**Grant Agreement N°:** 101016673
**Topic:** ICT-40-2020

The European Cloud Computing Hub
to grow a sustainable and comprehensive ecosystem

# D1.3: Impact analysis on cloud research programme: success stories and best practices

Revision: v.1.0

| | |
|---|---|
| **Work package** | WP 2 |
| **Task** | Task 2 |
| **Due date** | 30/09/2022 |
| **Submission date** | 07/11/2022 |
| **Deliverable lead** | ATOS |
| **Version** | 1.0 |

# Abstract

This report contains an analysis of the impact achieved by European research projects, as well as the success stories identified and how to replicate them. Ending with a set of recommendations for maximising impact in future projects.


**Keywords: Impact, innovation, exploitation, methodology**

**Document Revision History**

| Version | Date | Description of change | List of contributor(s) |
|---|---|---|---|
| V0.1 | 22/10/2022 | ToC and initial content | Lara López (ATOS) |
| V0.2 | 04/11/2022 | Final version | Lara López (ATOS) |
| V1.0 | 06/11/2022 | Review and formatting | Giovanni Rimassa (MARTEL) |

**Disclaimer**



| Project co-funded by the European Commission under ICT-40-2020 | | |
|---|---|---|
| Nature of the deliverable: | R | |
| Dissemination Level | | |
| PU | Public, fully open, e.g. web | √ |
| CI | Classified, information as referred to in Commission Decision 2001/844/EC | |
| CO | Confidential to HUB4CLOUD project and Commission Services | |

** R: Document, report (excluding the periodic and final reports)*
*DEM: Demonstrator, pilot, prototype, plan designs*
*DEC: Websites, patents filing, press & media actions, videos, etc.*
*OTHER: Software, technical diagram, etc*

# EXECUTIVE SUMMARY

This document is the last one of a series of two with the main goal of identifying best practices and success stories, elicited from ICT-15 and ICT-40 projects, in terms of societal and business innovation.

In order to achieve this goal, a set of activities has been implemented to be able to provide clear and reasoned conclusions from the information gathered from different projects. An initial survey about the impact-related activities performed where launched, collecting information in terms of innovation, standardisation, dissemination and exploitation activities. Furthermore, this information was followed by the application of an innovation radar, based on the survey answers, to the projects participating in the two iterations. In this way, the level of innovation and the maturity of the solutions can be initially assessed, prior to the end of the projects. This information was also shared within all participants so they can undertake any corrective action, if needed, to maximise the impact of the project. In parallel, based on the KPIs identified by HUB4CLOUD, an overall impact assessment was also performed to measure not only the potential impact of research in both society and industry, but also to identify any potential gap that is preventing projects to reach their maximum potential, or any key best practice that can be replicate in future research projects. Finally, a general assessment about the replicability of success stories and best practices that any project can adopt from their start is also provided.

With these activities, HUB4CLOUD aims to answer three main questions:

- Which factors determine the success of a funded project in terms of impact?
- How to create conditions for replicating such success factors?
- In which outcomes should the EC invest to accelerate the digitalisation of European economy and society?

# TABLE OF CONTENTS

# LIST OF FIGURES

# LIST OF TABLES

# ABBREVIATIONS

| | |
|---|---|
| **AI** | Artificial Intelligence |
| **DIH** | Digital Innovation Hub |
| **EC** | European Commission |
| **FaaS** | Function as a Service |
| **KPI** | Key Performance Indicator |
| **OS** | Open Source |
| **PM** | Person/Month |
| **TRL** | Technology Readiness Level |
| **XR** | eXtended Reality |

# 1 INTRODUCTION

The present document summarizes major hints and findings related to the impact generated by ICT-15 and ICT-40 projects thanks to the European Commission funding, as well as the best practices identified by the abovementioned projects. It also identifies some gaps related with these projects preventing them to reach their maximum potential in terms of impact.

## 1.1 Overview and Objectives

*T1.2 Impact and success factors analysis* deals with measuring the impact generated by European research projects from the business and technical point of view. This report focused on analysing the investments and activities done in terms of innovation, business development, dissemination, communication, standardisation and open source contributions by ICT-15 and ICT-40 projects, in order to identify gaps and barriers that should be bypassed for impact maximisation, as well as to identify their best practices and how they can be replicable by new funded projects.

## 1.2 Relation to other HUB4CLOUD activities

Results of this activity feeds T1.3, as a result of the identification of the most prominent innovation results from the running projects and the future challenges identified by ICT-15 and ICT-40 projects. Best practices and success stories are also used by T2.2 as part of the dissemination activities. Furthermore, this task also provides inputs to T3.2 and T3.3 in order to identify the most successful business models to be applied and the needed cloud computing skills that need further development.

## 1.3 Target audience

This report focuses on management boards of research projects, as impact is a transversal issue affecting managerial, technical, business and dissemination activities. It also tries to provide some recommendations that can be followed by other EU-funded projects in order to identify barriers from early steps while learning from past experiences from other projects. At the same time, it also provides best practices that can be adopted in order to maximise their impact.

## 1.4 Structure of the document

The document is structured as follows:

- **Section 1.** Contains the introduction of the report and what can be expected from it.
- **Section 2.** Presents a small overview of the methodology, already presented in D1.2, to easiest the readiness of the document.
- **Section 3.** Provides the results of the second interview and the analysis of the answers received.
- **Section 4.** Measures the impact of the projects based on a set of KPIs in terms of innovation, exploitation and overall impact.
- **Section 5.** Presents the analysis of the latest success stories and a set of recommendations about how them, and the ones already analysed in D1.2, can be replicated by other projects, as well as a set of recommendations for future work to help EU-funded projects to maximise their impact.
- **Section 6.** Provides the conclusions of the activities performed.

# 2 METHODOLOGY

This section presents a summary of the methodology already presented in D1.2 to ease the readability of the document.

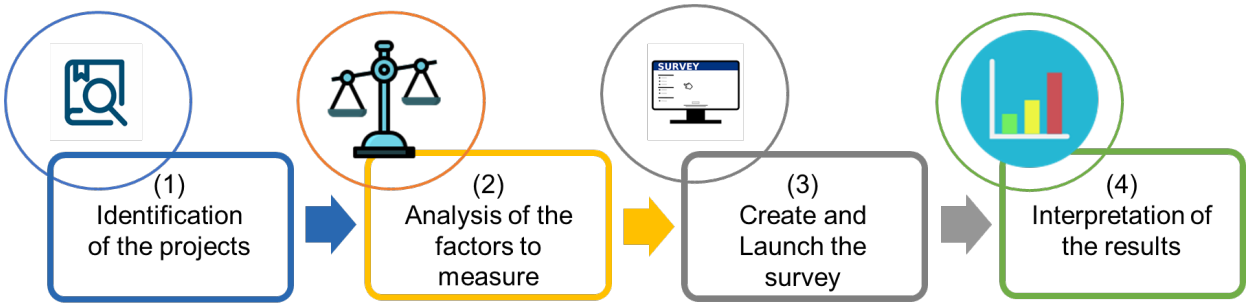



*Figure 1: Methodology for Impact Analysis*

As it can be seen in the figure above, Step 1 of the methodology relies on the preparation of the surveys in order to gather the needed feedback to perform the analysis.

On the other hand, Step 2 focuses on analysing the success stories provided by the different projects, identifying key factors that can be replicated in other projects. This work, combined with the results of the survey provides the inputs for eliciting a series of recommendations that can be followed by different projects, even at proposal preparation phase, in order to maximise the impact of their results.

# 3 HUB4CLOUD 2ND SURVEY

In order to gather additional feedback about ICT-15 and ICT-40 projects, a new survey was produced and made available. While the first survey focused on identifying success stories and replicability criteria, this second one focused on how projects are driving impact along their lifecycle and what they think they will need to maximise it.

The list of project participants in this iteration is as follows:

- ICT-15 projects:
  - PLEDGER [1]
  - RAINBOW [2]
- ICT-40 projects:
  - PHYSICS [3]
  - CHARITY [4]
  - AI-SPRINT [5]

This sample represents the status of projects at different stages, as ICT-15 projects are close to their end while ICT-40 projects are still in the middle of their lifespan. PLEDGER and RAINBOW projects also participated in the first iteration of this activity thus, it is possible to track the common progress of their activities. At the same time, a comparison between ICT-15 and ICT-40 projects, that started one year later, can be also established to identify how new projects are benefiting from lessons learned in previous ones.

Overall results of this survey are presented in the following subsection.

## 3.1 Survey analysis

This section analyses responses to the HUB4CLOUD survey, grouping them according to how they were presented in the online version.

### 3.1.1 General information


As it was presented in the previous section, there is a good balance between ICT-15 and ICT-40 projects that are at different stages of their lifespan.

In this way, it is possible to compare how projects progress according to their time plan, and even how starting later may have an impact on their overall progress.

*Figure 2: Maturity of surveyed projects*

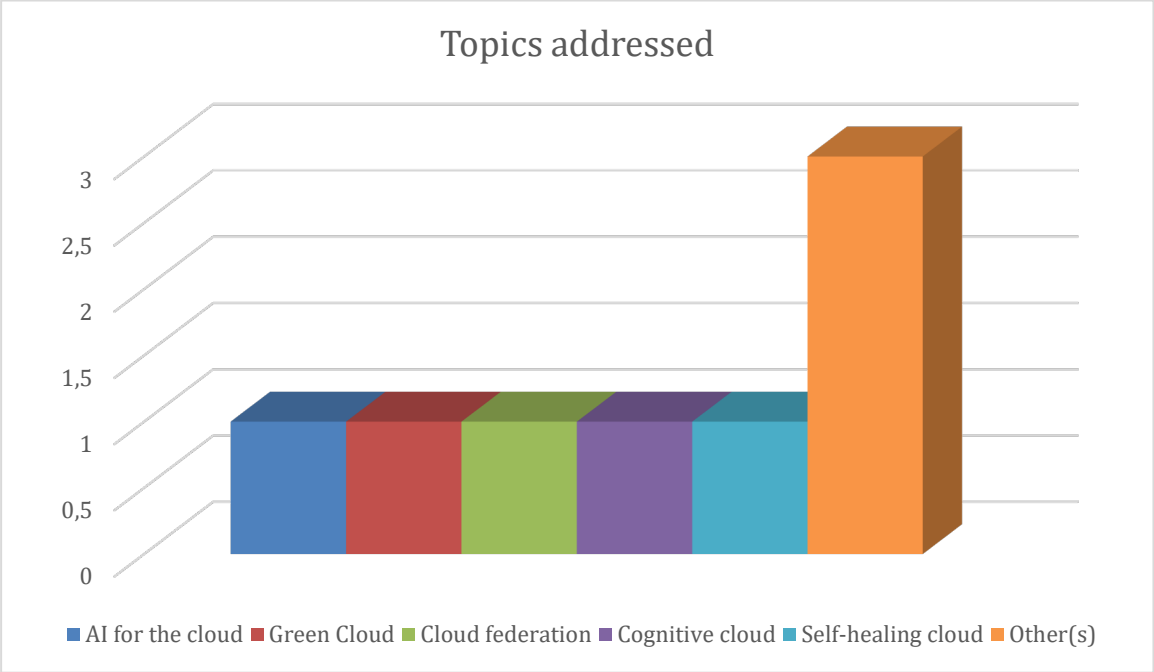



*Figure 3: General cloud/edge topics addressed*

As it can be seen in the figure above, projects are addressing very diverse topics, plus additional ones such as FaaS, fog computing or performance optimisation. However, these topics are very broad and many research domains or areas can fit in more than one of them. For this reason, projects were also consulted about the specific research domains they are addressing. The list of domains is as follows:

- Energy efficiency
- Orchestration, auto-scaling and placement
- QoS and QoE
- Network slicing
- Trust and security
- Automation
- Zero-touch configuration
- Resource management
- Data storage, processing and sharing

In this way it is easier to identify in which challenges there is still room for further research, as all of them are transversal to the topics identified by HUB4CLOUD, according to the EC strategy.

