-IoT to the standards ecosystem.

Create IoT D6.6 assesses the status of relevant standardisation across the IoT domains represented by the IoT Large Scale Pilot. The deliverable highlights the standards implemented by the different LSPs and their contribution to SDOs. As highlighted in D6.6: "The five LSPs (of the first generation) of the LSPs have made a great contribution to standardization in a variety of SDOs and SSOs.

These contributions were, in most cases, supported by a Standardization Plan defined upfront at the beginning of each LSP project and further elaborated with the progress of the work"
Among the relevant contributions by the LSPs listed in D6.6:

- "-The collaborative development by LSPs of a 3D Reference Architecture model.
- -The Minimum interoperability Points (MIMs) specified by ACTIVAGE, IoT2020 and SYNCHRONIOCITY.
- The MONICA requirements for a new standard for time-critical data links for IoT sensors.
- The LSPs contributions to SAREF (Smart Appliances REFerence ontology);
- AUTOPILOT contributions to oneM2M,
- The contribution of SynchroniCity to the ITU Study Group 20 on IoT and Smart Cities"[1].

Recently, the ETSI specialist task force (STF) 547 has contributed to the field by developing a framework for IoT standardization that addresses interoperability across IoT domains.

The task force has produced a coordinated set of technical reports (TR):

- TR 103 591 Privacy study report- Standards Landscape and best practices
- TR 103 5333 Security Study report- Standards Landscape and best practice
- TR 103 534-1 Teaching material – Part 1: IoT Security and Teaching material
- TE 103 534-2 Teaching material- Part 2: IoT Privacy and Teaching material
- TR 103 535 Guidelines for using semantic interoperability in the industry
- TR 103 536 Strategic/technical approach on how to achieve interoperability/interworking of existing standardized IoT platforms
- TR 103 537 Plug test preparation on Semantic Interoperability

The task force has also produced a special report:

SR 003 680 Guidelines for Security, Privacy and Interoperability in IoT System Definition. A Concrete Approach.

[1] Create IoT, *Deliverable 06.06-Final report on IoT standardisation activities*, 2020, p. 60.

These achievements were presented and discussed during the CREATE-IoT event "Navigating IoT architectures and standards". The discussion is reported in D6.11[2].

Synchronicity defended interoperability as one of its main pillars to achieve scalability and replicability. The project started with a strong commitment with the OASC Principles and that included NGSI interfaces as reference. During the project this evolved (in parallel) through two different objectives:

- On the one hand, the FIWARE Foundation and the FIWARE data models[3] evolution. This work is aligned with the results of the GSMA IoT Big Data Project, which works in harmonizing APIS and data models for fuelling IoT and Big Data Ecosystems. These models were foster to be used in all the pilots (mandatory requirement for the Open Call new pilots) of the project as a reference. When the models could not accomplish the pilot's needs, these were improved, extended or new one appeared.
- OASC evolution to the final OAS MIMs (Minimum Interoperability Mechanisms) that were finally stablished when the project was coming to the end. MIMs were strongly promoted and supported with NGSI as a standard interface allowing interoperability. The SYNCHRONICITY Guidebook contains the result of all the work, dissemination, promotion and final outcomes about OASC and MIMS[4].

The strong commitment between the project and NGSI standard and NGSI FIWARE data models included the validation of data sets and the data models exposed. A validation tool[i] was developed during the project, which created different reports about the current status of the data sets and its compliance with the NGSI FIWARE data models.

5.1.2 Progress towards IoT platform/device interoperability

As stated in the previous section, the contributions of CREATE-IoT on standardization and the support provided during the project lifetime have provided a remarkable contribution specifically along the dimension of interoperability of platforms and devices.

5.1.3 IoT platform openness

The work of ETSI specialist task force (STF) 547 has contributed to the field by developing a framework for IoT standardization that addresses interoperability across IoT domains. The task force has produced a specific technical report dealing with IoT platforms:

- TR 103 536 Strategic/technical approach on how to achieve interoperability/interworking of existing standardized IoT platforms

This and related reports were matter of discussion and exchange during the CREATE-IoT event "Navigating IoT architectures and standards" as reported D6.11.[2]

5.1.4 Open IoT data sets availability

CREATE-IoT has fostered the availability of open IoT data through several activity streams, mostly related to the intense work developed under WP05:

- D05.09 - IoT Data Value Chain Model Common Event:
    - Workshop on "Policies to Support Open Data Marketplaces", falling under WP05 on "IoT Policy Framework - Trusted, Safe and Legal Environment for IoT" under task

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[2] Create-IoT, *Deliverable 06.11- Workshop on "Navigating IoT architectures and standards"*, 2020.

[3] FIWARE Data Models: https://github.com/FIWARE/data-models

[4] SYNCHRONICITY guide book: https://synchronicity-iot.eu/wp-content/uploads/2020/01/SynchroniCity-guidebook.pdf.

T05.02 (Data in the context of IoT applications). It addresses Data sharing in IoT ecosystems, Data-supported Services Concepts and Best Practices
    - Keynote in the context of "Data Sharing Days / How to use data sovereignty to create value?"
- Workshop “Data sharing in agriculture. Towards a European agriculture data space” on 10 June 2020, also supported by AIOTI, DG CONNECT and DG AGRI. The workshop addressed the sharing of any kind of data, but IoT-generated data is definitely one important component of the valuable data sources in agriculture. This workshop was intended to feed the debate on the implementation of the EU Strategy for Data released on February 2020 by the European Commission.

5.1.5 IoT market-readiness

CREATE-IoT contributed along this dimension through the LSP support work developed in WP2 focused on business models and sustainability, which we detail in the next Section 5.**Error! Reference source not found.**.

5.2 Business Opportunities and Social Impacts

5.2.1 Adoption of IoT-based business models

The establishment and creation of IoT-based models must take into account the different layers present within IoT technologies and the relative members of the value chain created around them. Through the development of business and sustainability models for large-scale IoT scenarios (D2.05), CREATE-IoT has identified the key trends and the progress of the business models from platforms to added-value services manipulating and actioning the data gathered using new devices, platforms and network.

Supporting the LSPs, models for the exploitation and commercialisation of the activities relied upon two key approaches; exploiting the assets created and proven throughout the projects and the extension of the use cases with their own commercialisation as complete services which are results-focused for their context. While scalability of the developed solutions and use cases remains a challenge for all IoT business models within the LSPs, this has been mitigated by the promotion of standards, interoperable solutions and platforms and the growth of the ecosystem to include traditional and non-traditional actors throughout CREATE-IoT lifetime.

