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Summary					
No and name	**D03.02 Analysis on IoT Platforms Adoption Activities**				
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DoW	Having completed the data gathering and stakeholder engagement in task T03.01, this task will analyse the information gathered and identify the most effective drivers for Internet of things (IoT) adoption as well as barriers to adoption should they also become apparent. In order to do this we will have to assess the success of the different platforms in terms of their adoption. This will need to be done carefully and will need to take into account the state of development of the platforms. This comparison will look at the number of deployments of the platforms, the number of third party organisations engaging with the platforms, the number of end users and when available other indicators such as the revenues generated by the platforms for the developers and revenues generated for the third part adopters. Having assessed the relative success of the platforms, we will need to analyse the characteristics of each platforms and identify the common characteristics of the most successful platforms in terms of adoption. Having done this we will re-engage with the stakeholders in each platforms and play back our conclusions to them to test their agreement with our conclusions. Another important objective of such analysis is the collection of best practices in the creation, marketing and management of programmes (e.g. open calls, Start-up Weekend or Hackatons, etc.) for fostering new platforms/technology adoption. Where possible, best practices will be debated with other engaged stakeholders and will result in a blueprint to boost and maximise the adoption of innovative technologies, with particular focus on interoperability across IoT platforms. The task will produce a report (D03.02) of the conclusions from the analysis identifying the key drivers for IoT adoption, the potential barriers and how to avoid them.				
Comments					

Document history

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1. EXECUTIVE SUMMARY

Publishable summary

The purpose of this document is to seize a methodology for enabling - in the first place - the IoT European Platforms Initiative (IoT-EPI) actors to identify their position in the current IoT landscape.

The IoT platforms ecosystems maturity evaluation framework is intended to act as a self-assessment tool and provides an understanding of the current strengths and weaknesses of an IoT platforms ecosystem and its adoption readiness by different ecosystem participants. The derived insights can be used to further identify priorities to increase the adoption of an IoT platforms ecosystem and to build successful innovation communities around them. The proposed framework consists of three elements:

- A maturity model for IoT platforms ecosystems highlighting dimensions and fields relevant to adoption.
- A methodology that describes how to implement and use the model to identify strength and weaknesses of an ecosystem and identify opportunities to increase the adoption readiness of the IoT platforms ecosystem.
- A set of tools in form of KPI and questionnaire that allow the model to be instantiated and parameterised for a specific IoT platforms ecosystem in the form of a survey and a KPI mapping table

An analytical framework has been created in order to:

- Document, examine, and assess the maturity (level) of the platform itself and of its degree of adoption;
- Enable the identification of "best practices" and "barriers".

The Framework for developing the assessment model is constituted of different elements such as Maturity Assessment Model (MAM) and Self-Assessment tool. The MAM is described by three distinct levels:

- A level consisting of six dimensions, which define the Model;
- A level which identifies fields that make up properties of each dimension;
- A level that draws upon each of the properties and identifies useful Key Performance Indicators (KPIs).

These KPIs have been structured as an investigatory tool (a questionnaire) for collecting qualitative and quantitative information that will enable IoT innovation platforms to perform the maturity assessment validation. The concept supporting the development of the MAM with the aim to help IoT ecosystem platforms such as EPI-IoT platforms, and on broader perspective platforms adopters, by:

- Assessing the level of adoption of the IoT platforms.
- Transferring the best practices.
- Identify barriers and the limits for enhancing and stimulating the successful adoption of the IoT platforms.

Non-publishable information

None.

2. INTRODUCTION

2.1 Purpose and target group

The document aims to support IoT platforms ecosystems in understanding their key success factors and their barriers for adoption. Platform adoption is considered from the point of views of both, IoT developers, who build services on top of IoT platforms and end users of these services. In order to foster their adoption, IoT ecosystem platforms need to look deeply at existing and successful IoT ecosystem platforms in order to plan an effective strategy [11].

In order to become scalable IoT platforms ecosystems it may be crucial to be able to independently identify and be aware of strengths and weaknesses. Hence, the framework proposed in this report aims to help in this crucial operation by providing a self-assessment tool. The self-assessment tools will play an important role for questioning whether activities already put in place are effective or not in terms of adoption.

The IoT is defined by the transformative convergence of technologies and the IoT landscape is characterised by multiple competing platforms across most of the vertical and horizontal segments of the marketplace. IoT is facilitated by advances in devices, wireless connectivity and platforms, together with economic enablers such as the decreasing costs of hardware, computing and bandwidth. In addition, factors such as the globalization of information and the digitalization of our societies accelerates the development and deployments of IoT applications.

The widespread deployment of IoT solutions requires avoiding the creation of "Subnets of Things" or "Internet of Silos" and rather focus on developing IoT platforms ecosystems for cooperation across value networks created by various stakeholders.

This is supported by the emergence of a number of leading solutions in the various spaces of local connectivity, wide area connectivity and service or application layer that simplify IoT application development and allow industry to work together using global standards.

The changes in processing requirements for different IoT applications require the integration of mobile edge computing, multi-access edge computing that provides developers and content providers computing/processing capabilities and an IT service environment at the edge of the network. In addition, data processing and applications could be concentrated in devices at the network edge.

The purpose of this document is to seize a methodology for enabling - in the first place - the IoT-EPI actors to identify their position in the current IoT scenario. This document follows the ambition that the IoT-EPI sets on developing a successful IoT platforms scenario. Specifically, the methodology illustrated in this context aims at addressing the conceptual and technological challenges arising by the growth of the overall IoT landscape that includes a variety of features from developing scalable architecture and moving from closed to open system, to designing interaction protocols.

2.1 Contributions of partners

HIT are the T03.02 task leader and has in particular coordinated the preparation of the blueprint to boost and maximise the adoption of innovative technologies.

DIGICAT has worked closely with HIT to deliver the analysis and proposed several key dimensions that underpin this framework.

INNO has contributed to the analysis of key drivers and barriers, and ensured the link with similar analysis undertaken on user’s acceptance.

SINTEF has provided the structure and contributed on defining the maturity assessment model for IoT ecosystem platforms. The work was focusing on identifying the dimensions, the fields related to these dimensions and the Key Performance Indicators (KPIs) associated to these dimensions, fields and the methodology for implementation.

2.2 Relations to other activities in the project

The inputs to this activity are related to the previous task T03.01 (IoT platforms engagement), which form the basis for our analysis of the IoT platforms information. The outputs from this activity are related to the next task T03.03 (Dissemination of the conclusions on IoT adoption), which will use the results for further discussions and conclusions on the IoT adoption work.

As discussed in [2] and [11], IoT technologies carry technological and business challenges. On the one hand, the IoT industry will require new business models and product-service combinations to address and tackle the challenges in the Digital Single Market (DSM) [15]. On the other hand, IoT platforms achieve a number of main objectives such as flexibility, usability and productivity [1]. An IoT platform facilitates communication, data flow, device management, and the functionality to enable applications. The goal is to build IoT applications within an IoT platforms framework. The IoT platforms allow applications to connect machines, devices, applications, and people to data and control centres [11].

Assessing and evaluating the readiness of IoT platforms and their adoption provides an occasion for the IoT-EPI projects to learn about the status of their activity. Moreover, improving awareness of requirements and gaps on the adoption of IoT platforms can set a prospect for technological and business advancement. The proposed Maturity Assessment Model will simplify the complex analysis of IoT platforms ecosystem.

3. IoT Platforms Ecosystems Framework Overview

IoT platforms are the key component for connecting devices, data collection and processing, and user interfaces on web-based settings. They coordinate and manage a significant number of connected devices while guaranteeing the security and privacy of the data exchanged, and solving interoperability issues. The examination discussed in [11] addresses the core elements that allow the existence of IoT platforms ecosystem: security and privacy, data processing and data sharing, developers activity and final users identification. Moreover, platforms are applied across industries and are used as Platform-as-a-Service (PaaS), Infrastructure-as-a-Service (IaaS), Software-as-a-Service (SaaS). All the different uses of the IoT platforms (i.e. SaaS, PaaS and IaaS) confront various challenges among which security is one of the important ones.

In this framework, IoT platforms ecosystems are combining devices, networks and endpoints, and converging multiple IoT applications, and support end-to-end security solutions.

3.1 Consideration of the complexity IoT Platforms ecosystem

Figure 1 describes the complexity of understanding the traditional interpretation of the IoT ecosystem. In fact, as the illustration highlights the IoT ecosystem is shaped by a constellation of different vendors, intricate market relations, applications, and contextual inputs. This interpretation of the IoT ecosystem reflects the representation of the digital single market expressed through new products and services. As IoT and related revenues are driving the digital economy, the IoT ecosystem "cuts across vertical areas, in convergence between the physical and digital worlds. It combines connectivity, data generation, processing and analytics, with actuation and new interfaces, resulting in new products and services based on platforms and software and apps." The complexity of the IoT ecosystem requires a reconfiguration of business dynamics and outcomes for addressing the development of new "stakeholders, partners and consequences for the market." Hence, the structure of IoT innovation processes need to address the links that impact the market; the IoT value network Figure 2.

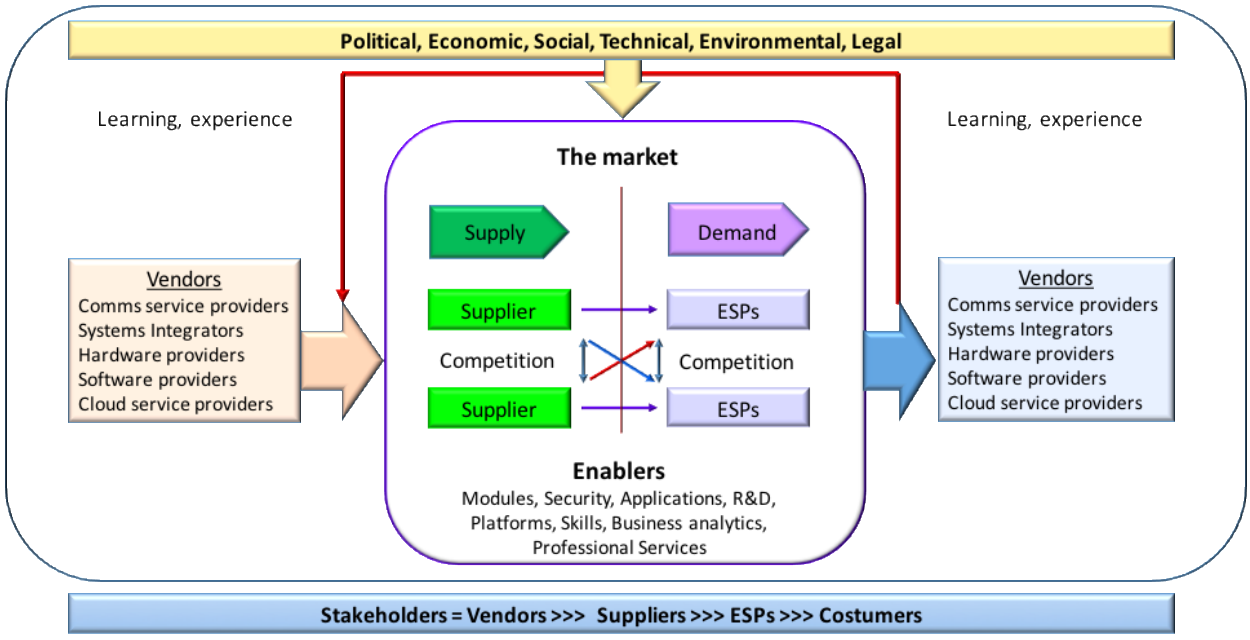

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Figure 1. The IoT ecosystem

The IoT network highlights the features that allow identifying the value propositions and revenue streams within the IoT ecosystem by combining the business models adopted by different stakeholders in the network. In this analysis of IoT configurations, platforms play the role of

market enablers and, as the ecosystems are growing, it becomes strategic to develop a methodology for documenting, analysing, and assessing the maturity of underlying platforms themselves and their adoption. Even though the discussion on the effect of adoption, review, and technology assessment has been opened [1][3], little research has been done by the IoT community in respect to the IoT platforms. Hence, the need for capturing the maturity level of IoT platforms ecosystem is growing in importance increasing - ecosystem maturity - as well as the level of adoption of IoT platforms - adoption readiness.

