

CROSS FERTILISATION THROUGH ALIGNMENT, SYNCHRONISATION AND EXCHANGES FOR IoT

H2020 – CREATE-IoT Project

Deliverable 02.03

Common methodologies and KPIs for design, testing and validation

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1. PUBLISHABLE SUMMARY

This deliverable acts as a logical and subsequent step regarding the Key Performance Indicator (KPI) elicitation exercise achieved with the release of D01.04 [1] (Common methodology and KPIs for design, testing and validation), in which the initial list of common KPIs was published.

This initial list aimed at being the first entry point for all LSPs to discuss on a common approach to evaluating, at least, IoT high level performance. This list was used as an input to Activity Group (AG) 01 (IoT Focus Area Sustainability). All LSPs, as they are represented through this AG, either used the KPI input to provide their view or referenced their approach to the model provided. This way, the output of the discussion was a valuable set of KPIs per LSP, namely:

- Common KPIs from the provided list which the LSP considers key to assess its success.
- A new set of domain-specific KPIs used to evaluate particularities of each LSP related to the vertical addressed.

This report documents this procedure and, more importantly, explains the best practices and conclusions that can be extracted from the feedback received, in a form of a new and refined **list of critical KPIs for common evaluation of LSPs**.

Following this line of thought, the document is structured in the following sections:

- Section 2 documents the process followed for the KPI elicitation, discussion with LSPs and refinement through the needed interactions. It also covers the planned next steps for explaining and introducing the final list of common KPIs to LSPs so that they can incorporate them to their evaluation process.
- Section 3 covers the down selection of KPIs done at each LSP level. From the whole list of provided KPIs, each LSP will select those which are, from their point of view, more aligned to their needs.
- Based on the previous chapters, section 4 acts as summary and way forward for all the feedback collected. New KPI lists will be analysed looking for synergies and commonalities. At the end, a minimum and core list of general IoT KPIs is presented, being CREATE-IoT proposal for evaluation.

2. STRATEGY FOR KPI IDENTIFICATION AND COLLABORATION

Among the coordinating activities carried out by CREATE-IoT as one of the two CSAs supporting the IoT European Large-Scale Pilots Programme, the development and implementation of common methodologies and KPIs to measure the LSPs performance and impact throughout the duration of the Programme plays a pivotal role. Indeed, a common methodological performance framework involving each LSP and spanning the whole IoT European Large-Scale Pilots Programme is instrumental to guide the LSPs towards their specific objectives while making sure that the overall Programme effectively tackles the challenges and measure the KPIs identified by the European Commission in the initial call and Work Programme. In short, the KPIs are being established, among other reasons, to assess the level of integration of advanced IoT technologies across multi-industry value chains, the degree of scalability that a multitude of IoT applications in a variety of use cases can sustain, the level of user acceptability of each LSP and use-case and the type of business model underpinning each LSP in view of the sustainability of each single project and the Programme as a whole.

The strategy for the identification of KPIs is to be intended as a collaborative, iterative and multi-directional process involving CREATE-IoT both in its coordinating and supporting nature to the IoT Focus Areas, as well as in its role of creating a shared arena where the multiple work streams developed by the various LSPs and use cases can be aligned and integrated. The strategy includes the active participation of the LSPs in order to maintain a constant and updated visibility on their specific KPIs and propose a meaningful and actionable common framework.

2.1 KPIs identified by CREATE-IoT as a working list

The initial list of KPIs presented in D01.04 (Common methodology and KPIs for design, testing and validation)[1] presented a comprehensive set of KPIs organized along a top-down theoretical framework consisting of three distinct levels.



Figure 1. The Cornerstone: Eight KPIs Dimensions identified in D01.04

- A first level outlining a series of “dimensions” identifying “where” the impacts are going to exert their effects;
- A second level with number of “fields”, that is a series of more specific and circumscribed sub-areas assign to each dimension to further narrow down, and better delimit, the impact spheres;

- A third level of specific, measurable metrics associated to each field – the actual KPIs.

Figure 1 above presents a graphical representation of the eight dimensions, the first level of the common methodological framework, identified in D01.04. The eight dimensions are:

- **Dimension 1:** Technology development measuring the type of support and the effects generated by the IoT European Large Large-Scale Pilots' Programme on ICT vendor and suppliers of IoT technology.
- **Dimension 2:** Technology deployment and infrastructure measuring the degree of adoption, integration and performance of IoT technology across the LSPs and the whole Programme.
- **Dimension 3:** Ecosystem strategy and engagement measuring the extent to which an ecosystem strategy is in place and how well it is followed by the LSPs.
- **Dimension 4:** Ecosystem Openness and External Collaboration measuring the degree of openness and accessibility of the LSPs ecosystem for third parties outside the Programme.
- **Dimension 5:** Marketplace and business impacts measuring the LSPs' readiness for business transactions in terms of business effectiveness but also in terms of security and trust.
- **Dimension 6:** Societal and economic impacts measuring the LSPs' societal and economic impacts in the short and long-term.
- **Dimension 7:** Policy and governance impacts measuring the LSPs impact to the existing national and European policy issues related to IoT
- **Dimension 8:** Community support and stakeholders' inclusion measuring how LSPs demonstrations are going to be actually adopted by the community in the long run.

For each of the above-listed dimension, a number of second-level “fields” are identified and, to each field, a 3rd-level KPI list is assigned. A graphical representation of dimensions, fields and KPIs is offered in Figure 2 below.

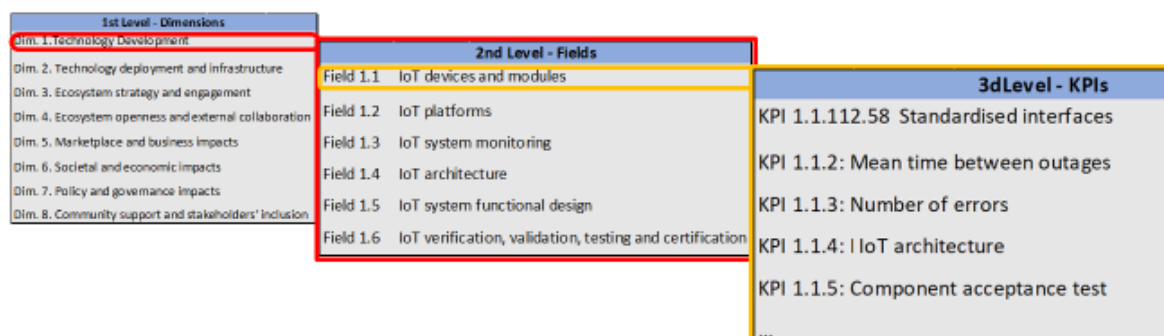


Figure 2. The hierarchical structure of dimensions, fields and KPIs

The initial working list of KPIs identified by CREATE-IoT and fully presented in detail in D01.04[1] has been the result of an extensive effort of desk and secondary research to investigate the existing material pertaining to the European IoT Large-Scale Pilots. While working on D01.04, CREATE-IoT interacted and conducted interviews (either face-to-face or by telephone) with each LSP to understand its specific measurement need and then carefully considered and analysed the initial objectives as well as the actual achievements of each LSP project and each demonstration to make sure that the dimensions, fields and KPIs actually devised in the initial list were sufficiently extended to serve the needs of the overall Programme as well as the requirements of each individual LSP.

In conducting this exercise, CREATE-IoT further organized the initial list of KPIs along three main types of indicators, each addressing a specific level of analysis:

- **Generic indicators** referring to areas of performance or evaluations that are common to all KPIs and all products, services and projects. These indicators will be applied to all LSPs and to the IoT European Large-Scale Pilots Programme as whole;
- **Cross-domain indicators** operating at a lower level by intercepting those processes and features pertaining to more than one domain and therefore potentially referring to more than one LSP but not to the Programme as a whole;
- **Domain-specific indicators** designed for, and applying to, a single domain and are therefore used to measure the performance and impacts of one specific LSP.

At the same time, the common methodologies and KPIs presented in D01.04[1] carefully considered the measurement needs at programme level in order to serve as a benchmark for the overall IoT ecosystem in Europe and beyond and allow the ecosystem stakeholders to verify the level of advancement, performance and impact of specific IoT demonstrations in well-defined domains.

2.2 Collaboration with LSPs

The collaborative and iterative approach put in place to design and finalize the initial list of KPIs presented in D01.04 was revamped and used to a more intensive degree in the subsequent phase of activities carried out by CREATE-IoT under WP2, Task 02.02 “Validation methodologies, best practices and business models” led by IDATE. The aim of this subsequent set of actions was to expand and adjust the initial list of KPIs to ensure the full coverage of the Programme objectives and make sure that individual requirements of each specific LSP will be duly taken into a consideration in the final list of KPIs – the list that will be used to measure each LSP and the overall European IoT Large-Scale Pilots Programme across a comprehensive set of dimensions.

