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## Supporting Internet of Things Activities on Innovation Ecosystems

# H2020 – UNIFY-IoT Project

# Deliverable 01.03

# Activities Fostering Value Co-creation: Interim Report

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| **DoW** | This deliverable is an outcome of task T01.02: Fostering Value Co-creation in IoT Ecosystems. The task receives inputs from task T01.01 and the value co-creation framework that has been presented in deliverable D01.01, and aligns with the analysis performed in WP02, WP03 and WP04 to characterize the different value axes: monetization, adoption, societal awareness and acceptance. The value co-creation framework presented in deliverable D01.01 is incrementally implemented in the task T01.02, in which all IoT technology and application stakeholders are engaged to evaluate how value co-creation works in the IoT field. The methodology presented in this document looks at the relationship between the degree of IoT platforms ecosystems' value co-creation activities and the perception of their innovativeness. The methodology identifies key components of value co-creation based on the framework presented in deliverable D01.01. IoT platforms ecosystems with a higher degree of involvement in co-creation activities are in a better position to develop and highlight the innovative aspects of new products, processes, services, experiences developed in the IoT use cases and applications. | | | | |
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# 1. EXECUTIVE SUMMARY

## 1.1 Publishable summary

Value co-creation in IoT platforms ecosystems is addressing the activities describing how customers, end users, application owners, and developers could be involved as active participants in the design and development of personalized IoT applications, use cases, products, services, and experiences in IoT platforms ecosystems.

The following document provides the methodology and tools to implement the IoT value co-creation framework elaborated in [10] to IoT platforms ecosystems implementing various IoT use cases and applications. The methodology reflects the changes in the IoT value co-creation system based on new IoT business models frameworks [9] that includes focusing on co-creators of value, moving from value chains to value networks, evolving from product value to network value, building new concepts of complex co-opetition, and providing strategy in relation to the entire value IoT ecosystem.

The methodology is framed around three stages: report, act and impact. It covers all pillars that have been presented in the context of the value co-creation framework. The methodology is applied on the IoT European Platforms Initiative (IoT-EPI) projects for evaluating the active participation of stakeholders in the co-creation process. This process is enabled through multiple interaction channels, using means of IoT platforms around which the use cases and applications are built.

This deliverable is structured as follows:

- Section 2 provides a general introduction to the document including the purpose of the deliverable and the relation to other activities in the project.
- Section 3 provides a methodology to implement and evaluate co-creation, taking into account the three stages: report, act and impact.
- Section 4 provides a detailed elaboration of KPIs, covering all four pillars of the value co-creation framework ("Why", "What", "Where" and "How") and providing a deeper overview from the "Why" value axis: monetization, adoption and societal awareness and acceptance issues.

Finally, section 5 contains a summary of the final remarks and conclusions, while section 6 gives the list of references, and section 7 gathers the relevant appendices to this document, including self-assessment questionnaire that enables the reader to use the methodology and the KPIs in his own project.

## 1.2 Non-publishable information

None, the document dissemination level is public.

# 2. INTRODUCTION

## 2.1 Purpose and target group

The main purpose of this deliverable is to present an overview of the activities to foster value co-creation, based on the value co-creation framework defined within the scope of the WP01 of the UNIFY-IoT project. Value co-creation aims to facilitate the mutual generation of value through the development of joint products and services using the IoT platforms stemming from IoT-EPI projects. The target group of the value co-creation activities are mainly the IoT-EPI projects, but include also other relevant stakeholders associated to the IoT ecosystem and value network. The described framework can be generalized to be implemented in other technological contexts.

## 2.2 Contributions of partners

**SISAX-M** coordinated the task activities and consequently took care of organisation of meetings, and virtual communication.

**SINTEF** contributed to the notion of knowledge co-creation in IoT ecosystems, with focus on the involvement of IoT technology developers and end-users in the process of co-creation of knowledge, value and innovation within an IoT ecosystem. The work provides the basis for a conceptual framework for understanding and analysing the knowledge, cooperation and business-based processes in IoT ecosystems and how these can be leveraged to foster innovation.

**DIGICAT** ensured full engagement with the WP03 outputs on adoption of IoT platforms.

**INNO** provided information related to the open-platform.eu portal, and worked specifically on connections with other platforms documenting project outputs to ensure interoperability of the portal with other initiatives.

**ISMB** contributed to the overall implementation and evaluation of the value co-creation mechanisms defined in Task 01.01 with special attention to the networking activities engaging the projects' stakeholders. ISMB provided support in the engagement of the Task Forces, and the organization of the workshops.

**HIT** supported the engagement of stakeholders with special attention towards the EIT ICT Labs KIC partners and towards SMEs

**CEA** contributed to the dissemination and networking in the IoT domain related to smart cities.

## 2.3 Relations to other activities in the project

The activities fostering value co-creation presented in this interim report are closely related to the parallel activities being carried out in all other WPs of the UNIFY-IoT project. WP02, WP03 and WP04 provided relevant inputs concerning the three value axes (i.e., monetization, adoption and societal awareness and acceptance) to ensure the alignment with these dimensions; while WP06 provides the basis for understanding and analysing the knowledge, cooperation and business-based processes in IoT ecosystems and how these can be leveraged to foster innovation. Furthermore, activities related to this deliverable take into consideration the results from the IoT-EPI Task Forces to guarantee the alignment of the proposed activities with the ongoing activities and developments made by all IoT-EPI projects.

# 3. METHODOLOGY TO EVALUATE VALUE CO-CREATION

Value co-creation is key enabler for involving a variety of heterogeneous yet complementary IoT stakeholders (from large-scale companies to SMEs, passing through end users, governmental bodies and NGOs) into the open innovation ecosystems. This principle materializes in the uptake of integrated IoT offerings harnessing a common technological infrastructure (e.g., IT building blocks made available by enabling platforms such as FI-WARE) and a set of capabilities and resources provided by several actors (e.g. tangible and intangible assets that are part of RIA's foreground). Afore-mentioned solutions answer market needs (e.g. requirements of project's users and customers) and/or societal challenges (e.g., environmental and social priorities at the core of the EU policy agenda) while democratizing the access to IoT-related know-how (e.g. through Open Education Platforms).

The initial focus of WP01 activities was on exploring, codifying and communicating possible co-creation approaches and tools fitting with needs of projects belonging to the IoT-EPI ecosystem and have been extensively documented in [10]. The subsequent activities are addressing the evaluation of the extent to which co-creation practices have been experimented by RIAs and on the appraisal of results achieved.

To connect the various phases composing the UNIFY-IoT co-creation journey, the consortium has adopted as integral part of WP01 a three-pronged approach, which has been suggested by the evaluation team during the first review meeting:

1. Report, which has been successfully completed with the release of [10].
2. Act, which is meant to put in action the valuable contents of step 1 within the RIA cluster.
3. Impact, which has the mission of measuring the effects of step 2 through the definition of KPIs.

With the purpose to operationalize such a modus operandi within the scope of WP01, the present chapter is framed around these three stages. These are examined respectively in section 3.1 (report), 3.2 (act) and 3.3 (impact).

## 3.1 The *report* phase

The period ranging from M1 to M9 was specifically focused on the 'report' phase. Given the role of interim report assigned to the present deliverable, this section takes stock of achievements as well as underlying strategies that are peculiar to UNIFY-IoT's approach to value co-creation. By doing so, it recaps which resources are now available for experimentations conducted by IoT-EPI RIAs ('act' phase) and highlights the dimensions that are of paramount importance when it comes to KPI construction ('impact' phase).

### 3.1.1 The notion of value co-creation in UNIFY-IoT

As presented in [10], UNIFY-IoT defines the value co-creation tenet by referring to a constellation of actors working together on mutually agreed joint developments taking place into the European IoT ecosystem. The open innovation paradigm that is fostered by the IoT-EPI initiative could thus take place in different forms, such as – inter alia – jointly developed technical solutions (e.g. common APIs), pilot partnerships, alliances in exploitation actions, synergies in platform community building, joint educational initiatives.

It has to be noted that value co-creation in IoT-EPI may occur both within RIAs and among RIAs, where common opportunities (and challenges) are identified. Moreover, value co-creation

in IoT-EPI is not limited to the boundaries of the RIA ecosystem, but rather co-creation practices can leverage outcomes of previous/running IoT projects (e.g. FP7, H2020, EIT) as well as assets and know-how brought in by external players (e.g. end users, communities of practice).

Drawing on such foundations, the IoT-EPI value co-creation landscape (for which the reader is referred to D01.01) is summarized in Figure 1.

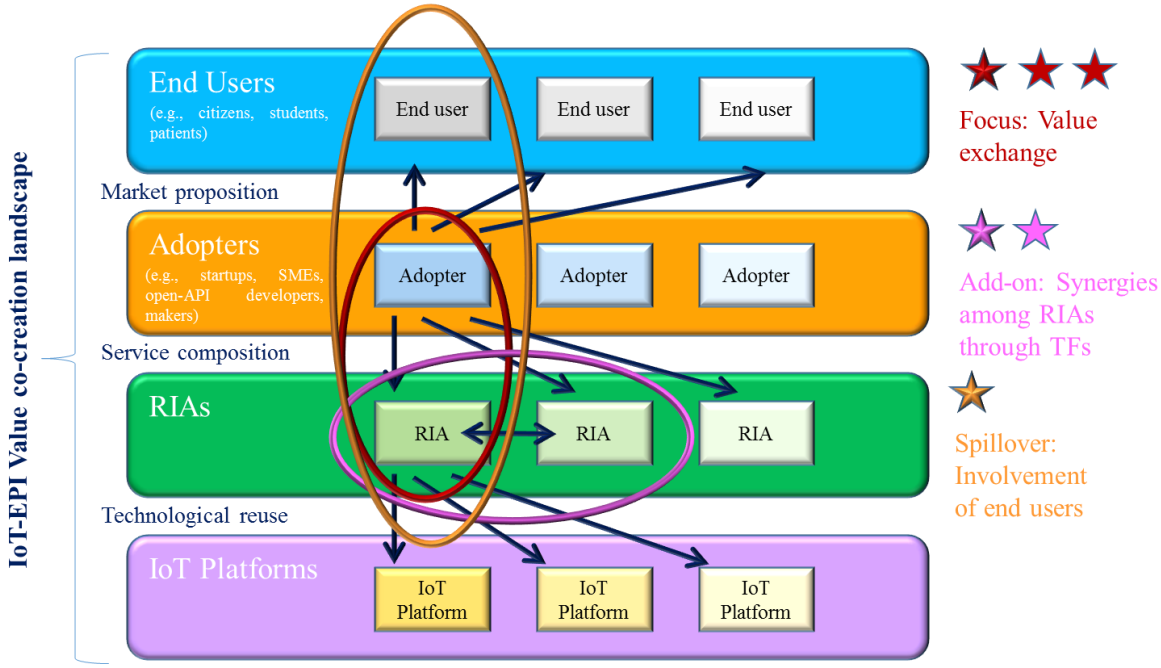


**Figure 1. IoT-EPI value co-creation landscape**

In such an ecosystem, as part of the 'report' phase, three key dimensions of value co-creation have been devised and prioritized according to UNIFY-IoT DoA and IoT-EPI agenda:

- Value exchange, which captures IoT ecosystems and adopters working together to design, test and validate demand-driven solutions and features that RIAs are unveiling.
- Synergies among IoT ecosystems through TFs, which consider horizontal cooperation for sharing assets and core competencies, valorise technological complementarities and pursue joint exploitation roadmaps.
- Involvement of end users, which resembles the original notion of customer co-creation [12] by witnessing the emergence of empowered users seeking greater input and control over product development activity.