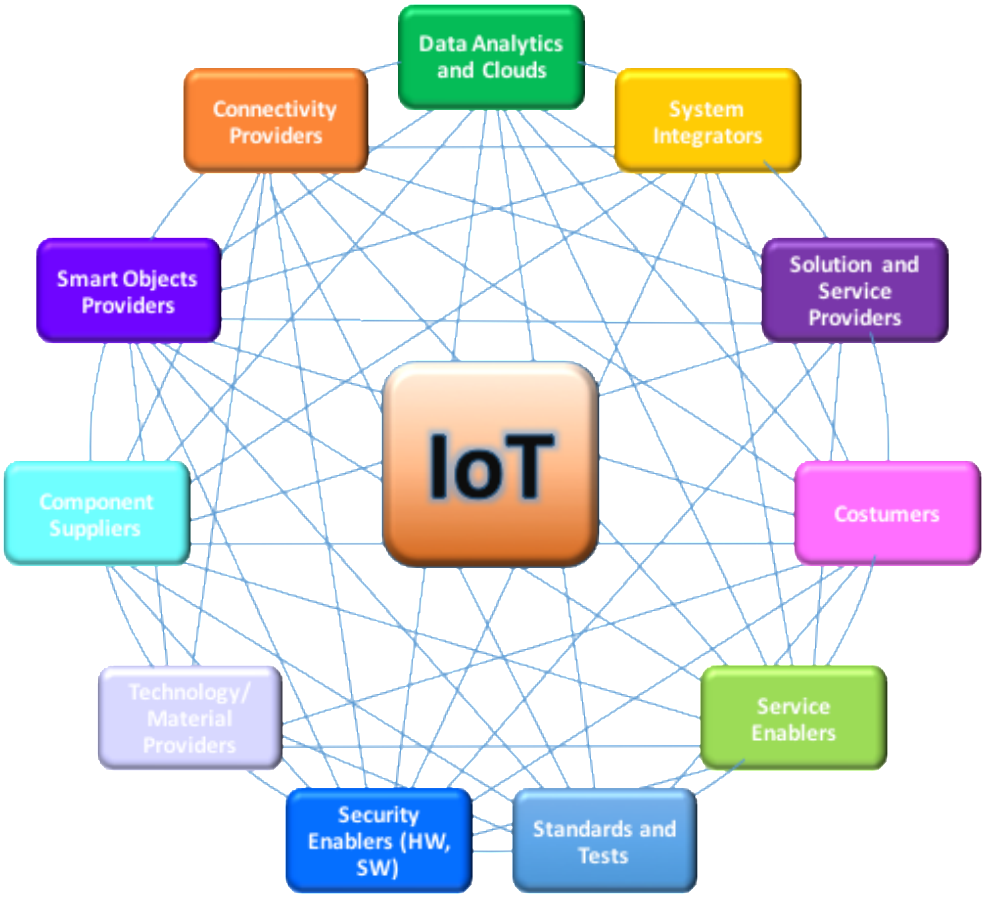

Figure 2. The IoT network

In order to answer these needs, we have developed an initial model for supporting the assessment of the prospective success of the platforms, by providing the description of a set of dimensions that allows analysing the characteristics of IoT platforms ecosystems and identifying the characteristics of the most successful IoT platforms ecosystems in terms of adoption.

The model allows evaluating concerns related to the deployments of the IoT platforms, the number of third party organisations engaging with the platforms, the number of end users and other indicators such as the revenues generated by the platforms for the developers and revenues generated for the third part adopters.

The model provides a mechanism to identify best practices used by the IoT platforms and IoT ecosystems in different use cases and applications. The analysis that follows from the application of of the proposed model and implementation methodology allows identifying the key drivers for IoT adoption and the potential barriers.

The methodology provides a mechanism to identify best practices used by the IoT platforms and IoT ecosystems in different use cases and applications. The outcome of the methodology allows identifying the key drivers for IoT adoption and the potential barriers.

Figure 3. The overall concept behind the maturity assessment model

The methodology proposed for assessment is generic and can be used by any IoT platforms ecosystems. For the IoT-EPI projects assessing and evaluating the readiness of IoT platforms adoption provides an opportunity to reflect about the status of their ecosystem. Analysing the status of the adoption can help and support a reaction for framing further implementation of IoT platforms. Moreover, improving awareness of requirements and gaps on the adoption of IoT platforms can set a prospect for technological and societal advancement.

The concept supporting the development of the MAM (Figure 3) has the aim to help IoT ecosystem platforms such as EPI-IoT platforms, and on broader perspective platforms adopters, to:

- Assess the level of adoption of IoT platforms.
- Identify barriers and the limits for enhancing and stimulating the successful adoption of IoT platforms.
- Transfer identified best practices.

Several frameworks and methodologies address the maturity and adoption of technological systems [1]. Developing assessment methods becomes relevant as multidimensional aspects of political, legal, environmental, influence touch the technological evolution. There is a number of ways to assess the maturity level of a technology depending on product development stage [14], on the associated costs [10], on the requirements of the design [5][4]. Further, the analysis could inversely focus on the risks and the limitations interfering the maturity of technologies [7][9]. However, analysing IoT technology readiness includes a conjunction with coordination and association performances [10].

The self-evaluation tool draws on a comprehensive general review that includes core features of IoT platforms ecosystems. By analysing literature and the work already completed by UNIFY-IoT, a set of core dimensions relevant for adoption have been observed. Starting from the observed dimensions, a set of measurable levels have been created (see Section 4). As for the measurable dimensions, they can be adopted by IoT ecosystem platforms for self-assessment.

3.2 IoT Platforms Ecosystems Framework for evaluation

The framework is intended to act as a self-assessment tool for IoT ecosystem platforms. It provides an understanding of the current strengths and weaknesses of an IoT platforms ecosystem and its adoption readiness by different ecosystem participants. The derived insights can be used to further identify priorities to increase the adoption of an IoT platforms ecosystem and to build successful innovation communities around them. The proposed framework consists of three elements:

- A maturity model for IoT platforms ecosystems highlighting dimensions and fields relevant to adoption (Section 4).

- A methodology that describes how to implement and use the model to identify strength and weaknesses of an ecosystem and identify opportunities to increase the adoption readiness of the IoT platforms ecosystem (Section 5).
- A set of tools in form of KPIs and questionnaires that allow the model to be instantiated and parameterised for a specific IoT platforms ecosystem in the form of a survey and a KPIs mapping table (Section 6).

In the following chapters, each of these elements will be presented in more detail.

Figure 4. Framework Working Flows

The IoT platforms ecosystems framework based on the three main elements (the maturity model, the methodology and the set of tools) is the foundation for the self-assessment and comparison. Using the methodology and the set of tools, a self-check implementation is developed and gives stakeholders the ability to check the maturity of the IoT platforms ecosystems using the dimensions described in the next chapter.

4. MATURITY ASSESSMENT MODEL FOR IOT PLATFORMS ECOSYSTEMS

In the following section, a Maturity Assessment Model (MAM) for IoT platform ecosystem is presented. The aim of the assessment model is to understand best practices that foster the adoption of the IoT platforms and the barriers that hold back their adoption. The model leverages past research and investigations on the IoT landscape dimensions. For each dimension, suitable fields and KPIs have been identified and a self-assessment tool has been developed accordingly.

4.1 Introduction to the Maturity Assessment Model

An analytical framework has been created in order to: a) document, examine, and assess the maturity (level) of the platform itself and of its degree adoption; b) enable the identification of "best practices" and "barriers".

The Framework for developing the assessment model is constituted of different elements such as MAM and Self-Assessment tool. The proposed MAM is structured in three distinct levels: A first level consisting of six model dimensions; a second level, which identifies fields that make up properties of each dimension; a third level draws upon each of the properties and identifies useful Key Performance Indicators (KPIs). These KPIs have been structured as an investigatory tool (a questionnaire) for collecting qualitative and quantitative information that will enable IoT innovation platforms to perform the maturity assessment validation. The MAM aims to trigger a conscious enhancement approach based on benchmarking with other IoT ecosystem platforms.

By answering to the questions of the self-assessment tool, IoT innovation platforms will be classified themselves into one of the following levels of readiness (See also Annex: KPIs Proposal):

- N/A: Not Applicable
- Level 0: Outsider
- Level 1: Beginner
- Level 2: Intermediate
- Level 3: Experienced/Top performer

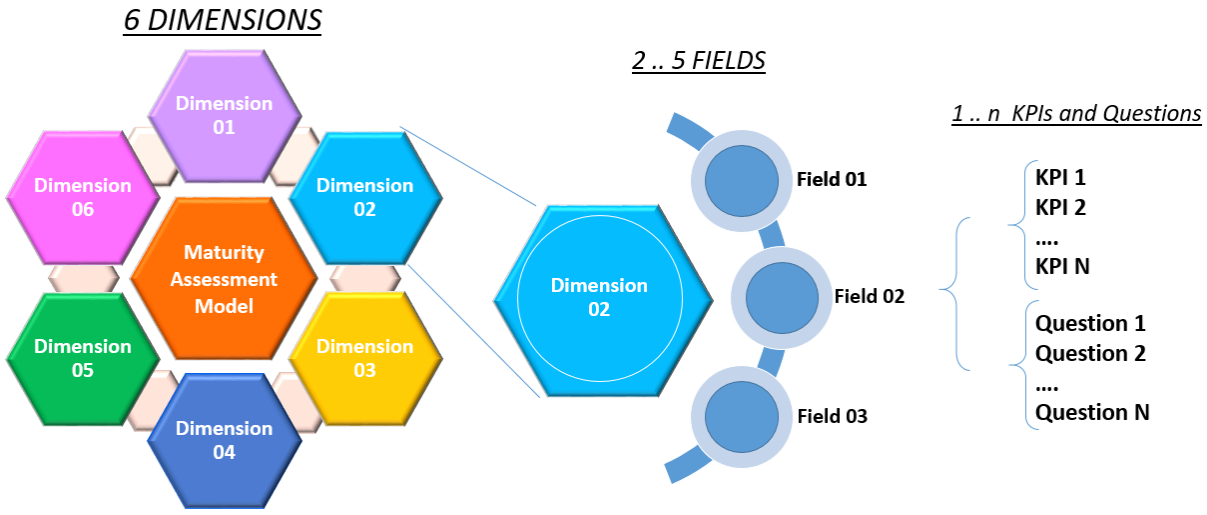

Figure 5. The overall Framework for the Maturity Assessment Model

4.1.1 Dimensions

The successful adoption of an IoT platform ecosystem relies on a variety of factors that together determine the likelihood of its development into a thriving innovation ecosystem. Based on results according to past research and investigation we propose six dimension that we consider important contributing factors towards successful adoption:

- **Strategy & Stakeholder Engagement**: Successful adoption requires a well-formulated ecosystem vision supported by an appropriate engagement strategy with key stakeholders and alignment with the overall policy landscape.
- **Community Support:** The level of community support determines the attractiveness of an ecosystem. Appropriate mechanisms and tools can bring down the barriers for participation effectively and reduce the learning curve to become productive.
- **Ecosystem Openness:** Very closed ecosystem are likely to attract fewer participants. An ecosystem should be open at the right levels to encourage the right stakeholders to participate and reduce the barriers for it.
- **Technology Advancement:** Available technologies and technical features can significantly increase the attractiveness of an ecosystem as they can increase the productivity and install confidence that an ecosystem is likely to persist and be future proof.
- **Marketplace Mechanisms**: Adequate market place mechanisms can install trust among end users in a system and increase the likelihood of participation. Participation can be further incentivised if the ecosystem provides mechanisms to easily extract value flows for the participants.
- **Technology Inclusivity:** An ecosystem is seldom in isolation and has to consider external factors such as existing standards, reference architectures and other contributing ecosystem technology such as IoT devices, service layers etc. The more likely an ecosystem is inclusive of other popular technologies the higher it is likely to be adopted.

Figure 6. IoT Maturity Assessment Model (MAM)

4.2 Fields

Each Field described in the previous subsection is delineated by a set of different areas of action and operation. With the notion of "field", the aim is to highlight those features that push the evolution and the accomplishment of the IoT platforms.

Thus, the notion of "field" defined as a "*network, or a configuration, of objective relations between positions*" [8] allows a systematic investigation for analysing phenomena and their distribution into an ecosystem.

Based on different results according to past research and investigation of the IoT landscape, the following fields have been identified for each dimensions presented in the following sub-sections.

4.2.1 Strategy and stakeholder engagement

In the IoT landscape, each IoT ecosystem platform has its own strategy that aim to engage relevant stakeholders (end users). Strategy and Stakeholder Engagement dimension aims to identify how well the ecosystem strategy of each IoT platform ecosystem is defined in order to maximize adoption. Indeed, the fields related to this dimension aim at disentangling the definition of the strategy to adopt for maximising the adoption.

- **Ecosystem awareness**: IoT platforms ecosystems is described in [11] "as the foundation for new value creation and the driver for developing new IoT applications". In line with this definition of ecosystem, this field focuses on mapping customers, competitors, and potential partners.
- **Partnership and adoption strategy**: As the ecosystem drives the development of the IoT applications, partnerships have to be in line with the adoption strategy (e.g. Microsoft set up "consortium" from each country to be the "go to" partners for the new Azure IoT based solutions.) The field aims to assess the appropriateness of a partnership and adoption strategy both in terms of nature of stakeholders and timing.
- **Stakeholder participation**: An ecosystem is established as well by the participation of stakeholder engagement. This field aims at investigate the level of participation of stakeholders into the activities of the ecosystem, in order to understand how well the partnership and adoption strategy is being executed. The different levels will correspond to the evolution from proof of concept stage (e.g. only consortium partners involved) to full implementation of partnership strategy with the adequate partnerships and alliance realized.
- **Public / government engagement**: IoT ecosystems require awareness and dialogue with the policy makers and regulators to ensure that barriers and opportunities for ecosystem growth are appropriately identified and that technology development aligns with the legislative context and regulative context.

4.2.2 Community Support

Adoption of IoT platforms ecosystems can be encouraged by effectively engaging with stakeholders through different channels and tools and by bringing down barriers for technology adoption. Possible measures include:

- **Developer programmes**: As the community/network is affecting the competitive capability of the platforms ecosystem, the role of developers is key for reinforcing the community. Hence, this field investigate the support provided to developer – i.e. documentation, code, examples, and tutorials
- **Education programmes**: In line with activities planned for supporting developers, this field looks at the existence of a comprehensive training curriculum and its level of accessibility. Moreover, the field look at the link between academic and entrepreneurial world by looking at how training material is embedded in academic institutions.
- **Accessibility programmes** (language customisation, support for disabled developers/customers etc.): Planning actions towards accessibility implies a/v contents available to ease the accessibility of products consider differences among potential users (e.g. text to speech etc.). Moreover, this field focuses on the expression and translation of information into languages that are relevant for the market.

- **Community engagement**: Actions for engaging the community are including actions such as events, competitions, hackathon. Thus, this field aims at analysing the kind of actions taken for stimulating and fostering the adoption.

4.2.3 Ecosystem Openness

The core intent of the Ecosystem Openness dimension is to track how open and accessible is the IoT platform ecosystem in terms of architecture and interoperable solutions.

- **Cross-sector awareness and support**: This field relates to an understanding of the ecosystem of primary and related sectors and potential strategy to approach new markets. It also relates to the available technical support that the ecosystem may provide to ease adoption in new sectors.
- **Value chain positioning:** This field relates to the awareness of the ecosystem value network and the clarity of roles different stakeholders can assume along the value chain.
- **Open Source strategy**: Open source strategies can drive further adoption [11]. This field examines whether an open source strategy exists and how well it is leveraged to foster further the IoT ecosystem adoption.
- **Openness of business models**: IoT platform ecosystems reframe the conventional linear streams within a network of stakeholders. Thus, the focus shifts towards an ecosystem level for maximizing the benefits for target groups. A more open business model across the value chain can encourage participation of more diverse stakeholders and encourage adoption.

4.2.4 Technology Advancement

IoT technologies evolve quickly, and the evolving traits include a combination of technological advancements, economic, and societal development. Technology is a moving target and the advancement of IoT technology are relevant forms of concerns. This because current technology may solve issues for yesterday challenges but may not be able to address emerging ones. This dimension focuses on the technological offer whether or not it is appealing and matching with the existing and emerging demands of the IoT markets that the ecosystem is serving.

- **Technical richness**: IoT platforms offer a variety of different technical features that can add significant benefits to service developers and end users. While core functionality is similar across different IoT platforms it is in specific technical features IoT platforms can differentiate themselves from another. Unique features or best in class features can be powerful attractors for service developers, however they should be also perceived as valuable to potential adopters.
- **Simplified complexity**: The complexity of IoT product is one of the features that challenge IoT platform adopters - i.e. manufactures. Thus, one of the requirements for IoT platform deployment is to be there to meet the needs of production/rendering processes. Thus, IoT platforms need to be easy to use and need to hide the complexity of systems. At the same time, the availability of the right support tools and mechanisms can make simplified greatly the complexity of tedious tasks.
- **Technical readiness**: This field focuses on the maturity of underlying technology base. The aim is to investigate readiness level for commercial operation. This investigation is overall linking to the dynamic and sharp IoT value network, which is the stage of a huge range of technologies that are differently competitive and risky. The field looks at the evolution and flexibility of IoT platforms, as they need to iterate their performance across products and systems.

4.2.5 Marketplace Mechanisms

IoT technology became one of the stimuli of the current industrial changes. However, as the technological offer is increasingly evolving so is the way companies engage in the ecosystem. As IoT technologies challenge the market with dedicated mechanisms and frames to open toward multiple industries and areas of application, there is an increasing need to provide market place mechanisms to bring down barriers on the IoT platforms market.

- **Monetisation mechanisms**: A key barrier encountered by IoT ecosystem is how ecosystem participants are able to generate revenue for providing value in it. A well-established market place offering monetisation mechanisms such as billing and accounting functionality (e.g. like an app store equivalent) can significantly boost adoption levels.
- **Business models**: While trying to enhance monetization mechanisms, it is relevant for ecosystem stakeholders to utilise appropriate business models. The Business Model Framework [2] describes how stakeholders of the IoT industry can choose different ways of generating service content, managing the technology and creating value. The availability of proven models is key for attracting ecosystem participants as they find it easier to extract value from it.
- **Privacy, Security and Trust**: This field highlights tools to ensure trust/reputation among partners, and mechanisms for securely and trustworthy collection data of participating end-users. In a previous analysis [12] lack of trust has been described as one of the barriers to adopting an IoT platform. An IoT ecosystem that ensures trust of its participants and their services and respects privacy concerns of them is likely to gain increased adoption.
- **Legislation**: Differences in legislation and regulation can be a significant barrier in fostering the adoption of a platform in different markers. Non-compliance may affect international growth, as regulation may happen differently in different regions. Thus, the investigation in this field would focus on how well IoT ecosystem are prepared to deal with different legislative and regulatory environments.

4.2.6 Technology Inclusivity

The IoT ecosystem includes a huge variety of existing technologies, and it is increasingly important for technologies to reliably work together. This is a particular challenge, as IoT ecosystem have to rely on resources able to ensure constant innovation regarding collective capability.

Heterogeneity of technology ensures technology advancement and is essential for the evolution of the ecosystem. However, it increases the complexity of integration. By providing out-of-the box support for a specific technology, IoT platform ecosystem can bring down the barriers for adoption as it simplifies the participation of stakeholders already familiar with a type of technology.

- **Supported standard**: There is a variety of IoT standards on the market which vary in their adoption levels across different sectors. Supporting leading standards out of the box provides a higher probability that service developers and end users can utilise existing infrastructure and experience, thus increasing the attractiveness of an IoT platform ecosystem.
- **Supported devices**: The IoT market is flooded with IoT platforms, nevertheless there are a variety of platforms that experience high popularity with the developer community. IoT platform ecosystem that offer native support or ready to go example code for popular IoT platform can make it easier for developers to get started with their pre-existing experience and device based solutions.
- **Interoperability**: The market is still fragmented and dotted by a variety of incompatible platforms and technologies. Support for interoperability in an ecosystem can increase its attractiveness as it eases the integration of different components and alignment with other technology ecosystems.
- **Validation, verification, testing, and certification**: Interoperability and compliance are essential for ecosystem participation, but are difficult and costly to establish. A trusted ecosystem can more rapidly emerge if tools concerning validation, verification, testing and certification exist.