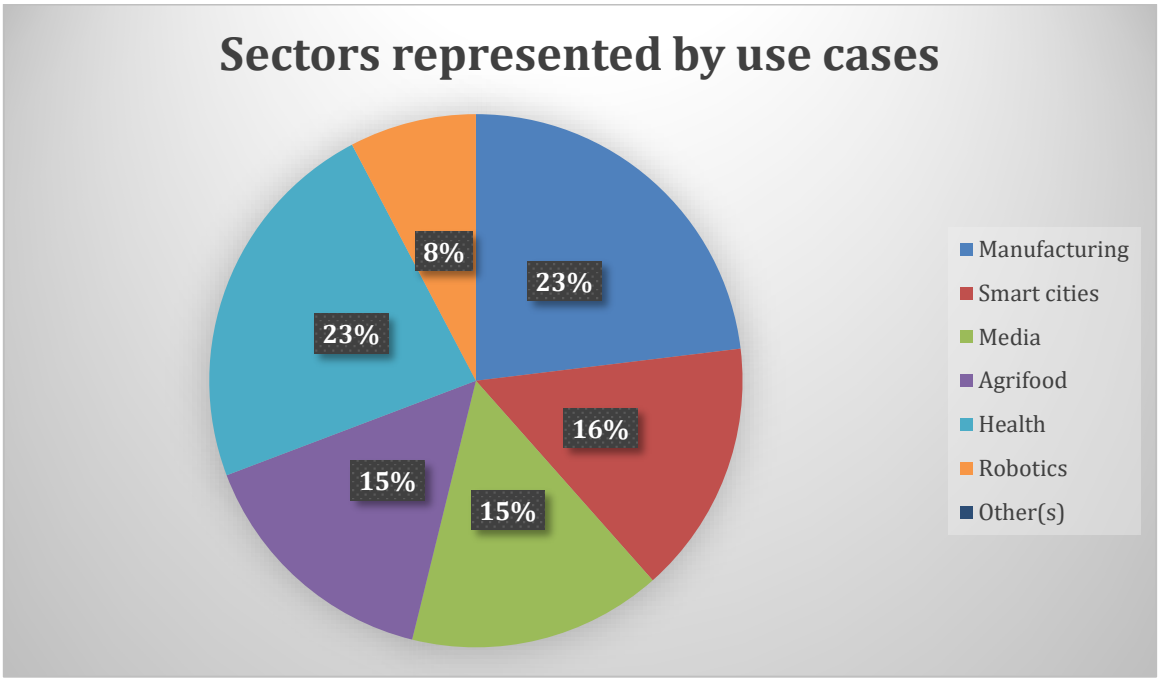



*Figure 4: Sectors represented by project use cases*

According to the survey answers, there is a great variety of vertical sectors represented in the projects. Apart from the most representative ones, identified by HUB4CLOUD, there are also others such as unmanned vehicles, aerospace or online gaming. All projects added an additional remark stating that although only these verticals were represented in the project, their solutions try to be agnostic of the domain and thus, they can be applied to whatever vertical is proposed making the needed adaptations.

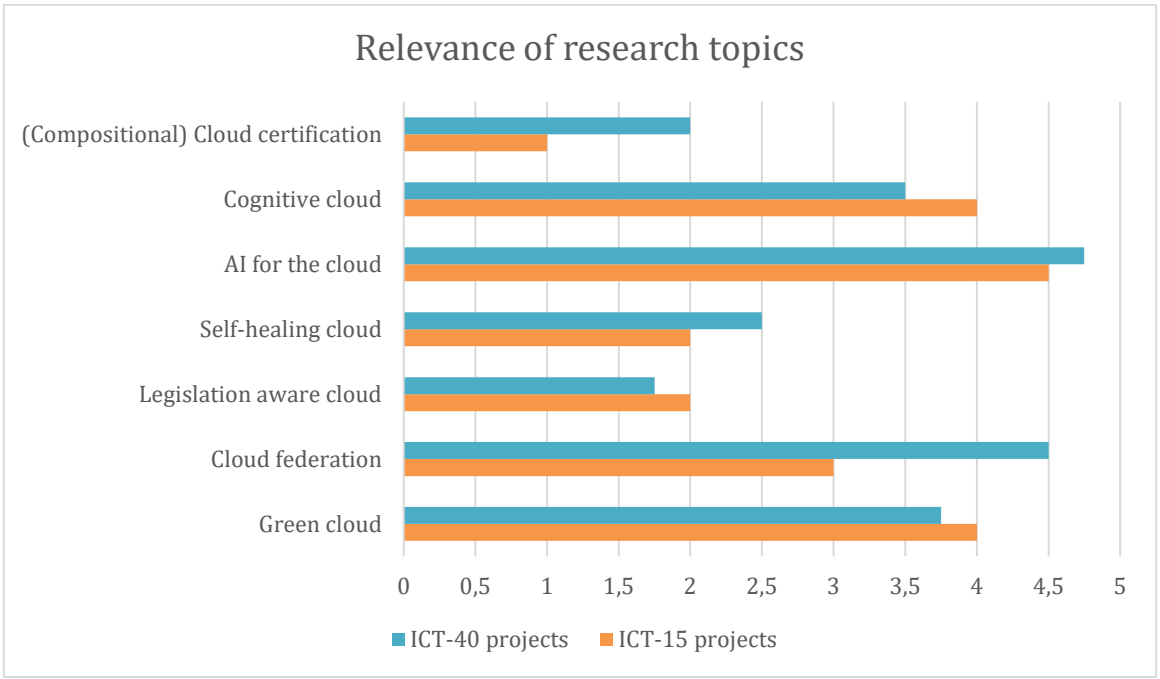



*Figure 5: Relevance of cloud/edge research topics*

Projects were also surveyed about the future relevance for seen for the cloud/edge research topics identified by HUB4CLOUD. As it can be seen in the figure, although the different nature of

the projects, responses are quite similar. However, as explained before, these topics are very broad. For this reason, the last question of this block is an open one where all participants could indicate with specific research domains they foresee as the promising ones in the near future. According to the answers, the list of research domains is as follows:

- Distributed AI
- Smart control planes
- Integrated data pipelines
- Energy-aware systems
- Trust and security
- Swarm computing
- XR services in cloud environments

### 3.1.2 Innovation

This section tries to analyse the innovation potential of the different project results according to the efforts invested in this activity. However, this is difficult to measure based on the different project structures, as some of them have a specific task for managing innovation while others not. Thus, as innovation affects to all project levels, from management to technical development and even exploitation of results, PM-efforts will not be accounted, instead of that, results, activities performed, and general knowledge will be taken into account for doing the assessment.

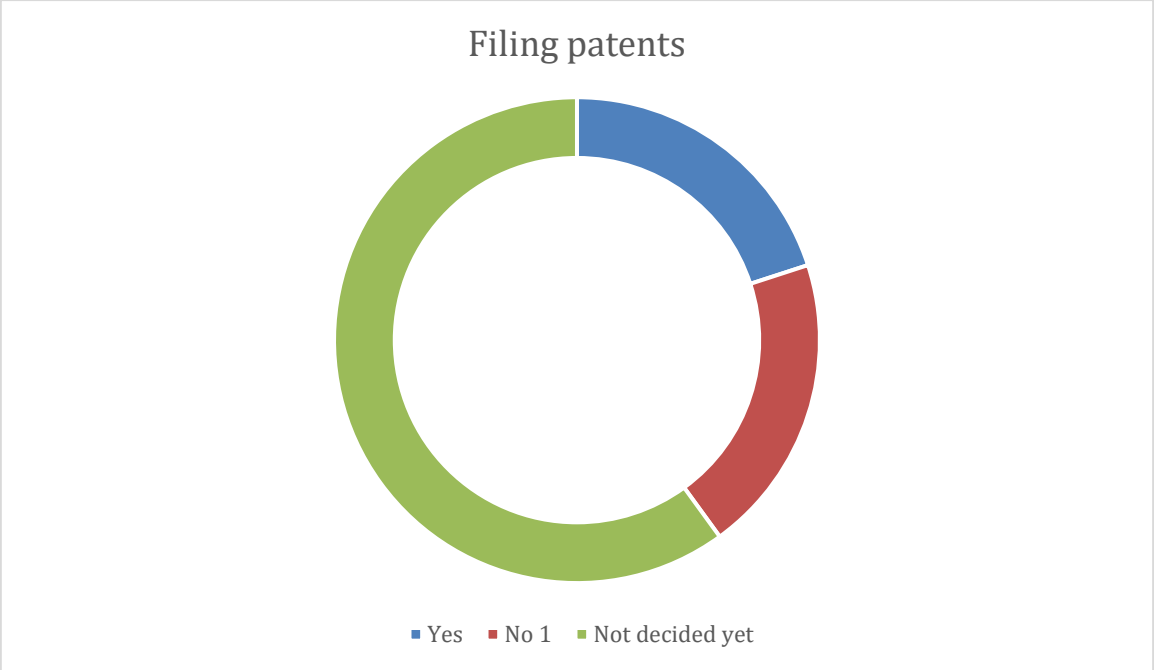
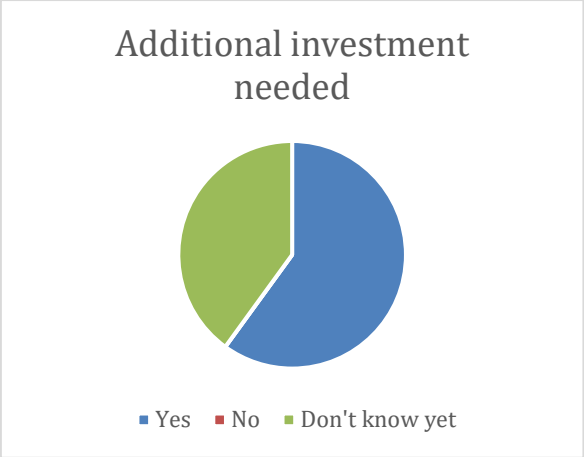



*Figure 6: Plans for filing a patent*

According to the answers to this question, only one project is thinking on filing a patent before the end of the project lifespan. But most of them have not decided yet if they will be able to do so or not. Taking into account that the majority of these project results is developed software, and that software is not patentable in Europe, sometimes is complicated for a project to identify whether something can be patented or not. At the same time, filing a patent is a long process for ending in a rejection.