Furthermore, a fourth dimension to be considered has to do with co-creation actions within RIA consortia, which are in place on a daily basis to ensure the achievement of complex projects results stemming from a set of partners combining assets and competencies in a deeply intertwined way. From this standpoint, each ecosystem could be seen as a major joint development or, alternatively, as a coalescence of various interlocked joint developments orchestrated at consortium-level.

### 3.1.2 The value co-creation framework in a nutshell

The 'report' phase focused on the co-creation framework with the aim of supporting IoT-EPI stakeholders and IoT professionals at large in the co-design of IoT joint developments involving a variety of actors that are interacting into an open innovation ecosystem. While the reader is referred to [10] for a detailed explanation, Figure 2 pinpoints the outline of the framework made available to RIAs.

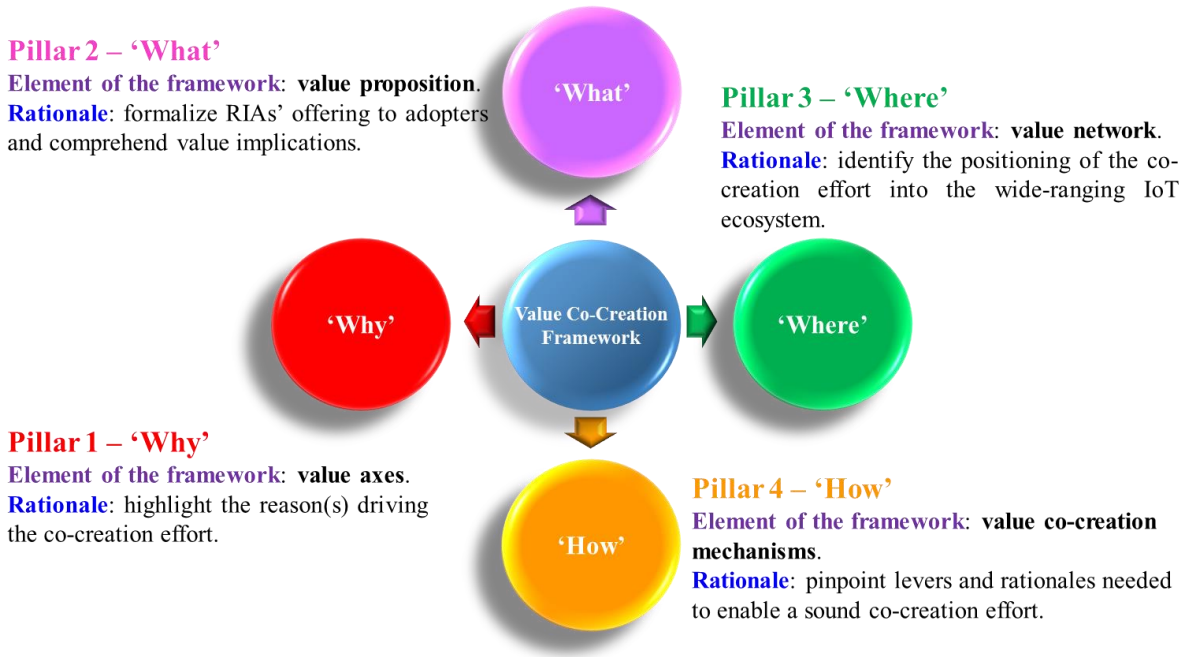


**Figure 2. Value co-creation framework**

Pillar 1 (Why) – Value axis

Acknowledging that in absence of a purpose, cause, or belief that motivates the effort, actors do not have a driver for undertaking any action, the first pillar has to do with motivations fuelling the co-creation effort, i.e., the forces acting as 'engine' of multi-actor joint endeavours in the IoT ecosystem. In doing so, the framework draws on the triangulation among UNIFY-IoT value axes: monetization [9], adoption [11], societal awareness and acceptance [13]. Along these lines, each of the axes has been characterized by means of a taxonomy presented in [10]:

- Monetization has been associated to value capture goals (premium, freemium, free).
- Adoption has been modelled through targeted market share (innovators, early adopters, early majority, late majority, laggards) [14].
- Societal awareness and acceptance has been framed around the overcoming of five main barriers related to trust, regulation and legislation, skills and competencies, market, and interoperability.

Pillar 2 (What) – Value proposition

The second pillar intends to formalize 'what' each joint development offers to target segments (i.e., 'adopters' in the UNIFY-IoT jargon) with the purpose of creating value along the dimensions outlined in pillar 1. The value proposition offered by each joint development is decoupled in two elements: the technological value proposition and the facilitation and supporting measures. The first pillar addresses the technological features (e.g., open APIs, software components ready to be installed on-premises, fit-for-purpose services, mobile applications, Web applications, platforms or systems, etc.) as part of the core sustainability strategy for the IoT ecosystems. The second pillar addresses actions put in place during the lifetime of the projects in order to foster community establishment and to accelerate the uptake of the technological solutions (e.g., coaching and mentoring, business incubation/acceleration, networking and brokerage, tutorials and user manuals, provision of computing infrastructure as a service, hackathons). The resulting two-fold value proposition is offered to target segments of adopters, such as start-ups, SMEs, large enterprises, makers, universities and research bodies, students, NGOs, public sector bodies, etc.

Pillar 3 (Where) – Value network

The purpose of the third pillar is to contextualize the offering outlined in pillar 2 into the wide-ranging IoT ecosystem, while recognizing that the notion of value network has gradually gained recognition in the IoT area. It takes into account the coexistence of several interacting value chains and the presence of platforms fostering vertical, horizontal or functional integration.

Pillar 4 (How) – Mechanisms for value co-creation

The forth pillars examines the key decisions that involved RIAs have to consider, while building the joint developments. Recognizing that such choices shape the value configuration and the organizational model of RIAs as well as their prominent touchpoints with other actors situated in the IoT ecosystem, the mechanism of value co-creation could be related both to technological and strategic choices. Examples of the former are adoption of open standard, open data licenses, open source licenses, use of platforms to distribute project code, use of third-party's catalogues/marketplaces to distribute project results, interoperability with other IoT-EPI projects. Examples of the latter are external access to the platform, network leadership in collaboration, recourse to co-creation catalysers, liaisons with educational/research bodies, use of MOOC platforms to disseminate educational materials, involvement in the policy-related debate.

The combination of the four afore-mentioned pillars resulted in a toolkit that can be used by RIAs and IoT stakeholders at large for rapid prototyping joint developments based on value co-creation principles. The toolkit is made up in the form of four instruments which have been analysed, selected, documented and experimented in the 'report' phase (between M1 and M9):

- [Why] Taxonomy diagram with checkboxes for selecting co-creation motivations.
- [What] Value Proposition Canvas [15] with predefined template for both customer profile (e.g., IoT target segments of adopters) and value map (e.g. IoT technological value proposition, IoT facilitation and supporting measures).
- [Where] Portfolio of value network mapping techniques (e.g. e3-value [16], VNA [17], Board of Innovation [18]) and related on-line or off-line tools.
- [How] Checklist of value co-creation mechanisms with a predefined checkbox for options associated to each mechanism.

### 3.1.3 Focus on user, social and societal awareness

This report extends the UNIFY-IoT values access discussed in D01.01 with further details on societal awareness and user acceptance. This additional characterization provides a better disambiguation of the terminology and allows a finer differentiation of the nuances of awareness that could emerge in the IoT realm.

On high level, it seems apparent that the next generation Internet will promote the harmonious interaction between human, societies, and smart things [19]. This will determine an evolution from the things-oriented perspective to the social side of IoT based on three types of sensing awareness:

- User awareness
- Social awareness
- Societal impact

**User awareness** refers to the ability to understand the context and behavioural patterns related to application domains in personal Internet of Things, since IoT technologies and IoT applications have become increasingly distributed and their elements work in everyday life and personal aspects of the users. Some domain examples of this category are human location, human activity, and daily routine patterns (e.g. home, healthcare, fitness, smart cars, social networking and so on). User awareness not only defines what a user can or cannot do, but also incorporates advising

to increase awareness of the benefits and risks that may affect them individually. This can be supported by a systematic delivery of awareness programmes and training [20].

**Social awareness** refers to group and community levels and goes beyond personal contexts. Social awareness reveals the patterns of social interactions detected by IoT technologies and applications (e.g., group detection, friendship prediction, situation reasoning), human mobility, etc. also thanks to their interaction with the social networking layer. In fact, according to the article *From "Smart Objects" to "Social Objects"; The Next Evolutionary Step of the Internet of Things" [21]*, it is possible to identify three stages of social involvement of the objects composing the Internet of Things:

- In the first stage, objects can post information about their state in the social networks of humans.
- In the second stage, objects can interact at the application layer in social networks with humans and other objects.
- At the third stage, objects socially interact with each other to build a communication network.

In the scientific arena there have been, and still are, extensive discussions on what an object really has to say to another object for which you really need an IoT and how these 'conversations' among objects may promote the development of human society.

**Societal impact** of IoT technologies and applications gives the ability to understand the evaluation of the impacts of this technology on society at large [22]. In order to understand the IoT impact it is important to evaluate the capacity of IoT applications to:

- **Drive organizational and institutional innovation** linked to the transformation of the amount & flow of information
- **Automate and prescribe** activities, for example by allocating a function to a system or by supervising the fulfilment of an activity.
- **Transform** or suggest activities, for example by redesigning a process removing human intervention in order to increase reliability (but which also increase the potential for societal vulnerability)

### 3.1.4 Engagement with RIAs in the report phase

The gathered inputs and feedback from RIAs has represented as integral part of the 'report' phase. This process has been realised by two prominent 'touchpoints', namely the co-creation questionnaire and the co-creation workshop, which are juxtaposed in Table 1.

**Table 1. Input collection from RIAs**

| | Questionnaire | Workshop |
|---|---|---|
| Main aim | Know IoT ecosystems better and understand their needs | Get a grasp of the ease/difficulty encountered by projects in the usage of the co-creation framework |
| Timing | Prior to framework development | Validation stage of the framework development |
| Channel | Web (CAWI powered by UNIFY-IoT) | Physical (IoT-EPI Common Workshop held in Valencia) |
| Outcome obtained | Rich and fine-grained picture (albeit preliminary) of IoT ecosystems value proposition and interpretation of value co-creation | Feedback on the framework + initial collection of joint developments resulting from co-creation efforts across RIAs |

As captured in the table above, the co-creation questionnaire has been the prominent tool to gather inputs prior to framework development and, more generally, to mitigate the inherent

information asymmetry existing between CSAs and RIAs. The wide-spectrum questionnaire aimed to set solid foundations for the value co-creation framework investigated key aspects such as value propositions offered by IoT-EPI projects, stakeholders targeted as customers/users and co-creation practices already in place or planned within the project lifecycle. Results coming from respondents are presented in [10].

The value co-creation framework development – described in [10] – is characterized by two distinctive traits, which highlight analogies between the methodological approach adopted for conceiving the value co-creation framework and the approach expected in its use:

- **Co-creation approach**. The co-creation framework has been itself a result of co-creation practices that called upon numerous stakeholders during in the 'report' phase situated in the IoT-EPI galaxy. The reader may notice a gradual expansion in the spectrum of stakeholders involved in the co-creation process, selected on the basis of their capacity to offer diversified perspectives and competencies in the pursuit of a unique objective.
- **Iterative approach**. As any IoT co-creation joint development is built iteratively by means of build-measure-learn cycles, even the co-creation framework has undertaken a similar development. It is important to note that customer feedback during product development has been integral to the lean start-up process [23] and ensures that the producer does not invest time designing features or services that consumers do not want. The continuous feedback comes from contributors, testers and observers (internal and external).