5.2.2 IoT-based business volume

CREATE-IoT has not specifically provided direct market development support to the IoT LSPs, their partners or the piloted applications. However, our project has provided valuable support on two key cross-cutting dimensions that are the basis for market development: exploitation strategy and (business) sustainability. This work was developed under WP2 in cooperation with U4IoT and the supported LSPs and is duly reported in the following deliverables:

- D02.05 Business and sustainability models for large-scale IoT scenarios
- D02.06 Workshop on sustainability
- D02.07 Workshop on exploitation strategy

5.2.3 Social impact of IoT

CREATE-IoT’s mandate and activities did not include the social impact of IoT among its areas of coverage, so the project did not provide comprehensive contributions along this dimension. However, there are at least two related elements that can be considered as partial contributions:

- WP03 work on the combination of IoT and Arts, and how Arts-led methodologies do not only drive innovation but also allow to discover ways to explore human and social impacts of new technologies.
- WP05 work on the concepts of trust, which can be clearly linked to the social dimension. Please refer to Section 5.4**Error! Reference source not found.** for details on this.

5.2.4 Social perception of IoT

In a similar vein, social perception of IoT did not receive a specific attention of CREATE-IoT. However, the work developed by WP05 on acceptance and trust definitely counts as partial contribution. Please refer to Section 5.4 for our contributions along the elements of trust and acceptance.

5.3 Ecosystem Openness and Value Chain Involvement

5.3.1 IoT ecosystem diversity

The main contribution of CREATE-IoT on this regard can be broken down two main streams of activity: workshops oriented toward many different communities and our support to communication and dissemination.

CREATE-IoT has stimulated informed exchanges and debates among diverse IoT stakeholders through a considerable variety of workshops and webinars covering many IoT dimensions organized by our project.

Remarkably, especial effort was given to involve actors from outside the IoT LSP community, including national or regional administrations and IoT initiatives. Examples of contributions in form of events from some of our WPs follow:

- WP01:
  - D01.07 Pan-European workshop with national initiatives for digitising industry across the EU,
  - D01.09 Public-Private Partnerships collaborative event
  - D01.10 - IoT large-scale pilots' event with national and regional initiatives
  - Webinar-workshop Data sharing in agriculture: Towards a European agriculture data space
- WP02:
  - D02.06 Workshop on sustainability
- WP03:
  - D03.05 - List of the IoT Community of Artists
  - D03.08 - Round-table at Ars Electronica
- WP05:
  - D05.09 - IoT Data Value Chain Model Common Event
- WP06:
  - D06.08 - Interoperability Framework Workshop
  - D06.09 - Workshop on LSPs use cases: integration and standardisation alignment
  - D06.10 - Workshop on IoT standardisation activities
  - D06.11 – Workshop on common IoT standardisation framework

CREATE-IoT has also contributed by supporting communication and dissemination at IoT LSP Programme level through our activities in WP7) as a means to reach the largest audience and help attract the active interest of additional IoT stakeholders into the ecosystem.

The SME segment is discussed in detail in the next section.

5.3.2 SME share in the ecosystem

The role of SMEs in the ecosystem is highly important to ensuring the uptake and adoption of the technologies and advances generated within the Large-Scale Pilots. SMEs operate at different positions within the ecosystem and can be seen as providers, integrators and adopters. Throughout the Large-Scale Pilots, there has been a focus on the inclusion of SMEs both within the respective projects and through the disbursement of funds through the Open Calls.

These Open Calls resulted in 317 proposals received between IoF2020, SYNCHRONICITY and ACTIVAGE reaching over 1000 interested SMEs and the inclusion of hundreds of SMEs in the roles of technology providers, pilot leaders and testers while integrating them within the network and ecosystem created around the projects.

CREATE-IoT facilitated the coordination of the Open Calls across the relevant pilots, providing common methods and producing the D2.04 SME Engagement guide which supported the applicants and the hosting of a series of user and 3 SME involvement workshops (D3.03 and D3.04). The outcomes of the workshops, identified the following:

- SMEs tend to enter the IoT market through adjacent technologies and market applications either through the development of hardware, cloud-based applications or networks.
- The role of SMEs in providing rapid innovation is important and their presence has been necessary but the value chain also contains large actors with deep partners that makes it difficult to compete at the leading edge.
- SMEs require greater knowledge and understanding of key stakeholders to better apply their solutions across the value chain.
- Including SMEs results in a greater level of collaboration, by their nature, SMEs tend to form partnerships more readily due to limitations on their resources or knowledge.

To ensure that this community and ecosystem of IoT SMEs was maintained, CREATE-IoT launched the IoT Next Club, designed to integrate SMEs both inside and outside the LSP community and those who applied to the open calls. The IoT Next Club provides the space for over 230 members to find partners, seek financing, be showcased and participate in regular thematic webinar sessions on topics such as cybersecurity, trust and data protection and IP strategies.

5.3.3 IoT demonstration

As CSA project, CREATE-IoT could not have a direct contribution in terms of IoT demonstration. However, regular visibility has been provided to IoT LSPs and other external activities throughout the large family of events and workshops organized by CREATE-IoT, in which those projects and initiatives could present their piloting and demonstration efforts.

5.4 Acceptance, Accessibility and Compliance

5.4.1 User trust

The development of trust is a key concern for the deployment of IoT solutions. To this extent the policy framework developed by CREATE-IoT in D05.01[5] has taken into account the different dimensions of user's trust.

According to the framework trust must be understood in different dimensions:[6]

[5] CREATE-IoT, Deliverable D05.01 *IoT Polocy Framework*.

[6] CREATE-IoT, *Deliverable 05.08, IoT Policy Framework Common Event*, 2020, p. 8.

- "*Socio-economical perspective* as it is recognized that "trust enhances economic efficacy under certain conditions"
- *Business perspective* as "trust in IoT is an indispensable prerequisite for the growth of IoT business".

Inputs on trust from different deliverables are summarized in CREATE-IoT D05.02[7] which offers a summary of the main trust concepts of the CREATE-IoT policy framework as shown in Table 3. It also provides the viewpoint of standardization on trust.

Table 3: Trust concepts as presented in D05.01and D05.02

Concept	Description
Overall perspective	Complexity of interactions: • The concept of trust is highly complex with no definitive consensus. • Applied to IoT Systems one proposal is to decompose trust into device trust, entity trust and data trust. The complexity of interactions in an IoT systems calls for a focus on important interactions which can be identified as interfaces between relevant IoT architecture entities. Trust frameworks: • IoT bridges virtual, digital, physical worlds. • It must integrate security, safety, reliability, connectability, resilience, availability, dependability, privacy. • It includes a community vision (friendship, ownership, community).
Socio-economical perspective of trust	• Trust enhances economic efficiency under certain conditions. • An individual, societal or relationship viewpoint is needed, to ensure that economic transactions are mutually beneficial rather than exploitative.
Business perspective of trust	• IoT business subject to a series of adoption factors relevant for trust, such as reputation. • It is based on user's perception, and influenced by the social environment
Technical perspective of trust: components	• Includes society, technology, information, knowledge, users and humans. • Includes concerns (e.g. security, privacy, safety …). • Enabled by processes.