Projects were also questioned about the overall TRL of their results in order to better assess when

they will be market ready. In this sense 3 out of 5 answered that their final TRL is between 6 and 7, while the rest considered that depending on the tool the current TRL is between 3 and 8. However, even those projects with the lowest TRL considered that their results will be market-ready in 1–3-year time.




As expected, based on the answers to the previous questions, those projects with a higher TRL that considered that will be market-ready in 1-3-year time will need further investments before reaching that state. According to their thoughts, it will be a combination of developing new functionalities in new research projects and internal investments from the owner organisations. In this way results will not be only market-ready but remain competitive in the changeable environment of cloud/edge computing market.

*Figure 7: Additional investment needed for being market-ready*

4 out of 5 projects consider that there is a clear market need for their project results although there is some competition, while the other project considers that there is no similar solution to the ones proposed by itself. Furthermore, all projects are willing to maintain results going on with more research activities or even incorporating them into their project portfolio (in the case of industrial partners).

In order to start creating awareness around project results before its end, 4 out of 5 projects already have an external stakeholders' engagement plan set in place, based mainly on dissemination and dedicated training activities. Most of the projects are not measuring yet the number of stakeholders reached and engaged through these activities.

Taking into account that start-ups are considered as innovative due to their nature, only one project has interacted with one while the rest do not have any involved in the consortium or are interacting with any of them mainly due to the associated costs to the software developed within the projects.

Regarding the technical assets developed within the project, only one project considered that at its end any potential end user will just need to plug and play its results for using it. The rest of the projects consider that results will need a few adaptations for being reusable in different contexts. The majority of this results are, or will be, released under an open source licensing scheme and code will be available through the project website or external public repositories, with the corresponding installation and usage guidelines.

Project use cases will be used not only to demonstrate the value of project results, but also to collect useful information for promoting them. In this sense, all use cases will be developed in real-world environments, or the closest possible, and specific metrics are measured so project benefits can be measured. Only one project considers that measuring these benefits is not useful for assessing the project impact.

Finally, all projects are developing 8 or more technical innovations as part of their results. And they consider that it will be useful to have some initial guidelines about how to better manage innovation to maximise their impact, increase the excellence, improve efficiency or reaching external stakeholders.

### 3.1.3 Exploitation and business development

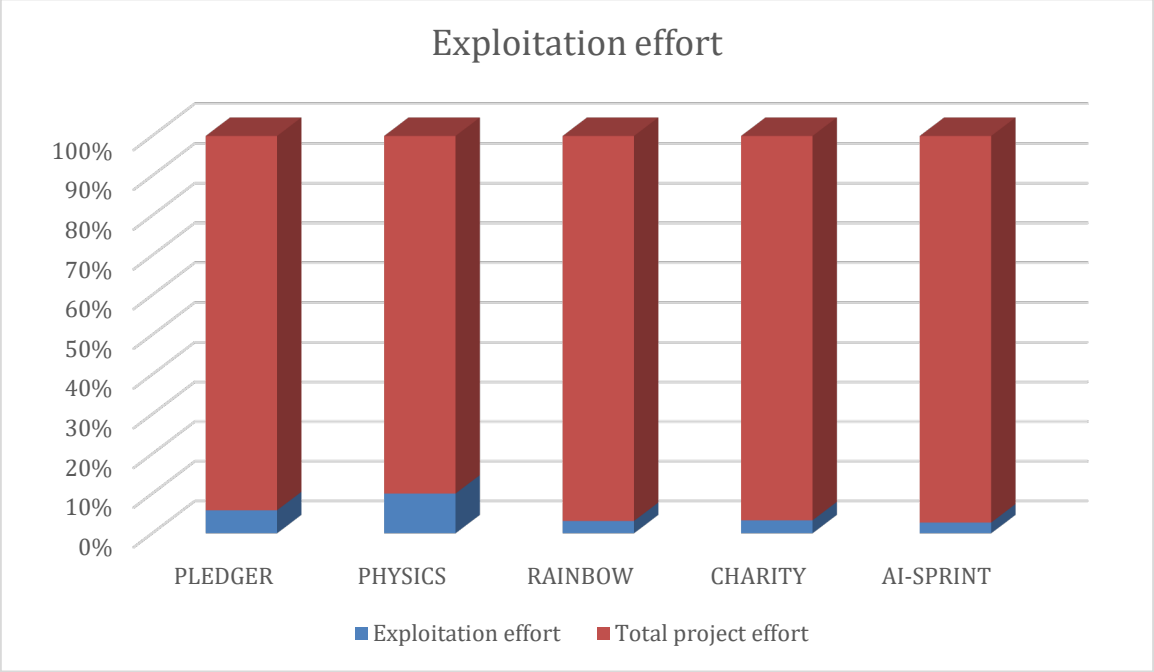



*Figure 8: Exploitation efforts compared to overall project effort*

As it can be seen in the figure above, in general projects dedicate very little effort to exploitation and business development activities compared with the amount of effort invested in the project. This will may impact in the quality of the activities performed.

The first activity performed in the context of exploitation is the development of the project value proposition. 4 out of 5 projects have a value proposition for the project in general and a few more for specific results. While one project only ha a generic value proposition. All of them are adapted to targeted stakeholders. However, all projects, except one, do not know the difference between a project value proposition and a typical cloud/edge value chain.

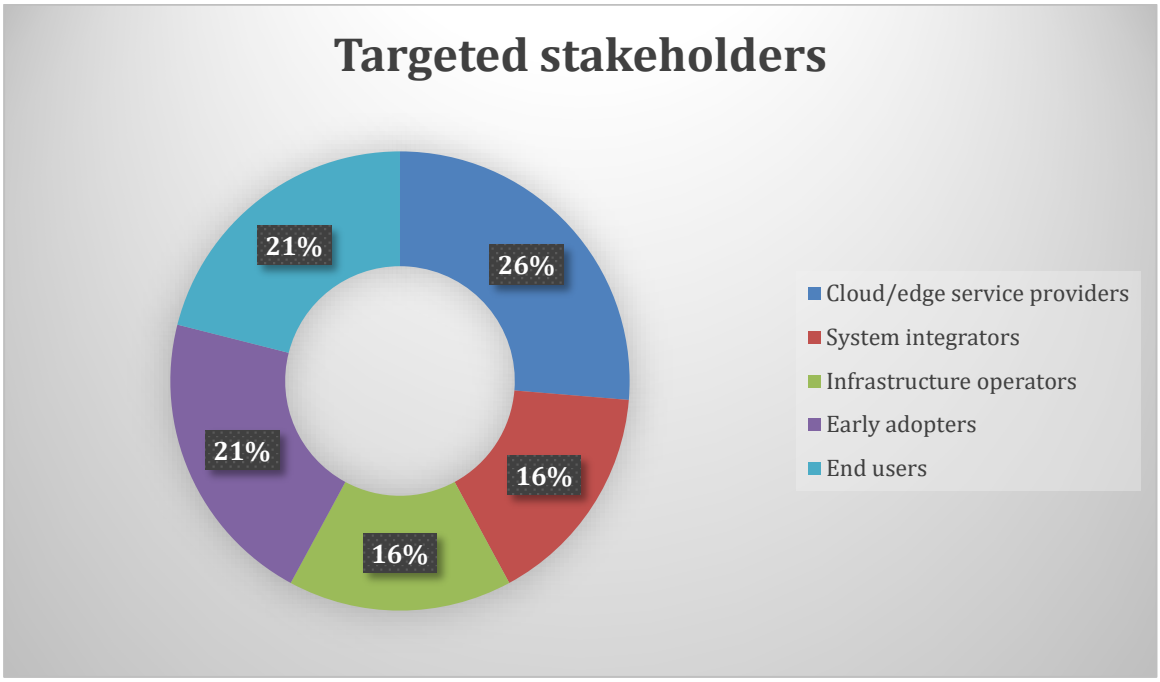



*Figure 9: Main targeted stakeholders*

According to project expectations, there is a balance between stakeholders coming from the supply and demand sides. This is mainly because projects can operate as providers for end users or transfer their results to other organizations acting as such.

At the same time, there are also some inconsistencies in the ICT-40 projects' answers to the survey that are limiting the analysis of results. As an example, one project stated that it has individual and joint exploitation plans. However, they are only performing market or competitor analysis for individual results but providing one single business model for the whole platform, while sustainability relies on individual partners' intentions. On the other hand, ICT-15 projects that are close to their end were able to provide more consistent answers.

With these inconsistencies in mind, ICT-40 projects consider that they do not have any difficulty implementing exploitation plans. While ICT-15 projects found some difficulties on developing a joint exploitation strategy given the different nature of consortium members.

Finally, 4 out of 5 projects will consider useful to have any guideline to follow or even a set of recommended tools or resources to be used along the project lifespan.