2.2.1 Interaction with the LSPs – First Step

The first step of the CREATE-IoT’s team was to contact each LSP and obtain their existing list of KPIs as designed and devised by their own DoW and subsequent modifications. Upon receipt of the LSPs KPIs lists, a series of individual calls between CREATE-IoT and each LSP were organized to discuss the list and request clarifications, where necessary

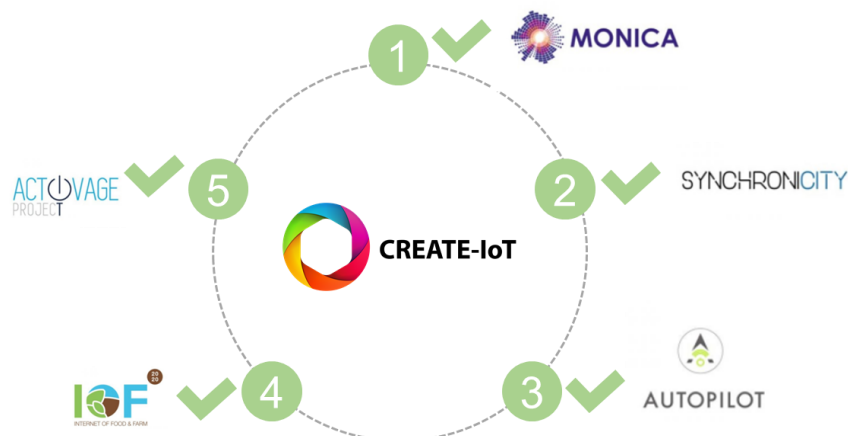


Figure 3. Collaboration with LSPs – First Step of Interaction with LSPs

The KPIs lists received from the LSPs were carefully checked for consistency at individual level (i.e. for each LSP), at Programme level (i.e. across the five LSPs) and were thoroughly compared with the initial list of KPIs presented by CREATE-IoT in D01.04. This exercise led to an in-depth and systematic comparison of all the KPIs available at a specific point in time and

provided a first, comprehensive overview of all the indicators designed at project and programme level. The comparison was carried out along three hierarchical levels to maintain consistency with the initial list devised by CREATE-IoT. For each LSP, KPIs pertaining to each level were assigned and then compared with the initial list of CREATE-IoT. This produced an intelligible Excel document that highlighted:

- Common KPIs, that is KPIs that were identified at the 3rd level of the common methodological framework by CREATE-IoT and that are present across all LSPs;
- Missing KPIs, that is KPIs that were identified at the 3rd level of the common methodological framework by CREATE-IoT and that are not present or considered by the LSPs;
- Additional KPIs, that is KPIs that were identified by one or more LSPs but that were not initially devised by the common methodological framework produced by CREATE-IoT.

The results were summarized in an Excel file that was circulated to all LSPs for further checking and validation. The Excel file had the following form:

Legend	KPI peculiar of a given LSP								
	No correspondence found for a given KPI								
D1.4 Create IoT		AutoPilot			Monica				
List of KPIs formulated in the Create IoT D1.4 Deliverable		Same structure of D1.4, some differences due to LSP's specificities			Restricted list of KPIs compared with D1.4 and also different focus (not LSP performance but rather specific project effectiveness)				
1st Level	2nd Level KPI	1st Level	2nd Level	KPI	1st Level	2nd Level	KPI		
1.Technology C1.1 IoT dStandardised interfaces		1.Technology Developme1.1 IoT devices and Standardised interfaces							
1.Technology C1.1 IoT dMean time between outages		1.Technology Developme1.1 IoT devices and Mean time between outages							
1.Technology C1.1 IoT dNumber of errors		1.Technology Developme1.1 IoT devices and Number of errors							
1.Technology C1.1 IoT dErrors detected during execution		1.Technology Developme1.1 IoT devices and Errors detected during execution							
1.Technology C1.1 IoT dComponent acceptance test		1.Technology Developme1.1 IoT devices and Component acceptance test							
1.Technology C1.1 IoT dRelease incidents		1.Technology Developme1.1 IoT devices and Release incidents							
1.Technology C1.1 IoT dIssue tracking									
1.Technology C1.1 IoT dTime for error fixing		1.Technology Developme1.1 IoT devices and Time for error fixing							
1.Technology C1.1 IoT dMean time for error fixing		1.Technology Developme1.1 IoT devices and Mean time for error fixing							
1.Technology C1.1 IoT dService acceptance test		1.Technology Developme1.1 IoT devices and Service acceptance test							
		1.Technology Developme1.1 IoT devices and Communication data security							
		1.Technology Developme1.1 IoT devices and Adherence with the AUTOPILOT in-vehicle IoT platform architecture							
		1.Technology Developme1.1 IoT devices and Implementation of the in-vehicle API							
1.Technology C1.2 IoT PI Wireless interoperability		1.Technology Developme1.2 IoT Platforms Wireless interoperability							
1.Technology C1.2 IoT PI Open source platform		1.Technology Developme1.2 IoT Platforms Open platforms / existing systems that are supporting IoT need to be used in the pilot sites							
1.Technology C1.2 IoT PI Scalability spec		1.Technology Developme1.2 IoT Platforms Scalability spec/ IoT devices connected to AUTOPILOT IoT servers							
1.Technology C1.2 IoT PI Scalability demo		1.Technology Developme1.2 IoT Platforms Demonstration / IoT Platform operation and interoperability							
1.Technology C1.2 IoT PI Smart end-nodes/edge devices		1.Technology Developme1.2 IoT Platforms Scalability spec / Smart Edge Devices			Technological impact			Impact on IoT technologie	Total number of v
1.Technology C1.2 IoT PI Standardised interfaces		1.Technology Developme1.2 IoT Platforms Standardised interfaces							
1.Technology C1.2 IoT PI Security measures		1.Technology Developme1.2 IoT Platforms Security and Privacy / Security and privacy measures implemented by design							
		1.Technology Developme1.2 IoT Platforms Interoperability / Federated IoT Platforms and Interoperability							
		1.Technology Developme1.2 IoT Platforms Scalability spec / Pilot services transferred between test sites							
		1.Technology Developme1.2 IoT Platforms Scalability spec / Vehicles within AUTOPILOT IoT Platforms							
		1.Technology Developme1.2 IoT Platforms Scalability spec / External information sources used							
		1.Technology Developme1.2 IoT Platforms Scalability spec / Virtual Entities							
		1.Technology Developme1.2 IoT Platforms Scalability spec / Use Cases Realized							
		1.Technology Developme1.2 IoT Platforms Dissemination / Contributions to Standards							
		1.Technology Developme1.2 IoT Platforms Privacy protection							

Figure 4. Comparison between CREATE-IoT KPIs list and each LSPs KPIs list

The first step of interaction with the LSPs led to a wide varying set of results having, though, one key element in common – all LSPs were still at a very initial stage of KPI design, measurement and validation and the provided input was primarily an early draft likely to be subject to a set of subsequent changes in the months to come.

At the level of individual LSP:

- SYNCHRONICITY outlines a shortlist of around 20 KPIs, mainly inline with CREATE-IoT areas but very use case specific.
- AUTOPILOT resulted to be the LSP having KPIs more aligned with D01.04, with only minor differences reflecting LSP specificities;
- ACTIVAGE presented a restricted list of KPIs compared with D01.04 with essentially two lists of KPIs: Global KPIs (common to all deployment sites) and IAS (Impact Attainment Strategy) related.
- IoF2020 KPIs were particularly use-case specific. They were divided into three broad categories (economic, environmental and social KPIs) common to all use cases. Within each category, though, there were very use case specific KPIs (e.g. for Soya protein management use case economic KPIs include crop yield, soya quality, water use);

- Monica presented a restricted list of KPIs, focused more on single project effectiveness rather than on LSP performance;

These results were submitted to each LSP individually during the second step of interactions between CREATE-IoT and the LSPs.

2.2.2 Interaction with the LSPs – Second Step

The second step of interactions took place in April and early May 2018: CREATE-IoT contacted and carried out a series of one-to-one calls and in-depth interviews with:

- MONICA, on 24th April 2018
- IoF2020, on 26th April 2018
- ACTIVAGE, on 27th April 2018
- SYNCHRONICITY, on 4th May 2018.
- AUTOPILOT, on June 5th, 2018.

Each interview with the LSPs lasted at least one hour and was based on a detailed questionnaire. The questionnaire was structured in a way to capture the latest developments in the update of the KPIs list by each LSPs with the aim to:

- Get a better understanding of how each LSP handles the performance evaluation and the impact of the project vis-à-vis the overall programme and the wider ecosystem in Europe;
- Identify potential points of contact and exchange between the CREATE-IoT's general methodological KPIs framework and the KPIs devised by the LSPs in order to finalize the general framework and make it beneficial for the LSPs and the overall Programme.

Target for interviews:

Partners of Large Scale Pilot project responsible for KPI definition and follow up, Quality process, Performance Evaluation and/or Impact Management.