5.4.2 **User satisfaction**

In order to facilitate user's satisfaction and engagement Create IoT has identified an engagement framework which has to be understood as a core component of the policy framework. The engagement framework is composed by different elements: ethics, standards and guidelines, legislation and contractual agreements. This work is condensed in the following deliverables:

- D05.01 - IoT Policy Framework (Initial)
- D05.02 - IoT Policy Framework Evaluation & Final IoT Policy Framework

5.4.3 **Regulatory compliance/readiness**

The maximization of benefits from IoT deployments and the increases of trust is also a specific result of regulatory compliance especially in the context of data protection and security. Create IoT has made the IoT privacy framework part of its policy framework.

As underlined in D. 05.01.: "There is therefore an underlying relation between the need of privacy and the consequential need of trust in the IoT architectures handling our personal data, which renders necessary to make the IoT trustworthy and the data processing operations taking place therein transparent".

[7] CREATE-IoT, Deliverable D05.02 *IoT Policy Framework Evaluation and Final IoT Policy Framework*

CREATE-IoT has also developed a security framework considering the following elements: ensuring IoT security mechanisms; ensuring IoT data protection; ensuring IoT system resilience; providing IoT system/application trust.

The relevance of ensuring legal compliance was also highlighted in the context of CREATE-IoT D.05.07 which discussed the main compliance issues faced by LSPs. As the report concluded: "(...) the discussion confirmed that compliance is essentially the denominator of common interest for all LSPs Projects.

However, 'compliance to what' seems to differ according to each specific vertical/application domain"[8]. This signals that the scope of compliance is very different according to each vertical and different expertise are needed. This was already signalled by CREATE-IoT D.05.06 titled "*Legal IoT Framework Evaluation and Final Legal IoT Framework*" and in its initial version D05.05 "*Legal IoT Framework (Initial)".*

Create IoT has also facilitated the dissemination of best practices developed in the context of LSPs through the editing of the AG05 good practices paper "*Personal Data Protection for Internet of Things Deployments: Lessons Learned from the European Large-Scale Pilots of Internet of Things*".[9]

5.5 Summary of CREATE-IoT contributions to the framework

In this section we provide a quick summary of our project's different contributions along each dimension of the proposed EU IoT Value Chain Integration Framework, see Table 4.

Our project's mission was to support LSPs' core efforts, facilitate a level of coordination and orchestration at programme and external level, and stimulate exchanges among stakeholders of the IoT ecosystem, both from the IoT LSP community and beyond.

Along these main avenues, CREATE-IoT has provided a number of contributions that have not only serviced the IoT LSPs, but also provide valuable tools to facilitate the integration of IoT technology and market development efforts at EU level in the future. We highlight the following elements:

- An extraordinary contribution in the standardisation and interoperability plane, thanks to the intense work developed by WP06
- Solid contribution in the aspects of trust and regulation, thanks to the work developed by WP05
- An important share of energy was devoted in WP02 to supporting and engaging SMEs, as key actors within the IoT value chain and ecosystem
- Special attention was placed to reach out and engage external communities and stakeholders, especially during the second half of the project. Thanks to this, important actors such as national or regional IoT initiatives and administrations were included in our workshops, thus facilitating the knowledge, influence and alignment of the IoT LSP Programme in current and future IoT initiatives.
- Intense support and coordination efforts within the IoT LSP community across all domains

[8] CREATE-IoT, Deliverable D05.07 *Legal IoT Framework Common Event*, p. 15.

[9] IoT-LSP Programme, Activity Group 05, *Personal Data Protection for Internet of Things Deployments: Lessons Learned from the European Large-Scale Pilots of Internet of Things*. Available online: https://www.activageproject.eu/docs/publications/Personal%20DataProtection%20for%20IoT%20Deployments%20-%20final%20(MI).pdf

Table 4: Summary of CREATE-IoT contributions to the proposed EU IoT Value Chain Integration Framework

KPIs	Contributions (short description)	CREATE-IoT activity or deliverable
Dimension 1: IoT Technology and Standards		
1.1 IoT standardisation	Support to IoT standardization at IoT LSP Programme level. Standardization ecosystem analysis and alignment Strategy and coordination plans for IoT interop. and standardization	D06.01, D06.02, D06.03, D06.04, D06.05, D06.06, D06.07, D06.08, D06.09, D06.10, D06.11
1.2 IoT platform/device interoperability	Recommendations for platform interoperability LSP assessment of convergence and interoperability	D06.01, D06.02, D06.03, D06.04, D06.05, D06.06, D06.07, D06.08
1.3 IoT platform openness	Recommendations for platform interoperability	D06.02, D06.03, D06.06, D06.08, D06.11
1.4 Open IoT data sets availability	IoT Data Value Chain Model Workshop on Policies to Support Open Data Marketplaces Workshop "Data sharing in agriculture: Towards a European agricultural data space"	D05.03, D05.04, D05.09
1.5 IoT market-readiness	Support to LSPs on business sustainability and exploitation strategy	D02.05, D02.06, D02.07
Dimension 2: Business Opportunities and Social Impacts		
2.1 Adoption of IoT-based business models	Support to LSPs on business models and sustainability models	D02.05
2.2 IoT-based business volume	Support to LSPs on business models and exploitation strategy	D02.05, D02.6, D02.07
2.3 Social impact of IoT	Indirect contribution through WP03 work on IoT and Arts and WP05 work on trust	D03.03, D03.05, D03.08, D05.
2.4 Social perception	Indirect contribution through WP05 work on trust and acceptance	D05.01, D05.02, D05.06, D05.08
Dimension 3: Ecosystem openness and Value Chain Involvement		
3.1 IoT ecosystem diversity	Stimulating community exchanges and debates among IoT stakeholders through numerous workshops Engagement of actors external to the IoT LSP community, national and regional initiatives Support to communication and dissemination at IoT LSP Programme level	D01,07, D01.09, D01.10, D02.06, D03.05, D03.08, D05.09, D06.08, D06.09, D06.10, D06.11
3.2 SME share in the ecosystem	Support to LSP Open Calls through an SME Engagement Guide 3 SME engagement workshops Launch of the IoT Next Club	D02.04, D03.03, D03.04

KPIs	Contributions (short description)	CREATE-IoT activity or deliverable
3.3 IoT demonstration	Indirect support to LSPs through engagement in workshops and visibility	
Dimension 4: Acceptance, Accessibility and Compliance		
4.1 User trust	IoT Policy Framework featuring trust as one of its pillars IoT Policy Framework Common Event	D05.01, D05.02, D05.08
4.2 User satisfaction	IoT engagement framework	D05.01, D05.02
4.3 Regulatory compliance/readiness	Legal IoT Framework and evaluation	D05.05, D05.06, D05.07

6. SELECTION OF LSP CONTRIBUTIONS TO THE FRAMEWORK

CREATE-IoT has supported the IoT European Large-Scale Pilots Programme in the development of a common methodology and in the design of horizontal KPIs to measure the LSPs impact on the overall programme. Horizontal refers to the horizontal impacts of the Programme across all focus areas. The horizontal KPIs are measuring the contribution of the LSPs participating in the programme to the achievement of the strategic impacts of the programme and underlining their cumulated value added. They have been developed on the basis of an iterative process led by CREATE-IoT in collaboration with the LSPs.