### 3.1.4 Impact

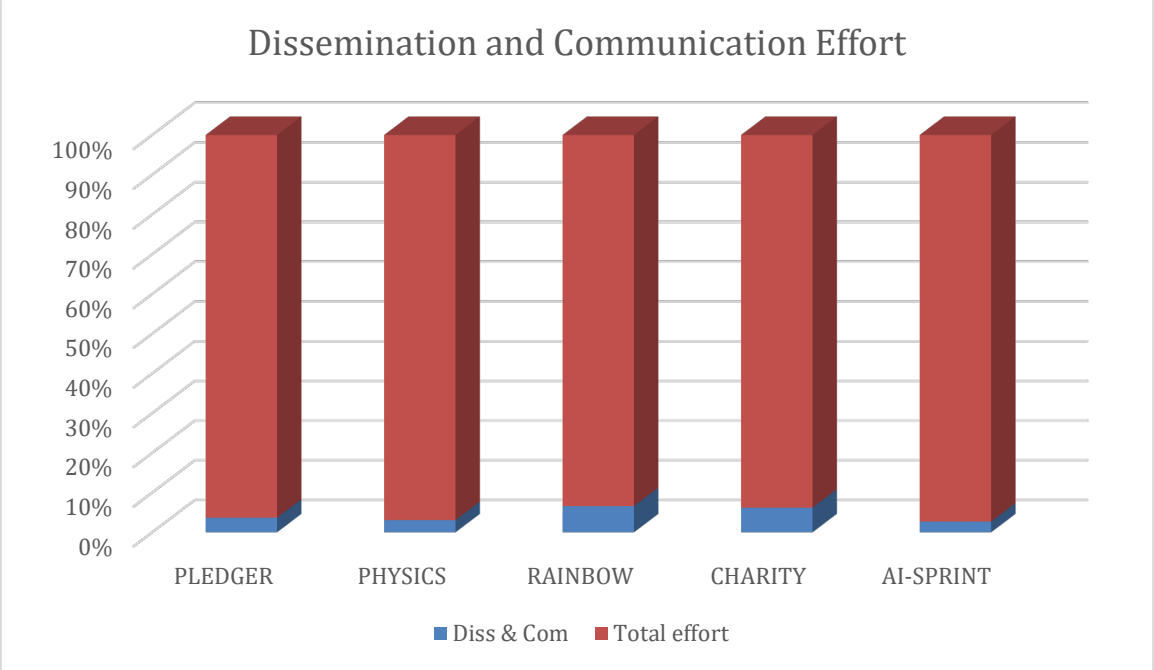



*Figure 10: Dissemination and Communication efforts compared with total project ones*

As it happens with the exploitation and business development activities, projects dedicate a small effort to dissemination and communication activities. However, all projects are very active in these activities.

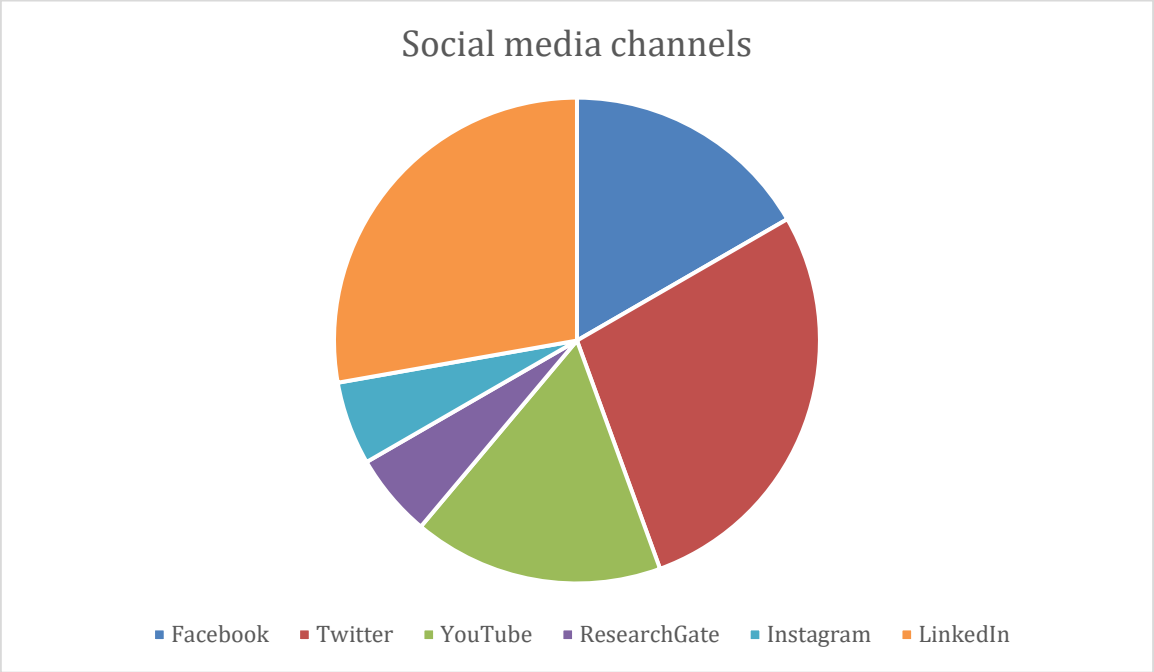



*Figure 11: Main social media channels used*

As expected, projects all projects are using Twitter, as it allows an easier interaction with other stakeholders through small and quick publications, and LinkedIn, as it is the preferred network for professional content. Some projects are also using their own YouTube channel for sharing videos and demos, and Facebook for publishing longer posts. ResearchGate is used by one project to share its publications. While Instagram is used as a novelty by one project. As expected, ICT-15 projects have more followers (around 1.000) in their social media channels, while ICT-40 projects are still growing (around 400). Although asked about, none of the projects is measuring its penetration rate, impact rate or engagement one.

In terms of scientific publications, the average is 12, including journals, magazines and conference papers. This means that, at least, the scientific impact of European projects is high. In line with this, projects also participated in several events to present results. Furthermore, all of them are involved in training activities for external stakeholders.

Regarding collaboration, all projects are collaborating with other research projects or related initiatives. But only two are extending these collaboration activities with open source communities or DIHs. Regarding any support activity for helping them maximising the impact of their efforts, only 3 projects considered that it will be useful to have any recommendation about activities to be performed or events to attend. From these three, only one considered useful to have any support reaching external stakeholders.

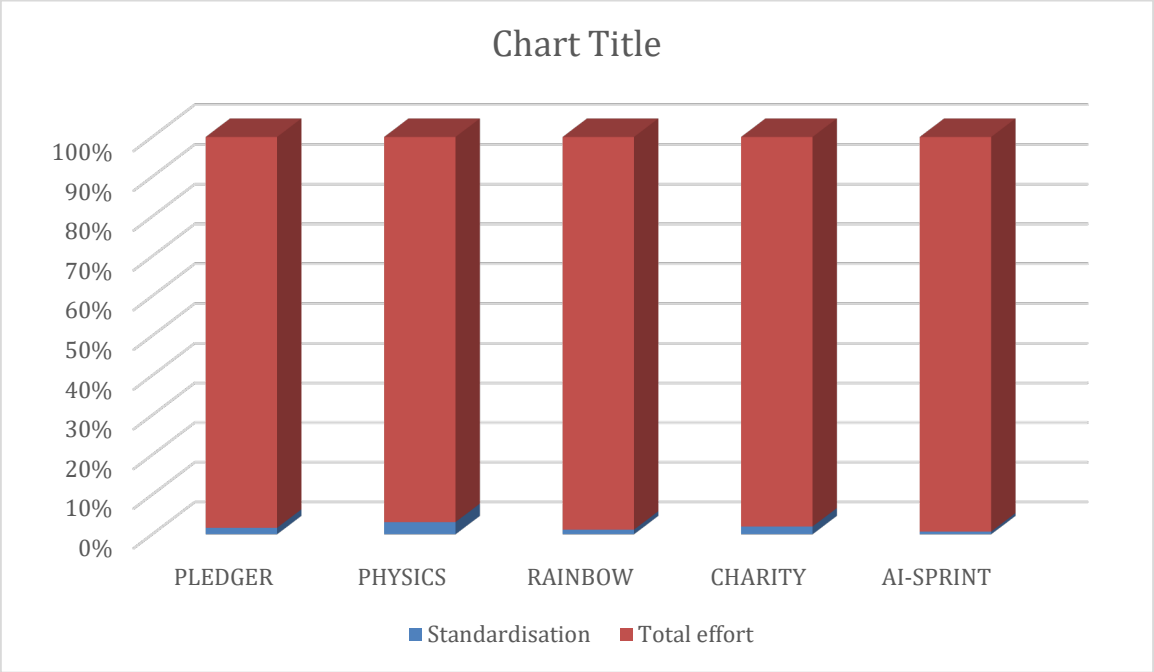



*Figure 12: Standardisation efforts compared with total project efforts*

Projects are investing very little efforts on standardisation activities, also reflected in their delivery: only 2 projects have a dedicated deliverable, 2 projects have a standardisation section in other deliverables and 1 project has nothing in its plan.

Surveyed projects are not adopting standards, however, they are using/following standardised de-facto edge-related tools, such as Prometheus [6], Kubernetes [7] or OpenWhisk [8]. This make sense as the most used cloud standards, such as OASIS TOSCA [9], cannot be extended to the edge.

In general terms, projects considered that it is not difficult to contribute to any de facto standard as they have some partners in the consortium already involved in related bodies.

Regarding open source, all projects are using any open source tool. And all of them considered impossible to perform the work they are doing without using any of them. At the same time, all of them are planning to release at least some of their tools under an open source licensing scheme, publishing them in a public repository, such as GitHub.

As for their plans to contribute to an open source community, as it happens with the standards, only projects who have a partner in the consortium that is member of an existing community are planning to do so.

Finally, all projects will consider to have some recommendations and guidelines for contributing to standards or open source communities before the start of the project, beyond involving a representative of a community as a consortium member.

# 4 IMPACT ASSESSMENT

This section analyses the impact of ICT-15 and ICT-40 projects in terms of innovation, exploitation and overall impact (mainly dissemination, communication, standardisation and open source activities).

This analysis will also help to identify gaps and barriers that will be used to develop further recommendations for future projects.

| INNOVATION | |
|---|---|
| **Patents** | Only one project is aiming to file a patent, while others still have not thought about it yet. Patents are not only a mean to protect intellectual property, but a way to demonstrate the innovations developed by a project. However, filing a patent is a long process, which requires a lot of effort, and many organizations do not have the resources, nor the knowledge needed to do so. |
| **Capital investment** | Most of the projects, except one, considered that their results only need a few adaptations to be adopted by other organizations. However, when talking about TRLs, results will not be market-ready unless further investments are done. In their sustainability plans projects relied more on individual actions rather than on joint ones. |
| **Market potential** | Projects foresee a huge market potential for their results, however, not all of them are analysing either the current market context or their competitors. Thus, it makes really difficult for them to develop an appropriate go-to-market strategy or even properly estimating the ideal time-to-market. |
| **Start-ups involvement** | Only one project is involving start-ups in its activities. Although their innovative concept, this type of companies is already starting their business activities, thus, they are not really consolidated in the market. Pandemics has highlighted the volatility of the market and how they can easily disappear or rise. Thus, it is a high risk to involve any of them in a consortium. Also, they are not an easy target for commercializing project results. |
| **Partners commitment** | Surveyed projects considered that partners are willing to maintain project results based on their individual exploitation plans. However, it is not clear, according to their sustainability plans, what will happen with the project as a whole. Ideally this consideration should be also included as the core of the joint exploitation plan in order to be more focused on real situations. |
| **End-user engagement** | Although most of the projects already have and end user engagement plan, projects are in contact with external stakeholders mainly from the scientific community. In terms on early adopters, they can get valuable feedback from the involved pilots. However, all of them considered that it will be useful to have some recommendations about how to reach end users, which is the basic step to be performed before thinking on engagement. |
| **Number of reusable assets** | Most of the projects considered that their assets will be reusable with a few adaptations, while only one considered it as a plug-and-play matter. Also, the majority of the results will be released under an open source licensing scheme. This is in line with their exploitation plan, mainly based on individual intentions. |