Supporting partners from CREATE IoT:

- [Synchronicity](#): ATOS supported by MI
- Autopilot: SINTEF supported by ISMB and GTO
- [Activage](#): NUIG
- IoT2020: UNP supported by ISMB
- Monica: ISMB

Interview Guide

1.1 Introduction

Target: presenting the context of the Interview, validating the interviewee is the right contact

1.1.1 Presentation of Interview Objective

- Gathering a better understanding of how LSP are handling Performance Evaluation and Impact Management
- Identification of potential point where exchanges on evaluation methodologies could be beneficial to the LSP

1.1.2 Presentation of the Interviewee

- Name, Organisation
- Role in the LSP project

Figure 5. Example of the Interview Guide used in the Second Step Interaction with the LSPs

This second step of interactions with LSPs added more clarity on the internal roles and responsibilities related to the KPI design, selection, validation and measurement within each LSP and the status of the process. In general, a common structure of KPIs at LSP level was unveiled. This structure encompasses two main sets of KPIs, one at the level of the overall LSP to measure the general performance of the project, and one at the level of the individual use cases or specific pilots carried out and coordinated within each LSP. However, a considerable degree of variation

in the development and implementation of these two sets of KPIs across the four LSPs interviewed emerged during our interactions. In particular:

- MONICA has developed a first, initial framework of KPI which has been timely shared with CREATE-IoT and is currently discussing internally how to assess the pilot-specific KPIs and which use cases within its project will be measured. The process is ongoing and will produce an initial report on use-case-related KPIs before the Summer holidays and an internal interim report in Month 24 of the project (January 2019) focusing on the overall project and its impact assessment;
- IoF2020 has developed a large and detailed set of KPIs focused on product and specific use cases but has now planned the implementation of select number of general KPIs to be applied to the overall project;
- ACTIVAGE has so far adopted a bottom-up approach and devised a series of KPIs for each use case and deployment site with the aim to establish a common framework of KPIs serving the whole project. ACTIVAGE will share the latest status of KPIs as of now with CREATE-IoT and keep it in the loop with any further development;
- SYNCHRONICITY leverages a set of KPIs partly developed for the measurement of smart city performance in previous projects. The framework encompasses city-specific KPIs and other, more general and horizontal KPIs, focusing on more general aspects of the project. A public, complete deliverable will be available before the Summer break and the data collection process will start after Summer continuing throughout the second year of the project.

2.2.3 Interaction with the LSPs – Third Step

Finally, all LSPs met in person at the IoT Week 2018 in Bilbao in early June 2018 to provide further update on the KPI development status.

All aforementioned outcomes and analysis were disclosed and presented to all LSPs, together with a first proposal of common KPI categories and metrics (to be further explained in section 4).

This report serves as output for this third interaction step, moving forward to further collaborative steps planned for the future and explained in section 5)

3. ANALYSIS OF GENERAL KPIs SELECTED BY LSPs

This section is oriented to provide a detailed view into each LSP approach to KPIs and evaluation frameworks, with the focus on identifying those metrics which are in line with CREATE-IoT's initial approach as stated in D01.04 report[1].

This way, one section is opened per each project, with the following structure:

- **Project Performance and Evaluation Methodology.** This subsection covers the timeline of the project and the expected milestones with respect to evaluation set on the proposal. It also analyses the WPs/Tasks in charge of performing such analysis and the documents covering this thematic with their correspondent due dates.
- **Comparative analysis of KPIs.** In this paragraph, the correspondence with CREATE-IoT identified KPIs is put on test. For each metric pointed out by the LSP, a direct correspondence with D01.04 KPIs is outlined (if not a domain-specific KPI). This will allow identifying the overall KPI areas in which the project is more interested on.
- **Vision of the project KPIs and Evaluation Process.** Finally, a brief assessment is provided in terms of foreseen alignment with CREATE-IoT and other LSPs. These conclusions will be compiled to draft a short list of common KPIs in section 4.

3.1 SYNCHRONICITY

3.1.1 Project Performance and Evaluation Methodology

The SYNCHRONICITY project main performance and evaluation work is carried out through WP6 which has set up individual indicators for measurements. The Methodology behind measurement is based on a monitoring framework, with close interactions with other WPs.

SYNCHRONICITY released a draft deliverable named “KPI Framework”[1], which concern two of the work package's objectives:

- O6.2: extending and, where appropriate, developing an impact assessment framework for cities to more accurately capture the merits of Internet of Things (IoT)-enabled smart city solutions.
- O6.4: utilising the developed impact assessment framework to validate the merits of the pilot technologies and the proposed business models.”

Previous works on smart city KPIs have been used by the SYNCHRONICITY project as a base for creating indicators.

According [1] to SYNCHRONICITY: “In the beginning of the SYNCHRONICITY project, a set of projected KPIs were outlined. During the first year of SYNCHRONICITY project, a KPI taskforce was created to evaluate, work and refine the relevant measures for monitoring the project. The taskforce represented different consortium partners and proceeded with its work both through monthly meetings and individual work between the meetings. The resulting list of the KPIs differs slightly from those envisaged at the outset of the project; this underlines the dynamic nature of KPI assessment.”

The definitive version of the KPI framework deliverable for the SYNCHRONICITY project is expected in June 2018.

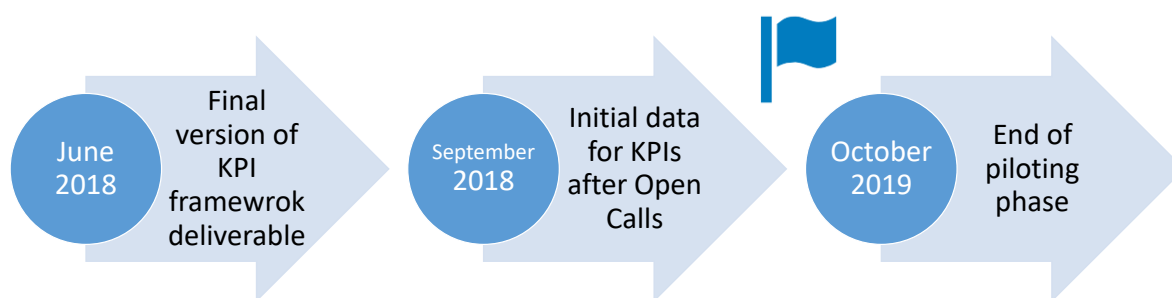


Figure 6. SYNCHRONICITY timeline. The flag represents when D02.03 KPIs will enter the loop.

The SYNCHRONICITY project has also reached to other cities beyond the scope of the project to present their KPI approach and gather feedback on the evaluation process put in place.

After the closure of the open call in September, SYNCHRONICITY will have initial data on KPIs. In the following years, SYNCHRONICITY will collect data in a “continuous process”.

The end of the piloting phase of the SYNCHRONICITY project is scheduled for October 2019.

Table 1. KPI's monitoring frequency[1]

KPI	Cadence
Citizen Centred	M24, M32
Awareness impact	M14, 24, 32
Perceived value from the citizens	M24, M32
Service implementation	M24, M32
Perceived value from the local government and decision makers involved	M14, 24, 32
IoT connected devices	M24, M32
Open data sets	M14, M24, M32
Quality of open data	M14, M24, M32
Apps developed	M24, M32
Improved interoperability	M24,32
Participatory governance	M24, M32
SME involved	M24, M32
Partners' engagement	M24, M32
Local Job creation	M14, M32
Data privacy	M14, M24, M32
Replication potential	M24, M32
New follower city members/interested	M14, M24, M32
Beyond the zone	M24, M32

SCHEDULE	
JUNE 2018	Open Call launches
1 ST WEEK OF JUNE 2018	Open Call events will be held in Antwerp, Caruoge, Eindhoven, Helsinki, Manchester, Milan, Porto & Santander
JUNE 2018	Webinar Open Call information
10 TH SEPTEMBER 2018	Webinar Open Call information
OCTOBER–NOVEMBER 2018	Selection of winning projects and announcement
NOVEMBER–DECEMBER 2018	Finalising of administration and assignments
JANUARY 2019	Start of piloting phase in all partnering cities
JANUARY–FEBRUARY 2019	Workshop in London with the 8 partnering cities and the winning projects and project partners
OCTOBER 2019	End of piloting phase

Figure 7. General project duration, test and deployment timing[1]

3.1.2 Comparative analysis of KPIs

Initially, the number of KPIs as defined by the SYNCHRONICITY project was 21, compared to 200 for the KPIs defined by CREATE IoT D1.4.

However, this list was just used for the proposal and a new one was released. In its dedicated document, SYNCHRONICITY outlines, 18 KPIs distributed between the following categories:

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

A total of 3 KPIs were removed in this second list of KPIs (compared to the first one).