In this Section we provide an analysis of the contributions of three of the IoT LSPs already finalized (AUTOPILOT, MONICA and Synchronicity). This analysis has been a post-hoc exercise performed by CREATE-IoT on those three projects, for which information could be collected and interpreted from the point of view of our proposed IoT value chain integration framework. As such, the information in this section serves as a sample of how LSPs are able to provide contribution to the overall framework.

6.1 AUTOPILOT

6.1.1 Main contributions to the framework

AUTOPILOT started with defining a methodology to evaluate autonomous vehicles and IoT ecosystems according to defining the KPIs. An approach from use cases, through KPIs, to autonomous vehicles integration. Initially, AUTOPILOT started with 22 KPIs with specific project targets and divided into five main objectives:

1. Define and implement an IoT architecture for Automated Driving.
2. Realize IoT-base Automated Driving Use Cases.
3. Advanced Business Models and Services.
4. Involve Users, Public Services, and Business Players.
5. Contribute to Standards.

A lot of effort was put into further developing of the KPIs and documented in AUTOPILOT D5.3 (Performance and KPIs for autonomous vehicles and IoT pilot impact measurement) [6]. The prepared KPIs were divided into fields and mapped to different AUTOPILOT use cases. The synergy effects with CREATE-IoT D01.04 (Common methodology and KPIs for design, testing and validation) were emphasized and exploited.

The work analyses and provide an extensive number of KPIs for autonomous vehicles and IoT pilot impact measurement, categorized into fields and mapped to the different AUTOPILOT use cases. For further information we refer to the deliverable D5.3 in this project [6]. A methodology to evaluate autonomous vehicles and IoT ecosystems were described, and include the approach to define KPIs, evaluation elements, development lifecycle, and objectives and expected impacts. The performance and KPIs regarding design, testing, validation, and impact assessment for autonomous vehicles and IoT pilot impact measurement are described.

In addition, the autonomous vehicles and IoT KPIs across application domains are addressed. IoT platforms, sensors, and connectivity are the basis for vehicle connected autonomy in the new Mobility-as-a-Service (MaaS) paradigm. Autonomous vehicles and driving, as other domains, require multiple sensors embedded in all manner of smart devices across the IoT landscape, and are moving from products to services and experiences, from industry silos to complex connected ecosystems and value chains. All of this requires innovative use of KPIs across application domains to succeed. Several KPI fields are useful across IoT application domains, like smart cities, smart farming, smart living/wearables, and aging well. For instance, the issue of scalability is important for preparation for a rapid increase in IoT devices and users. Another important IoT issue is the faster design cycles and needs for software upgrades, compared to what is being used traditionally in the automotive industry. These upgrades demand scalable data processing and memory capabilities.

Standardization activities were an essential part of the AUTOPILOT project strategy. During the lifecycle of the project, 25 contributions based on the activity carried out in AUTOPILOT have been submitted to Standard Development Organizations (SDOs) [3]:

- Six contributions submitted to oneM2M (five accepted and integrated in TR-0026) and to AIOTI WG3, adding new use cases focused on autonomous driving.
- Participation to the last ETSI ITS CMS Plugtests™ with a vehicular PKI compliant to the new security standards ETSI TS 102 941 v1.3.1 e ETSI TS 103 097 v.1.3.1: compliance and interoperability tests together with 25 stakeholders and 50 observers.
- The PKI by CNIT is available to the project to test secure V2X communication.
- Realization a NGSI-LD Context Broker SCORPIO following the ETSI ISG Context Information Management standard. Integration with AUTOPILOT oneM2M platform and interworking with SynchroniCity LSP. SCORPIO will be released as Open Source.

A significant number of use cases based on AUTOPILOT activity was approved by oneM2M and included in TR-0026 "Vehicular Domain Enablement" [4] and by AIOTI and included in report "IoT relation and impact on 5G" [5]. The following table provide the list of contributions and obtained results [3]:

Table 5: Simplified list of AUTOPILOT contributions to SDO/WG [3]

SDO / WG	Title	Description	Link to Contribution in the SDO Website	Status (2019)
oneM2M	Requirements for TS0002	Requirements on network support for time critical IoT data	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=24622&fromList=Y	Agreed
oneM2M	Autonomous Driving section for introduction	Introduction for TR-0026 on autonomous driving and levels of automation	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=20914&fromList=Y	Agreed
oneM2M	Data model for vehicular	Need to have data model for automotive IoT data		Ongoing
oneM2M	AUTOPILOT IoT architecture slideset	AUTOPILOT architecture explained	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=24622&fromList=Y	
oneM2M	Use case on Automated Valet Parking	Use case from AUTOPILOT	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=26179&fromList=Y	Agreed
oneM2M	Use case: Platooning	Use case from AUTOPILOT	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=26181&fromList=Y	Agreed
oneM2M	Use case: Highway Pilot	Use case from AUTOPILOT	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=26239&fromList=Y	Agreed
oneM2M	Use case: Car Sharing	Use case from AUTOPILOT	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=26144&fromList=Y	Noted
oneM2M	Use case: Car Rebalancing	Use case from AUTOPILOT	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=26235&fromList=Y	Agreed
oneM2M	Use case: Urban Driving	Use case from AUTOPILOT	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=26238&fromList=Y	Agreed
oneM2M	Data model for platooning - informative	Informative: data model	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=25906&fromList=Y	Noted