| | |
|---|---|
| **Pilots in real action** | All of the projects surveyed are deploying real-world pilots, or the closest to it, in their use cases. This will help them dealing with requirements that can be found when reaching other organizations for commercialising results. |
| **EXPLOITATION** | |
| **Value proposition** | All projects have a value proposition, some of them for the project in general, other ones for specific assets while others for both of them. However, this does not always match their exploitation plans what is limiting them. Also, from the surveyed projects only one knows the difference between the value proposition, or the message to be transmitted to a specific stakeholder, and the value chain, or the actors and actions to be undertaken. Thus, their exploitation seems to be weak in terms of actors' identification and offering to be developed. |
| **Market/competitors' analysis** | Not all the projects have performed a market analysis or a competitors' analysis. This is in line with those projects with a majority of academic partners in the consortium. However, even academia must remain competitive when developing innovations. Thus, it is directly opposite to their previous affirmation of having a huge market potential as they are dealing with an unknown market. |
| **Business models** | Some projects have a business model for the whole platform, others have business models for specific assets and others have them for both the platform and specific assets. Again, it is not aligned with what they have expressed in their exploitation plans. Thus, the strategy identified by them seems not to be the most appropriate one. |
| **Sustainability plan** | Projects considered that partners are willing to maintain their own results according to individual exploitation plans. However, in terms of sustainability it is not well defined. At the same time, the plan itself does not match with the exploitation one, so it becomes a little bit disconnected. |
| **IMPACT** | |
| **Social networks** | All projects are active in social media channels, maintaining two or more, and publishing not only pieces of news but also videos, reports or other publications. Most of them are also measuring the number of followers, visits or views but not the engagement rate due to the lack of knowledge on marketing activities. |
| **Publications** | Projects are very active in terms of publications, from conference papers, journals and magazines to newsletters or blogposts. Thus, using many different channels to reach a wider audience. |
| **Contribution to standards** | In terms of standards, projects are not actively contributing to them. This can be due to the reason that most of them are focusing on edge computing, where there is a jungle of standards, or the lack of partners involved in active groups. However, they are more active on de-facto standards due to the technologies that they are using or the openness of these bodies. |
| **Contribution to Open Source communities** | Some of the projects are contributing to specific projects in some open source communities. This is directly linked with the previous KPI. |

*Table 1 : Impact assessment KPIs*

# 5 SUCCESS STORIES AND BEST PRACTICES

This section analyses the second round of success stories identified by ICT-15 and ICT-40 projects. At this time, only one project considers that have something useful enough to be shared.

Also, according to the KPIs identified in D1.2, some recommendations about how to replicate a success story are provided.

## 5.1 Analysis of success stories

**Analysis of RAINBOW success story**

- One new solution developed, tested in tree real-world environments.
- The solution has received a best paper and a best demo award.
- Everything was developed with the available resources.
- Market and technological needs are identified, tested within the use cases, and covered as demonstrated in them.
- Nonexternal users were involved as part of this activity
- The solution has market potential as analysed by the consortium.

**Overall findings**

- Although the project seems to have results with a meaningful impact, as demonstrated with the awards received, there is still more work to do in order to attract and engage external stakeholders who will pay for using it.
- The platform is owned by several partners, but there is no description about how they plan to proceed once the project lifespan has ended.

## 5.2 Innovation radar applied to success stories

Based on the analysis of success stories, provided in D1.2 and in the previous sections, and the answers to the different surveys. A lighter version of the Innovation Radar [10] provided by the European Commission has been applied to the different projects in order to identify their potential.

**ACCORDION Innovation Radar results**

According to the information provided by the project, it seems to have a good balance between the innovation readiness and management, and the market potential. This means that the maturity of the solution, although not market-ready, is enough so it has gathered interest outside the consortium and it is shared with others so it can be easily adopted.

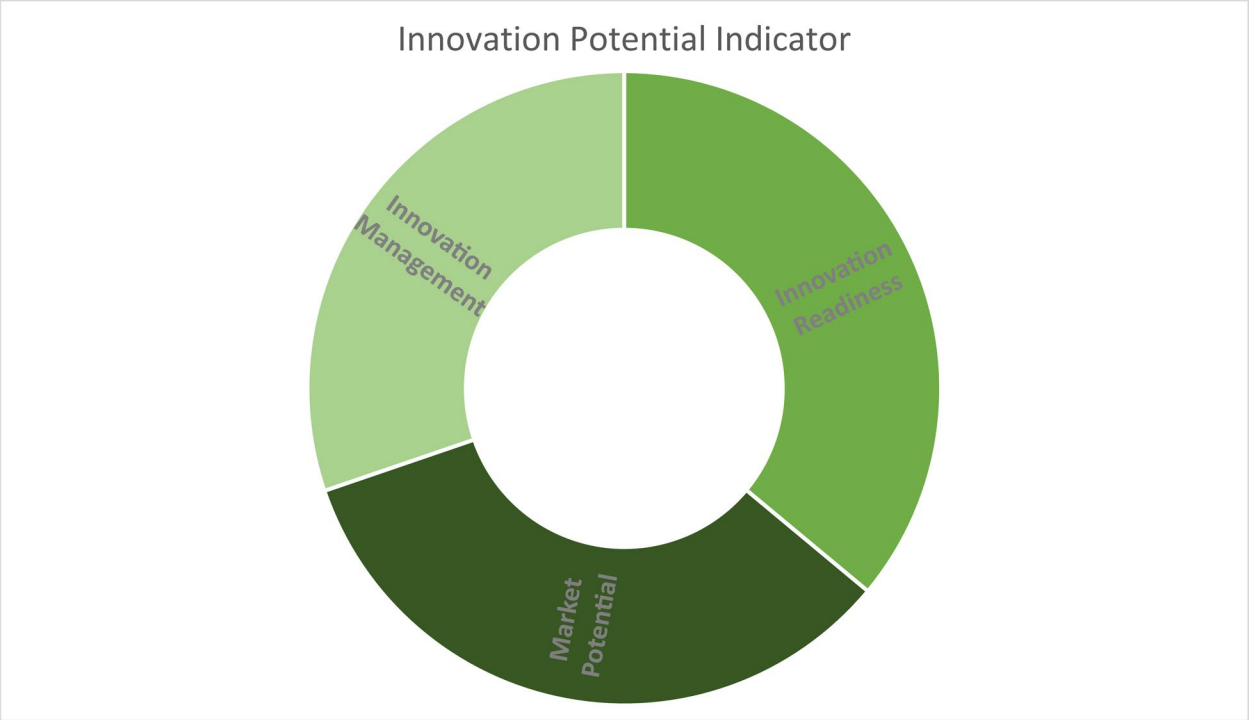



*Figure 13: Innovation potential of the ACCORDION success story*

On the other hand, the innovation capacity is quite high as the results were developed with the consortium resources. Again, although the final TRL is not too high and it will need further investments, this success story does not measure the commercialisation potential but how it was considered as a contribution to an existing open source community.

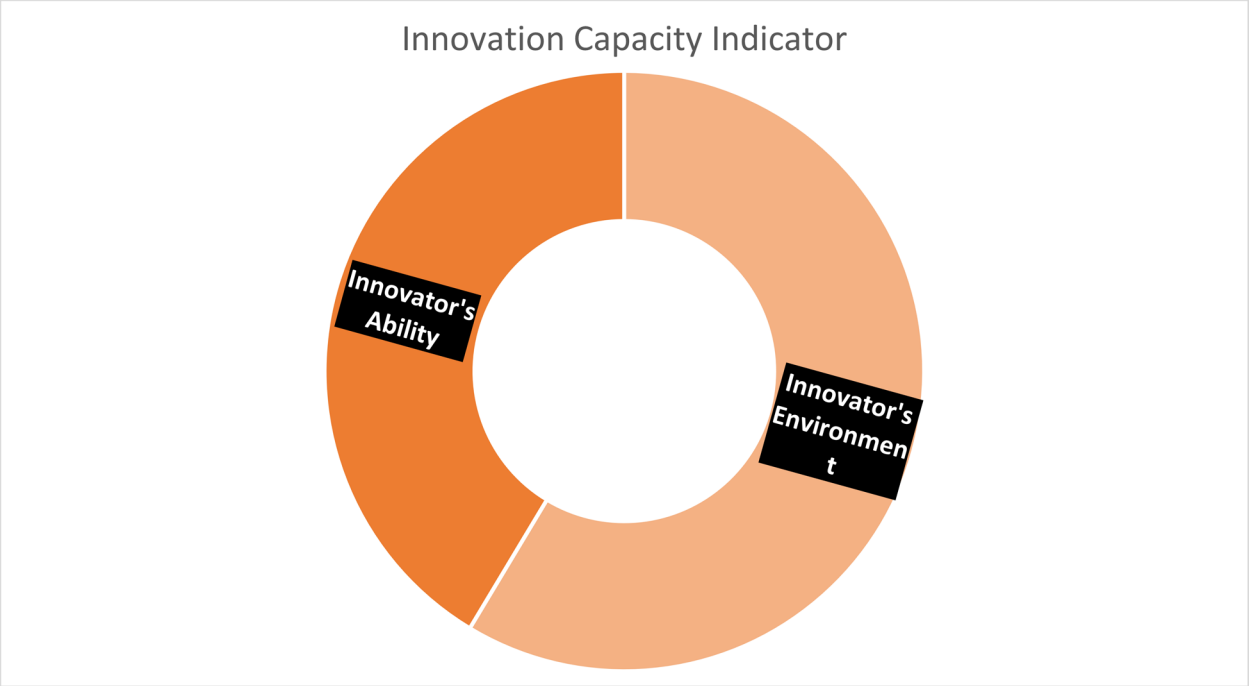



*Figure 14: Innovation capacity of the ACCORDION success story*

Finally, the overall assessment concludes that the potential on this result mainly relies on the partner(s) who is providing it as it cannot be considered as a market-ready solution.