D1.4 Create IoT			Synchronicity		
1st Level	2nd Level	KPI	1st Level	2nd Level	KPI
1. Technology Development	1.2 IoT Platforms	Smart end-nodes/edge devices		Innovation	IoT connected devices
				Innovation	Apps developed
3. Ecosystem strategy and engagement	3.1 Ecosystem awareness	Ecosystem Members		Local eco-system involvement	Partners engagement
4. Ecosystem openness and external collaboration	4.3 Openness of business models	Business model replicability		Replication and Scalability	Replication potential
4. Ecosystem openness and external collaboration	4.4 Open source strategy	Interoperability		Innovation	Improved interoperability
4. Ecosystem openness and external collaboration	4.4 Open source strategy	Discovery		Innovation	Quality of open data
4. Ecosystem openness and external collaboration	4.4 Open source strategy	Platform usage		Innovation	Open data sets
5. Marketplace and business impacts	5.3 Business benefits	Business market needs		Access to services	Service implementation
5. Marketplace and business impacts	5.3 Business benefits	Business impact		Governance	Perceived value from the decision makers
5. Marketplace and business impacts	5.3 Business benefits	Consumer impact		Social Innovation	Perceived value from the citizens
6. Societal and economic impacts	6.2 Employment macro-impact	Direct employment generation		Local eco-system involvement	Local Job creation
6. Societal and economic impacts	6.3 User worktime/life impact	Life – Privacy & Personal Data Protection		Safety	Data Privacy
6. Societal and economic impacts	6.3 User worktime/life impact	Life – Citizen Involvement Participation			
				Social Innovation	Citizen centred
				Social Innovation	Awareness impact
7. Policy and governance impacts	7.1 European IoT Ecosystem promotion and	Validity on EU Member States		Replication and Scalability	New follower city members interested
7. Policy and governance impacts	7.1 European IoT Ecosystem promotion and	Proven replicability			
				Replication and Scalability	Beyond the zone
7. Policy and governance impacts	7.4 Impact on SMEs, start-ups and young entrepreneurs	Involvement		Local eco-system involvement	SME involved
8. Community support and stakeholders' inclusion	8.4 Community engagement	Citizens' involvement		Local eco-system involvement	Participatory governance

Figure 8. KPI comparison between synchronicity's KPIs and CREATE-IoT D1.4

Notes: Green indicates a KPI peculiar of a given LSP (no equivalent)

3.1.3 Vision of the project KPIs and Evaluation Process

According to SYNCHRONICITY [2] in its dedicated deliverable, the goal of its KPIs strategy is to “monitor whether the project creates services with and for the citizens and enables IoT innovation. These two themes cover the elements and individual indicators of the KPI framework”.

The KPIs and approach defined by SYNCHRONICITY aim clearly at demonstrating the value of the project outcomes to other cities beyond the project. The evaluation methodology is thus fully

to the service of the Exploitation strategy of the project with an objective of promoting the project's outcomes and replicating the project's deployments.

This general objective orients the project KPI more toward evaluation of its impact rather than evaluation of the project implementation (and technology) direct performances. This is reinforced by the demand of the potential customers of the project (cities) that insist more on KPIs focusing on benefit for citizens and end user satisfaction rather than technological performance.

3.2 AUTOPILOT

3.2.1 Project Performance and Evaluation Methodology

To provide the quantitative and qualitative evidence of the added value of IoT technology for automated driving, all large-scale pilot tests are evaluated. The added value is formulated in hypotheses on objectives, ambitions and impact, and is measured in KPIs or metrics from several perspectives. The AUTOPILOT project initially defined high-level KPIs to measure its impacts based on the following five main objectives:

- Define and implement an IoT architecture for autonomous driving.
- Realize IoT-base automated driving use cases.
- Advanced business models and services.
- Involve users, public services, and business players.
- Contribute to standards.

Furthermore, a number of tasks in the AUTOPILOT project are dedicated to collecting KPIs or metrics to address different perspectives or objectives of the project. For instance, the following tasks in WP4 and WP5:

- Automated driving performance and safety KPIs are collected in task T4.2, and quality of life KPIs in task T4.4 related to the topic of progress on benefits to the public.
- Progress on economic growth and job creation. Business impact KPIs linked with cost benefit analysis in task T4.3.
- KPIs for scientific dissemination and project events organisation are collected in task T5.2.
- Business exploitation KPIs relating to the dependability, robustness, resilience, adaptability and sustainability of the piloted technology are collected in task T5.3 in order to validate business processes and models in relation to the AUTOPILOT's pilot sites and use cases.
- KPIs for design, testing, validation and impact assessment for autonomous vehicles and IoT pilot impact measurement are collected in task T5.4. The KPIs are categorized into several fields and mapped to the different use cases in the project.

Deliverable D5.3 (Performance and KPIs for autonomous vehicles and IoT pilot impact measurement) is a public deliverable. This document is addressed to AUTOPILOT partners working in various WPs, especially those participating in design, testing, validation, impact assessment activities. But it is also relevant for stakeholders and partners working on IoT European Large-Scale Pilots (LSP) Programme projects who are tackling similar issues. The final part of the document also addresses briefly the autonomous vehicles and IoT KPIs across application domains.

More generally, it offers a first indication to all partners of how the AUTOPILOT project intends to contribute to KPI evaluation in order to enhance the project results. A timeline related to KPIs is indicated in Figure 9. For people external to the project it could offer both a methodological approach and specific technical information on KPIs for design, testing, validation, and impact assessment.

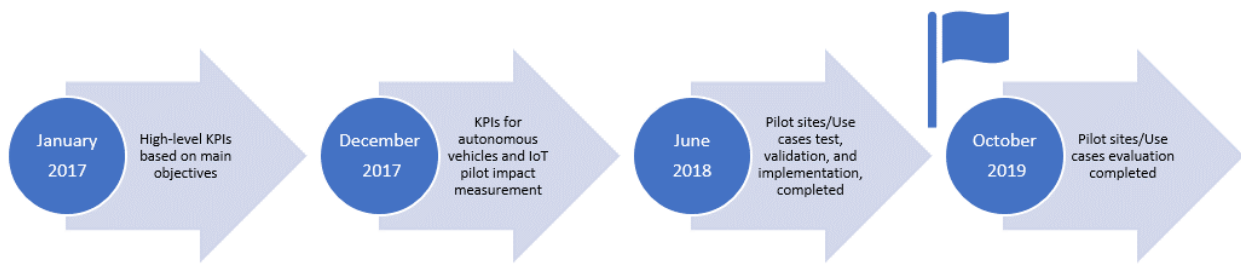


Figure 9: AUTOPILOT timeline. The flag represents when D02.03 KPIs will enter the loop.

3.2.2 Comparative analysis of KPIs

The AUTOPILOT project selected for design, testing, validation, and impact assessment the same categories of KPIs as CREATE-IoT, for the following categories:

- Technology Development
- Technology deployment and infrastructure
- Ecosystem strategy and engagement
- Ecosystem openness and external collaboration

Inside these categories, AUTOPILOT mostly chose the exact same KPIs except for a few exceptions due to AUTOPILOT's specificities. In addition, AUTOPILOT added some specific KPIs in each previous category.

AUTOPILOT project uses the other of CREATE-IoT KPIs for evaluation other activities (i.e.: automated driving performance and safety, quality of life, progress on economic growth and job creation, business impact, business exploitation, etc.)

- Marketplace and business impacts
- Societal and economic impacts
- Policy and governance impacts
- Community support and stakeholders' inclusion

3.2.3 Vision of the project KPIs and Evaluation Process

The AUTOPILOT project started with the project's use cases that need to be achieved to define the performance goals. To achieve success, KPIs are defined through common metric indicators and metrics used by the use cases. The idea is to focus on the domains, areas, fields and critical factors, and to address the elements that are needed to complete the evaluation and identification of results to assess design, validation and testing to achieve the autonomous vehicle integration goal. However, the project makes recommendations that should be considered in the evaluation of the performance of IoT ecosystems. Most of the IoT infrastructure aspects like: Communication channels, Interoperability, Service-based, Context-awareness, Data management, Remote management, Security, Privacy, Standards (open), Defined APIs, Event management, Analytics and User interfaces are addressed by the KPIs in the project. These aspects and its KPIs are in many cases transferable to other IoT domains.

The current analysis seems to demonstrate that AUTOPILOT KPI work focus strongly on the evaluation of the direct project activities: efficiency of technologies and deployment methodologies.

In an ongoing work on the development and integration of IoT devices into the IoT ecosystem (task T2.4), the AUTOPILOT project partners are evaluating the project impacts in terms of developed IoT devices and their contribution to increase in Automated Driving (AD) levels according to automation levels given by SAE International association [6]: 0) No automation, 1)

Driver assistance, 2) Partial automation, 3) Conditional automation, 4) High automation, and 5) Full automation.

3.3 ACTIVAGE

3.3.1 Project Performance and Evaluation Methodology

The relevant WP for performance evaluation and monitoring is WP6, with the task 6.1 in particular. It is the first active task in WP6. Other Tasks in WP6 will use the result of task 6.1 result to

- Add concrete evaluation procedures and tools (T6.2),
- Refine and extend the framework along the three axes QoL & Independence (T6.4), Service Sustainability (T6.5), and Innovation and Growth (T6.6),
- Apply its interim and final versions (to be created in the course of the above activities) in practice (T6.3), and
- Create the ACTIVAGE White Book (T6.7)”[4]

Regarding the relation to pilot sites, ACTIVAGE chose a “bottom up” approach[4] where the definition of evaluation processes and KPI was done first at a local level in each deployment site before being centralized and coordinated at project level. The ACTIVAGE project already released the following dedicated deliverables:

- Consolidated List of KPIs and Coordinated Methodology for Evaluation, 1.0, ACTIVAGE, July 2017
- Tools and processes for the implementation of the evaluation methodology, 1.0, ACTIVAGE, October 2017

The Global KPIs definition was done by the ACTIVAGE project based on an iterative process. “The GLocal Evaluation Framework is based on a bottom up approach providing Deployment Sites (DS) with guidelines and instruments to collect qualitative and quantitative Local Key Performance Indicators (KPIs), in order to generate an overall critical mass of evidence.” [4]

There are two running periods for the ACTIVAGE project:

- July-October 2018
- April-July 2019

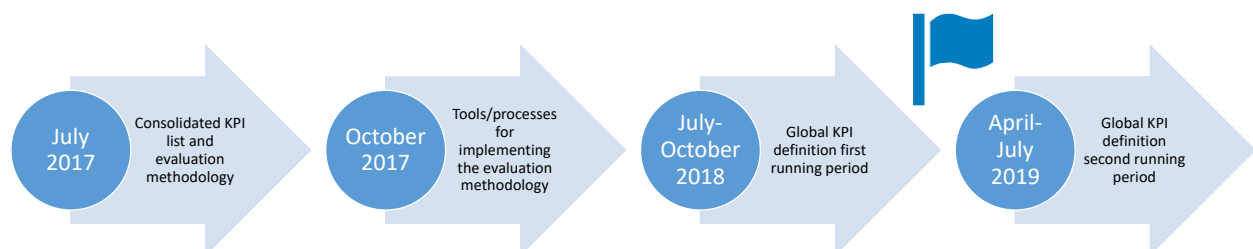


Figure 10. ACTIVAGE timeline. The flag represents when D02.03 KPIs will enter the loop.