Table 1. Maturity Assessment Model: dimensions and fields and KPIs description

Maturity Assessment Model		
Dimensions	**Fields**	**KPIs description**
Strategy and Stakeholder Engagement	*Ecosystem awareness*	• Level of awareness of ecosystem stakeholders
	Partnership & adoption strategy	• Appropriateness of partnership strategy • Appropriateness of adoption strategy • Ease of stakeholder participation
	Stakeholder participation *Public / government engagement*	• Stakeholders involved • Platform users/adopters • Regulations and public policies having an influence on the platforms • Interaction with authorities of interaction with authorities
Community Support	*Developer programmes*	• Support measures for developers • Interaction with developers • Contribution and involvement of developers
	Education programmes	• Education and training, hand-on seminars offers provided • Dissemination activities
	Accessibility programmes	• Contribution of developers • Localisation support for websites and software
	Community engagement	• Appropriateness of engagement strategy • The nature and heterogeneity of community engagement activities • Engagement with activities with 3rd parties
Ecosystem Openness	*Value chain positioning*	• Openness of value chain(s) and value network(s) • Value network participation
	Cross-sector awareness and support	• Sector/market strategy document • Adoption readiness
	Open source strategy	• Open source readiness
	Openness of business model	• Business model flexibility
Technology Advancement	*Technical richness*	• Feature richness • Perceived usefulness of technical features
	Simplified complexity	• Productivity gain • Features used for interfaces with users, other devices • Upgradability and functionality extension
	Technical readiness	• Technology readiness level • Manufacturing readiness
Marketplace Mechanisms	*Monetisation mechanisms*	• Availability and nature of mechanisms that allow exchange of value flows for ecosystem participants including value added services, apps., IPs, universal connectivity, features for analytics and prediction, real time data access, etc.
	Business model	• Subscription, value proposition, value chain/value network in the IoT ecosystems, concept for building the business ecosystem and the role of the platforms as catalytic element

	Legislation, Privacy, security and trust	• Resilience: dependability, trustworthy, reputation the size of the ecosystem, integration of security in the IoT architecture, security by design, end-to-end, by default
	Legislation	• By creating legislation, clarifies issues such as ownership of data, privacy and security. Aligns in a national/European level. How the platform captures the unify market/ Digitizing European Industry – flexibility across platforms
Technology Inclusivity	*Supported standards*	• Support for popular IoT standards in the IoT platform ecosystem
	Supported devices	• Types of natively supported IoT devices
	Interoperability	• Level of technical, syntactic, semantic, organizational maintenance of the interoperability. Interoperability across use cases and sectors
	Verification, validation, testing, and certification	• Mechanisms for providing validation, verification, testing for developers and certification solution/bodies/schemes for end users.

5. METHODOLOGY

5.1 Methodology to collect, analyse and evaluate data for the Maturity Assessment Model Validation

The questionnaire will be submitted to a selected sample of population presenting the similar profile features per each IoT ecosystem platforms. It is expected to have at least three respondents per IoT ecosystem platforms.

5.1.1 Average reply rate per question

As a first result, assessing the general behaviour of the IoT ecosystem platforms, the average reply rate will be calculated. The result will be presented as a histograms graph (see Figure 7), where each column presents the answer to a single question and they are grouped per single field. There will be 26 groups, as the number of the fields, but each group will have a different number of columns according to the number of questions of the field. This data presentation will provide a very quick view of the general level of maturity in each field giving at the same time the opportunity to discover unaligned behaviours highlighted by specific questions. Of course, all this evaluation considers the aggregation of all the IoT innovation platforms and do not allow analysis on a single one.

Relation question value

- N/A: Not Applicable
- Level 0: Outsider; Value of the answer: 0
- Level 1: Beginner; Value of the answer: 1
- Level 2: Intermediate; Value of the answer: 2
- Level 3: Experienced/Top Performer; Value of the answer: 3

Average reply rate per question formula (Z)

$$\frac{\text{Question}_1(\text{IoT Ecosystem platform}_1) + \text{Question}_1(\text{IoT Ecosystem platform}_2) + \ldots + \text{Question}_n(\text{IoT Ecosystem platform}_n)}{n} = Z_1$$

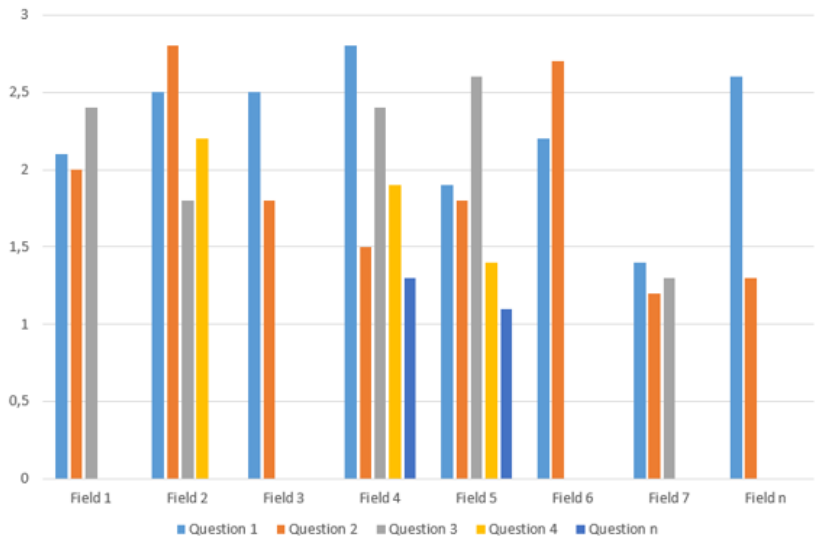

Figure 7. Exemplification of average reply rate per question formula

5.1.2 Average reply rate per field

The second step implies the calculation of the average reply rate per single field (average of all answers to all questions of a single field). There will be 26 columns as the number of the fields. The column will be grouped according the 6 dimensions. Figure 8 will provide a very quick view of the general level of maturity in each dimensions, giving at the same time the opportunity to discover unaligned behaviours highlighted by specific fields. All these evaluations consider the aggregation of all the IoT platforms ecosystem involved.

Average reply rate per field formula (S)

$$\frac{Z_1(\text{Field}_1) + Z_2(\text{Field}_1) + \ldots + Z_n(\text{Field}_1)}{n} = S_1$$

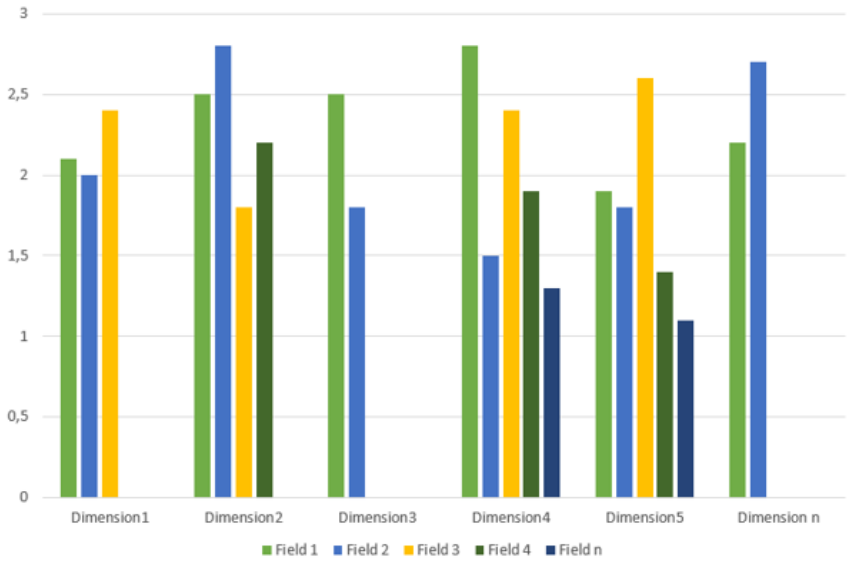

Figure 8. Exemplification of the average reply rate per field

5.1.3 Best Practices and Barriers of a single IoT ecosystem platforms

Considering the analysis of each IoT platforms ecosystem, a set of radar plots will be generated that contains - one per each field or 26 graphs overall. Each radar plot will have as many radius as the number of questions for the specific field. On each radius, related to questions, two values (points) will show:

1) the average of ALL answers to a single question provided by all the respondents except the examined IoT platforms ecosystem and

$$Z_1 - \text{Question}_1(\text{IoT Platform Ecosystem}_1)$$

2) the average of ALL answers to the questions provided by respondents of the examined IoT ecosystem platform.

$$\text{Question}_1\ (\text{IoT Ecosystem Platform}_1)$$

If the value (point on the graph) of the IoT ecosystem platform is higher (external) than the average of the other IoT ecosystem platforms a best practice has been developed by the IoT ecosystem platform when compared to the others. If the value (point on the graph) of the IoT ecosystem platform is lower (internal) than the average of the other IoT ecosystem platforms a lower

performing, incomplete practice or a barrier has been faced by the IoT ecosystem platform when compared to the others.

Except the cases where the two points on the graph are very close, it is expected to have many action points about the need to spread a best practice to other IoT ecosystem platforms or, on the contrary, to improve the approach and analyse the benchmarking of the other IoT platforms ecosystem.

This analysis of the 26 graphs has to be replicated for all the IoT platforms ecosystem involved in order to collect a list of action points per each IoT platforms ecosystem.

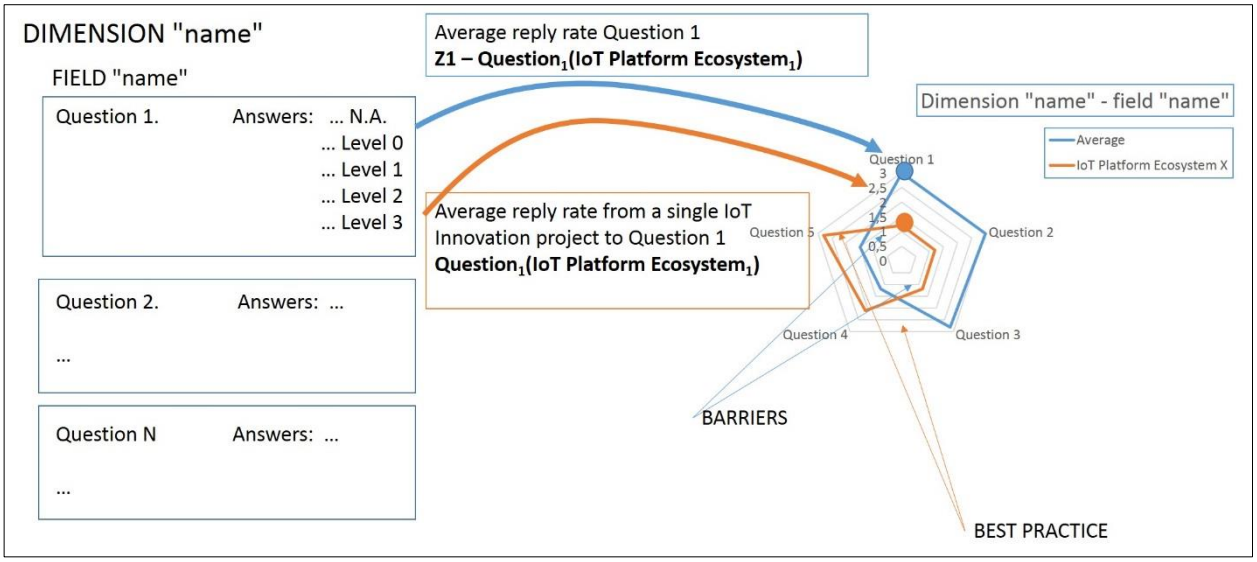

Figure 9. Maturity Assessment Model Graphical Rendering

5.1.4 Aggregated behaviour of a single IoT platforms ecosystems

Two additional typologies of radar graphs can be generated to support the evaluation of a single IoT ecosystem platform. The approach is going to be similar as the one explained in the previous section: on the one side, ALL answers to questions provided by all respondents except the ones of the examined IoT ecosystem platform; on the other side ALL answers to questions provided by the respondents of the examined IoT ecosystem platforms.