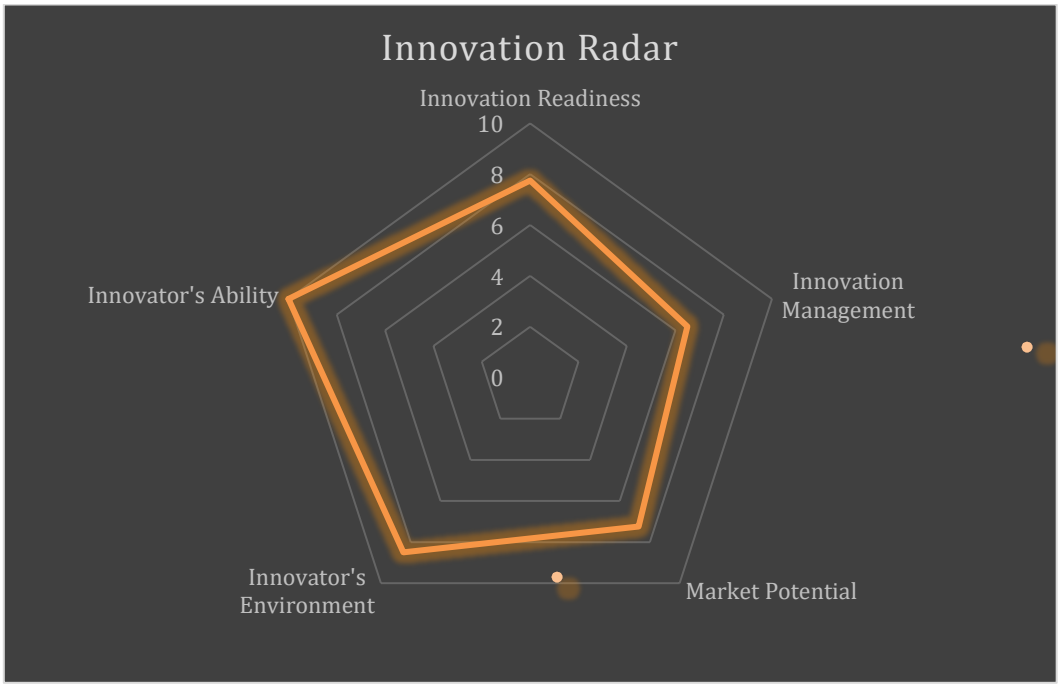



*Figure 15: Innovation Radar of the ACCORDION success story*

**SODALITE Innovation Radar results**

Regarding SODALITE success story the innovation readiness is a little bit higher, as one of the solutions has been already by a municipality. And, although it cannot be replicated because it belongs to an use case, it cannot be developed with the support of the SODALITE project.

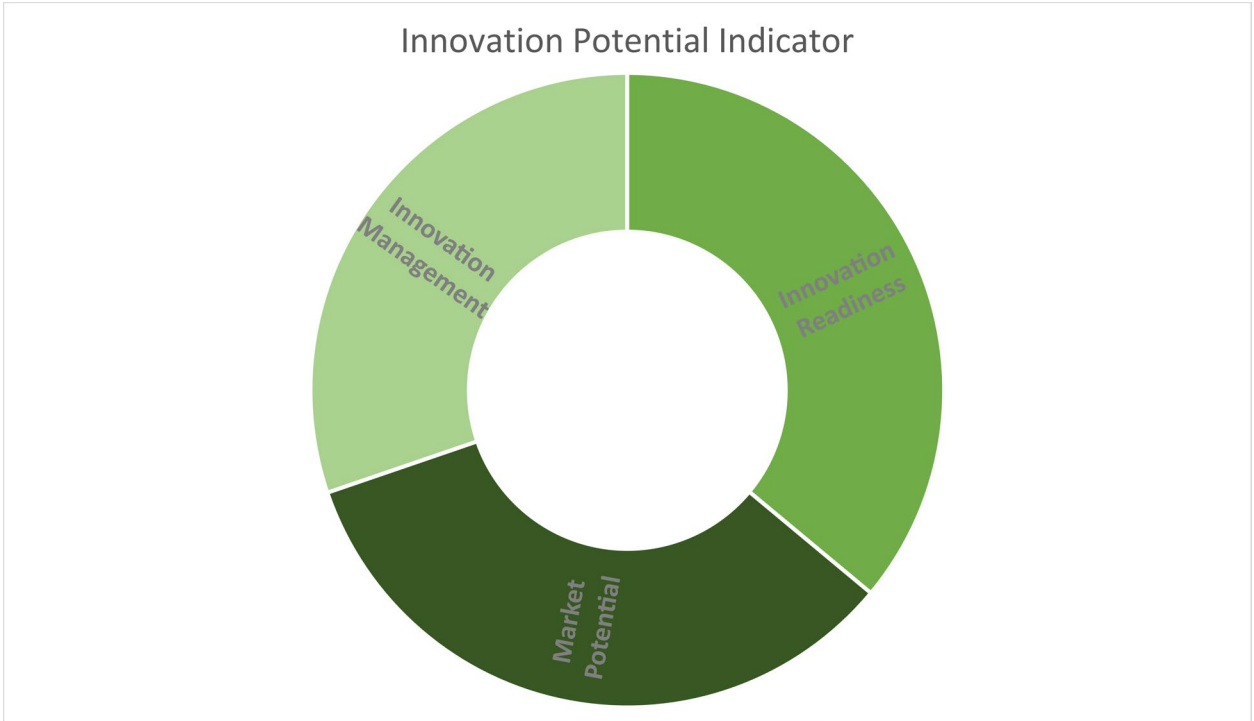



*Figure 16: Innovation potential of the SODALITE success story*

Regarding the innovation capacity, the innovator's environment is higher as there is, at least, one partner fully committed to support the solution once the project has ended.

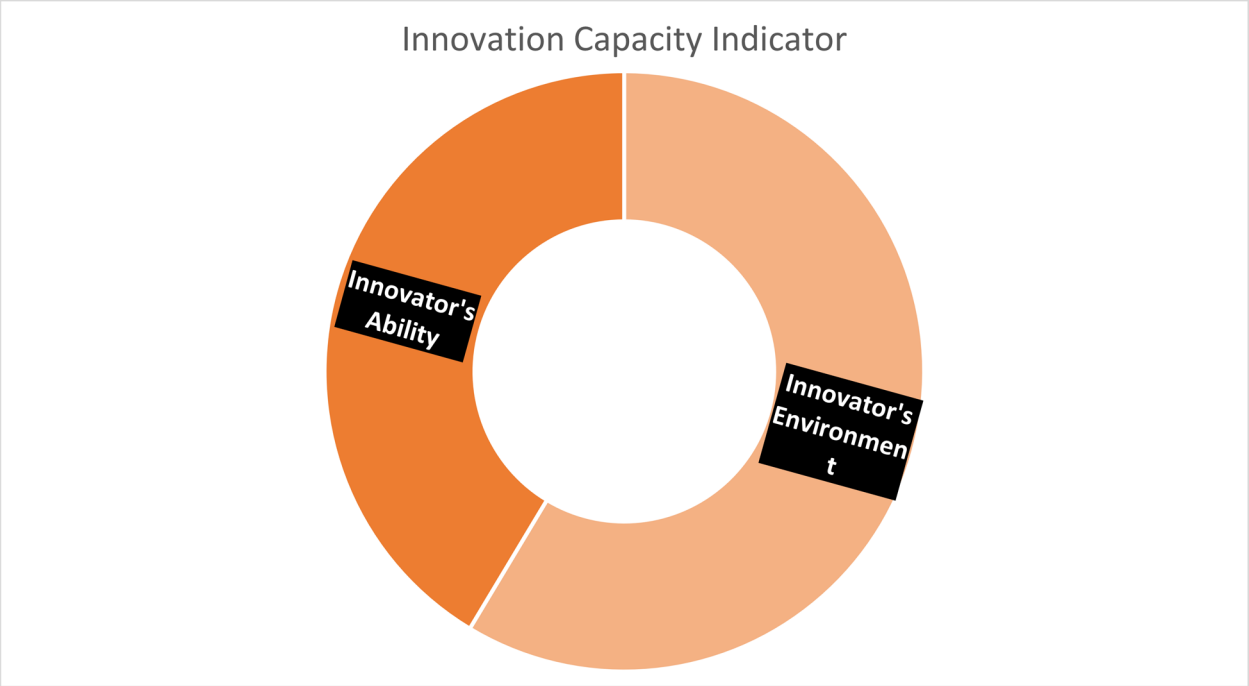



*Figure 17: Innovation capacity of the SODALITE success story*

Finally, as a conclusion, SODALITE results have a great potential as it has been demonstrated that it can be applied, and used by external stakeholders, in a real-world environment.

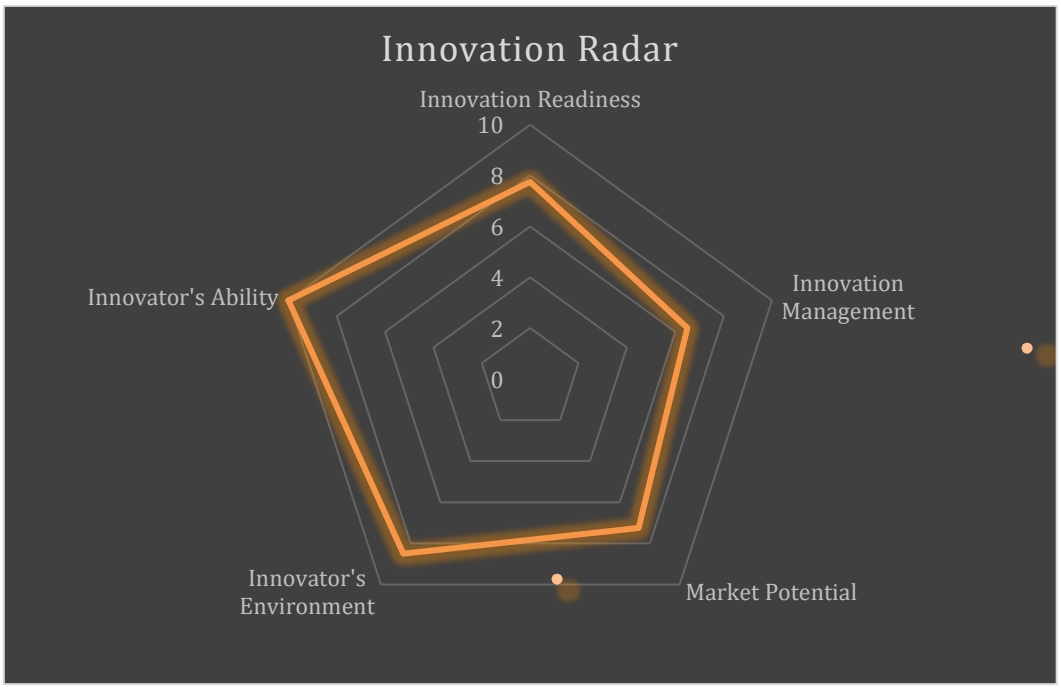



*Figure 18: Innovation Radar of the SODALITE success story*

**PLEDGER Innovation Radar results**

For the PLEDGER success story, the innovation management is bigger than the other two as the partners involved are willing to commercialise services on top of the solution or already use them, as planned before the end of the project.