3.3.2 Comparative analysis of KPIs

All in all, the total number of KPIs as defined by the ACTIVAGE project is 42, compared to 200 for the KPIs defined by CREATE IoT D1.4. All categories of CREATE IoT D1.4 are covered, with the exception of Technology deployment and infrastructure and openness and external

collaboration. The focus is chiefly on the categories “Technology Development” and “Marketplace and business impacts”

ACTIVAGE chose to divide its KPI into two categories:

- Global KPIs: 13 KPIs focusing on the project socio economic impact
- IAS (Impact Attainment Strategy): 29 KPIs focusing on the project implementation and technological results.

The ACTIVAGE KPI definition was guided by the “Triple Win Strategy” building up on the European Innovation Partnership (EIP) on Active and Healthy Ageing (AHA) results. This provides the projects KPIs on three domains: quality of life, sustainability and innovation and growth. These KPIs are referred to as “Global KPIs” by the ACTIVAGE project.

ACTIVAGE Performance Indicators are aligned with the three categories of Triple Win strategy (EIP on AHA initiative):



Source: ACTIVAGE presentation at AG01 meeting

Figure 11 – ACTIVAGE KPI approach based on the EIP on AHA results

These “Global KPI” are complemented by the Impact Attainment Strategy (IAS) KPIs that target both the technological evaluation of the platform developed within ACTIVAGE (AIOTES KPI) and the impact evaluation that focus on dissemination, standardization and co-creation KPIs.

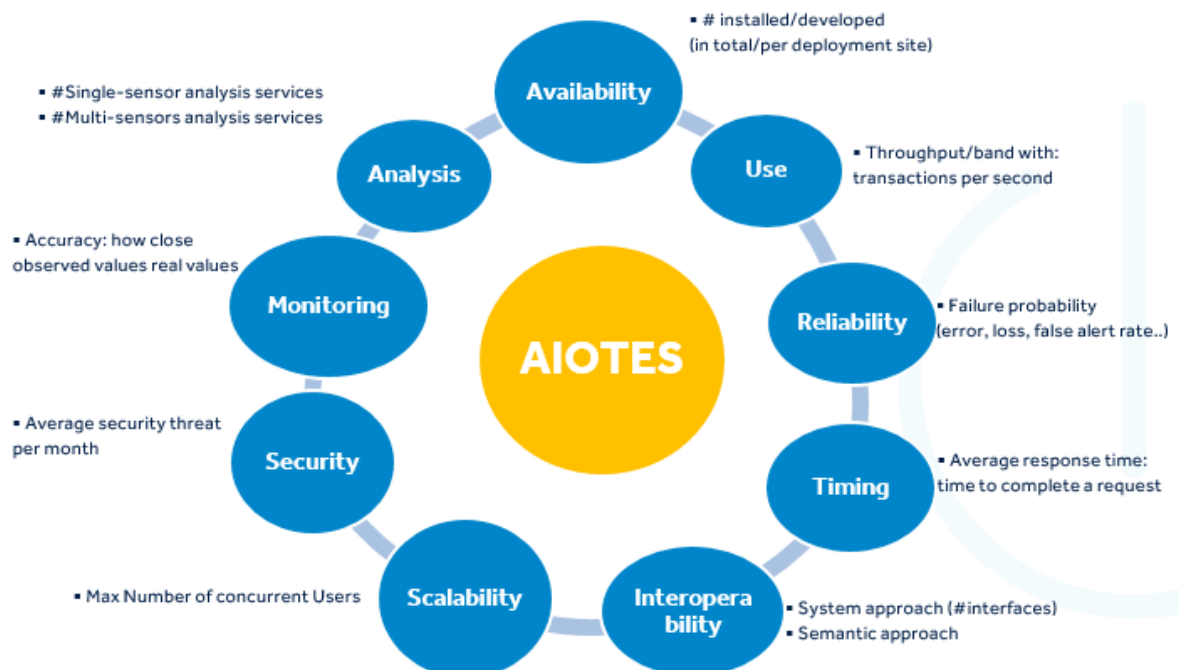


Figure 12- ACTIVAGE Technological platform evaluation KPIs

Source: ACTIVAGE presentation at AG01 meeting

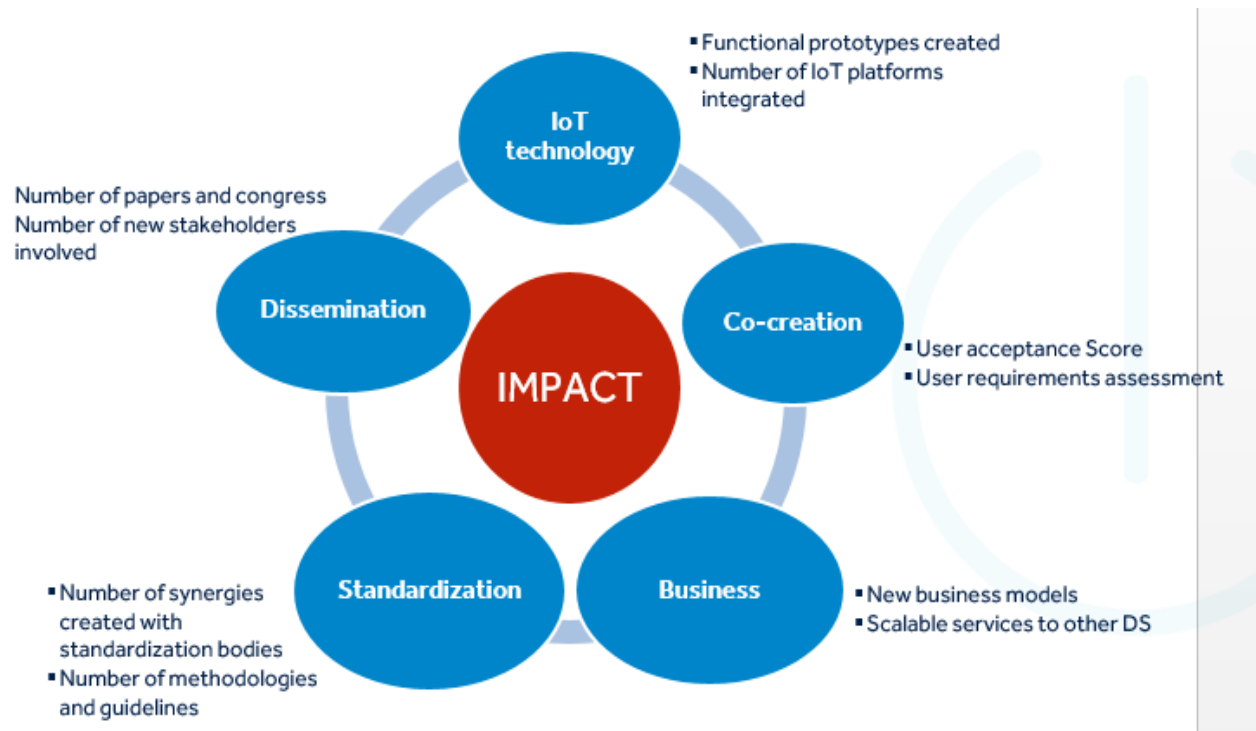


Figure 13 ACTIVAGE Impact strategy evaluation KPIs

Source: ACTIVAGE presentation at AG01 meeting

3.3.3 Vision of the project KPIs and Evaluation Process

The vision of ACTIVAGE related to the evaluation of the LSP and its projects covers both socio-economic impacts and project-specific KPIs.

In one of its documents[4], ACTIVAGE stated its main goals for the evaluation process:

“One of the main goals in ACTIVAGE is to create the EVIDENCE and to be the reference DRIVER of a virtuous circle of the AHA-IoT market growth. According to this goal, a tailored reference evaluation framework is the pivotal tool to support an effective, structured and homogenous impact assessment of ACTIVAGE services implemented at Deployment Site (DS) level.