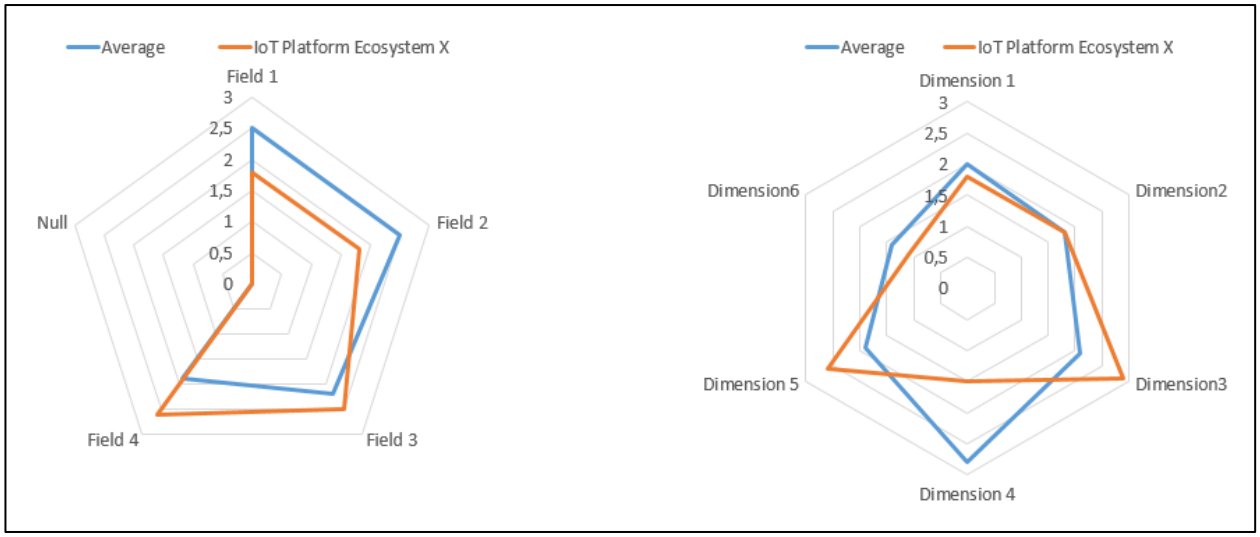

Figure 10. [a] Dimension graph; [b] Maturity Assessment Model graph

With the first type of graph presented in Figure 7 the average of all questions related to a single field are calculated, presented on each radius of the graph and compared between a single IoT ecosystem platform and the others.

With the second kind of graph as shown in Figure 8 the average of all questions related to a dimension are calculated, presented on each radius of the graph and compared between a single IoT ecosystem platforms and the others.

The 'MAM graph' is useful since it enables the understanding of weaknesses in terms of dimensions; evidenced in the examined IoT innovation platforms (see Figure 9). Starting from them, the investigation can move in depth to analyse the critical 'dimension graphs' or even further in depth to analyse the field graphs.

6. KEY PERFORMANCE INDICATORS (KPIS)

6.1 Introduction of the KPIs

In order to assure the adoption of the IoT ecosystem platforms, it is fundamental to define Key Performance Indicators (KPIs) that reflect strategic (business and technical) drivers to ensure that all IoT ecosystem platforms are working to the same goals and strategies and to provide standardization, collaboration and coordination [18][19].

"Key Performance Indicators (KPIs) are quantitative and qualitative measures used to review an organisation's progress against its goals. These are broken down and set as targets for achievement by departments and individuals. The achievement of these targets is reviewed at regular intervals."[16]

According to the literature, KPIs should be relevant and consistent with the specific vision, strategy and objectives, focused on the strategic value rather than non-critical local outcomes; representative and pertinent to the project together with its operational performance; clear and punctual in order to easily understand the concept behind, attainable and measurable, updated to secure their applicability and consistency.

6.2 Key Performance Indicators in IoT platforms landscape

The first and most important challenge is to ensure that key performance indicators reflect strategic drivers and are consistent with the vision and goal of IoT ecosystem platforms. According to the literature, KPIs and key action initiatives require several intermediary steps such as creating strategies, objectives and critical success factors. The vision of the future (mission) must be supported by the how (strategy), the what (objectives), the focus areas (critical success factors), the metrics (KPIs) and the action plan (key action initiatives) to realize full actuation. Table 2 explains how in the MAM KPIs are generated starting from dimensions and fields.

In IoT-EPI context those steps are pretty clear: the vision of the future (mission) is the adoption and interoperability of the IoT projects. A framework for developing the maturity assessment model has been provided in order to check whether activities already put in place are effective and efficient in terms of adoption. MAM has been defined by a set of different dimensions broken down in fields (critical success factors).

Table 2 Maturity Assessment Model and the structure for generating KPI starting from Dimensions

KPI generation

Dimension - General target

Field - Specific target

KPI n

- Self-explanatory title
- Calculation - Definition (i.e.: ratio between #successful implementation and #overall implementation)
- Source - How and where collect values to avoid misunderstanding (#successful implementation and #overall implementation)

Target - Expected value of the KPI (in different phases: beginning, current, final target)

Fields provide the minimal granularity that allow identifying the right Key Performance Indicators (KPIs) to measure the performance of the entire IoT ecosystem. By building on the top of the KPIs, an investigatory questionnaire (key action initiatives) for collecting qualitative and quantitative information have been structured, in order to enable IoT platforms ecosystems to perform the maturity assessment validation. The MAM will provide information about the fulfilment of the mission.

6.3 Key Performance Indicator Creation

As mentioned, KPIs are related to each field (i.e. Business Model) of a specific dimension (i.e. Marketplace Mechanism). It is possible to have more than one KPI per field of each dimension. However, the absence of KPIs may indicate the need for an extensive description of conditions and results.

The structure for generating KPI is effectively the instrument for creating the Self-Assessment evaluation model exemplified in Table 2 and Table 3.

Table 3. Practical example of KPIs structure starting from a Dimension

KPIs example

Dimension: Marketplace Mechanism

Field: Business Model

KPI description: Subscription, value proposition, value chain/value network in the IoT ecosystems, concept for building the business ecosystem and the role of the platforms as catalytic element.

KPI 1

- Title: Success of business models developed
- Calculation: (#business model used in real cases) divided (#overall business models developed)x(100)
- Source: List of business models developed; List of real case of application;
- Target: >50% beginning, >80% regular operation

KPI 2

- Title: Number of different business models developed
- Calculation: #overall business models developed
- Source: List of business models developed
- Target: >=1 beginning, >=3 regular operation

As KPIs play a central role as a parameter for Self-Assessment evaluation, the framework includes a set of questions and answers that have been paired with the KPIs and that constitute the actual Self-Assessment tool (See Annex A).

6.4 Self-Assessment tool

Table 4 represents a practical example of the outcomes of the Maturity Assessment Model as for that it is the base for the Self-Assessment validation tool.

The Self-Assessment tool is an occasion for profound investigation of the adoption conditions of the IoT platforms ecosystem.

The tool is based on the discussed Dimensions and Fields (see Chapter 4) and the related KPIs. Moreover, by applying, analysing, and comparing results from the Self-Assessment tool, the definition of a set of best practices related to the IoT platforms ecosystem will be possible.

Table 4. This question exemplifies the Self-Assessment tool

Example of question

Questions: Is the IoT-EPI business model adapt and tested to ensure revenue streams for external stakeholders?

Level of usage of the different supported business model.

Answers:

a) Not Planned,

b) Not yet implemented,

c) Implementation Formulated,

d) Implemented and sporadically reviewed,

e) Implemented and regularly reviewed

7. IoT Platforms Ecosystems Maturity Evaluation Framework – Outlook and Future Development

7.1 Summary and Conclusion

This document aims to provide a methodology able to grasp what are the best practices and barriers of adoption in the IoT Platforms landscape. Through the proposed methodology, IoT platforms initiatives will be able to identify their position in the current IoT scenario and they will have the possibility to strengthen their weaknesses in order to develop a successful IoT platforms ecosystem. The document lays the foundation for a guideline in order to frame priorities to increase the adoption of an IoT platforms ecosystem and to build successful innovation communities around them. The conclusion of the analysis will be disclosed in the Dissemination of the conclusions of the IoT Adoption document that will be released later this year.

7.1.1 Framework development - Maturity Assessment Methodology and self-assessment tool

A framework has been created in order to document, analyse, and assess the maturity (level) of the platforms itself and its adoption and, through its application, will be possible to identify "best practices" and "barriers" (See Chapter 3).

The maturity assessment model allows to define criteria through which IoT innovation platforms will classified themselves into level of readiness:

- N/A: Not Applicable
- Level 0: Outsider
- Level 1: Beginner
- Level 2: Intermediate
- Level 3: Experienced/Top performer

This classification is based on a number of key dimensions. Each of these dimensions is further divided into fields, which are operationalized with appropriate KPIs and questionnaires.

7.1.2 Applying the framework in the IoT platforms ecosystems context

The framework for the MAM has been developed with the specific intention to focus on the "adoption of IoT platforms ecosystems" **(**See Chapter 4 and Chapter 5**)**. The framework has a double purpose. On one side, the framework highlights the barriers that hold the adoption back and the best practices that drive towards a successful adoption of IoT platforms ecosystem. On the other side, the framework gives an opportunity for IoT ecosystems to identify the strengths, weaknesses, opportunities, and threats for planning actions for improvement.

In line with past research on the IoT platforms landscape, dimensions, fields, and KPIs have been identified for developing a self-assessment tool (see Chapter 6.4) that will be further developed accordingly.

7.1.3 Implementation of the IoT platforms ecosystems maturity evaluation framework

To ensure that the IoT platforms ecosystems develop rapidly, it is paramount that beginners and outsiders replicate the best practices used by the experienced/top performers. In this context, the MAM is improved as result of the feedbacks received from EPI-IoT stakeholders that are using theself-assessment tool.

After having explored the possible KPIs, and analysed the dimensions and the fields that characterise the IoT value network, UNIFY-IoT presented, discussed, and reframed these characteristics together with the EPI-IoT platforms. During the IoT-EPI get-together in Berlin on the 14 March 2017, UNIFY-IoT organised an investigatory round-table to present the initial model

and to discuss each dimension and field. During the round-table, participants pencilled in and noted features recognized as relevant for the definition of the self-assessment tool.