As a consequence, the combined effort in framework design and the iterative process largely inspired by design thinking [24] and lean approach [25] pointed out a key role played by end users in the 'report' phase. In fact, while the generative action was residing within the boundaries of UNIFY-IoT consortium, RIA teams have been involved in experimentation with the framework and some of its components. This was supported by coaching provided by UNIFY-IoT partners (e.g., see D01.01 for the report of the IoT-EPI Common Workshop held in Valencia) as well as in the validation of the toolkit provided (e.g., teamwork activity and subsequent debate in Valencia, conversations and feedback after the workshop). Moreover, an additional round of external validation took place on the occasion of the review meeting in Vienna, when the evaluation team provided feedback and guidance for the months to come.

### 3.1.5 Outcomes of the report phase

The main results in the 'report' phase could be summarized as follows:

- Clear mapping of the IoT-EPI value co-creation landscape
- Portrays of IoT-EPI RIAs via the co-creation questionnaire
- Release of the value co-creation framework
- Fieldwork trials with the value co-creation framework and its components (e.g. IoT-EPI Common Workshop held in Valencia) as well as with other co-creation practices (e.g. RIA collaboration workshop co-located with IoT-EPI Meet & Review in Vienna)
- Alignment with IoT-EPI task forces (e.g. convergence with the TF on business models in terms of tools for rapid prototyping)

The completion of the 'report' phase and the attainment of such outcomes triggered priorities for the 'act' phase:

- Intensify the engagement with RIAs
- Expand the scale of experimentation for the value co-creation framework
- Support RIAs in cultivating follow-ups of joint developments

Building on outcomes obtained hitherto, further priorities come to light apropos of the 'impact' phase (as part of T01.02):

- Define a portfolio of KPIs meant to appropriately capture the impact ushered-in by value co-creation practices along the three value axes (i.e., monetization, adoption, societal awareness and acceptance)
- Customize the KPIs to reflect peculiarities exhibited by specific use cases or specific stakeholders that are deemed of relevance for RIAs
- Demonstrate achievements on the occasion of M21 IoT-EPI Common Workshop.

## 3.2 The *act* phase

As the activities of UNIFY-IoT are fully in line with the requirements towards the RIAs with regard to the exploitation of their results, engagement by the RIAs is considered to be intrinsically motivated. However, due to the fact that the tasks might prioritised differently as exploitation activities are rather at the end of the respective projects, special engagement opportunities had to be created.

This refers first and foremost to specific workshops organized in cooperation with BE-IoT. These workshops offer great opportunities to create concrete touch points with the RIAs and to ensure a good transfer of knowledge between the RIAs and between UNIFY-IoT and the RIAs.

## 3.3 The *impact* phase

T01.02 intends to build on the knowledge generated, validated and disseminated (‘report’ phase) as well as on the hands-on experimentation with co-creation practices conducted by RIAs (‘act’ phase) to measure, document and evaluate the impact determined by value co-creation as innovation catalyser in the IoT-EPI ecosystem. Such a process is part of the activities planned by UNIFY-IoT consortium to foster value co-creation.

KPI construction hinges on value axes and co-creation mechanisms documented in D01.01 with the intent to roll-out a systematic measurement of impacts created by value co-creation practices in view of multiple value nuances that are common to all IoT solutions provided by IoT-EPI RIAs. Moreover, besides a core of ‘horizontal’ KPIs, there is a need to customize some of the KPI portfolio to reflect peculiarities exhibited by specific application domains and/or specific stakeholders that are deemed of relevance for RIAs. The extended portfolio of KPIs, coupled with the underlying rationale, is presented in section 4.

The collection of up-to-date co-creation impacts will be performed in coming months by means of questionnaires shared with the RIAs, which will be supplemented by some to highlight success stories of value co-creation to be reported in D01.02. As far as the survey is concerned, section 7 contains the outline of the questionnaire.

# 4. VALUE CO-CREATION KPI

To operationalize the appraisal of value co-creation KPIs lying at the core of the 'impact' phase, the UNIFY-IoT consortium considers as key dimensions the three value axes (i.e. monetization, adoption, societal awareness and acceptance), as reported by Figure 3. In a hierarchical perspective, a number of fields (called 'areas') are associated to each value axis, while each area groups one or more measurable metrics (i.e. KPIs).

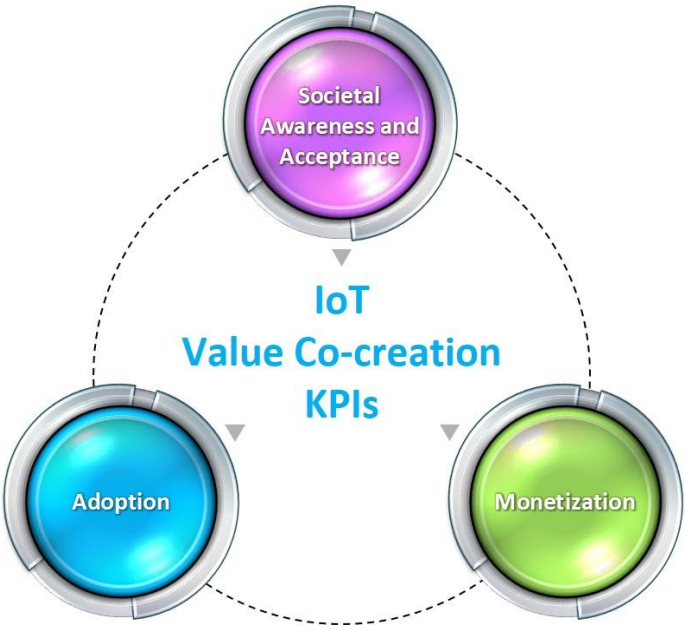


**Figure 3. KPIs generation through value axes analysis**

The resulting portfolio of value co-creation KPIs has been conceived and developed to ensure continuity with [10] by drawing on the value co-creation framework already available. In fact, KPIs selected to document results obtained by RIAs touch upon all the various co-creation nuances ushered-in by the four pillars of value co-creation framework:

- Pillar 1 (Why) – Value axes, which refer to motivations driving a joint undertaking;
- Pillar 2 (What) – Value proposition, which has to do with the fit-for-purpose offerings resulting from a joint undertaking;
- Pillar 3 (Where) – Value network, which pertains to the engagement with other IoT stakeholders as part of a joint undertaking;
- Pillar 4 (How) – Mechanisms for value co-creation, which examine the co-creation practices that RIAs may want to harness while building a joint development.

While considering all value co-creation dimensions, the process of KPI generation has been framed around the three value axes (i.e. monetization, adoption, and societal awareness and acceptance). They represent the key areas on which RIA consortia intend to materialize impacts in terms of appropriation of value from commercial endeavours (i.e. monetization), diffusion and democratization of IoT technologies (i.e. adoption), and clearing societal hurdles related to trust, regulation and legislation, skills and competencies, market, and interoperability (i.e. societal awareness and acceptance).

To make the reader acquainted with such a process, Table 2 works as incidence matrix mapping the correspondence among KPI areas (each of them related to a value axis) and the pillars of the

value co-creation framework. As a matrix that shows the relationship between two classes of objects, Table 2, illustrates by means of a three-value ordinal scale (i.e., H stands for 'high', M for 'medium', and L for 'low') the extent to which a given KPI area reflects a specific pillar of the value co-creation framework.

An example could be provided with reference to areas defined in Table 2. Considering the KPI area related to partner ecosystem, this exhibits the following:

- a medium connection with value axes (as the presence of partner ecosystem has an influence on adoption and monetization but, taken alone, it does not have a game-changing role)
- a medium connection with value proposition (as the presence of partner ecosystem can result in improved and more interoperable products and services)
- a high connection with the value ecosystem (since the partner ecosystem inherently consists of relationships with other stakeholders)
- a high connection with mechanisms for value co-creation (given that the bulk of value co-creation mechanisms have to do with engaging external actors into an open innovation environment).

A similar approach is beneficial for the reader in a two-fold perspective: looking at rows, Table 2 allows to single out the specificities of each KPI area while, looking at columns, the table helps to identify where to look in coming sections for KPIs to appraise RIA performance along a specific co-creation dimension (i.e. pillar).

**Table 2. Mapping among framework pillars and value axes**

| Value Axes/Areas | Where? Value network | How? Value Co-Creation Mechanism | Why? Value Axes | What? Value Proposition | Description of relevant area for KPIs |
|---|---|---|---|---|---|
| **MONETIZATION** | | | | | |
| Value-added service | L | M | M | H | Value added services that are provided by the platform allowing the stakeholders to use their involvement in the value networks. |
| Subscription model | H | L | M | H | Attractiveness to subscribers. The length of the service period and contract, connectivity charges, peak or seasonal usage and the primary units of measurement. |
| Real-time data access | M | L | M | L | Intensity and speed of interactions. The ability to capture, store, aggregate, correlate and filter data from different internal and external sources in both batch and real-time and using edge computing technologies. |
| Apps | M | M | M | H | Attractiveness to users. Security, compliance and complexity elements |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | addressed. Addressing cross industrial sectors applications. |
| Multi-level support | M | M | H | L | Scope of product. Multi-level support used of different XaaS (platform, infrastructure, software, thing, etc.) solutions for implementations. |
| Universal connectivity | H | L | M | L | Diversity of standards supported by the platform. Heterogeneity of connected devices. |
| Ability to analyse and predict | M | M | H | H | Level of analysis and prediction (owner vs. user), time range of prediction, reliability in relation of time, time range of prediction. |
| Multi-level management | L | M | M | H | The management at different layers of the IoT architecture and the granularity of platform management. |
| End-to-End features | M | M | H | H | IoT platforms offering end-to-end (E2E) features that are integrated into the platforms and manage the services over all IoT architecture layers (i.e. security, encryption, authentication, payments, etc.) |
| Platforms, products, services, experiences | H | H | M | M | Linking the monetization approach to how the IoT platforms ecosystems create new value for the value networks stakeholders. |
| Adaptability, flexibility | L | H | M | M | Flexible and configurable access and authorization control, designed for networking and data agnosticism. |
| Stakeholder involvement | H | H | H | M | Involvement of the stakeholders in the development of the IoT platforms and applications that affect the decisions and influence the implementation of these decisions. |
| **ADOPTION** | | | | | |
| Interoperability | H | H | M | M | Capability of IoT platforms to communicate with each other using specific protocols and data formats (technical interoperability) as well as |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | to understand the meaning of the exchanged information (informational interoperability). This is achieved through the adoption of open standards. |
| Standardisation | M | H | M | L | Linking the adoption aspect to the current heterogeneous IoT landscape in terms of compliance with relevant standards and generation of initiatives to further support the ongoing IoT related standardization endeavour. |
| Core capabilities | H | H | L | M | Offering of functionalities and methodologies to enable plug and play usage of IoT platforms also supporting open API and access to existing ecosystems of IoT devices. |
| Partner ecosystem | H | H | M | M | Capabilities and initiatives aiming to exploit an ecosystem of partners and promote the adoption the platforms within and across verticals domains. |
| Security and privacy | M | M | H | H | Support for security and privacy protection within and across IoT platforms, thus addressing two of the main concerns hindering wider adoption of IoT. |
| Dependability | L | L | M | M | IoT platforms offering features to ensure system availability, management of failures as well as robustness to crisis and disturbances in operating conditions. |
| Trustworthiness | M | M | H | H | IoT platforms deserving the trust of other entities based on current/past actual and expected behaviour, reputation, availability and reliability of exchanged data. |

| | | | | | |
|---|---|---|---|---|---|
| Design and development participation | H | H | M | L | Engagement of the most relevant communities of users in the design and development activities of IoT platforms and new applications, taking into consideration functional, interoperability as well as reliability aspects. |
| Adopters level of control | H | H | M | L | Availability of features, methodologies and tools for adopters allowing them to adjust and customize IoT platforms functionalities and behaviour. |
| **SOCIETAL AWARENESS AND ACCEPTANCE** | | | | | |
| Content provision | H | L | L | M | OEP Registrations<br>OEP Content providers<br>OEP Content provided |
| Content usage | L | M | L | H | OEP users' typology<br>Match-making area queries<br>Average rating<br>Match-making area results |
| End users consideration | M | M | L | H | Requests made on the OEP regarding privacy, protection of data and trust<br>OEP Content related to privacy, protection of data and trust<br>OEP Content typology related to privacy, protection of data and trust |