The overall goal and distinguish challenge related to the ACTIVAGE Evaluation Framework is to provide a structured methodology and reference tools tailored to support the quantification and qualification of impact EVIDENCE and the identification of SUCCESS FACTORS of the ACTIVAGE AHA IoT ecosystems. Such a set of results will constitute the value-based reference for decision makers to support the definition of SCALING UP and REPLICATION strategies of IoT solutions for Active and Healthy Ageing”.

The main goal of the KPI strategy for ACTIVAGE is the replication of the project results in other sites and the demonstration of the socio-economic benefits of the projects solutions, in line with the exploitation strategy of the project. This is illustrated by the Global KPIs, defined in line with the EIP on AHA to maximize their visibility in the AHA community.

However, ACTIVAGE is complementing this approach with KPIs that target more directly the project implementation and that are closer to what could be common KPIs for the LSP program. These are the Impact Attainment Strategy KPIs that focus more on the technological achievement of the project and on direct project metrics.

3.4 IoF2020

3.4.1 Project Performance and Evaluation Methodology

IoF2020 performance and evaluation work is split between an evaluation of project KPIs focusing on the project implementation and the evaluation of use case specific KPIs focusing more on the impact of the project.

IoF2020 has released a first deliverable on month 6: the **KPI Catalogue**. For each use case, this deliverable lists all KPIs and variables measured regarding its business impact and shows the value network characteristics of each use case. This might be a valuable source for other companies in this field to assess their performance and enhance the understanding of market potentials.

The monitoring of the KPI is done in an annual basis with regular reports: The **Annual Implementation and Performance Monitoring Report (at month 12, 24, 36 and 48)**.

Each year, each use case will deliver a report of technical improvements and testing stating and explaining the current status of development, the successfulness of implementation, and achieved performance of the IoT system/solution. These reports will be published jointly at the end of each year of project implementation.

Overall the project has adopted two distinct timelines for the evaluation of the use cases and for the evaluation of the project performances.



The evaluation of the project performance is following the project review schedule, while the evaluation of the impact of the project deployment (use case by use case) is done on a 6-month period basis.

3.4.2 Comparative analysis of KPIs

The IoF2020 project did not adopt any available KPI as defined by CREATE IoT. The LSP initially had very use case specific KPIs (“DS-driven”) with three categories:

- Economic
- Social
- Environmental

The evaluation will be mainly based on a regular survey process (data collection form once per year).

Economic KPI	Example (within-field zoning management): Production cost, work time, product quality
Social KPI	Example (within-field zone management): time management, user satisfaction, planning conflicts)
Environmental KPIs	Example (within field zoning management): pesticide use, CO2 emissions, Fertilizer use

Figure 14. IoF2020's categories of KPI

In addition, IoF2020 released a document[5] outlining its “project KPIs”, which aim to measure progress on each of its four project objectives (01-04).

According to the IoF2020 team, “the list of KPIs in the table [below] could also be used as a basis to assess the *overall* project KPI Reusability, which we should measure every three months and evaluate during our quarterly physical PSG meetings”

Obj.	Target outcomes	Key Performance Indicators (KPIs)
O1	Demonstrated IoT solutions	✓ Number of conducted demonstration sites and testbeds
		✓ Number of application areas involved
		✓ Number of user organizations participating in the use cases
	Validated business cases	✓ % of productivity growth expected by the users involved (each use case will define specific indicators to measure this KPI)
		✓ % of sustainability improvement expected by the users involved (each use case will define specific indicators to measure this KPI)
		✓ Acquired new business by IoT developers during the project
O2	Integrated and adapted IoT components	✓ Number of IoT devices implemented (especially sensors and actuators)
		✓ Number of IoT communication components implemented (wireless networks, IoT platforms, gateways, etc.)
		✓ Number of IoT applications available
	Usage of open IoT architectures and platforms	✓ Number of IoT Reference Architecture instances
		✓ Number of FIWARE GEs instances
		✓ Number of open datasets used
	Reuse of IoT components	✓ Number of IoT components that are reused in multiple IoT solutions
		✓ Average number of installations per reusable IoT component
O3	Validated user acceptability	✓ Number IoT Systems based on existing IoT standards
		✓ % of identified standardization gaps that resulted in pre-normative change proposals submitted to IoT standardization bodies
	Data governance and ethics	✓ User satisfaction of the demonstrated IoT solutions (scale of 5)
		✓ % of Use cases with a positive Security and Privacy Impact Assessment
		✓ % of Use cases with a positive Liability Assessment
		✓ % of Use cases that (re-)use existing code of conducts or guidelines for data sharing
O4	Validated business models	✓ % of Use cases with a viable business model (as assessed by business model experts)
		✓ Investments (and/or commitments) by industry for project results exploitation
		✓ Number of IoT developers trained in business modelling and innovation
	IoT Ecosystem for large scale take-up	✓ Number of new stakeholders involved (end-users, IoT companies, consultants, R&D organizations, investors, standardization bodies, policy makers, etc).
		✓ Number of new Agri-Food and IoT communities involved
		✓ Number of active partners in the LSP

Figure 15. IoF2020 project KPI

3.4.3 Vision of the project KPIs and Evaluation Process

IoF2020 has defined precise KPI for the evaluation of the project implementation, that are related to the type of KPI defined by CREATE-IoT in Deliverable 4.1. This shows a willingness of the project to control and monitor its processes and implementation in direct link with the project management.

The evaluation of the impact of the project is done separately and is in link with the exploitation and sustainability strategy of the project. The objective is here to evaluate the results of the project and to promote them, so they can be replicated in other deployments.

3.5 MONICA

3.5.1 Project Performance and Evaluation Methodology

In the MONICA project, the impact assessment deliverable (D9.1) is expected to divide KPIs in dimensions and subdimension – measuring Monica impact (technological and socio-economic).

MONICA provided initial KPI at the proposal stage, these were then revised when the project started to define more ways of measurements and some additional KPIs.

MONICA has a specific constraint regarding their technology deployments in that they have to be ready for specific dates (outdoor events dates) which they cannot control or modify. This constraint adds an additional dimension to the way they measure KPIs: they have to assess in advance which technology will be ready to deploy and ensure the relevance of the KPI collection accordingly.

The following criteria have been used by MONICA to define their KPIs:

- **Comprehensiveness:** Impact indicators should cover diverse aspects of Impact: technological, environmental, socio-economical, etc.
- **Comparability:** The KPIs should be defined in a way that the data can be compared scientifically over time before and after deploying Monica technologies at the different pilots.
- **Availability:** The KPIs should be quantitative and the historic and current data should be either available or easy to collect.

The roadmap of the project regarding deployment and evaluation is divided in three cycles, as presented below:

CYCLE	YEAR	MONTH	ACTION
Cycle 1	Year 1	Month 1 (Jan) – Month 9 (Sept) 2017	Impact Assessment (IA) Process Framework developed
Cycle 2	Year 2	Month 18 (June) – Month 24 (Dec) 2018	IA process trialled at pilot events, analysis of results fed back to pilots and stakeholders, IA process refined

Cycle 3	Year 3	Month 28 (April) – Month 34 (Oct) 2019	IA process undertaken at events, analysis of results fed back to partners and stakeholders, IA process further refined.
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The initial Framework regarding KPIs was already delivered.

- Monica is currently discussing with pilots about assessment D8.1 pilot plans (pilot specific assessment), currently understanding which use case of the 11 events will provide data for d8.1. It may be available in 1-2 months
- During Month 24 (January 2019), an internal interim report for all ~~non-use~~non-use case related KPIs (overall monitoring of partners for project KPIs)

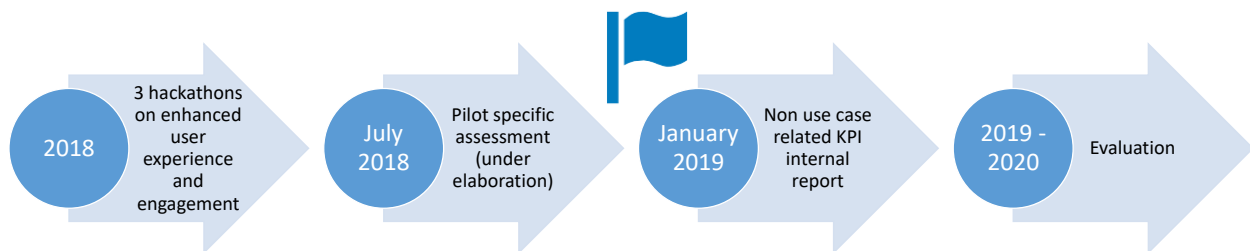


Figure 16. MONICA timeline. The flag represents when D02.03 KPIs will enter the loop.

3.5.2 Comparative analysis of KPIs

The number of KPIs as defined by the MONICA project is 46, compared to 200 for the KPIs defined by CREATE IoT D1.4.