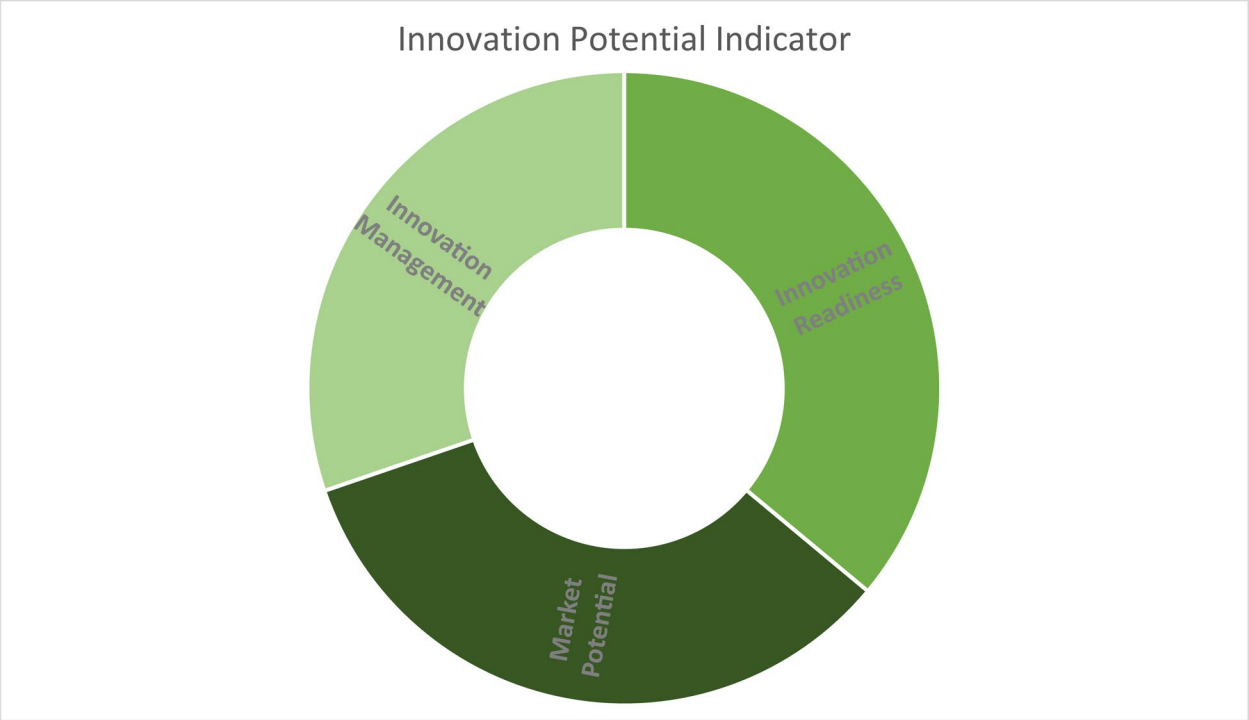



*Figure 19: Innovation potential of the PLEDGER success story*

Regarding the innovation capacity of the success story, as in the case of SODALITE one, it relies on the environment as the partners involved are willing to continue investing on the solution even after the granted period.

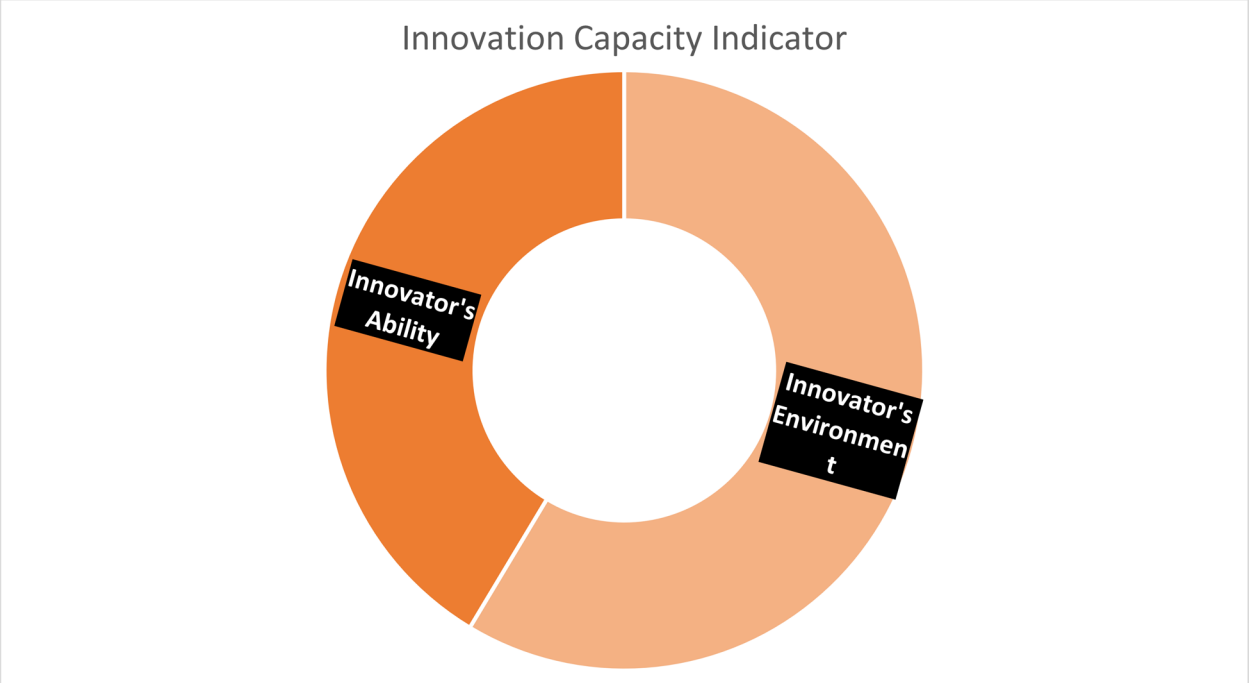



*Figure 20: Innovation potential of the PLEDGER success story*

Compared with SODALITE, the overall score is lower as the project was still running by the time the success story was provided. However, it shows a great potential in terms of reaching the market.

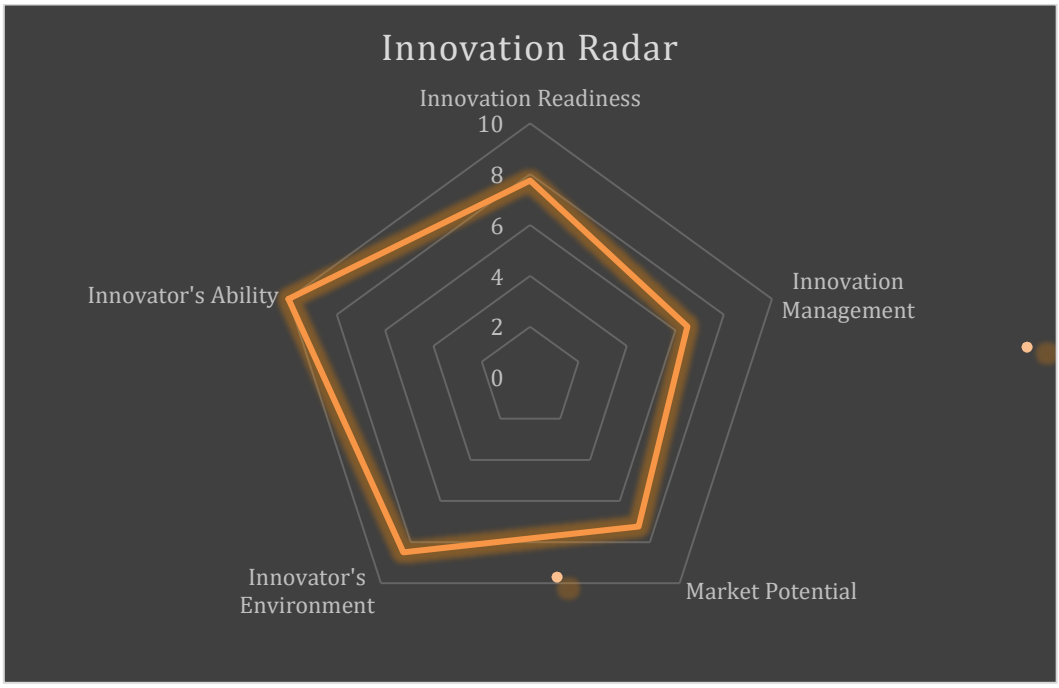



*Figure 21: Innovation Radar of the PLEDGER success story*

**RAINBOW Innovation Radar results**

The indicators of the innovation potential of the RAINBOW success story are very similar, as the solution has demonstrated that it has a good market potential and that the partners are willing to maintain results.

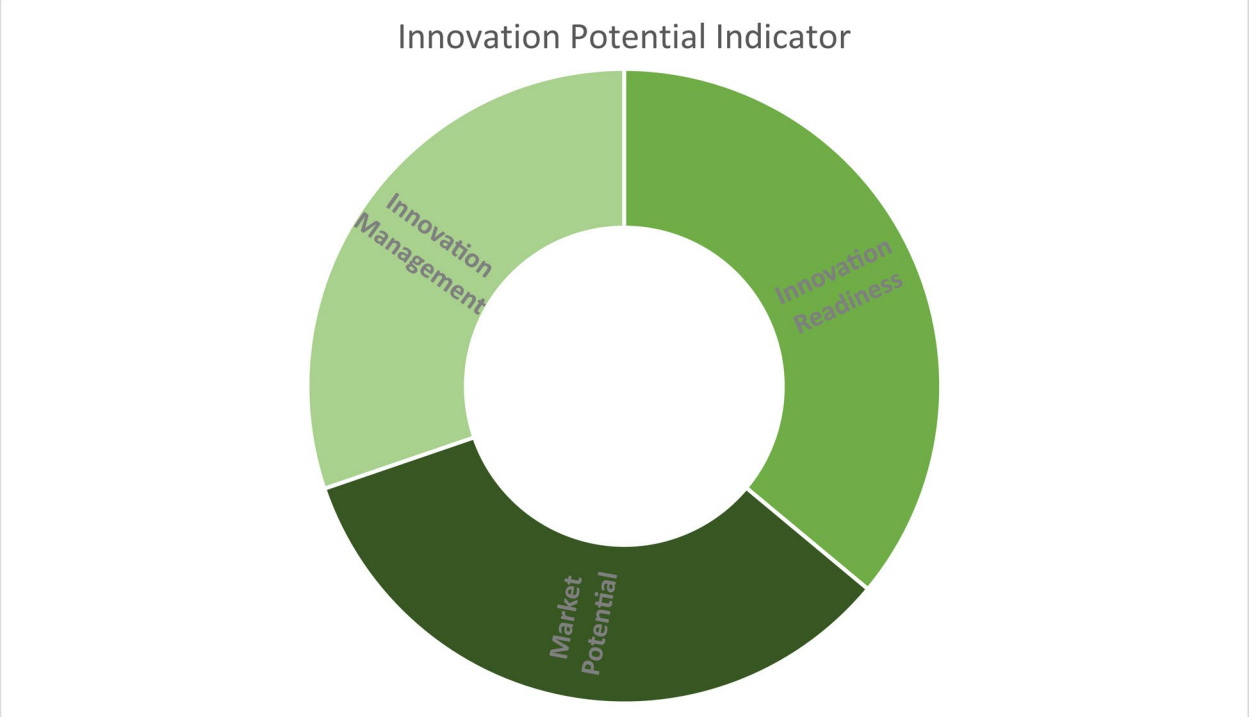



*Figure 22: Innovation potential of the RAINBOW success story*

As it happens with other success stories, RAINBOW success story has a market that demands this kind of solutions and that it is potentially willing to adopt them.