KPIs under each area should comply with the SMART criteria [26]:

- Specific (i.e., target a specific area for improvement)
- Measurable (i.e., quantify the indicator of progress)
- Achievable (i.e., consider results that can be realistically achieved, given available resources)
- Relevant (i.e., identify results that are pertinent to economic, social or environmental goals)
- Time-bound (i.e., specify when the results can be achieved)

KPIs obtained could be classified taking into account the 'logic chain' tenet, which is considered a key reference in seminal impact assessment studies published both by the European Commission [27] and other international organizations (e.g., OECD [28] and the World Bank [29]).

Drawing on state of the art impact assessment practices and techniques, the adaptation of the principle of the chain of effects could result in:

- **Readiness KPIs**, which measure contextual factors enabling the implementation of value co-creation mechanisms in the IoT-EPI ecosystem.
- **Usage KPIs**, which measure the uptake of value co-creation mechanisms in the IoT-EPI ecosystem.
- **Result KPIs**, which measure the tangible outcomes generated by RIAs as a consequence of the usage of co-creation mechanisms in the IoT-EPI ecosystem.

Examples based on such a classification and on the SMART criteria are manifold. Framed along the three value axes they can be described as follows:

- **Monetization**
  - Percentage of partners in RIA teams acquainted with lean start-up and design thinking mind set (readiness KPI)
  - Number of co-created business models prototyped by means of Value Proposition Canvas and Business Model Canvas (usage KPI)
  - Number of co-created business models turned into new business lines implemented by RIAs' business partners by the end of the project (result KPI).
- **Adoption**
  - Number of code lines available in Github for hackathons (readiness KPI)
  - Number of developers engaged in hackathons (usage KPI)
  - Number of software components collaboratively developed during hackathons, which have been turned into features of commercial IoT-related products (result KPI).
- **Societal awareness and acceptance**
  - Number of external users subscribed to OEPs powered by RIAs (readiness KPI)
  - Number of educational contents related to privacy, trust and protection of data which have been uploaded by RIA partners on OEPs (usage KPI)
  - Number of leading European universities adopting OEPs as official educational source for IoT-related academic courses (result KPI).

Drawing on afore-mentioned methodological underpinnings, sections situated in the present chapter illustrate mechanisms and KPIs for each of the UNIFY-IoT value axes, respectively monetization (section 4.1), adoption (section 4.2), and societal awareness and acceptance (section 4.3).

Section 4.4 deals with the adaptation of the KPI framework to specific application domains and/or specific stakeholders with the purpose to address emerging priorities exhibited by RIA consortia.

## 4.1 Monetization

Monetizing in the hyper-connected society is not limited to physical product and services. Other revenue streams are possible after the initial product sale, including value-added services, product experience, subscriptions, and apps, which in the new digital economy can exceed the initial purchase price.

As clarified in D02.01, IoT ecosystems offer composite solutions comprising of large heterogeneous systems of systems beyond an IoT platform and solve important technical challenges in the different industrial verticals and across verticals.

When it comes to monetization, a new approach is required to create (i.e. perform activities that increase the value of a company's offering and encourage customer willingness to pay) and capture (i.e., appropriate customer value, turning into revenue) value [30] in the IoT ecosystems (Figure 4).

As pointed out in D02.01, making money in the connected space is not limited to physical product sales: other revenue streams become possible after the initial product sale, including value-added services, subscriptions, and apps, which can easily exceed the initial purchase price.

Figure 4 describes how value can be created in the context of IoT ecosystem and the actual transition from (virtual) value into money has to be done by the application of a respective business model.

While several known business models from the software industry can be applied (e.g., freemium models), complete new models also arise by the combination of hardware and software aspects, such as the sensor-as-as-service model. In D02.01 this aspect has been elaborated in detail.

**THE INTERNET OF THINGS REQUIRES A MINDSET SHIFT**
Because you'll create and capture value differently.

| | | TRADITIONAL PRODUCT MINDSET | INTERNET OF THINGS MINDSET |
|---|---|---|---|
| VALUE CREATION | Customer needs | Solve for existing needs and lifestyle in a reactive manner | Address real-time and emergent needs in a predictive manner |
| | Offering | Stand alone product that becomes obsolete over time | Product refreshes through over-the-air updates and has synergy value |
| | Role of data | Single point data is used for future product requirements | Information convergence creates the experience for current products and enables services |
| VALUE CAPTURE | Path to profit | Sell the next product or device | Enable recurring revenue |
| | Control points | Potentially includes commodity advantages, IP ownership, & brand | Adds personalization and context; network effects between products |
| | Capability development | Leverage core competencies, existing resources & processes | Understand how other ecosystem partners make money |

**SOURCE** SMART DESIGN HBR.ORG

**Figure 4. IoT mind-set shift (source Smart Design)**

Qualitative indicators should be augmented with quantitative ones, in order to obtain a fair success/failure metric and an objective way to quantify the results.

When defining KPIs for the monetization related to the results of the co-creation processes, i.e. the (commercial) exploitation of use cases and resulting business cases, the schedule of the respective activities and consequently the ability to collect respective indicators is a significant challenge.

To overcome this challenge, two sets of indicators have been defined. The leading indicators that can be measured already during the implementation phase of the RIAs, and the lagging indicators expected to be measured after the implementation period of the RIAs.

IoT business models are identifying the target customer, the value proposition towards the customer, the value chain behind the creation of this value, and the revenue model that captures the value.

In this context, a number of possible areas have been identified for monetization as presented in Figure 5:

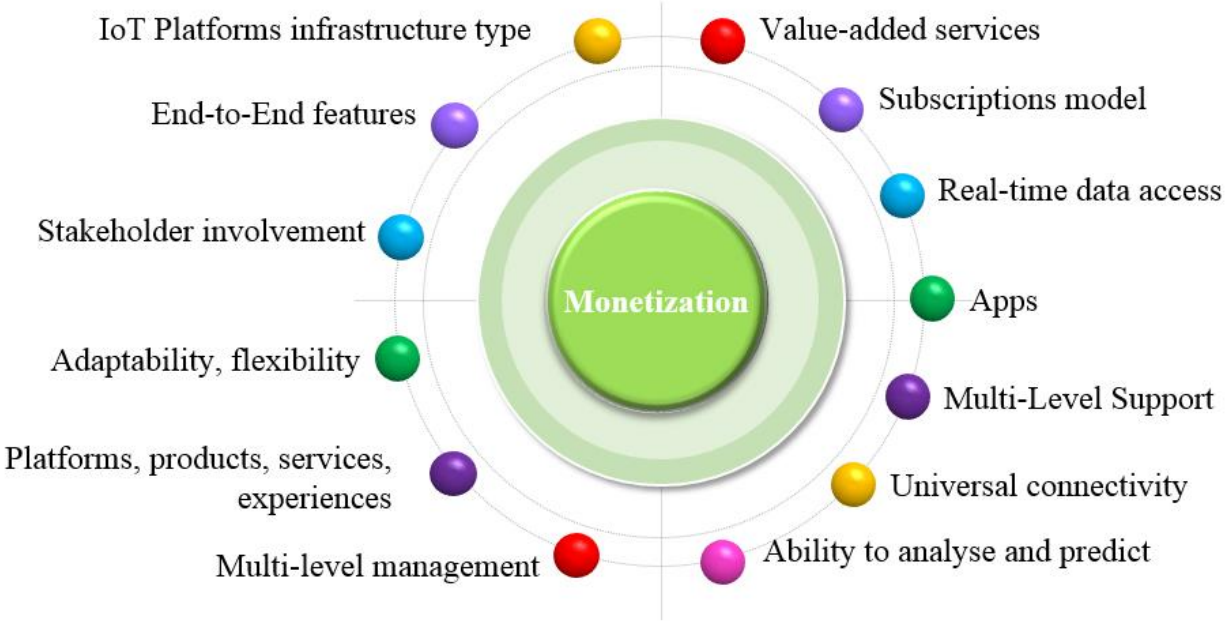


**Figure 5. Value axis monetization and the related areas**

### 4.1.1 Value-added services

Value-added services include additional services, logistics, metering, asset management, and urban operations. They allow the stakeholders to use their involvement in the value networks by moving up the value chain and provide industry relevant end-to-end solutions and services in the IoT platforms ecosystem.

### 4.1.2 Subscriptions model

The subscription model to the IoT platforms is important to analyse the billing mechanisms, the change in pricing with scaling, and the industrial sector base subscriptions.

The subscription model relates to the length of the service period and contract, connectivity charges, peak or seasonal usage and the primary units of measurement (devices, users, storage, etc.).

The scalability plays an important role considering increasing the number of devices and transactions in the use cases and IoT applications. By using a subscription model to build the monetization solution scale can easily and seamlessly be obtained. However, allowing new business models and pricing models is essential.

### 4.1.3 Real-time data access

IoT services support all the phases from sensing/actuating, connecting, processing through to analysis, prediction and action. In this context, the access to data in real-time is a differentiator for many applications.

This includes the ability to capture, store, aggregate, correlate and filter data from different internal and external sources in both batch and real-time and using edge computing technologies and components into the IoT platforms.

Integrating to the enterprise backend business systems and other data sources, machine data can be transform into a rich pool of valuable information.

With capability such as real-time rules engines, advanced analytical features and complex predictive capabilities, enterprises can be provided with actionable business insights to reduce costs and enhance revenue, improve business processes automation, as well as expand their ecosystem and offerings.

### 4.1.4 Apps

The advances in networks and connectivity, and the increased heterogeneity of edge devices that connect to the internet using various IoT platforms affects both B2B and B2C service models while generating the need for creating Apps for various services. Integrations of IoT platforms both unidirectional (e.g. inbound or outbound) and/or bidirectional (e.g. to/from a specialized analytical engine or different IoT platforms), requires an open interface approach (open APIs).

### 4.1.5 Multi-Level Support

The issues require the IoT platforms to provide insight and value across entire value networks, and for any business model used by the IoT ecosystem stakeholders: B2B, B2C, B2B2C, etc. This is essential considering the use of different XaaS (platform, infrastructure, software, thing, etc.) solutions for implementations.

### 4.1.6 Universal connectivity

Universal connectivity and data access provides opportunities to monetize data sharing schemes for mobile network operators and other stakeholders in the IoT value networks. The IoT platforms providing multi-protocol connectivity equal protection across multiple communication protocols and designed for networking agnosticism are required.