During the round-table, members of the IoT platforms ecosystems addressed relevant aspects for best shaping and describing the fields by actively participating in the presentation. Additionally, participants gave valuable feedback related to the broad aspects that a self-assessment tool should look at. For instance, one of the participants noted that such kind of tool is useful for describing an ecosystem in place that needs to be advanced or for highlighting reasons behind specific choices. Besides, the self-assessment tool would help rising awareness on where the ecosystem is heading. The identification of strategic directions of IoT platforms ecosystems helps to assess the capability to adapt, align and differentiate among partners, stakeholders, and competitors.

The IoT platforms ecosystems are benefiting from a clear understanding of the barriers and the enablers encountered over time. However, there actions taken internal by the IoT ecosystems that may stimulate or holding back the development of the IoT platforms. In this respect, participants highlighted how the method of storing data and the generated patents within an IoT platform ecosystem may define its success.

It is recognised by the IoT-EPI stakeholders that the maturity assessment model can be used as an analytical instrument aiming to generate ideas and actions to expand further the development of IoT platforms and their ecosystems. Hence, the challenges for the round-table were to highlight for each dimension features and elements that could better describe the fields, and for each field to note potential questions for unveiling the IoT ecosystem platforms experiences.

7.1.4 Deployment of the self-assessment tool

The framework for the development of the Maturity Assessment Model described in this blueprint provides the core basis for deployment in the following stages of Innovation Activities for IoT Platforms Adoption (WP3) (See Chapter 5). The further development of the self-assessment tool combines the suggestions and the recommendations collected with the help of the EPI-IoT platforms during the round-table held in Berlin, together with the elements discussed and presented in this document.

The self-assessment tool will be used across EPI-IoT platforms ecosystems through the support of the Innovation Task Force to collect information for outlining the best practices that IoT platforms ecosystem adopts for improving their success.

7.1.5 IoT adoption workshop

The feedback collected from the deployment of the self-assessment tool across EPI-IoT platforms ecosystems will be analysed and reframed to outline the best practices for leading toward a successful IoT platforms ecosystem. The results of the analysis will be presented to the EPI-IoT platforms ecosystems within a workshop as a conclusion of the related activity. By displaying the results to the community, the intention is to allow EPI-IoT platforms ecosystems to learn from each other, to improve their performance and to benchmark each other solutions collectively.

IoT platforms ecosystems focus on new technology, innovation, business models, monetization and outsiders and beginners need more explicitness and understanding of the significance, potentials, and benefits of IoT to their platforms ecosystems. The stakeholders through the use of the self-assessment tool could become aware of the significance of the different dimensions and fields described in the MAM to support them to define an effective strategy and take other appropriate measures for improving their performance.

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9. ANNEX: KPIS PROPOSAL

Dimension: Strategy & Stakeholder Engagement

Field	Ecosystem awareness	
KPI1	Title	Identification of ecosystem stakeholders (customers, partners, competitors).
	Calculation	# of stakeholders provided with significant characterization
	Source	Internal documents and reports of the consortium/platform managers
	Target	N/A: not applicable, this KPI is mandatory; Level 0: at project level - map of ecosystem provided in one deliverable; Level 1: stakeholders are clearly identified, but one or more category is not accurately assessed; Level 2: the map of ecosystem exists and clearly identify the landscape. Clarity can be improved for one or more category of stakeholders; Level 3: the map of ecosystem is regularly screened and updated with an assessment of new competitors, customers, partners;
	Question	Did you undertake tasks to identify who are your customers, partners, competitors?

Field	Partnership & adoption strategy	
KPI1	Title	Partnership strategy
	Calculation	- a partnership strategy exists with a clear methodology for each kind of stakeholders - clear roadmap has been identified with milestones and realistic targets - risks and mitigation strategy has been identified
	Source	Internal documents and reports of the consortium/platform managers
	Target	N/A: not applicable, this KPI is mandatory; Level 0: at project level - deliverable on partnership strategy that contains all elements listed below; Level 1: one or more category of stakeholders doesn't have a clear strategy; Level 2: the strategy exists but need refinements based on the implementation; Level 3: strategy regularly updated in closed loop with the implementation;
	Question	What is your partnership strategy?

Field	Partnership & adoption strategy	
KPI2	Title	Readiness of participation for stakeholders
	Calculation	Rules of participation defined Process defined and accessible to potential participants
	Source	Website, communication towards participants
	Target	N/A: not applicable, this KPI is mandatory Level 0: rules exists; Level 1: the clarity of the rules need to be improved; Level 2: the transparency and rapidity of process need to be improved; Level 3: transparency and rapidity of participant enlistment of participant;
	Question	What are the rules and process communicated to external stakeholders to foster the adoption of the platform?

Field	Partnership & adoption strategy	
KPI3	Title	Strategy for adoption
	Calculation	Clear go-to-market strategy in place matched by extensive community engagement activities.
	Source	Internal documents and reports of the consortium/platform managers
	Target	N/A: if the platform development is still at a proof of concept stage; Level 0: at project level: deliverable on partnership strategy that contains all elements listed below; Level 1: one or more category of stakeholders doesn't have a clear strategy; Level 2: the strategy exists but need refinements based on the implementation; Level 3: regularly updated in closed loop with the implementation;
	Question	What activities are you undertaking to engage stakeholders?

Field	Partnership & adoption strategy	
KPI4	Title	Easiness of participation for stakeholders
	Calculation	Rules of participation defined Process defined and accessible to potential participants
	Source	Website, communication towards participants

	Target	N/A: not applicable, this KPI is mandatory; Level 0: rules exists; Level 1: based on stakeholders' feedback, the clarity of the rules need to be improved; Level 2: based on stakeholders' feedback the transparency and rapidity of process need to be improved; Level 3: transparency and rapidity of participant enlistment of participant;
	Question	How easy it is for stakeholders to participate?

Field	**Stakeholders' participation**	
KPI_1	Title	Number stakeholders involved
	Calculation	#Number of stakeholders by nature (academic, industry, business field)
	Source	List of stakeholders
	Target	N/A: not applicable, this KPI is mandatory; Level 0: mixed of stakeholders involved; Level 1: one or more category doesn't involve the stakeholders targeted in the strategy; Level 2: the involvement of stakeholders is globally in line with the strategy, but still fragile in a long term perspective; Level 3: involvement of stakeholders is in line with the strategy and secured in a long term perspective;
	Questions	Which type of stakeholders (i.e. academic, industry, public, end users) are involved in your ecosystem? How many of them are occasionally/regularly participating?

Field	**Stakeholders' participation**	
KPI_2	Title	Number of platform's users_/adopters
	Calculation	Numbers of users of the platforms
	Source	List of users and adopters
	Target	N/A: not applicable, this KPI is mandatory; Level 0: users from the direct network of the consortium; Level 1: users from the "known" ecosystem, i.e. players active in the community; Level 2: external users in line with the adoption strategy, but using the platforms still at a discovery stage;

		Level 3: external users/adopters in line with the adoption strategy and using actively the platforms;
	Questions	Who are the stakeholders using the IoT platform ecosystem? Who are the stakeholders contributing the IoT platform ecosystem?

Field	Public / Government engagement	
KPI_1	Title	Number of identified regulations and public policies having an influence on the platforms
	Calculation	#of regulation identified
	Source	List of regulation identified
	Target	N/A: no target. Level 0: identification of regulations that influence the IoT platform; Level 1: assessment of the alignment of the regulations and the ecosystem objectives; Level 2: identification of stakeholders (relevant agencies/ government bodies) in charge of the regulations; Level 3: interaction with relevant agencies/government bodies about the regulations that influence the adoption of the IoT platform;
	Questions	What regulations can influence the adoption of your IoT platform ecosystem in different markets? What EU/national policies align with your ecosystem objectives? Please describe your interactions with public authorities and regulators?

Dimension: Community support

Field	Developer programme	
KPI$_1$	Title	Number of support measures to developers
	Calculation	Number of support measures
	Source	List of available documentation, tutorial, forum, etc.
	Target	N/A: if documentation is external to the platform; Level 0: basic tutorials; Level 1: several supporting measures have been created; Level 2: assessment of the relevance of documentation to developers' needs; Level 3: mixed of several support measures (code examples, forum, etc.) provided in line with developers' needs;
	Questions	What is the documentation you created to support developers? Is the documentation in line with developers' needs?

Field	Developer programmer	
KPI$_2$	Title	Interaction with developers
	Calculation	Existence of mechanism to gather developer feedback such as bug reports, feature requests, questionnaire
	Source	List of mechanisms
	Target	N/A: no interaction is schedule Level 0: mechanisms in place; Level 1: based on developers' feedbacks, mechanisms are not enough efficient Level 2: some developers' requests need to be implemented Level 3: satisfaction of the developers' community
	Questions	What mechanisms do you support to interact with the developers' community? How do you gather and implement feedback from developers (bugs, feature requests...)

Field	Developer programmer	
KPI$_3$	Title	For open source platform, active contribution of developers
	Calculation	Number of contribute developers

	Source	List of contribute developers
	Target	N/A: the platform isn't open source; Level 0: >1 developers; Level 1: a small group of developers is active (1-10) but insufficient to guaranty active contribution in a long term perspective; Level 2: a small group of developers is active (1-10) and sufficient to guaranty active contribution in a long term perspective; Level 3: active contribution from a large and diversified group of developers (>10);
	Question	In case of open source, how can developers actively contribute to the development of the IoT platform?

Field	**Education programme**	
KPI_1	Title	Number of education offers provided
	Calculation	# education modules
	Source	Internet website, list of modules
	Target	N/A: no target Level 0: existence of modules; Level 1: education offer on 1 specific topic Level 2: education offer on >1 specific topics Level 3: comprehensive training curriculum free of charge.
	Questions	Are you providing an education offering? What is you educational offering towards potential adapter?

Field	**Education programme**	
KPI_2	Title	Dissemination activities
	Calculation	Number of dissemination channels
	Source	List of dissemination channels
	Target	N/A: no target Level 0: dissemination trough a dedicated website or via the platform; Level 1: >2 channels used, mainly web-links, referencing, social media; Level 2: >5 channels used, including specific communication in events (round tables, posters, etc.); Level 3: internal and external dissemination on relevant other platforms;

	Question	How do you communicate about the platform? What channels do you use?

Field	Education programme	
KPI3	Title	Dissemination activities
	Calculation	Number of dissemination channels
	Source	List of dissemination channels
	Target	N/A: no target Level 0: dissemination trough a dedicated website or via the platform; Level 1: >2 channels used, mainly web-links, referencing, social media; Level 2: >5 channels used, including specific communication in events (round tables, posters, etc.); Level 3: internal and external dissemination on relevant other platforms;
	Question	How do you communicate about the platform? What channels do you use?

Field	Accessibility programme	
KPI1	Title	Accessibility to impaired people
	Calculation	Number of available to ease the accessibility
	Source	List of available content
	Target	N/A: no accessibility programme; Level 0: 10% of the overall content; Level 1: 30% of the overall content; Level 2: 60% of the overall content; Level 3: 100% of the overall content;
	Question	How do you support the accessibility of information about IoT platform ecosystem to impaired people (e.g. blind, deaf etc.)?

Field	Accessibility programme	
KPI2	Title	Localization support for websites and software
	Calculation	Number of languages implemented
	Source	List of language implemented
	Target	N/A: no target

		Level 0: 1 language; Level 1: 2 languages; Level 2: 3-4 languages; Level 3: >= 5 languages;
	Question	Do you provide localisation support of your websites and software for different target markets?