oneM2M	Requirements for TS0002	Requirements on network support for time critical IoT data	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=24622&fromList=Y	Agreed
oneM2M	Autonomous Driving section for introduction	Introduction for TR-0026 on autonomous driving and levels of automation	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=20914&fromList=Y	Agreed
oneM2M	MAS - AUTOPILOT	AUTOPILOT Data Model	http://member.onem2m.org/Application/documentApp/documentinfo/?documentId=26633&fromList=Y	Noted
AIOTI	Use case on Automated Valet Parking	Use case from AUTOPILOT	https://aioti.eu/wp-content/uploads/2018/06/AIOTI-IoT-relation-and-impact-on-5G_v1a-1.pdf	Agreed
AIOTI	Use case: Platooning	Use case from AUTOPILOT	https://aioti.eu/wp-content/uploads/2018/06/AIOTI-IoT-relation-and-impact-on-5G_v1a-1.pdf	Agreed
AIOTI	Use case: Highway Pilot	Use case from AUTOPILOT	https://aioti.eu/wp-content/uploads/2018/06/AIOTI-IoT-relation-and-impact-on-5G_v1a-1.pdf	Agreed
AIOTI	Use case: Car Sharing	Use case from AUTOPILOT	https://aioti.eu/wp-content/uploads/2018/06/AIOTI-IoT-relation-and-impact-on-5G_v1a-1.pdf	Agreed
AIOTI	Use case: Car Rebalancing	Use case from AUTOPILOT	https://aioti.eu/wp-content/uploads/2018/06/AIOTI-IoT-relation-and-impact-on-5G_v1a-1.pdf	Agreed
AIOTI	Use case: Urban Driving	Use case from AUTOPILOT	https://aioti.eu/wp-content/uploads/2018/06/AIOTI-IoT-relation-and-impact-on-5G_v1a-1.pdf	Agreed
ETSI SmartM2M	Federation of IoT automotive Data Model with SAREF	AUTOPILOT Data Model	https://portal.etsi.org/ngppapp/ContributionCreation.aspx?primarykeys=152934&source=WNJKPQWRZMUL	Noted
ETSI ISG CIM	Federation of IoT automotive Data Model	AUTOPILOT Data Model	https://portal.etsi.org/ngppapp/ContributionCreation.aspx?primarykeys=152912&source=ZGMTZBEVXMYT	Noted
ETSI ISG CIM	Data models	AUTOPILOT Modelling	https://docbox.etsi.org/ISG/CIM/05-CONTRIBUTIONS/2018//CIM(18)000133_AUTOPILOTModelling.pptx	Noted
ETSI TC ITS	ITS Security - ETSI 6th CMS Plugtests™	AUTOPILOT Public Key Infrastructure for trusted and secured V2X communication	https://www.etsi.org/events/1141-plugtests-2019-itscms6	Agreed
AIOTI	ETSI G5 versus LTE-V2X	ETSI G5 versus LTE-V2X	https://aioti.eu/aioti-report-on-iot-relation-and-impact-on-5g/	Report

6.1.2 Summary

KPIs	Contributions (short description)	KPI value (if available)
Dimension 1: Technology development		
1.1 IoT standardisation	Identified relevant SDOs. Influenced SDOs with results obtained in the project. Performed interoperability TESTFEST to demonstrate the compliance to standards of the solutions implemented in the project pilot sites.	25 contributions

KPIs	Contributions (short description)	KPI value (if available)
1.2 IoT platform/device interoperability	Contribution/involvement of oneM2M, AIOTI, Smart M2M, and others in project use cases and activities.	n/a
1.3 IoT platform openness		n/a
1.4 Open IoT data sets availability		n/a
1.5 IoT market-readiness	HD Maps for Automated Driving Vehicles.	1
Dimension 2: Business Opportunities and Social Impacts		
2.1 Adoption of IoT-based business models		n/a
2.2 IoT-based business volume	Collaboration strategy: Alliances and partnerships with other companies or consortia	n/a
2.3 Social impact of IoT	Improved road safety. Improved personal mobility and sustainable mobility.	Contributions to socially relevant aspects
2.4 Social perception		n/a
Dimension 3: Ecosystem openness and Value Chain Involvement		
3.1 IoT ecosystem diversity	Developed a range of driving services to be tested in four different driving modes and six different Pilot sites. The project mobilized 45 partners in 4 different sectors: development of autonomous driving vehicles, development of IoT and networks, collection of data to evaluate the systems and end-users organisations.	Wide stakeholder engagement
3.2 SME share in the ecosystem		n/a
3.3 IoT demonstration		n/a
Dimension 4: Acceptance, Accessibility and Compliance		
4.1 User trust	End users involved in testing the IoT solution. Trust in privacy and data protection measures for piloted services.	Positive results in terms of perceived traffic safety, stress reduction in pilots
4.2 User satisfaction	End users involved in testing the IoT solution.	Positive results in comfort and stress reduction in pilots
4.3 Regulatory compliance/readiness		n/a

6.2 MONICA

6.2.1 Main contributions

MONICA defined, in its first phase, an assessment and validation framework that was used to measure assessment, validation and replication process in a clear, rigorous, and accessible manner to all stakeholders.

The aim of the Impact Assessment and Validation process in MONICA was to:

- Establish validation methods to assess the impact of the MONICA's solutions against KPIs across and within the pilot sites.
- Undertake an assessment of the methods used in order to obtain qualitative and quantitative results, including lessons learned, that support replication.
- Analyze sufficient numbers of relevant data (before, during and after each pilot event), guided by stakeholders, to be able to undertake a formal assessment of the social-economic impacts, technological impacts and user acceptability of the project.
- Demonstrate the generic applicability and interoperability of experimental testbeds and open platforms in validation of the Internet of Things technologies.

The impacts are defined and evaluated around three main categories and related areas, through a systematic quantitative and qualitative assessment of the observed results and lessons learned from the project's activities:

1. Socio-economic impacts
    a. The Value Chain in MONICA
    b. New business opportunities
    c. Business models
    d. Improved quality of life
    e. The MONICA Development Toolbox
2. Technological impacts
    a. Demonstration under real-life conditions
    b. Standards and pre-normative activities
    c. The interoperability of the MONICA platform and technologies
3. User acceptability
    a. User satisfaction
    b. Comfort of the device
    c. Increased security perception in an open-air event
    d. Privacy concern of the user following the use of the device

Some of the impacts listed above have been quantified with a set of 19 KPIs.

Eleven (11) KPIs have been defined to measure Socio-economic impacts, in particular to measure the progress on citizen benefits, safety, comfort, health, public services, economic growth, entrepreneurship, etc.
Six (6) relevant KPIs have been defined to measure technological impacts, in particular the progress in scalability and resilience, the applicability of different kind of wearables, integration of heterogeneous IoT enabled sensors and actuators (including professional measuring equipment and drones), simultaneous support for many, real time closed-loop applications, and interoperability with legacy IoT platforms and cloud services, including social media. Two (2) relevant KPIs have been defined to quantify user acceptance and in particular to measure privacy, security, vulnerability, liability, identification of user needs, concerns and expectations of the IoT solutions.
The validation of results is based on demonstrations/deployments done in 2018 and 2019 and results are connected to MONICA use case groups: Crowd and Capacity Monitoring, Crowd Management and Communication, Sound Level Monitoring, Adaptive Sound Field Control and User Experience.
MONICA managed the contribution to the consolidation and coherence work with Create- IoT and for this reason, MONICA categories/KPIs and CREATE-IOT Dimensions/Categories could be linked.