### 4.1.7 Ability to analyse and predict

Provide functions to collect, analyse process data. Integrate algorithms to predict based on collected data sets. Integrating real-time and historical data, and use real-time rules engines, advanced analytical features and complex predictive capabilities, can be provided with actionable business insights to reduce costs and enhance revenue, improve business processes automation, to expand the IoT ecosystem and offerings.

### 4.1.8 Multi-level management

The multi-level management solutions for IoT platforms seamlessly translates and integrates a uniform set of commands and information to facilitate provisioning, multi-level, and multi-mode access for IoT users/developers/applications.

Multi-level management allows for the control of IoT applications both on the analytics and device level and allows easily deploying, updating, and maintaining the connected devices to the IoT platform for various use cases and applications.

### 4.1.9 End-to-End features

The issue considers the IoT platforms offering end-to-end (E2E) features that are integrated into the platforms and manage the services over all IoT architecture layers. Example of E2E features are E2E security mechanisms, multi-level authentication, E2E data encryption, etc.

Mobile apps and connected devices need to be authenticated separately and both the app and the end user’s/end device's credentials must pass authorization, while authentication and key management is done without user configuration, so the data encrypts automatically. Other example E2E payment solutions

### 4.1.10 Stakeholder involvement

The stakeholder involvement is emerging as a means of describing a broader, more inclusive, and continuous process between the IoT platforms ecosystem and those potentially impacted that encompasses a range of activities and approaches, and spans the entire life of IoT use cases and applications. This process involves the stakeholders in the development of the IoT platforms and applications that affect the decisions and influence the implementation of these decisions. These important elements influence the value creation, key success factors, product strategies, ecosystem partnering, competitive threats and monetization opportunities. The stakeholders involvement have to be considered over various dimensions such as large vs. small stakeholders, incumbents vs. new entrants/Disruptors, industrial vs. consumer, product vs. service vs. experience, and end-user products/services/experiences/apps vs. infrastructure/platforms.

### 4.1.11 Adaptability, flexibility

The IoT platforms need flexible and configurable access and authorization control, designed for networking and data agnosticism. The platforms have to include intuitive tools for the manufacturer to customize the definition for what data to collect for a given device and how it is to be collected (e.g., how often, how much). The IoT platforms should easily integrate new data and event sources into your existing business model logic and price plans, while set up and define various new types devices. The platforms accept a heterogeneity of devices that allows applications to work with an IoT platform for all edge devices used for different use cases.

### 4.1.12 Platforms, products, services, experiences

Considering the different IoT platforms offerings that have different monetization options available to it are depending on the industry sector, market segments, products, services, experiences, technology and other variables. The common denominator is linking the monetization approach to how the IoT platforms ecosystems create new value for the value networks stakeholders. Many approaches include streamline operations, reduce costs, add new value and increase revenues.

### 4.1.13 IoT Platforms infrastructure type

The IoT platforms implementations across different industry verticals reveal the use of more than 360 IoT platforms that are using Platform-as-a-Service (PaaS), Infrastructure-as-a-Service (IaaS), Software-as-a-Service (SaaS) deployments.

IoT PaaS platforms are built based on event-based architectures and IoT data and provide data analysis capabilities for processing and managing IoT data. IoT-as-a-Service can be built on these different deployments.

All the deployments (i.e. SaaS, PaaS and IaaS) have their challenges and security is one important issue that is connected to identity and access management. The IoT platforms ecosystems, which provide E2E security solutions, have an advantage in value co-creation axes.

**Table 3. Monetization KPIs**

| Areas | KPIs |
|---|---|
| Value-added services | Number of services offered (#) |
| | Operation cost per service (€) |
| Subscriptions model | Number of subscribers (#) |
| | Average subscription duration (#) |

| | |
|---|---|
| | Ratio subscriptions vs. cancellations (%) |
| | Growth rate subscribers (%) |
| Real-time data access | Number of queries per minute / hour (#) |
| | Data volume per minute / hour (GB) |
| | End-to-end latency |
| Apps | Number of downloads / installations |
| | Usage time per minute / hour |
| | Number of users |
| Multi-Level Support | Number of levels supported |
| | Number of service level agreements / underpinning contracts |
| Universal connectivity | Number of standards supported (e.g. Bluetooth, ZigBee, …) |
| | Number of connected devices |
| Ability to analyse and predict | Level of analysis and prediction (owner vs. user) |
| | Time range of prediction |
| | Reliability of prediction in relation of time (%) |
| | Time range of prediction |
| Multi-level management | Number of levels effected / included (#) |
| | Number of IoT applications |
| End-to-End features | Number of features (#) |
| | Number of architectural layers effected |
| Stakeholder involvement | Number of stakeholder groups |
| | Number of stakeholder |
| | Conversion rate (possible interested user vs. lead customer) |
| Adaptability, flexibility | Number of platforms supported |
| | Level of facilitation / facileness of updates |
| Platforms, products, services, experiences | Number of feedbacks |
| | Number of complaints |
| | Number of helpdesk queries |
| | Number of recurring users |
| | Average rating |

| | |
|---|---|
| IoT Platforms infrastructure type | Platform-as-a-Service (PaaS) |
| | Infrastructure-as-a-Service (IaaS) |
| | Software-as-a-Service (SaaS) |
| | IoT-as-a-Service |

## 4.2 Adoption

As described in Deliverable 01.01, the focus on adoption is about understanding and highlighting the "enablers/inhibitors" that drive the spreading of IoT platforms. UNIFY-IoT WP03 activities are specifically devoted to analyse adoption aspects and relevant results have been exploited here. Following the path suggested in Deliverable D01.01, this section analyses the features and aspects that trigger the engagement and adoption of IoT platforms, also defining some quantitative indicators.


**Figure 6. Peculiarities of adoption**

As outlined in Deliverable D01.01, the success of an IoT platform depends on both users and developers. However, the adoption of a technology is performed by users and is affected by a number of features [34][35] that can positively or negatively stimulate the final acceptance and uptake of a technology.

Universal dynamics of adoption can be applied to different innovations and provide a broad understanding of the effectiveness of technologies. Yet, for the discussion related to IoT platforms to be effective, there is the need to focus on those specific criteria that trigger the adoption of such kind of technology.

The adoption approach related to the consumer-culture, perceives co-creation in connection with the possibility for users to achieve their goals by adapting the products as they need [18]. As for

this perception of adoption, another core point is related to the possibility to exchange and co-create.

The adoption of an IoT platform depends additionally on adopters having the possibility to "seat at the (head of the) table acting as partner, solvers and shapers into the open innovation process" (Deliverable D01.01).

As collaborative and participatory adoption of IoT platform is enhancing the opportunities of adopting a platform are increasing. In this context, seven areas have been identified to describe the adoption value axis (Figure 7).

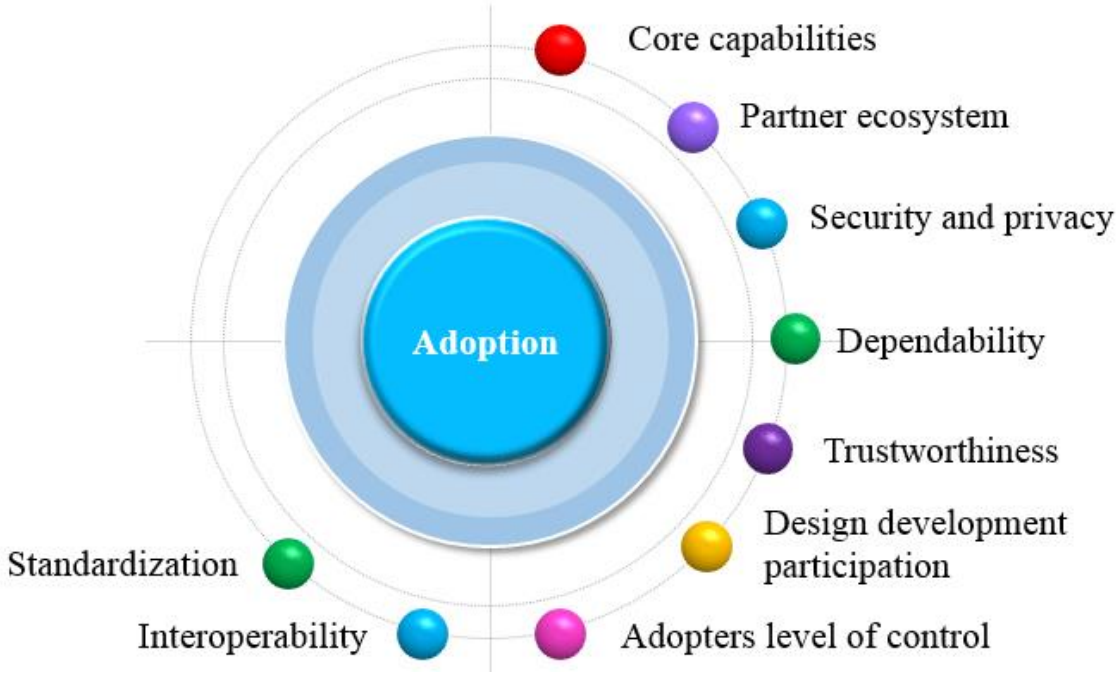


**Figure 7. Value axis adoption and the related areas**

Each area portrays a set of features and capabilities that trigger the adoption of an IoT platform across users. Moreover, in addition to the IoT platforms, the interoperability solutions being developed within RIAs are considered. By describing each area, we highlight features that define the Key Performance Indicators (KPIs).

### 4.2.1 Interoperability

In the current heterogeneous IoT scenario, a major feature allowing a wider uptake of IoT platforms is represented by the technical and informational interoperability. More specifically, technical interoperability refers to the ability of the considered IoT platforms to communicate using proper protocols and data formats, while informational interoperability covers the aspects linked to the meaning of the exchanged information. This can be achieved through the adoption of open standards and the support for features enabling plug and play and self-adaptable approaches.

### 4.2.2 Standardization

The compliance with standardized solutions at different levels of the reference protocol stack represents a key aspect to promote a wider adoption of IoT platforms and services also allowing the consolidation of the current IoT landscape. In this respect, [37] provides different views on current situation presenting the different SDO (Standards Developing Organization), Alliance and OSS (Open Source Software) initiatives and classifying them on two dimensions:

- Market (i.e., B2B and B2C IoT solutions)
- technology/solution/knowledge area (i.e., Service and App and Connectivity)

From the above views, it clearly emerges the heterogeneity and complexity of the current IoT related standardization activities, along with the need to promote the convergence of IoT standards. In such dynamic landscape, it is important to monitor ongoing standardization initiatives as well as the ones generated from IoT-EPI RIA projects.

### 4.2.3 Core capabilities

In order to facilitate the wider adoption of IoT in different application domains and heterogeneous scenarios, IoT platforms should support features enabling plug-and-go approaches and provide users with easy access to existing ecosystems of IoT devices. Such resulting core features should be easy to use as well as robust and stable, thus allowing to gain good reputation and to simplify the development process of new applications in different verticals.

In this context, Software Development Kits (SDKs), with relevant documentation describing platforms functionalities and best practices to develop new applications exploiting multiple platforms would represent an added value, actually supporting the development activities of single users and communities of users. The availability of such tools and documentation would also improve the visibility and reputation of the proposed solutions, thus igniting relevant co-creation initiatives.

### 4.2.4 Partner ecosystem

IoT platforms should be able to comply with heterogeneous ecosystems of partners thus supporting their adoption within and across different vertical domains.