Field	Community engagement	
KPI$_1$	Title	Community engagement strategy towards developers, end-users and customers
	Calculation	A clear strategy has been defined with appropriate engagement channels for end users and developers Behaviour analytics and satisfaction surveys are used to improve the effectiveness of communication
	Source	Internal documents and reports of the consortium/platform managers.
	Target	N/A: no strategy exists; Level 0: report on the strategy; Level 1: self-assessment of the relevance and efficiency of the strategy; Level 2: assessment completed with satisfaction survey towards the community; Level 3: dynamic update of the strategy based on implementation impacts;
	Question	What is your community engagement strategy towards developers, end-users and customers?

Field	Community engagement	
KPI$_2$	Title	Number and nature of community engagement activities
	Calculation	Number and nature of community engagement activities frequency of attendance in each event
	Source	List of events with the attendance list
	Target	N/A: no community engagement activities Level 0: mixed of activities undertaken; Level 1: insufficient impacts of the activities undertaken in comparison with the expectation that require important adjustments of the activities; Level 2: insufficient impacts of some of the activities undertaken in comparison with the expectation that require minor adjustments of the activities;

		Level 3: high level of satisfaction of participants and strong impacts in terms of community engagement;
	Question	Please detail your current community engagement activities - number and nature of events - attendance for each - results and impacts of each (satisfaction, follow up activities, etc.)

Field	**Community engagement**	
KPI$_3$	Title	Engagement community activities with 3rd parties
	Calculation	Number and nature of community engagement activities Frequency of attendance in each event
	Source	list of events with the attendance list
	Target	N/A: no community engagement activities with 3rd parties; Level 0: mixed of activities undertaken; Level 1: insufficient impacts of the activities undertaken in comparison with the expectation that require important adjustments of the activities; Level 2: insufficient impacts of some of the activities undertaken in comparison with the expectation that require minor adjustments of the activities; Level 3: high level of satisfaction of participants and strong impacts in terms of community engagement;
	Question	Please describe the other initiatives or third party events you are involved in: - number and name of initiatives and third parties' events (working group, portals, etc.) - nature of your engagement? (content provided, co-organisation of events etc.) - results and impacts of each?

Dimension: Ecosystem Openness

Field	Value chain positioning	
KPI$_1$	Title	Openness of value chain / network
	Calculation	Low …. high
	Source	Value network analysis
	Target	N/A: does not apply as the entire value-chain is closed to external stakeholders Level 0: no value chain analysis has been performed, no opportunities for competition along the value chain; Level 1: a value chain analysis has been performed with different players having the opportunity to take up different roles in the value chain; Level 2: competition is allowed in most parts the ecosystem; Level 3: competition openly encouraged along the value chain to grow the value and competiveness in the overall ecosystem;
	Question	Please describe what parts of your value-chain are open for competition?

Field	Value chain positioning	
KPI$_2$	Title	Value network participation
	Calculation	Low …. High
	Source	Ecosystem/market analysis
	Target	N/A: there is no value chain or network existing Level 0: outsider: monopoly Level 1: participation of some stakeholders along the value chain exists, although competition is limited Level 2: some parts of the value chain are freely open to competition along the value chain, while other parts are limited Level 3: multiple stakeholders actively participate and compete along the whole value chain and are able to derive value from it
	Questions	Please describe your value chain positioning Where do you allow for competition alongside the value chain and where is it closed? How active is the participation of stakeholders alongside the entire value chain?

Field	Cross-sector awareness and support	
KPI$_1$	Title	Awareness level of surrounding sector ecosystems
	Calculation	Low …. high
	Source	Sector/market strategy document
	Target	N/A: there is no suitable sector/market for such platform ecosystem Level 0: no sector/market strategy exists, no evidence available; Level 1: a sector strategy exists but is narrowly focused on a target sector; Level 2: market positioning is clearly defined, SWOT analysis of performed and includes an understanding of potential other secondary markets/sectors; Level 3: a credible go to market strategy for both primary and secondary sectors is clearly defined based on a realistic understanding of own position in the overall market;
	Questions	Please describe your strategy in terms of sector positioning? How open is your IoT platform for adoption in other sectors?

Field	Cross-sector awareness and support	
KPI$_2$	Title	Adoption readiness
	Calculation	Low …. High
	Source	Technical feature descriptions, market case studies
	Target	N/A: the platform is not intended for external adoption Level 0: no specific supports exists that would simplify the adoption of an IoT platform in other sectors; Level 1: some success stories / case studies exist that show how the IoT platform ecosystem can support secondary sectors however no specific technical support is provided; Level 2: specific tools, features or partnerships are embedded as part of an IoT platform ecosystem that simplify customization of solution to different sectors; Level 3: IoT platform ecosystem provides a rich set of tools, features or partnerships are embedded that make utilization in various sectors seamless;
	Questions	What measures do you provide to customize your IoT platform ecosystem for secondary sectors/markets? Do you have any evidence of how your platform ecosystem has been extended beyond the primary usage context? Do you have partnerships in place that can help you with adoption in other sectors?

Field	**Open source strategy**	
KPI1	Title	Open source readiness
	Calculation	n/a
	Source	Strategy document, open source plan, license choices
	Target	N/A: open sourcing elements is seen as a threat Level 0: the IoT ecosystem does not encourage or utilize open source Level 1: an basic open source strategy exists but the implementation is only nascent Level 2: a comprehensive open source strategy exists that supports well the ecosystem vision. Implementation is consistent with the strategy, including appropriate license choices Level 3: the ecosystem maximizes opportunities created by open source to its full potential.
	Questions	What approach does your IoT platform ecosystem take regarding open source? What aspects of your ecosystem are open source? What open source licenses do you consider? How large and active is the corresponding contributor community?

Field	**Ecosystem openness**	
KPI1	Title	Business model flexibility
	Calculation	number of possible business models
	Source	evidence from market use cases
	Target	N/A: the platform ecosystem does not support any alternative business models for any stakeholder Level 0: the ecosystem provides no business model opportunity for third parties; Level 1: the ecosystem value chain is dominated by the incumbents, providing only limited opportunities for third parties to participate; Level 2: the ecosystem supports multiple business model constellations for selected roles along the value chain; Level 3: the ecosystem supports multiple business model constellations for all roles along the value chain;
	Questions	What types of business models do you support for your IoT platform ecosystem participants?

		Is the whole value chain open for different business models? What are current restrictions?

Dimension: Technology advancement

Field	Technical richness	
KPI$_1$	Title	Feature richness
	Calculation	# value added features adding to the richness of the technology base of the IoT platform ecosystem
	Source	IoT platform description, feature list
	Target	N/A: always applicable Level 0: the IoT platform ecosystem is bare bones and provides no value added features Level 1: the IoT platform ecosystem provides some features beyond basic functionalities that are desirable for other ecosystem participants Level 2: the IoT platform provides various technical features that are desirable by the ecosystem participants and can be seen as clear differentiators compared to alternatives Level 3: the platform providers market-leading technical features and capabilities which are difficult to find in other IoT platform ecosystems
	Question	Please highlight key technological features that your IoT platform ecosystem is able to offer to participating 3rd parties

Field	Technical richness	
KPI$_2$	Title	Perceived usefulness of technical features
	Calculation	# perceived usefulness of features for the targeted ecosystem participants
	Source	End user survey's, feature utilization rates from logs, discussion forums
	Target	N/A: if end user is unable to use, check or perceive the feature available Level 0: none of the technical features are being utilized or perceived useful by the community Level 1: the IoT platforms provides some essential technical features which are utilized by ecosystem participants Level 2: the IoT platforms provides technical features which are often and widely used by ecosystem participants Level 3: the platform provides unique technical features that are frequently used by IoT ecosystem participant to improve overall competiveness of their products
	Questions	How well do these features align with your community/end user needs? How extensively are these features being utilized?

Field	Simplified complexity	
KPI1	Title	Productivity gain
	Calculation	# development time
	Source	Developer survey
	Target	N/A: always applicable Level 0: complex tasks are hard to perform without any support functionality from the IoT platforms Level 1: the IoT platforms provide some support functionalities that simplify the execution of more complex system operations leading to productivity gains for developers Level 2: the IoT platforms have functionalities that make most complex tasks simpler to perform, increasing significantly the productivity of developers Level 3: significant productivity gains have become a key market differentiator of the platform compared to other competitors of the market. This is widely recognized by developers and market analysts.
	Questions	Do you provide tools in your IoT platform ecosystem that simplify more complex tasks for end users? If so what are these? Are these tools unique on the market? Can they be considered a clear differentiator that provide a competitive advantage?

Field	Technical readiness	
KPI1	Title	Technology readiness level
	Calculation	TRL levels from 1…9 (very mature)
	Source	Test reports, Vendor statements, Market comparison
	Target	N/A: always applicable Level 0: (TRL1-2) the technology is in very early stages of development and not yet suitable for use Level 1: (TRL3-4) proof of concept exists that show the feasibility of some of technology Level 2: (TRL5-7) the technology is able to fully demonstrate its usefulness but cannot be fully used in a production system Level 3: (TRL 8-9) the technology is tested and bug free and can be reliably used in a production system
	Question	Please detail the technological readiness level of the underlying technology base of your IoT platform ecosystem

Dimension: Marketplace Mechanism

Field	Monetization Mechanism	
KPI1	Title	Easy support for monetization
	Calculation	# of billing or accounting mechanism developed inside the platform or tool
	Source	List of all operative billing and accounting mechanism developed inside a platform or tool
	Target	N/A: if the platform/tools doesn't imply the existence of a mechanism for billing/accounting Level 0: = 0 (zero), Level 1: = 1 beginning, Level 2: = 2 intermediate phase, Level 3: >2 regular operations.
	Question	How many billing and/or accounting functionalities does the IoT-EPI provide for third parties?

Field	Monetization Mechanism	
KPI1	Title	Monetization Mechanism efficiency (%)
	Calculation	#of case where a billing or accounting mechanism has been used in an application) divided (#of use of the platform or tool in an application) x (100)
	Source	List of all operative billing and accounting mechanism developed inside a platform or tool; list of all the case of application of the platform/tool
	Target	N/A: if the platform/tools doesn't imply the existence of a mechanism for billing/accounting Level 0: <50%, Level 1: >=50% beginning, Level 2: >=65% intermediate phase, Level 3: >80% regular operation.
	Question	What is the ratio of successful application of mechanism for billing and accounting developed in the IoT EPI?

Field	Business Model	
KPI1	Title	Success of business models developed (in%)
	Calculation	(#business model used in real cases) divided (#overall business models developed) x (100)
	Source	List of business models developed; list of real case of application.

	Target	N/A: Always applicable Level 0: <50%, Level 1: >=50% beginning, Level 2: >=65% intermediate phase, Level 3: >80% regular operation.
	Question	What is the ratio of successful application of business model developed in the IoT EPI?