The table below is filled taking into account the following MONICA deliverables: *D9.2 – Final Assessment, KPIs, and Validation Report of the MONICA IoT Platform*; *D9.3 – Replication reference Book and Roadmaps for MONICA Market Replication*, *D11.5 – New Markets segmentation and Sustainable Business,* D12.6 – *Final Replication, Exploitation and Business Plans.*

6.2.2 Summary

KPIs	Contributions (short description)	KPI value (if available)
Dimension 1: IoT Technology and Standards		**Expected by the project /(End of project)**
1.1 IoT standardisation	Contributions to ETSI, oneM2M and radio spectrum regulations	**1 (1)** MONICA has identified the requirement for a new standard/update of existing IoT standard, that provide guaranteed low latency and time jitter for RF connected end-to-end communication. The Industrial IoT segment is also in need for Low Latency and time jitter. Moreover, MONICA also achieved to be included in the comprehensive AIOTI study High Priority IoT Standardisation Gaps and Relevant SDOs.
1.2 IoT platform/device interoperability	The number of applications that integrate different wearables and other sensors	**20 (29)** The highest number obtained comes from the last MONICA demonstration Fête des Lumières in 2019. 8 demonstrations out of 25 exceeded the threshold of 20 established in the DoA
	Number of interoperability hooks to Smart City platforms demonstrated	**4 (4)** The MONICA platform worked with four platforms: the platform of the Torino municipality, used for the IoT sound level meters: the Smart City Platform of the city of Hamburg, the Noise Platform of the Greater Lyon Metropolis and the M2M platform of TIM.
	The total number of applications running simultaneously on the same platform during live event	**15 (41)** The highest number obtained comes from the Fête des Lumières demonstration in 2019. 19 demonstrations out of 22 exceeded the threshold of 15 established in the DoA.
	The largest number of simultaneous communication sessions during the events on one pilot	**8.000 (6.231)** The best result has been obtained in the Woodstower demonstration with the deployment of the crowd wristbands.
1.3 IoT platform openness	**The MONICA Development Toolbox** is an open software development toolbox and generic enablers that allows developers to rapidly develop new applications to be	N/D

	deployed within the MONICA platform. The development platform consists of a toolbox, tutorials and guidelines. It can be used to integrate various resources into the IoT Platform and can hide the complexity of the communication with IoT devices.	
1.4 Open IoT data sets availability	Public data from the MONICA project has been made available on two occasions, in Torino and Copenhagen.	N/D
1.5 IoT market-readiness	Solutions implemented by the project that reached a level of technology readiness of TRL6-8 which means that they are close to being commercially available on the market: • MONICA Sound Level Monitoring solution (TRL 7) • MONICA Adaptive Sound Field Control solution (TRL 6) • MONICA Crowd and Capacity Monitoring solution (TRL 8) • MONICA Crowd Management and Communication solution (TRL 7) • MONICA Collective Awareness Platform solution (TRL 9) • MONICA Visitor Experience Apps solution (TRL 8)	N/D (It's related to Business Models KPIs)
Dimension 2: Business Opportunities and Social Impacts		
2.1 Adoption of IoT-based business models	Number of sustainable, validated business models showing the potential from IoT platforms.	10 (6) MONICA platform is covered by a portfolio of six dedicated solutions that cover specific parts of the closed-loop functionality: Crowd and Capacity Monitoring, Crowd Management and Communication, Sound Level Monitoring, Adaptive Sound Field Control, Visitor Experience Apps and the Collective Awareness Platform. Therefore, six business model canvas have been produced. Business Model for the MONICA Crowd and Capacity Monitoring solution, one for the MONICA Crowd Management and Communication solution, one for Sound Level Monitoring solution, one for the Adaptive Sound Field Control solution, one for the Visitor experience solution and one for the Citizen engagement solution.

	Demonstrations of cloud interoperability with public services for business and private purposes	4 (2) Public data from the MONICA project has been made available on two occasions, in Torino and Copenhagen
	Impact on opportunities for entrepreneurs: acceptability of the toolbox and guidelines through validation in incubator environments	>95% (74%) The MONICA Development Toolbox is meant to enable companies to easily develop IoT applications. In March 2020 six developers have been recruited to test the toolbox and evaluate the usability. A questionnaire has been distributed among the testers and 74% is the result obtained analyzing the answers.
2.2 IoT-based business volume		
2.3 Social impact of IoT	Approval rate related to noise and security by professional organisers	>65% each (33%, 66%)
	Reduction of noise levels in low frequency octave bands in selected neighbouring areas	10 dB (11dB)
	Approval rate related to public participants exposed to the solutions	>60% (68%)
	Number of value chain actors involved in webinars, workshops and demonstrations	>800 (>1.600)
	Number of citizens using the Collaborative Awareness Platform	>1.000
2.4 Social perception	Satisfaction rate related to noise by neighbours, professionals and musicians	>50% (45%, 50%)
Dimension 3: Ecosystem openness and Value Chain Involvement		
3.1 IoT ecosystem diversity	MONICA ecosystem is composed by stakeholders representing the whole value chain from supply to demand	N/D Stakeholders involved in MONICA are • Solution developers • Solution providers (e.g. SMEs) • Research centers/Academia • Local authorities (Cities/municipalities) • Security/emergency services • Event organizer • Event visitors • Event authorities • Citizens
3.2 SME share in the ecosystem	Engagement through three hackathons	60 SMEs and developers
3.3 IoT demonstration	Progress in IoT pilots and demonstrators as accelerators of IoT take-up	N/D During the third year of MONICA Project 3 pilots were set up, replicating the deployment of MONICA Solutions. Total pilots of MONICA: 11+3

Dimension 4: Acceptance, Accessibility and Compliance		
4.1 User trust	Acceptability of data protection, privacy and trust schemes	>98% (59%, >98%) The result of 59% has been obtained interviewing a total amount of 779 respondents, and considering two kind of questions in the questionnaires distributed to users of LoRa trackers (security staff) and visitors who used the crowd wristbands or were monitored by cameras. The >98% is due to the fact that all the people approached in the MONICA pilots, accepted voluntarily to use and test the devices (smart glasses, LoRa trackers, staff wristband) during their shift after having read the informed consent form provided with the questionnaire.
	Number of users involved in the social media and Collective Awareness apps and sharing data	>1000 (500) Since it was not possible to keep track of all the interactions that the pilots had with their visitors, the total amount of 500 has been calculated considering the Torino CAP users and those giving feedback through the visitor apps.
4.2 User satisfaction	The **satisfaction of the use** has been evaluated through questionnaires distributed to the security staff who used the MONICA solutions (LoRa trackers, Smart glasses, COP) during their shift, and to the event's visitors who used the crowd wristbands and who downloaded the visitor apps.	N/D (Results available in D9.2 – Final assessment, KPIs and Validation Report of the MONICA IoT Platform)
	The **comfort of the device** has been evaluated through questionnaires distributed to the security staff who used the MONICA devices during their shift and to the festival goers who used the crowd wristband.	N/D (Results available in D9.2 – Final assessment, KPIs and Validation Report of the MONICA IoT Platform)
	Increased security perception in an open-air event: as well as being a socio-economic impact, the increased security perception in an open-air event is also important when looking at user acceptance, as it's very important to know what the visitor and neighbour perceptions are of the MONICA solutions. To measure how the security perception of the visitors can potentially change, if the event organizers would adopt new technologies to improve the security measures in the venue, a question has been added in the visitor and neighbor questionnaires.	N/D (Results available in D9.2 – Final assessment, KPIs and Validation Report of the MONICA IoT Platform)