Moreover, different complementary approaches should be used to exploit the ecosystem of partners available around the considered platforms. For instance, hackathons could be organized to support the evolution of the platform or the source code developed within the project could be made available to the public. In addition, a market place could be used to distribute project results and properly engage relevant stakeholders.

### 4.2.5 Security and privacy

One of the major concerns actually affecting the adoption of solutions based on IoT, and possibly open platforms, is related to the support for end-to-end security and privacy. This issue is further emphasized by the need to develop a broad and heterogeneous ecosystem, where devices could have limited memory and computing resources as well diverse security and connectivity features.

The design and selection of the most proper (standard) security and privacy mechanisms to be adopted is driven by different factors including performance, complexity and cost. In addition, since the envisioned reference scenario is characterized by the coexistence of a very large number of IoT entities, the scalability features are of utmost importance.

As a consequence, the native and scalable support for security and privacy protection within and across multiple IoT platforms represents a main requirement for IoT solutions to be more widely adopted.

### 4.2.6 Dependability

Dependability could be used to describe the IoT platform in terms of availability, reliability (thus properly managing failures when they occur) and maintainability (ease to correct or modify components as well as to support their evolution).

Moreover, aspects related to resilience are taken into consideration along with the robustness of the IoT platform to crisis and disturbances. In fact, the adoption of a platform may be influenced by the performance achieved and the behaviour demonstrated in a crisis scenario.

### 4.2.7 Trustworthiness

In connection with availability and reliability of a system and of the relevant exchanged data, the adoption of a platform may depend also on its level of trustworthiness. More specifically, trustworthiness is intended as the capability to provide accurate and reliable information, also avoiding information leaks, demonstrated by the evidence of current and past behaviour and system availability. In practice, trustworthiness can be considered as a metric of how much a system deserves the trust of its users [36].

In the end, users would adopt a platform if they consider it as trustable and if it behaves as expected in different operating conditions.

### 4.2.8 Design development participation

The adoption may be additionally stimulated by the level of users' participation in the design and development of new applications based on a considered ecosystem of IoT platforms. The higher is the level of participation allowed by a platform, the stronger would be the reputation of the product among the community of users.

In addition to the design and development of applications, users may also be involved in the evolution of the functionalities offered by the IoT platforms, taking into consideration functional, interoperability as well as reliability aspects. This also has a relevant impact on the final adoption of the platform.

### 4.2.9 Adopters level of control

The adoption of platform may finally depend on the level of users' empowerment looking for more control over development activity [22][23]. As a consequence, the availability of features, methodologies and tools for adopters allowing them to adjust and customize IoT platforms functionalities and behaviour would be definitely beneficial to increase the attractiveness of a platform, thus promoting its adoption.

**Table 4. Adoption KPIs**

| Areas | KPIs |
|---|---|
| Interoperability | Number of open IoT platforms made interoperable |
| | Compliance of the IoT platform with relevant open standards |
| Standardization | Compliance of the IoT platform with relevant standards |
| | Number of generated initiatives to support standardization of technologies for IoT connectivity |
| | Number of generated initiatives to support standardization of solutions for Services and Applications |
| | Number of generated initiatives to support standardization of solutions for B2B market |
| | Number of generated initiatives to support standardization of solutions for B2C market |

| | |
|---|---|
| Core capabilities | Ability to support plug-and-go based adoption of the platform components |
| | Availability of SDK |
| | Availability of documentation describing the platform functioning and best practices for its adoption |
| | Code quality index (possible models are described in [32]) |
| Partner ecosystem | Capability of the platform to work across verticals |
| | Number of hackathons organized to support the evolution of the platform |
| | Availability of the open source code in GitHub or other public repositories |
| | Use of third party's catalogues/marketplaces to distribute project results |
| | Capability of the involved ecosystems to scale up |
| Security and privacy | Availability in the IoT platform of features supporting security |
| | Availability in the IoT platform of features supporting privacy protection |
| | Availability of features supporting security across different IoT platforms |
| | Availability of features supporting privacy across different IoT platforms |
| Dependability | Availability of the IoT platform (the ratio of the uptime of the IoT platform in a given interval) |
| | Availability of mechanisms ensuring proper management of systems failures |
| | Availability of mechanisms ensuring robustness to crisis and disturbances |
| | Adoption of solutions to ease the modification and/or evolution of SW components |
| Trustworthiness | Fulfilment percentage of the expectations concerning system reply to events received |
| | Fulfilment percentage of the expectations concerning data collection |
| | Fulfilment percentage of the expectations concerning reliable data processing |
| Design development participation | Availability in the platforms of features supporting users' participation in the design and development of new applications |
| | Size of the community (number of people) supporting the design and |

| | |
|---|---|
| | development of new applications based on the considered IoT platform |
| | Size of the community (number of people) supporting the evolution of the IoT platform functionalities (design and development) |
| | Size of the community (number of people) supporting the evolution of the IoT platform interoperability features (design and development) |
| | Number of co-creation initiatives implemented to support design participation |
| | Number of external users involved in testing the interoperability solution |
| Adopters level of control | Availability of tools/features to be used by end users to customize the IoT platform and meet specific needs |
| | Availability in the IoT platform of administration tools/features for end users |
| | Availability of tools/features to be used by end users to customize the interoperability solution and meet specific needs |
| | Availability in the interoperability solution of administration tools/features for end users |

## 4.3 Societal awareness and acceptance

Societal awareness and acceptance, in comparison with the others areas presented in the sections above should be considered differently because the link between RIA's activities regarding value co-creation and a measurable increase of user's awareness and acceptance is indirect and relies on the impact and success of the others dimensions as well as on external factors.

As explained in the deliverable D04.01, many barriers covering a varied set of dimensions (trust, regulation and legislation, skills and competencies, market, and interoperability) plays a role in user's adoption and acceptance.

The barriers identified and the ways to address them target several stakeholders and cover a large variety of activities. The measure of the impacts in terms of increase of awareness and acceptance at societal level is thus a complex task.

The focus is on one instrument developed to increase awareness and acceptance at society level: the open education platform (OEP) supported by all IoT-EPI projects and coordinated in the dedicated Task Force on Education (TFE). The OEP objective is to:

- Become a hub for providing categorized/coherent IoT education content;
- Promote a virtual ground of interaction where IoT stakeholders (start-ups, companies, developers) address their current needs;

To serve these objectives, the OEP is organized in two main areas:

- **Education Area** offering IoT content at various levels for students and professionals;
- **Match-Making Area** where IoT stakeholders interact to address each-others needs and offer potential feedback and solutions.

**Education area** is organized in four sections:

- **IoT modules/courses** for beginners; intermediate; advanced users;
- **Life-long learning** for IoT professionals/developers;
- **Transversal skills** to improve innovation and entrepreneurship capacities;
- **Digital skills for end-users** to facilitate interaction/access to IoT technologies.

**Matchmaking** area is organized in three sections:

- **Challenges Section** to promote cooperation between companies and developers: The earlier offer potential challenges and developers provide a solution;
- **Match-Making Section** where IoT stakeholders call for a specific needed expertise;
- **Test-Bed Section** where companies present services and end-users can participate by providing feedback and potential ideas for improvements.

Figure 8 shows a snapshot of the OEP landing page [33]:

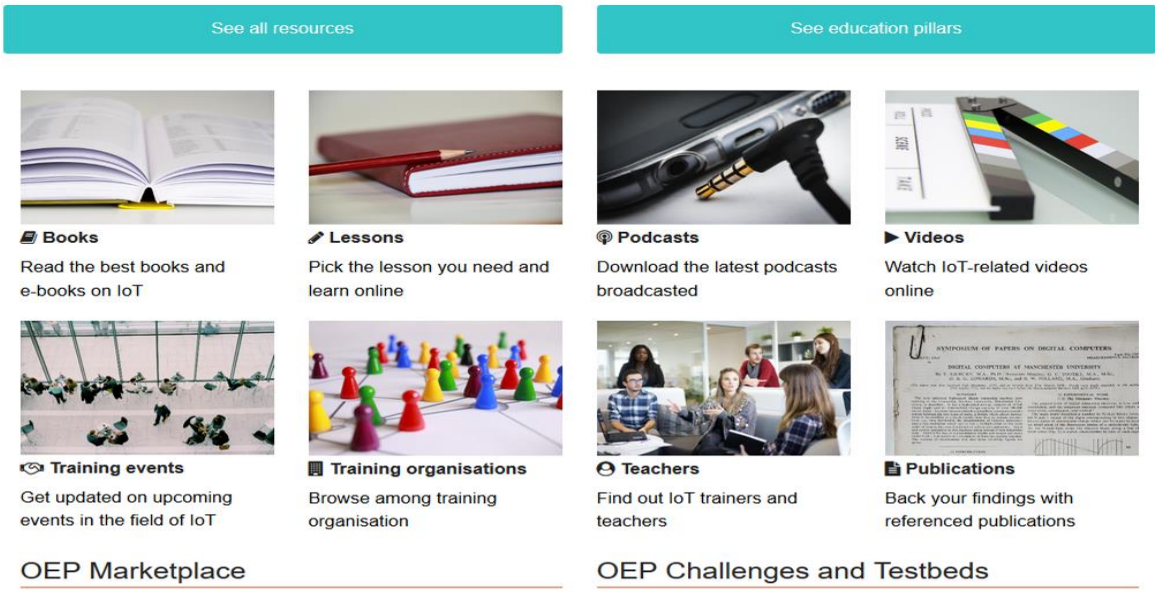


**Figure 8. OEP landing page**

When defining KPIs for the societal awareness and acceptance dimension with regard to the results of the co-creation processes, we thus focus on defining KPI related to the set-up of the platform (readiness), its use, in terms of both content repository and use of educational material and the interest driven by the platform for the various targeted stakeholders (Usage).

The OEP aims to be dynamically updated and evolved in parallel with the evolution of needs that will necessarily evolve with the adoption of IoT applications and services, some barriers disappearing when others appearing.

How end-users concerns are taken into account and addressed by the ecosystems is a key point to measure the maturity of IoT awareness and acceptance. In this context, the focus is on KPIs addressing this aspect.

The three main KPI areas are:

- Content provision, which deals with the capacity of the OEP to engage stakeholders in providing various, relevant and up-to-date training materials for various stakeholders

(students, professionals, start-ups, companies, developers etc.). The OEP is supposed to become *the place to go* for people being interested in gaining knowledge in IoT, whatever their profile, initial level and nature of interest and in the other sense, *the place to go* for sharing knowledge on this quick moving domain of IoT.

- Content usage, which deals with the exploitation of the OEP by various stakeholders, including the static part of the platform (education platform) and the dynamic part of the platform (matchmaking area).
- End-users consideration that focus on the specific content addressing end-users concerns such as privacy, security, data protection, etc.