The KPIs of the MONICA project cover chiefly the impacts of the projects, inside the following categories, defined by the MONICA team:

- Technological impact
- Socio-economic impact
- Environmental Impacts
- Quality of life

1st Level	2nd Level	KPI
1.Technology Development		
Quality of life	Convenience and Comfort of using techn	Staff: Usage ratio (Number of people, Frequency)
Quality of life	Convenience and Comfort of using techn	Staff: Willingness to use
Quality of life	Convenience and Comfort of using techn	Staff: Satisfaction Level with Equipment
Quality of life	Convenience and Comfort of using techn	Customers: Improved Satisfaction
Quality of life	Communication between Staff	Decrease in loacte staff time
Quality of life	Communication between Staff	Improved Communciation, handling events logistics, and problem solivng.
Quality of life	Saftey and security	Customers: Improved perception of Safety
Quality of life	Saftey and security	Customers: Post-accident usefulness
Quality of life	Saftey and security	Decrease in Accdients Rates
Quality of life	Saftey and security	Decrease in response time to Accdients
Quality of life	Saftey and security	Decrease in evacuation time
Quality of life	Openess and Public Participation	Number of accessed data times
Quality of life	Openess and Public Participation	Number of accessed data incidents

Figure 17. KPIs cover projects performance rather than LSP performance

The categories “Quality of life” and “Technological impact” are the ones with the most KPIs. As a result, the KPIs as defined by MONICA have a strong focus on the projects impact and its global effectiveness rather than the performance of the LSP processes and individual technology deployed.

3.5.3 Vision of the project KPIs and Evaluation Process

For the evaluation of the MONICA project, the focus is currently on the impacts of the deployment (noise reduction for instance) rather than on the performance of the LSP implementation and evaluation of the technology deployments.

This is aligned with a need to evaluate and demonstrate the efficiency of the solution developed within the project so that they can be commercially exploited beyond the project (exploitation strategy of the project).

4. LESSONS LEARNT

Once introduced the LSP approach, its commonalities and differences with respect to CREATE-IoT evaluation framework and using the first outcomes from LSPs, this section is in charge of closing the loop and providing a clear way forward so as to agree on a common list of horizontal KPIs to be assessed throughout all Pilot projects.

In order to do so, the following sections are included:

- **Work Programme KPIs.** Apart from the LSP specific challenges, the EC outlined a number of impacts and measurements in the programme itself. These impacts should be added to the loop and taken into account so as to guarantee the overall scope and results from LSPs are properly evaluated with respect to the EC expectative.
- **Horizontal evaluation assessment.** Using the outcome of section 3, a new KPI structure is proposed, creating a shortlist of main focus areas to match both the LSPs main interests and the EC expected impacts as explained in the previous section.

In addition, for each main KPI category identified in the previous section, 2-3 meaningful KPIs will be agreed to be used across all LSPs and, therefore, assess the performance of the project.

4.1 Work programme KPIs

In addition to all KPIs identified in D01.04 by CREATE-IoT partners regarding IoT metrics and all other expected indicators provided by LSPs as per their domain specific needs, there is also a third axis that must be considered, namely the impacts explicitly mentioned in the work programme.

The IoT LSP specific features, as described in the EC IoT Focus Area, can be summarized as: involving all value-chain actors, addressing business model validation & standardisation, addressing user validation and acceptability and up-scaling of open platforms like FI-Ware, CRYSTAL, UniversAAL.

Based on the aforementioned features, and as written in the Horizon 2020 Call Large Scale Pilots for IoT topic (IoT-01-2016) [7] addressed by all LSP, all projects should effectively measure their impact with respect to the following items. Pilots' impact should go beyond involved partners and will aim at influencing external communities by putting in place appropriate mechanisms.

1. Validation of technological choices, sustainability and replicability, of architectures, standards, interoperability properties, of key characteristics such as security and privacy;
2. Exploration and validation of new industry and business processes and innovative business models validated in the context of the pilots.
3. User acceptance validation addressing privacy, security, vulnerability, liability, identification of user needs, concerns and expectations of the IoT solutions
4. Significant and measurable contribution to standards or pre-normative activities in the pilots' areas of action via the implementation of open platforms
5. Improvement of citizens' quality of life, in the public and private spheres, in terms of autonomy, convenience and comfort, participatory approaches, health and lifestyle, and access to services.

6. Creation of opportunities for entrepreneurs by promoting new market openings, providing access to valuable datasets and direct interactions with users, expanding local businesses to European scale, etc.
7. Development of secure and sustainable European IoT ecosystems and contribution to IoT infrastructures viable beyond the duration of the Pilot.

As a proposal from the IoT-01-2016 call itself, the following KPIs should be taken into account so as to measure the performance of the projects:

- Ensure the longer-term evolution of the Internet of Things
- Critical Mass, leadership
- Rich portfolio of technologies and tools
- Guarantee the sustainability of the approach

Finally, the EC also provides a number of impacts to be used as basis for the measurement of horizontal activities, that is, the role of CREATE-IoT (LSP-02-2016). These impacts are described below:

- Ensure efficient and innovative IoT take-up in Europe, building on the various parts of the initiative (pilots, research, horizontal actions)
- Efficient information sharing across the programme stakeholders for horizontal issues of common interests
- Extension and consolidation of the EU IoT community, including start-ups and SMEs
- Validation of technologies deployment, replicability towards operational deployment
- Validation in usage context of most promising standards and gap identification
- Strengthening of the role of EU on the global IoT scene, in particular in terms of access to foreign markets

4.2 Horizontal evaluation assessment

The analysis of LSP evaluation approach (explained in detail in section 3) shows that the method used by all projects is mainly restricting the number of KPIs to be measured and particularizing them to the domain area they are covering.

The correspondence with CREATE-IoT KPI domains is shown in Table 2. Green cells indicate those domains in which the LSP defines, at least, one metric. On the other hand, red cells denote domains not relevant (at least in principle) for the LSP.

Table 2. LSP KPI mapping with respect to CREATE-IoT dimensions.

CREATE-IoT	SYNCHRONICITY	AUTOPILOT	ACTIVAGE	IoF2020	MONICA
Technology development	Innovation. Safety	Technology development	Technology development	Integrated/adapted IoT components, Open IoT architectures	Technological impact
Technology deployment and infrastructure	Replication and Scalability	Technology deployment and infrastructure	No KPIs defined	Reuse of IoT components	No KPIs defined
Ecosystem strategy and	Local Ecosystem	Ecosystem strategy and	Ecosystem strategy and	IoT Ecosystem for large scale	No KPIs defined

engagement		engagement	engagement	take-up	
Ecosystem openness and external collaboration	Local Ecosystem	Ecosystem openness and external collaboration	No defined KPIS	IoT Ecosystem for large scale take-up	No defined KPIS
Marketplace and business impacts	Access to services	No defined KPIS	Marketplace and business impacts	Validated business models, Economic	Participant approval
Societal and economic impacts	Social Innovation	No defined KPIS	Societal and economic impacts	Economic, social	Quality of life
Policy and governance impacts	Governance	No defined KPIS	Policy and governance impacts	Data governance and ethics	No defined KPIS
Community support and stakeholders' inclusion	Local Ecosystem	No defined KPIS	Community support and stakeholders' inclusion	Environmental	No defined KPIS

Using this scenario as starting point, the needed steps towards an agreed shortlist of horizontal and common KPIs are the following:

1. Reduction on the list of domains to cover the most relevant categories for LSPs.
2. Selection of a reduced number of metrics per domain so as to assess its performance, in alignment with the LSPs indicated metrics.
3. Cross check of domains and selected metrics to guarantee they are enough to measure the programme impacts. Propose new additional KPIs otherwise.
4. Final agreement on proposed metrics and identification of priorities per LSPs with respect to each domain.

4.2.1 New reduced KPI domain proposal

Given the feedback received from LSPs, Table 3 summarizes the new KPI domains proposed to cover the mainstream topics.

This mapping guarantees that all initial LSP interests are covered by at least one domain, merging also similar CREATE-IoT domains.

Table 3. Refined list of KPI dimensions.

Initial domain	New proposal of KPI domains
Technology development	IoT Technology and standards validation, up-scaling, replicability and sustainability
Technology deployment and infrastructure	
Marketplace and business impacts	Business opportunities, economic, environmental and societal impacts
Societal and economic impacts	
Ecosystem strategy and engagement	Ecosystem openness, development and value chain actors' involvement
Ecosystem openness and external collaboration	
Policy and governance impacts	General acceptability, user validation, perceived value and benefits
Community support and stakeholders' inclusion	

On the following sections, these new domains will be populated with a short list of KPIs to be used by all LSPs to assess their horizontal IoT performance.

4.2.2 First draft of horizontal KPI list to be tested on pilots

The following tables include the agreed proposal of KPIs to be measured per each new domain identified. These metrics are the result of open discussions with all actors involved and agreed in consensus. In particular, CREATE-IoT designed a short questionnaire and administered it online to all LSPs to collect their detailed input in a consistent and structured way.

Metrics highlighted in green denote those KPIs in which either all 5 LSPs agreed on measuring or just one LPS indicated their reluctance (more details in Table 8).

Apart from the common KPIs agreed, some LSPs introduced in this loop proposals on their side for common indicators. These proposals are marked in yellow. These yellow KPIs are still to be confirmed by other LSPs.

Finally, as a result of the reduction on the number of KPIs, CREATE-IoT partners also identified a couple of gaps for assessment. As these gaps are relevant to the programme objectives, they are also introduced here and marked in red.