	The privacy issue has been investigated both in 2018 and in 2019 in all the events where there have been devices deployed and technologies that were collecting information on routes of the user within the event venue: cameras, staff trackers and crowd wristbands.	N/D (Results available in D9.2 – Final assessment, KPIs and Validation Report of the MONICA IoT Platform)
4.3 Regulatory compliance/readiness	No KPIs were set for this aspect, but a public report is available on the MONICA website (D12.5 – Report on Standards Regulations and Policies for IoT Platforms)	

6.3 SYNCHRONICITY

6.3.1 Main contributions

In the time of writing CREATE-IOT D2.03 Common methodologies and KPIs for design, testing and validation, Synchronicity was proposing 18 KPIs, distributed in 7 categories. In that time, these categories had no a direct naming-match with dimensions or categories of CREATE-IOT. But even if the naming was different, a direct relation between SYNCHRONICITY categories/KPIs and CREATE-IOT Dimensions/Categories could be linked. These were the SYNCRONICITY categories (according to SYNCHRONICITY deliverable D6.3 KPI framework):

- Social innovation
- Access to Services
- Governance
- Innovation
- Local ecosystem
- Safety
- Replication and Scalability

With the final assessment of SYNCHRONICITY (D6.5 Final Impact Assessment Report), these categories changed slightly to be adapted to the 3 category levels: with a focus in the DoA objectives but also focusing on:

People, Planet and Prosperity as generally accepted bottom lines in the development of indicators systems (Huovila, Bosch & Airaksinen, 2019). In the SynchroniCity project, the bottom lines of smart city projects (People, Planet and Prosperity) form the basis and are included in the application themes of the Atomic Services: Human Centric Traffic Management, Multimodal Transportation and, Community Policy Suite (D3.6 Customized IoT service prototypes for lead ref. zones – advanced).

As a result, the final SYNCHRONCITY 3 categories levels are:

1. Ecosystem building
2. Services and the value created
3. IoT Infrastructure development

These categories can be related to CREATE-IOT horizontal KPI Domains.

Specially, about “ecosystem openness development and value chain actors”.

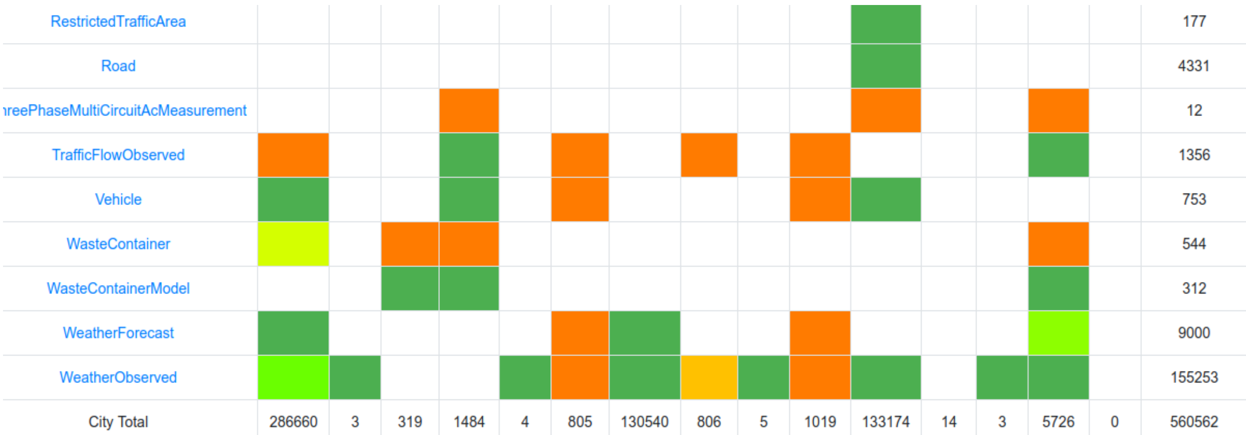
Some considerations about the KPIs included in those categories:

- Some KPIs are divided into measurements received by the project internal pilots (known as Reference Zones) and the new cities/pilots coming from the Open Call.

- Some KPIs are not so easily measured as a number. For example, KPI *3.6 Partners' Engagement*, provides not only numbers, but also a classification and distribution of partner's role. In the SYNCHRONICITY D6.5 there exists different figures showing these roles and their distribution. This is very remarkable because it is using the CREATE-IOT classification provided in CREATE-IOT T6.4 Data Collection.

Finally, in the following tables, these SYNCHRONICITY categories and its KPIs have been mapped into the CREATE-IOT dimensions framework. In green, some new KPIs.

In terms of interoperability, Synchronicity produced different data models during the project with the objective of standardizing the way of communicating. NGSI supported all the project about the creation of comment interfaces and interoperability mechanisms. The final result was 159 data sets (some of them replicated in different cities). These data sets are composed by different kind of entities with a number that varies depending on the moment of the project. This information can be checked by the SYNCHRONICY data models validation tool, where all the data sets are checked about its entities and its compliance with FIWARE data models. Through this tool, information about the data sets and its validation can be obtained any time: https://validation.services.synchronicity-iot.eu/table/



About 500k different entities.

6.3.2 Summary

KPIs	Contributions (short description)	KPI value (if available)
Dimension 1: IoT Technology and Standards		
1.1 IoT standardisation		
1.2 IoT platform/device interoperability	Number of IoT Connected Devices for the Open Call pilots	New installed devices for Synchronicity: 1694 Connected devices in the Open Call pilot's solutions (because of SYNCRHONICITY or other projects/programs): 2509 Average of 167 devices per Open Call pilot. Including other "entities" (no devices) connected. Such as roads, bus stops, etc: 544764, connected entities. More here: https://validation.services.synchronicity-iot.eu/table/