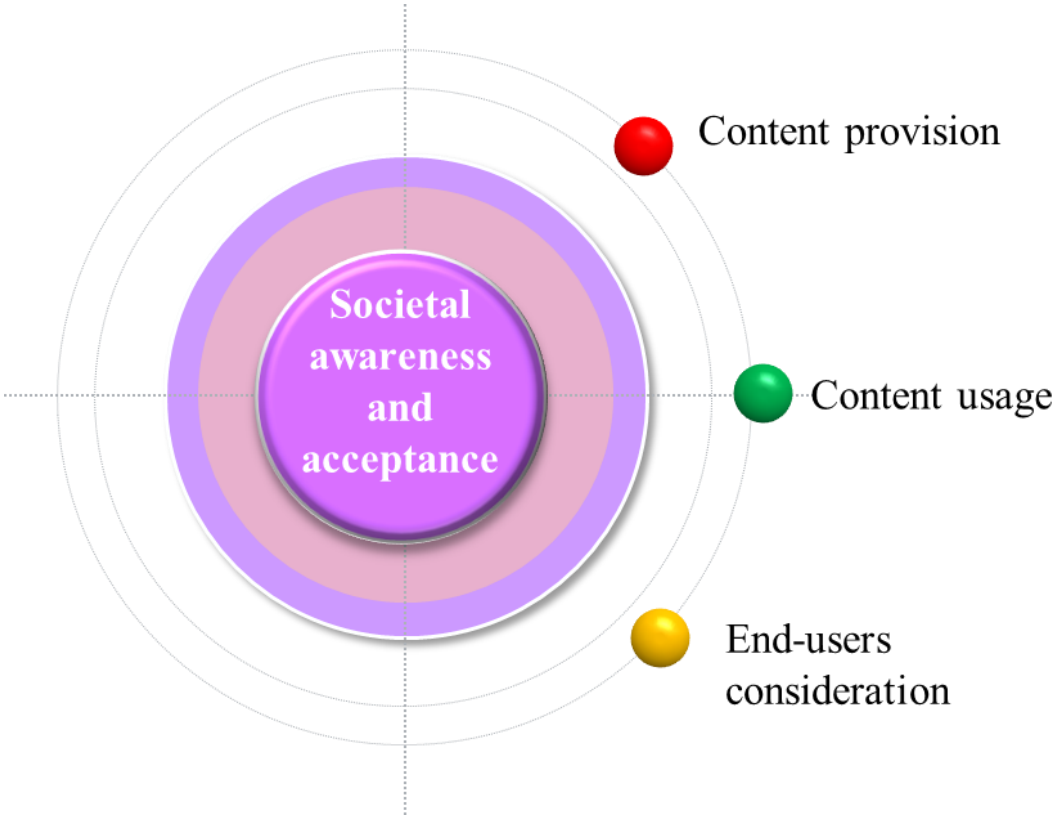


**Figure 9. Value axis societal awareness and acceptance and the related areas**

**Table 5. Societal Awareness and Acceptance KPIs**

| Areas | KPIs |
|---|---|
| Content provision | Number of people (researchers, developers, students, experts, businesspersons and other IoT stakeholders) registered in the OEP. |
| | Number of people (researchers, developers, students, experts, businesspersons and other IoT stakeholders) uploading content and actively participating in the OEP. |
| | Nature and variety of contents uploaded in the OEP (generic education material, specific techno, etc.) |

| | |
|---|---|
| Content usage | Number of people exploiting the material and information in section of the OEP, to be distinguished according to the category of stakeholders (researchers, developers, students, experts, businesspersons and other IoT stakeholders) |
| | Number of people (researchers, developers, students, experts, businesspersons and other IoT stakeholders) expressing their needs in different sections of the OEP and in particular in the market-place section where interaction among stakeholders are promoted |
| | Number of positive comments concerning the uploaded content (mandatory any time someone has access on this material). |
| | Number of interactions in the matchmaking areas |
| End-users consideration | Number of people (researchers, developers, students, experts, businesspersons and other IoT stakeholders) expressing their interests and needs towards privacy, protection of data and trust |
| | Number of people uploading contents related to privacy, protection of data and trust |
| | Nature of contents available on the OEP (good practice, guidelines, roadmap, etc.) related to privacy, protection of data and trust |

## 4.4 KPIs characterization based on use cases and stakeholders perspectives

Previous sections focused on the definition of KPIs mainly considering the three value axes i.e., monetization, adoption, societal awareness and acceptance as the key dimensions around which the actual impact of RIA projects can be measured. However, the above process of KPI generation is based on a more general perspective and is not fully considering the peculiarities of the different domains where IoT is exploited and the relevant ecosystems of stakeholders.

In fact, value can be perceived differently depending on the context defined by the application domain and the relationships among the involved stakeholders. In addition, the stakeholders may perceive the above relationships in different ways and this could apply to value as well: value can be seen from a customer or supplier perspective but also from the various perspectives represented by other stakeholders in a network [38].

Given such considerations, this section analyses the opportunity to define customized sets of KPIs to catch the different identified perspectives and provide a more efficient evaluation tool for the value co-creation methodologies implemented.

### 4.4.1 Domain specific KPIs

A first perspective being considered relates to the different application domains where IoT can be adopted. More specifically, in this analysis the scope is limited to a subset of use cases identified within IoT-EPI ecosystem. Such use cases include the scopes of the different RIAs and represent the converging trajectories among RIAs at pilot level:

- Smart City
- Environment/Energy Monitoring recycling
- Livestock Monitoring
- Port/Vessels Monitoring
- Mass market PLM / Smart retail/ Product monitoring

- Smart healthcare
- Smart Mobility

More details are reported in D01.01, where Figure 12 also depicts the mapping between the different RIA projects and the use cases covered.

In this context, the following subsections present some guidelines on how to characterize KPIs considering the different value axes and the above introduced use cases. It is worth stressing that the analysis presented is not meant to be comprehensive. In fact, the definition of the full list of specific KPIs is a process to be led by RIA projects and that significantly depends on the specific application use case and relevant context information.

#### 4.4.1.1 Monetization

While considering the expected outcomes of RIA projects in terms of integration platforms and SW solutions, a first suggested guideline is to address the monetization in each specific use case through an analysis on how to create value from data exploiting proper business approaches. More specifically, within the framework of the IoT-EPI Task Force on Business Models, some discussion focused on the definition of a set of questions to be answered when creating a data business (a documented webinar "Data Sharing Business Models" is accessible for all involved partner in the IoT-EPI project and uploaded on IoT-EPI website [31]). With these specific questions on delivery methods and revenue sources, it is possible to derive two main KPIs measure the business model success (Figure 10): the "Degree of Personalization" and the "Duration of Relationship". In addition, the different business models can also be combined cross-sectional.

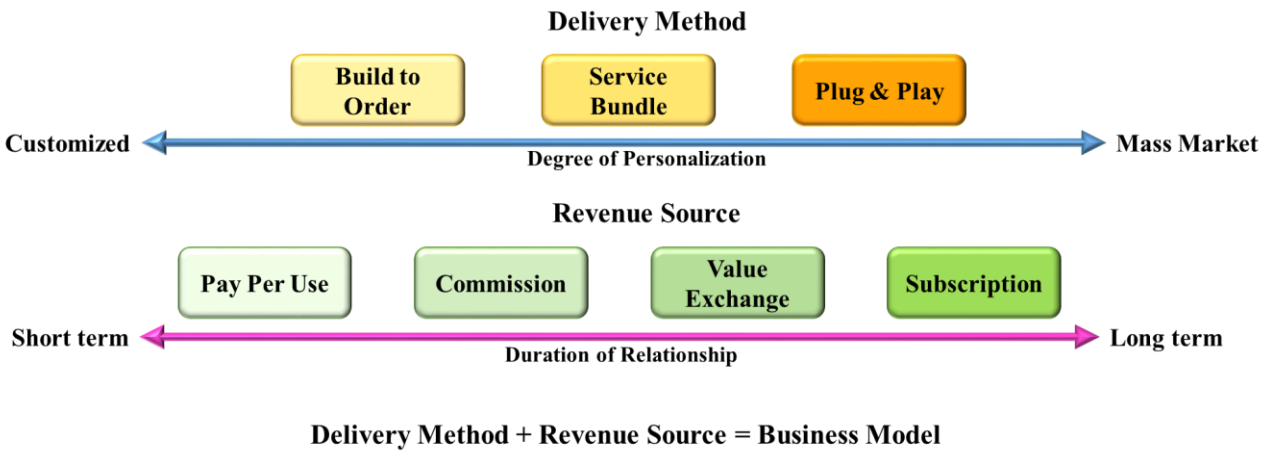


**Figure 10. Business Models in the Data Sharing Economy**

While defining other specific KPIs, it is worth taking into consideration the peculiarities of the analysed use cases.

For instance, smart city, environment/energy monitoring recycling and smart mobility use case share a higher complexity of the relevant ecosystem, actually composed of multiple and heterogeneous stakeholders and including different kind of government bodies. This is an emergent ecosystem that calls for the definition of innovative business models and for peculiar performance aspects to be monitored. The complexity of the relevant scenario represents an important factor: the smart city use case can be considered as a sum of different sectors and services.

A "Smart City" can use various innovative technologies, combines energy, mobility and infrastructure, aims to increase performance and efficiency as well as the participation of

citizens, enables innovation and improves the social and economic fabric of the city [39]. In this context, it is necessary to clarify the difference between ROI (Return of Investment) and monetization and, consequently, how cities can monetize their connectivity and the resulting data. This means that cities could make a switch from saving money to making money leveraging IoT technology.

A number of IoT smart city projects have a ROI (reducing waste, better water monitoring, improving public safety, etc…) but not necessary a revenue opportunity. An example of data stream monetization is given by the value added services built on top of free public data. Relevant services could combine multiple sources of information and data analytics techniques and made available through subscription fees. Monetization can be thus realised exploiting data availability, added value services and applications built on smart city enabling platforms [40].

In the considered smart city environment, data ownership is an additional aspect impacting on the definition of innovative business models. In a scenario where different stakeholders participate to the definition of a novel smart city services and where data from different vertical services are combined, data ownership plays a key role and should be properly handled from the technical and economic point of view. Moreover, federation among the different stakeholders and relevant data should be managed. The generation of public and private partnerships represents an additional sustainable model being implemented to drive smart technology solutions in smart city areas. All the above considerations can be finally used to characterize the specific smart city use case and to finally generate an ad-hoc list of KPIs. In the end, the proposed approach can be used to characterize a generic use case and identify the most proper list of indicators.

#### 4.4.1.2 Adoption

When considering the adoption in different use cases, it is first important to identify which are the characterizing factors that could specifically impact on the final acceptance and uptake of a technological solution. As concluded in section 4.2, the success of the considered IoT enabling solution depends on both users and developers and is affected by a set of additional features.

An in depth analysis of the single considered use case would allow to further characterize the users and developers, identify their requirements as well the additional features needed. This is the first step towards the definition of more specific KPIs.

The proposed characterization could take into consideration different aspects. Each application domain can be characterized by the set of involved stakeholders (along with their relationships) but also by the ecosystem of standards (e.g., communication protocols, data format and security) and technologies that need to be supported.

For instance, considering the Smart City use case already analysed for the monetization axis, it emerges a strong characterization associated to:

- Types of end users taken in consideration i.e., the citizen;
- Stakeholders involved (government bodies, utilities, citizens, …) and their interaction;
- Rules, regulations and policies;
- Complexity of the application scenarios of interest in terms of e.g., interoperability among novel and existing city legacy services and infrastructure, data ownership, cybersecurity and privacy, federation of smart city services, generation and consumption of open data services, importance of geolocation information, scalability;
- Possibility to trial a solution on a limited bases in a local context before full implementation;

It is then possible to exploit the above analysis and derive new KPIs associated to the areas describing the value axis of adoption (reported in Section 4.2).

#### 4.4.1.3 Societal Awareness and acceptance

While looking at the societal awareness and acceptance value axis, the significant categories of users to be considered are adopters, end users, futures developers, public sector and society at large. In this respects, there are some differences in terms of end users involved in the different application domains. For instance, it is worth highlighting that the involvement of private users (citizens) significantly characterizes the Smart City, Environment/Energy Monitoring recycling, Mass market PLM / Smart retail/ Product monitoring, Smart healthcare and Smart Mobility use cases.