It is important to note, thus, that this list is the outcome of the collaborative process described in section 2, which is still an intermediate step towards the final list of metrics, to be agreed in the workshop planned for M21 and described in section 5. Therefore, this proposal aims at being a working document for LSPs to discuss together and compile the final list in the following months, assessing the current proposal and most likely evolving, adapting, changing and even adding/deleting some KPIs.

These aforementioned metrics might evolve in the next coming interactions also specifying more precisely the way the metric is measured and assessed, depending on each LSP needs.

Table 4. IoT Technology and standards validation, up-scaling, replicability and sustainability domain KPIs.

Name	Description	Metric	Method of collection and measurement
Standardised interfaces	The number of standard interfaces for easy implementation.	Number	LSP to provide number of standard interfaces per component
	Counting of standards that were developed or applied within the LSP to raise machine interoperability	Number of organizations	Count companies by standardization bodies like CEMA, AIOTI or ETSI
Open source platform	IoT Open source standards and platforms supported by each LSP.	Percentage	What is the fraction (percentage) of IoT open source standards and platforms implemented/used against the total number of standards implemented?
Privacy and security aspects	Checklist of GDPR accomplishment	Percentage	LSP to provide number of solutions complying with GDPR
Number of market-ready IoT solutions	The number of products or services developed with the LSP that are available on the market	Number of market ready solutions	LSP to provide number of solutions developed within their own demonstration that could be ready to be launched in the market
Number of open data sets	Counting the number of open data sets made available by solutions of the LSPs	Number of open data sets published	Count by FIWARE or other market place owner like BIG IOT

Table 5. Business opportunities, economic, environmental and societal impacts domain KPIs.

Name	Description	Metric	Method of collection and measurement
User impact	LSPs' ability to track how their services/products are impacting their Business customers' daily activities, with a list of KPIs and associated measurements	Textual (Open Q) – LSPs' collected KPIs and metrics	Online Questionnaire answered by LSPs
Social impact	LSPs' ability to improve end-users' quality of life, working conditions, health, lifestyle, etc.	Textual (List)	Online Questionnaire answered by LSP
	Reduction of fuel, energy usage, CO2 at component production level etc.	t CO2 / user, area or volume of production	Questionnaire to deployment sites

Table 6. Ecosystem openness, development and value chain actors' involvement domain KPIs.

Name	Description	Metric	Method of collection and measurement
Interoperability	Ability of the solution adopted to interact with external parties	End devices supported.	LSP to provide number of end devices supported and number of available open APIs
		Available open APIs	
Discovery	Promotion of resources and openness	Resource views	LSP to provide Number of third parties actively interacting with open source services in the platform
Collaboration strategy	Ecosystem members	Number of stakeholders	Online Questionnaire.
Established demonstration site	Visitable test sites that present implemented IoT solutions to other interested end-users	Number	Number of demonstration site for IoT solutions

Table 7. General acceptability, user validation, perceived value and benefits domain KPIs.

Name	Description	Metric	Method of collection and measurement
Active users	Identifying the number of active users.	Number of monthly uses on Open API per developer	Online Questionnaire
	Daily IoT/technology usage	Number	Device usage logs
User involvement	Assessment of how end-users' feedback on accessibility are collected and how they are directly involved in accessibility improvement activities. Service Acceptance	Textual (List)	Online Questionnaire
		Percentage	

On the following interactions with LSPs, a specific round of discussion will be devoted on how to “operationalize” some of the indicators. This means establishing the **exact metric** and method of measurement for each indicator that will be **suitable to all LSPs**, or different vertical metrics.





These metrics are currently aligned with all the involved axis in this analysis, namely:

- CREATE-IoT view on horizontally measurable IoT areas
- LSP particular needs with respect to their domain specific constraints
- EC expectative on impact to be measured by pilots

The explicit mapping of all these three axes is explained in the table below. Per each metric on the analysis, the correspondence with the programme impacts (using the numbering in section 4.1) and the relevance to each LSP is described.

Colouring codes indicate (**GREEN**) those LSPs explicitly agreeing with the metric (or proposing it), (**RED**) LSPs reluctant to include the metric in the evaluation process initially and (**BLANK**) metric not yet evaluated for LSPs, as it is introduced in this report for next period discussion.

Table 8. KPI shortlist map with Programme impacts and pilot interests.

KPI Name	Programme impact	SYNCHRONICITY	AUTOPILOT	ACTIVAGE	IoF2020	MONICA
 IoT Technology and standards validation, up-scaling, replicability and sustainability						
Standardised interfaces	1,4,7	GREEN	GREEN	GREEN	RED	GREEN
Open source platform	1,6,7	GREEN	GREEN	RED	GREEN	GREEN
Privacy and security aspects	3,7			GREEN		
Market-ready IoT solutions	3,5,6				GREEN	
Number of open data sets	1,6,7				GREEN	
 Business opportunities, economic, environmental and societal impacts						
User impact	2,3,6	GREEN	GREEN	GREEN	GREEN	GREEN
Social	3,4,5				GREEN	
 Ecosystem openness, development and value chain actors' involvement						
Interoperability	3,4,6,7	GREEN	GREEN	GREEN	GREEN	GREEN
Discovery	3	GREEN	GREEN	RED	GREEN	GREEN
Collaboration strategy	1,2,3,4					
Established demonstration site	1,2,5				GREEN	
 General acceptability, user validation, perceived value and benefits						
Active users	3	GREEN	GREEN	GREEN	GREEN	GREEN
User involvement	3	GREEN	GREEN	GREEN	RED	GREEN

All in all, once the metrics presented in this chapter are agreed and the interaction is closed with the KPI workshop, they should be used by all LSPs to assess their performance and ease the review process with the European Commission given that they directly relate to the expected impacts.

5. DISCUSSIONS

Following the collaboration and the several steps of iteration with the LSPs described in the sections above, the CREATE-IoT Project focuses on the transfer to Programme level of the main best practices identified across the LSPs, ready for exploitation at the higher level.

The goal is to develop a set of KPIs that not only helps the IoT European Large-Scale Pilots Programme's stakeholders to understand how the deployments, use cases and pilots are performing but also helps stakeholders involved in the ecosystem to check that they are on the right path towards the pilots' and Programme's strategic goals.

The LSPs have, however, identified hundreds of KPIs to choose from; if the pilot ecosystems select the wrong ones, then all the deployments and pilots will use measurement indicators that do not align with the goals of the pilots and the Programme.

The common KPIs considered must be well-defined, quantifiable and communicated throughout the IoT ecosystem. They must also be essential to achieving the goals of the pilots, the IoT ecosystem and the Programme, at the same time being applicable to the domain covered by the LSPs and to the IoT ecosystem.

The activities presented in this document address the methodology to analyse and understand the KPIs across the LSPs' projects, define the criteria of selection and identify the possible common KPI candidates across the LSPs that are not only applicable to the domains covered by the LSPs and to the IoT ecosystem, but are also aligned with the goals of the pilots and of the Programme as a whole.

In this context, the focus of the work is on the validation methodologies for the design, selection and implementation of the (so-far identified) KPIs; the aim, at both LSP and Programme level, is to measure the success and assess the impact of the different pilots across the various use cases and among the different application domains.

Section 4 describes the main outcome of this deliverable and of the overall KPI assessment task, providing a comprehensive and horizontal list of metrics to be assessed across the LSP projects. The collaborative nature of this process, involving all relevant actors in selecting the relevant KPIs, ensures a straightforward way to achieve the assessment. The inclusions of the EC perspective and the Programme impacts also guarantee the proper alignment of the selected metrics with the strategic agenda.

A key step in this direction will be the design, organization and implementation of an interactive workshop on the evaluation of the various IoT FA based on the common methodologies and KPIs analysed and put forward in both D01.04 and the present deliverable (D02.03). The workshop (D01.06) will take place in m21/m22 of the CREATE-IoT Project and will aim to: present the shared set of common methodologies and KPIs; collect the necessary feedback from all the interested parties (the LSPs and other relevant stakeholders of the IoT European Large-Scale Pilots Programme); introduce the necessary corrective measures and improvements; and validate the final methodological framework and set of KPIs in the context of their implementations over the rest of the Project's lifetime. The discussions will address the use of common methodologies and KPIs for design, testing and validation of IoT technologies, as well as for applications deployment replicability. It is important to identify and encourage the use of common techniques and methodologies, identifying KPIs across the LSPs for design, testing and validation, impact measurement and replicability. All should help move towards operational deployment and be aligned with the objectives of the IoT European Large-Scale Pilots Programme.

The goal of the workshop will be to trim down the initial list of KPIs devised by the CREATE-IoT Project in D01.04 and D02.03 and to obtain a short, manageable, actionable list of a select number of indicators, fully shared by the whole Programme and to which all the Programme's participants can feel comfortable with committing.

LSPs will use this list of KPIs as basis to assess/evaluate the pilots and coordinate with IoT Focus Area sustainability activity group that will act as the placeholder for potential future interactions in this area.

The common KPIs are related to the IoT European Large-Scale Pilots Programme goal to ensure the longer-term evolution of the IoT, provide a rich portfolio of technologies and tools and to guarantee the sustainability of the approach. A set of KPIs will be dedicated to measure progress on citizen benefits, economic growth, job creation, environmental protection, productivity gains, etc., and should go beyond those partners involved in the pilots.

6. REFERENCES

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