	Perceived Improved Interoperability for the Open Call pilots	88% improved interoperability to be 4 / 5 or higher
	Perceived Improved Interoperability for the Reference Zone pilots	Not received in the time of writing the SYNCHRONICITY D6.5
1.3 IoT platform openness	Services Implemented During the Project: validated services created during the SynchroniCity project, Atomic Services and the Open Call pilot services	15 Atomic Services deployed in 25 RZ Applications Open Call pilots implemented 16 services with 50 IoT deployments.
1.4 Open IoT data sets availability	Number of open data sets in use:	43 data models 159 data sets
	Perceived Quality of Open Data: Open Call pilots' perspectives on the quality of open data (On a scale of 1-5)	open data used: 57 % of the pilots evaluated the quality of the to be 4 or 5 open data created: 81 % evaluated the quality 4 or 5
1.5 IoT market-readiness		
1.6 IoT services replication potential	To look at the number of replicated serviced during the project.	15 Atomic Services replicated in 25 RZ All validated Atomic Services were replicated at least in two cities. 63% of the Atomic Services were replicated in more than two cities (13% in 3 cities, 25% in 4 cities and 25% in five or more cities). All the 16 Open Call pilot services were also replicated in at least two cities. 69 % of the Open Call pilot services were replicated in three cities, 13 % in four cities and 6% in five cities
Dimension 2: Business Opportunities and Social Impacts		
2.1 Adoption of IoT-based business models		n/a
2.2 IoT-based business volume		n/a
2.3 Social impact of IoT	Users of the Services: The original focus was on the number of users of the services, however, while looking at this, the question of who the users are, became at least as relevant for the understanding of the impact created. There were some challenges in measuring the number of users due to the nature of different groups and thus varying reporting units, cars per day, citizens, and organisations.	The 16 Open Call pilots reported 57500 users.
2.4 Social perception		n/a
2.5 Local Job Creation	This KPI refers to the number of jobs created by the project	22 jobs created by the RZs 15 jobs created by the Open Call pilots
Dimension 3: Ecosystem openness and Value Chain Involvement		
3.1 IoT ecosystem diversity		
3.2 SME share in the ecosystem	Refers to the number of SMEs involved in all the processes in all the pilots (RZs and Open Call)	Open Call applications involved 227 SMEs

		After selection: 28 SMEs were involved The 8 Internal pilots involved 10 SMEs. In total 38 SMEs involved
3.3 IoT demonstration		
3.4 Awareness Impact	This indicator aims to capture the awareness impact made by the project. That is, it describes what target groups and to what extent, have been reached. Target groups of communications activities were small and medium-sized enterprises, large companies and cities.	% of the reached target groups couldn't be measured. (expectation of reaching 100 in the number of applications) 133 applications with 227 SMEs and 45 new cities
3.5 Co-creation (or participatory governance)	The aim of creating IoT-enabled services for and with the citizens	(Expectation % of citizens participating. This was no longer a valid to be measured. Instead of that a description of the co-creation tasks is provided for an understanding of the impact through co-creation) Five of the eight RZs accomplished a reachable percentage of accomplished Tasks or exceeded the minimum level. About the Open Call(16 pilots): • 6 exceeded the minimum level of accomplishment • 3 low percentage of accomplishment • 7 report 0% of accomplishment.
3.6 Partners' Engagement	To evaluate the ecosystem created during the project. Looking at the number of ecosystem actors. The involvement is not only provided as a number but complemented with a classification and distribution of roles. Following the CREATE-IoT categories; T6.4 data collection. More details about the role's distribution in SYNCHRONICITY D6.5.	91 organisations with a prominent role of ICT/IOT Providers.
Dimension 4: Acceptance, Accessibility and Compliance		
4.1 User trust		
4.2 User satisfaction (pilots as users of SYNCRONICITY platform)	Perceived value of the SynchroniCity technical framework for the pilots as users.	Received help: average rating was 3 (with a scale of 1 to 5), with 54% of respondents evaluating moderate help. Platform most valuable: • Integration with other services and products: 72% • Access to real time information: 63% • Organising data in a presentable and useful way: 36% • Integration between physical and digital infrastructures: 27%

		• Better digital accessibility: 18% Perceptions of the SynchroniCity technical framework: either slightly (50%) or significantly (50%) improved their service offer
	Perceived value of the end users of the Open Call pilot services (On a scale of 1-5)	88 % of the Open Call pilot projects satisfaction rate of 4 or higher There was one sole rating of 3 and none below 3. Average value of 4,17 / 5 it can be concluded that the expectation (70 % satisfied) was exceeded
	Perceived value of the Local Government and Decision Makers. This indicator concerns Reference Zone (internal pilots) leads' evaluation of the perceived value for the local government and decision-makers (On a scale of 1-5)	None rated 1 25% rated 2 13% rated 3 50% rated 4 13% rated 5
4.3 Regulatory compliance/readiness	The Level of Data Protection by the City: This KPI refers to the level of data protection by the city. This was evaluated by whether the RZs performed the PIA (Privacy Impact Assessment).	50% implemented the PIA The other 50% the pilot implementation did not require a PIA or the authentication and authorisation systems were not in place

7. CONCLUSIONS

7.1 Contribution to overall picture

This deliverable is an effort to provide a conceptual structure to understand the different elements that play relevant roles in the evolution and maturity of the EU's IoT market based on the experience gained by the IoT European large-Scale Pilots Programme projects. The framework presented in Section 4 considers different angles that play a role in the road towards a successful development of the vibrant IoT market and ecosystem in the EU. These angels (or dimensions, as we have referred to in this document) range from technology development (standardisation, readiness) to business development (business models), from the ecosystem dimension (diversity of actors and stakeholders) to the social impact and the impact of regulation. The intention is to provide a framework able to capture the most relevant factors involved in the complexity of IoT technology and market development.

Regarding the work developed by CREATE-IoT, the project has generated a multitude of contributions that can be regarded as catalysts or building blocks that will facilitate a deeper, better integration (or orchestration) of the EU IoT value chain in the future. This has been demonstrated in Section 5, from which we highlight the active role of the project along the standardisation dimension, in support to ecosystem building or in relation to trust and regulation.

CREATE-IoT has increased significantly the intensity of the activities developed during the second half in terms of organization of workshops and exchanges around different dimensions of the proposed framework with a large variety of stakeholders in relation to the IoT and digital transformation as result of the increased maturity of the results achieved by the programme projects. This has generated not only an important awareness about the IoT LSP Programme achievements among actors that were external to the Programme but has also facilitated their engagement with a wider stakeholder base towards future activities and integration.

The scope of the proposed EU IoT value chain integration framework goes well beyond the immediate results that the IoT LSP Programme may generate in the short term. The impact of the IoT LSP Programme in the framework, as large as it is expected to be, is factored in in the framework, and as already presented in Section 6 a preliminary analysis of contributions to the framework is coming from the three finished LSPs: AUTOPILOT, MONICA and SYNCHRONICITY.

The IoT European Large-Scale Pilots Programme and CREATE-IoT project have provided the framework and the mechanisms to ensure efficient and innovative IoT take-up in Europe, building on the various parts of the initiative, by supporting efficient information sharing across the programme stakeholders, extension and consolidation of the EU IoT community, including start-ups and SMEs through validation of technologies deployment, replicability towards operational deployment and identification/validation of most promising standards and gap identification in standardisation activities.

The work done has to be continued through solid support for future IoT technologies and applications in Europe and specific programmes addressing IoT and IIoT that are important enablers for digitising European industry.

This is critical considering that based on the EIB report [7] the adoption of digital technologies in Europe is slow when compared to the United States and many leading digital technology companies are based in the US or China. The study shows that EU firms lag in adopting digital technologies, particularly for IoT technologies.

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