The use cases related to Livestock Monitoring and Port/Vessels Monitoring mainly involve professional users. As a consequence, the KPIs to be considered for societal awareness and acceptance would need to be properly adapted.

As a first operating example, the list of specific KPIs for the Smart City uses case has been derived and reported in the following table, starting from the outcome presented in section 4.3.

**Table 6. Operating example (Smart City KPIs)**

| Areas | KPIs |
|---|---|
| Participate in increasing societal awareness and acceptance | Number of accounts registered in the OEP and classified as smart cities government representatives / industries (SMEs, LEs) and start-ups operating in the smart city sectors / citizens |
| | Number of content uploads/requests in the OEP from smart cities government representatives / industries (SMEs, LEs) and start-ups operating in the smart city sectors / citizens |
| | Number of Smart City initiatives reported in the OEP |
| Measure the increase of societal awareness and acceptance | Number of people (smart cities government representatives, citizens, researchers, developers, students, experts, businesspersons and other smart city stakeholders) expressing their needs in different sections of the OEP |
| | Number of people (smart cities government representatives, citizens, researchers, developers, students, experts, businesspersons and other smart city stakeholders) expressing their needs in the market-place section where needs and competences can be met |
| | Number of positive comments concerning the governing bodies satisfaction |
| | Number of interactions between smart cities governing bodies and citizens to collect citizens' needs (events, hackathons, workshops…) |
| | Number of citizens and communities subscribed to Smart Cities services |
| | Number of positive comments concerning the citizens satisfaction |
| | Number of public-private partnerships actually operating |
| Address end-users concerns | Number of inputs about needs for privacy, protection of data and trust and collected from smart cities government representatives / industries (SMEs, LEs) and start-ups operating in the smart city sectors / citizens |

The above specific KPIs could be also easily adapted to the other use cases where private users are involved by properly modifying the involved stakeholders. When considering professional users, the KPIs presented in section 4.3 would just need to be adapted and linked to the specific stakeholders involved. Similar approaches could be used to generate proper KPIs for the different use cases.

#### 4.4.1.4 Summary

Following the outcome presented in the previous 4.4 sub-sections, it is possible to summarize in the following table the level of characterization (L: low, M: medium and H: high) expected for the value co-creation KPIs w.r.t. application domains and value axes.

**Table 7. Level of characterization summarized**

| Application Domain | Monetization | Adoption | Societal Awareness and Acceptance |
|---|---|---|---|
| Smart City | H | M | H |
| Environment/Energy Monitoring recycling | H | M | H |
| Livestock Monitoring | H | M | H |
| Port/Vessels Monitoring | H | M | M |
| Mass market PLM / Smart retail/ Product monitoring | H | M | H |
| Smart healthcare | H | M | H |
| Smart Mobility | H | M | H |

This table is meant just to provide some indications concerning the work to be done for further analysing the different use case and detail specific KPIs.

### 4.4.2 Stakeholders specific KPIs

While refining the list of specific value co-creation KPIs, the perspective of the different stakeholders involved should be also taken into consideration. RIA projects already include a list of stakeholders e.g., IoT device manufacturers, IoT platform providers, IoT platform operators, IoT service developers, IoT service providers, IoT end users, R&I organizations. However, additional stakeholders, external to project consortia, should be identified and for all the resulting stakeholders, role and interactions in the overall resulting ecosystem should be carefully evaluated.

After having depicted a clear map of stakeholders, specific KPIs could be generated according to perspective that is selected/relevant. For instance, if the objective is to specify a list of value co-creation KPIs to be used by an IoT Device Manufacturer, the framework presented in section 4.1, 4.2 and 4.3 should be properly adapted, combining the characterization introduced to deal with the peculiar application domain. To better set up stakeholder-focused KPIs, four steps are proposed:

1. Identify key stakeholders;
2. Define the behavioural outcomes required from them;
3. Convert those behavioural outcomes into objectives;
4. Develop measures, the shortlist of which constitutes the KPIs for those objectives

This represents an approach that should be then applied by RIAs to autonomously derive the most relevant KPIs.

# 5. CONCLUSIONS

This document provides the methodology and tools to implement the IoT value co-creation framework elaborated in [10] to IoT platforms ecosystems implementing various IoT use cases and applications. The methodology is framed around three stages: report, act and impact. It covers all pillars that have been presented in the context of the value co-creation framework. The methodology is applied on the IoT-EPI projects for evaluating the active participation of stakeholders in the co-creation process.

The proposed value co-creation framework at the core of the present deliverable is made up of four pillars:

- 'Why', addressing the motivations driving the co-creation effort under construction;
- 'What', explaining the value proposition that is offered as result of the co-creation effort;
- 'Where', defining the target market in which the value proposition is offered, taking stock of the entire IoT ecosystem, and
- 'How', examining the key decisions that involved RIAs have necessarily to consider (a.k.a. levers) while building the joint developments.

The proposed framework is built as a toolkit made available to IoT ecosystems (IoT-EPI projects in this case), relevant stakeholders, and in general to IoT professionals to support the value co-creation process in IoT application deployments. In designing the framework, UNIFY-IoT consortium opted for an IoT-EPI-centric perspective that can be extended and applied to other IoT ecosystems.

To set the methodology for implementation of the value co-creation framework, UNIFY-IoT designed a questionnaire to capture the value dimensions described in the framework.

The methodology identifies key components of value co-creation based on the framework presented in [10].

Results gathered from this activity will be evaluated in order to identify the value co-creation mechanisms used by the projects and their stakeholder network. Inputs collected from this activity will be fed into the framework, together with results from IoT-EPI task forces to test the preliminary value co-creation results and allow IoT-EPI projects to familiarize with value co-creation concepts and mechanisms.

IoT platforms ecosystems with a higher degree of involvement in co-creation activities are considered in a better position to develop and highlight the innovative aspects of new products, processes, services, experiences developed in the IoT use cases and applications.

The IoT value co-creation methodology emphasis the total value offered to the stakeholders in the value network and present the shift from product-centric innovation to a more holistic approach that includes a combination of products, services and experiences. The value co-creation methodology deals with a shift from products/services to platforms that are needed to enable the participation of all the value network stakeholders. In this context, the IoT stakeholders are co-producers of products, services, experiences and value because they mobilize knowledge about the processes that affects the adoption of a value proposition. The study of platform architectures for service delivery is in line with value co-creation research. Value co-creation methodology embed the design of participation IoT platforms enabling seamless integration between products, services and experiences.

Value co-creation methodology presented is directly linked with the dimensions of the IoT business model applied by the IoT platforms ecosystems. In this context, innovation includes the building blocks of the IoT business model in addition to the specific characteristics of the market offer in an industrial sector.

The methodology described, show that the value co-creation is efficient when using new value co-creation processes that include the value axes and areas presented in the value-co-creation framework.

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# 7. APPENDIX - SELF-ASSESSMENT QUESTIONNAIRE

This section presents the outline of the self-assessment questionnaire that will be offered to the RIAs.

The main objective of this questionnaire is to collect inputs about impacts derived from the adoption of value co-creation mechanisms. The presented questionnaire complements the adoption of the KPIs framework defined in section 4. In addition to few questions on general information, the questionnaire includes three main sections organized following the 'logic chain' tenet used to classify the UNIFY-IoT KPIs framework:

- **Part I - Readiness:** to capture contextual factors enabling the implementation of value co-creation mechanisms in the IoT-EPI ecosystem.
- **Part II - Usage:** to measure the uptake of value co-creation mechanisms in the IoT-EPI ecosystem.
- **Part III - Result:** to measure the tangible outcomes generated by RIAs so far as a consequence of the usage of co-creation mechanisms in the IoT-EPI ecosystem.

***General Information***

- *RIA name*

  ---

- *Application domains (multiple choice)*
  - ☐ Smart City
  - ☐ Environment/Energy Monitoring recycling
  - ☐ Livestock Monitoring
  - ☐ Port/Vessel Monitoring
  - ☐ Mass market PLM / Smart retail/ Product monitoring,
  - ☐ Smart healthcare and
  - ☐ Smart Mobility

***Part I – Readiness***

- ***Is your project using source code hosting sites for project outcomes (e.g., GitHub, Source Forge, Open Platforms Portal, etc)***

  *Yes/No → If yes, please specify*

- ***Does your project adopt Open Standards within the developed software components?***

  *Yes/No → If yes please report a list*

- ***Does your project adopt Open Source Licences?***

  *Yes/No → If yes, please specify which licenses*

- ***Is your project adopting Open Data Licences?***

  *Copyleft/Copyright*

- ***Does your project adopt open API?***

  *Yes / No*

- ***Does your project offer SDKs?***

  *Yes / No*

- ***Does your project foresee tools/features to be used by end users to customize the interoperability solution being developed?***

  *Yes / No*

- ***Does your project foresee features supporting security across different IoT platforms?***

  *Yes / No*

- ***Does your project foresee features supporting privacy across different IoT platforms?***

  *Yes / No*

- ***Does your project use third party's catalogues/marketplaces to distribute project results?***

  *Yes / No → If yes, please specify (es. FIWARE, openplatform.org, etc…)*

***Part II – Usage***

- ***Please indicate the co-creation methodologies being currently adopted in your project***
  - ☐ *Collaborative design*
  - ☐ *Collaborative making (creation of virtual models)*
  - ☐ *Rapid prototyping involving end-users/relevant stakeholders*
  - ☐ *Virtual product/service launch*
  - ☐ *Collaborative hackathon*
  - ☐ *Open calls*
  - ☐ *Other, please specify*

- ***Number of co-creation initiatives implemented within the project and involving only consortium members***

  *Specify a number*

  *Additional notes could be inserted*

- ***Types of stakeholders engaged in the co-creation initiatives implemented within the project and involving only consortium members***

  *Specify*

- ***Number of people engaged in the co-creation initiatives implemented within the project and involving only consortium members***

  *Specify a rough number of people and relevant type of stakeholders involved in the different co-creation initiatives (e.g., 5 developers, 4 students, 2 researchers)*

- ***Number of co-creation initiatives implemented and involving people external to the project consortium***

  *Specify a number*

*Additional notes could be inserted*

- ***Types of stakeholders engaged in the co-creation initiatives implemented and involving people external to the project consortium***

  *Specify*

- ***Number of people external to the project consortium engaged in the co-creation initiatives***

  *Specify a rough number of people and type of stakeholders involved in the different co-creation initiatives*

- ***Number of tests with external users (alpha users and beta users) on the interoperability solutions being developed within the project***

  *Specify number*

  *Additional notes could be inserted*

- ***Number of co-created business models prototyped by means of Value Proposition Canvas and Business Model Canvas***

  *Specify a number*

- ***How many liaisons with educational/research bodies have been built by the project?***

  *Specify a number*

***Part III – Result***

- ***Software Components are reused into the RIAs***

  *Specify a list*

- ***Number of Business co-creation/Jamclasses realized***

  *Specify a number*

- ***Number of Business Models have been defined as a consequence of a specific co-creation exercise?***

  *Specify a number*

- ***How many education events (e.g., tutorials shared on social media and/or MOOC - Massive Open Online Courses) did you create?***

  *Specify a number*

- ***How many people external to the consortium participated to the education events?***

  *Specify a number*

- ***How many apps developed within the projects are currently available to be downloaded?***

  *Specify a number*

- *Did you establish an open source community of developers around the project outcomes?*
  - *Yes/No → If yes, please specify a number*