Field	**Business Model**	
KPI$_2$	Title	Number of different business models developed
	Calculation	#overall business models developed
	Source	list of business models developed
	Target	N/A: Always applicable Level 0: =0, Level 1: =1 beginning, Level 2: =2 intermediate phase Level 3: >2 regular operations
	Question	Is the IoT-EPI business model adapt and tested to ensure revenue streams for external stakeholders?

Field	**Legislation, Privacy, Security and Trust**	
KPI$_1$	Title	Regulatory and legal compliance ratio (%)
	Calculation	(#of big aggregated markets compliant in terms of regulatory and legal constraint) divided (5) x (100) {5 = number of aggregated markets: NA+LATAM+EUROPE+IMEA+FE}
	Source	list of big aggregated markets checked as compliant
	Target	N/A: Always applicable Level 0: <40% Level 1: >=40% beginning. Level 2: >=60% intermediate phase, Level 3: >=80% regular operation.
	Question	What is the ratio (%) of global coverage in terms of regulatory and legal compliance?

Dimension: Technology Inclusive

Field	Supported standards	
KPI1	Title	Open wireless standards supported by the IoT systems developed (%).
	Calculation	Fraction between the IoT systems developed supporting open wireless standards, and the all IoT systems developed supporting wireless standards (x100).
	Source	List of all IoT systems developed, and their wireless standard used
	Target	N/A: The IoT platform/tool do not consider open wireless standards Level 0: <= 20% (beginning) Level 1: > 20%, <= 50% Level 2: > 50%, < 80% Level 3: >=80% (regular operation)
	Question	What is the percentage of open wireless standards implemented, respect the total number of wireless standards used in the platform?

Field	Supported standards	
KPI2	Title	IoT Platform security level (wireless communication) (%).
	Calculation	Wireless communication standards in compliance with data regulations data security, divided all wireless communication standards used within the IoT Platform.
	Source	List of wireless standards used, and their security standard/level.
	Target	N/A: The IoT platform/tool do not consider wireless communication to be used (highly unlikely). Level 0: <= 20% (beginning) Level 1: > 20%, <= 50% Level 2: > 50%, < 100% Level 3: = 100% (regular operation)
	Question	What is the percentage of wireless communication standards in compliance with data regulations data security, respect all wireless communication standards used within the IoT platform/tools?

Field	Supported standards	
KPI3	Title	Open source SW supported by the IoT devices and connectivity developed (%).

	Calculation	Fraction between the IoT devices (connectivity) developed supporting open source SW, and all the IoT devices (connectivity) developed supporting SW (x100)**.**
	Source	List of all IoT devices developed, and their SW used.
	Target	N/A: The IoT platform/tool do not consider open source SW. Level 0: <= 20% (beginning) Level 1: > 20%, <= 50% Level 2: > 50%, < 80% Level 3: >=80% (regular operation)
	Question	What is the percentage of IoT devices (connectivity) developed supporting open source SW, respect all the IoT devices (connectivity) developed supporting SW?

Field	**Supported standards**	
KPI4	Title	Open technical standards supported by the IoT platform/tool (%).
	Calculation	Fraction between open technical standards supported by the IoT platform/tool, and all technical standards used (open, proprietary, non-standardized) (x100).
	Source	List of all technical standards implemented.
	Target	N/A: The IoT platform/tool do not consider open technical standards Level 0: <= 20% (beginning) Level 1: > 20%, <= 50% Level 2: > 50%, < 80% Level 3: >= 80% (regular operation)
	Question	What is the percentage of IoT open technical standards supported by the IoT platform/tool, respect all technical standards supported?

Field	**Supported standards**	
KPI5	Title	Open functional/industry standards supported by the IoT platform/tool (%).
	Calculation	Fraction between open functional/industry standards supported by the IoT platform/tool, and all standards used (open, proprietary, non-standardized) (x100).
	Source	List of all functional/industry standards supported by the IoT platform/tool.
	Target	N/A: The IoT platform/tool do not consider functional/industry standards

		Level 0: <= 20% (beginning) Level 1: > 20%, <= 50% Level 2: > 50%, < 80% Level 3: >= 80% (regular operation)
	Question	What is the percentage of open functional/industry standards supported by the IoT platform/tool, respect all standards used (open, proprietary, non-standardized)?

Field	Supported devices	
KPI1	Title	Devices connected and supported by the IoT platform/tool.
	Calculation	Number of devices connected and supported.
	Source	List of all devices connected and supported by the IoT platform/tool.
	Target	N/A: The IoT platform/tool do not consider supporting connected devices (highly unlikely). Level 0: <=5 (beginning) Level 1: > 5, <= 100 Level 2: > 100, < 500 Level 3: >= 500 (regular operation)
	Question	How many connected devices are supported by the IoT platform/tool?

Field	Supported devices	
KPI2	Title	Smartphone (or tablet) user interface supported by the IoT applications developed (%).
	Calculation	Fraction between the IoT applications developed supporting smartphone (or tablet), and all the IoT applications developed (x100).
	Source	List of all IoT applications developed, their user interface used or no user interface.
	Target	N/A: The IoT applications do not consider supporting user interfaces like smartphones (or tablets) Level 0: <= 20% (beginning) Level 1: > 20%, <= 50% Level 2: > 50%, < 80% Level 3: >= 80% (regular operation)
	Question	What is the percentage of user interface implemented which support smartphones (or tablets), respect the total number of IoT applications developed?

Field	Supported devices	
KPI3	Title	Gateway to the Internet supported by the IoT applications developed (%).
	Calculation	Fraction between the IoT applications developed supporting an Internet gateway, and all the IoT applications developed (x100).
	Source	List of all IoT applications developed, and their gateway (if any).
	Target	N/A: The IoT applications do not consider supporting gateways to Internet. Level 0: <= 20% (beginning) Level 1: > 20%, <= 50% Level 2: > 50%, < 80% Level 3: >= 80% (regular operation)
	Question	What is the percentage of IoT applications developed supporting Internet gateway, respect the total number of IoT applications developed?

Field	Interoperability	
KPI1	Title	Multi wireless standards supported by the IoT devices developed.
	Calculation	The number of wireless standards supported by each IoT platform/tool.
	Source	List of all IoT devices developed, and their wireless standard used
	Target	N/A: The IoT platform/tool do not consider supporting any wireless standard (highly unlikely). Level 0: <= 1 (beginning) Level 1: 2 (area focus operation) Level 2: 3 (regular operation) Level 3: >= 4 (advanced operation)
	Question	How many different wireless standards are supported by the IoT platform/tool?

Field	Interoperability	
KPI2	Title	Multi operating system (OS) supported by the IoT platform for interface equipment (e.g. Smartphone, tablet).
	Calculation	The number of OS supported by the IoT platform/tool for interface equipment.

	Source	List of all IoT platforms/tools, and their supported OS (if any).
	Target	N/A: The IoT platform/tool do not consider supporting any OS for interface equipment. Level 0: <= 1 (beginning) Level 1: 2 (area focus operation) Level 2: 3 (regular operation) Level 3: >= 4 (advanced operation)
	Question	How many different OS are supported for interface equipment by the IoT platform/tool?

Field	**Interoperability**	
KPI$_3$	Title	Multi wireless open protocols supported by the IoT platform/tool.
	Calculation	The number of open wireless protocols implemented in the IoT platform/tool.
	Source	List of all open wireless protocols implemented/supported.
	Target	N/A: The IoT platform/tool do not consider implementing/supporting any open wireless standard. Level 0: <= 1 (beginning) Level 1: 2 (area focus operation) Level 2: 3 (regular operation) Level 3: >=4 (advanced operation)
	Question	How many different open wireless protocols are supported by the IoT platform/tool?

Field	**Interoperability**	
KPI$_4$	Title	Level of new functions per IoT platform/tool (Competitiveness).
	Calculation	Number of new functions developed and integrated during the project.
	Source	List of IoT platform functions and date of implementation.
	Target	NA: The IoT platform/tool do not consider developing/implementing any new functions. Level 0: <= 1 (beginning) Level 1: > 1, <= 5 Level 2: > 5, < 10 Level 3: >= 10 (regular operation)

	Question	How many new functions developed and integrated in the IoT platform/tool during the project?

Field	Validation, verification, testing, and certification	
KPI$_1$	Title	IoT Platform dissemination (pilots/use cases).
	Calculation	Number of pilots and/or use cases where the IoT platform/tools is used**.**
	Source	List of all pilots and/or uses cases the IoT platform is used.
	Target	NA: The IoT platform/tool do not consider pilots or use cases, (explain why). Level 0: <= 1 (beginning) Level 1: > 1, <= 2 Level 2: > 3, < 5 Level 3: >= 5 (regular operation)
	Question	How many pilots and/or use cases are ongoing or carried out?

Field	Validation, verification, testing, and certification	
KPI$_2$	Title	Conformity with the essential requirements, hence benefit from free circulation in the European Market (CE marking).
	Calculation	Number of developed products (platforms, systems or devices) CE marked, divided all developed products (platforms, systems or devices) (x100).
	Source	List of all products (platforms, systems or devices) including not certified or certified (i.e. tested according to prevailing standards, Accreditation test laboratory, and date off pass).
	Target	N/A: The developed products do not need CE approval/mark (highly unlikely). Level 0: <= 20 % (beginning) Level 1: > 20%, <= 50 % Level 2: > 50%, < 100% Level 3: = 100% (regular operation)
	Question	What is the percentage of developed products (platforms, systems or devices) which are CE approved, respect all developed products (platforms, systems or devices)?

Field	Validation, verification, testing, and certification	
KPI$_3$	Title	IoT Platform dissemination (users).

	Calculation	Number of IoT platform/application users.
	Source	List of registered users (depersonalized data).
	Target	N/A: The IoT platform/application do not consider registered users (explain why). Level 0: <= 10 (beginning) Level 1: > 10, <= 100 Level 2: > 100, < 1000 Level 3: >= 1000 (regular operation)
	Question	How many registered IoT platform/application users?

Field	Validation, verification, testing, and certification	
KPI4	Title	IoT platform maturity.
	Calculation	Number of devices/nodes per platform/gateway demonstrated.
	Source	List of gateways, and their number of devices/nodes demonstrated
	Target	N/A: The IoT platform do not consider scalability, (explain why) Level 0: <= 5 (beginning) Level 1: > 5, <= 100 Level 2: > 100, < 500 Level 3: >= 500 (regular operation)
	Question	How many connected devices/end-nodes per platform/gateway are demonstrated?

Field	Validation, verification, testing, and certification	
KPI5	Title	IoT platform scalability.
	Calculation	Maturity levels: Level 0: Implementation in development. Level 1: Test implementation. Level 2: Pilot/use cases. Level 3: Implemented, applications running, and certified
	Source	List of all products (platforms, systems or devices) and its maturity level, including not certified or certified (i.e. tested according to prevailing standards, Accreditation test laboratory, and date off pass).
	Target	N/A: Implementation not started (explain why). Level 0: Implementation in development, (specification and requirements phase) Level 1: Successful test implementation carried out

		Level 2: Successful pilot/use cases carried out. Level 3: Successfully implemented, applications running, and certified, (regular operation)
	Question	How will you describe the IoT platform/tools maturity according to the targeted maturity levels?