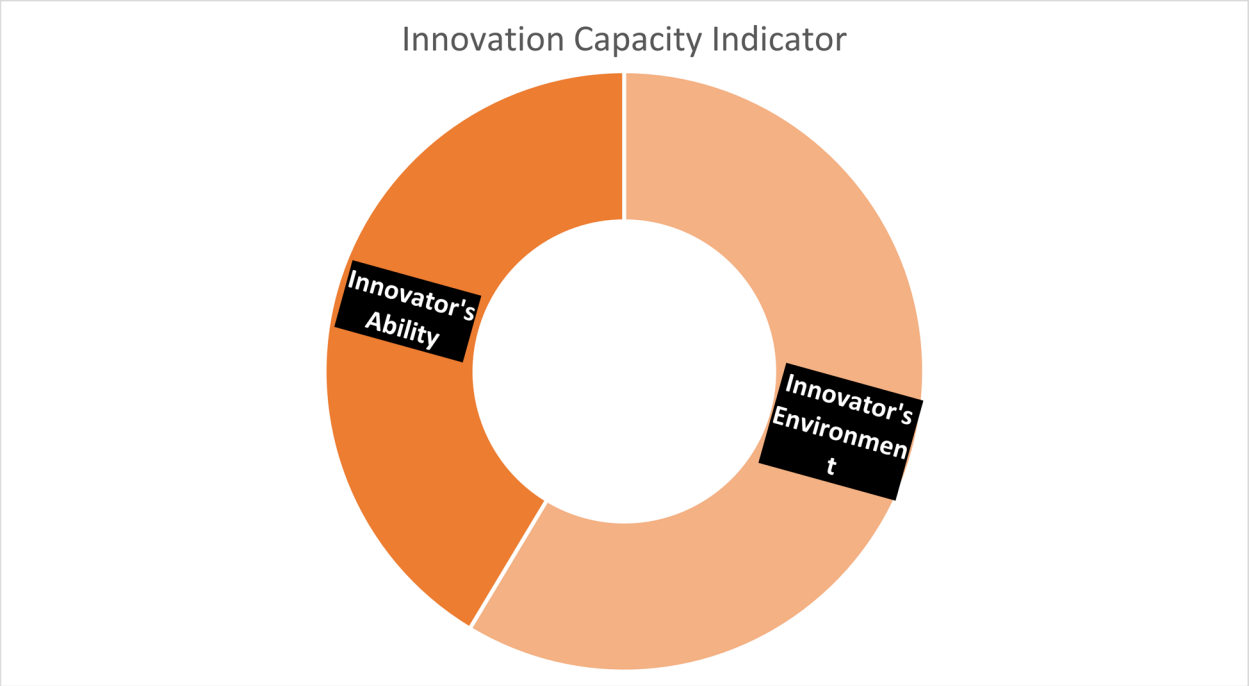



*Figure 23: Innovation capacity of the RAINBOW success story*

For the overall assessment, the success story is expected to have a significant market impact as long as the different partners involved in the exploitation invest the needed efforts for bringing it into the market.

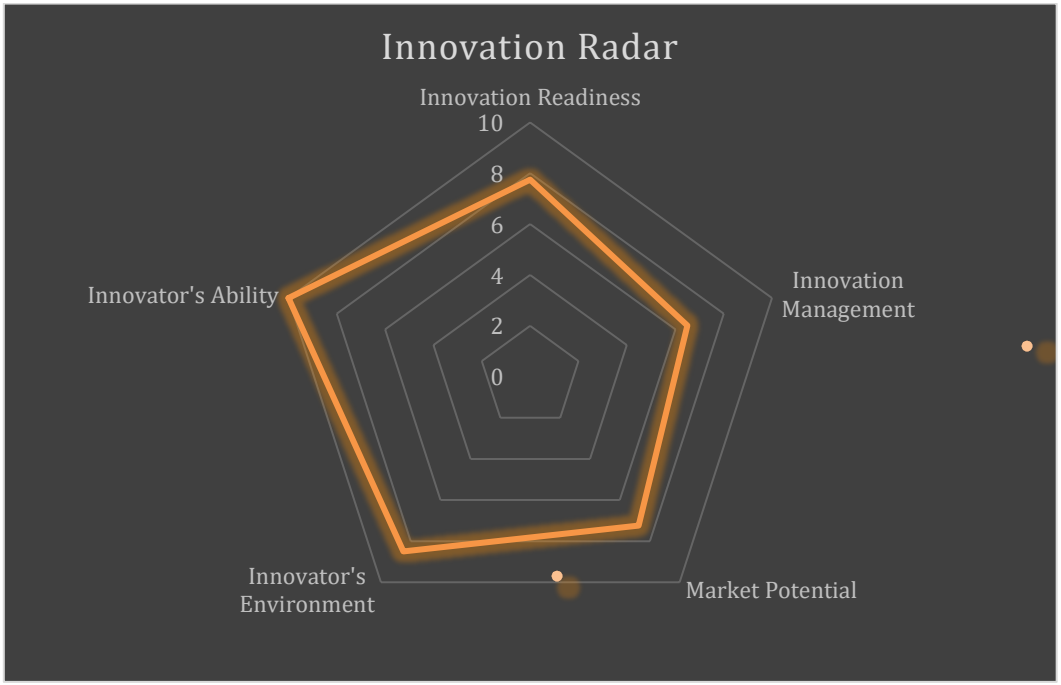



*Figure 24: Innovation Radar of the RAINBOW success story*

## 5.3 Replicability of success stories and best practices

According to the criteria for evaluating success stories presented in D1.2, and listed again here for the sake of clarity, each of them will be analysed to identify if it can be replicable and/or what else is missing.

| Criterion | Description |
|---|---|
| Effectiveness | Results of the activity must be measurable. |
| Efficiency | The activity must be carried out with a reasonable number of resources and time. |
| Relevance | The activity is solving a real need. |
| Sustainability | The activity can be performed with the available resources. |
| Replicability | The activity can be replicable by any other project. |
| Stakeholders' involvement | The activity involved different actors in the value chain. |

*Table 2 : Success stories KPIs*

**Replicability of ACCORDION success story**

| Criterion | Description |
|---|---|
| Effectiveness | The project has developed new technical components for resource management at the edge that can be used as a contribution to an external community. |
| Efficiency | The developments were developed within the project lifespan and with the available resources. |
| Relevance | The functionalities are covering a need of a project from an open source community who has not developed them. |
| Sustainability | It was performed with the available resources. |
| Replicability | Other projects can perform technical components on top of existing solutions and try to contribute to the community owning them. |
| Stakeholders' involvement | It involves an external community, who evaluated the contribution and accepted it. |

*Table 3 : Assessment of ACCORDION success story*

As most of the ICT-15 and ICT-40 are using almost standardised open source tools, any of them can develop additional functionalities on top of them and try to contribute to the community owning them. However, it is difficult contributing to an external open source community if none of the partners is involved in them.

**Replicability of SODALITE success story**

| Criterion | Description |
|---|---|
| Effectiveness | The project has developed new applications for end users. |
| Efficiency | They were developed within the project lifespan and with the available resources. |
| Relevance | As part of the use cases, the applications are solving real needs. |
| Sustainability | It was performed with the available resources. |
| Replicability | All projects are developing applications within their use cases. |
| Stakeholders' involvement | The actors involved are part of the consortium |

*Table 4 : Assessment of SODALITE success story*

All projects are developing applications for their use cases in order to demonstrate the viability of their proposed solution. This success story highlights the need of carefully selecting use cases for having a real impact in the market.

**Replicability of PLEDGER success story**

| Criterion | Description |
|---|---|
| Effectiveness | The project has developed two new applications that will be further used after the project lifespan. |
| Efficiency | The work was carried out within the project lifespan and with the available resources. |
| Relevance | The applications are solving real needs of the end users that aims to build business on top of them. One even plans to patent results. |
| Sustainability | It was developed with the project resources. |
| Replicability | All projects are developing applications for their use cases. |
| Stakeholders' involvement | As for the time the success story was provided, it only involves members of the consortium. However, it was planned to involve external stakeholders such as customers or citizens. |

*Table 5 : Assessment of PLEDGER success story*

Regarding the replicability of successful applications, it is a similar to what happens with SODALITE success story. As for the patent, it is important that partners are informed from the beginning about the possibilities for doing so. Thus, an IPR task is needed to support them.

**Replicability of RAINBOW success story**

| Criterion | Description |
|---|---|
| Effectiveness | The project has developed one platform. |
| Efficiency | The platform was developed within the project lifespan and with the available resources. |
| Relevance | The platform is covering a real market need. |
| Sustainability | It was developed within the project resources. |
| Replicability | All projects are developing platforms solving end user needs. |
| Stakeholders' involvement | Only members of the consortium are involved. |

*Table 6 : Assessment of RAINBOW success story*

Although all projects are developing results that are covering market needs, and demonstrating how through the project use cases, this is just one step before generating a significant market impact with end users adopting solutions.

## 5.4 Recommendations for future work

From the information provided by the surveyed projects and those ones providing a success story, some recommendations were elicited for maximising project impact. The summary is as follows:

- From the proposal phase it is important to carefully select the consortium as it has been demonstrated that it is difficult to contribute to a standard or a project owned by an open source community. If planned to do so, at least one member belonging to any of these bodies must be included in the consortium and a dedicated task should be listed as part

of the project activities to ensure the resources needed for carrying it out.

- All impact-related activities, such as exploitation, dissemination or standardisation must have a significant weight in the project efforts as they must be carried out on a professional way.
- In order to have a significant impact, partners in charge of these activities must be selected based on their experience and know-how. Also, all partners must be aware that they must contribute to all these activities, e.g., exploitation is also for academic partners and innovation is transversal to all project activities.
- More efforts must be invested on non-scientific dissemination, not only in industrial events, but also in any other media that will support reaching the widest audience.
- More time and effort should be dedicated to exploitation, following basic guidelines about the steps to be performed at different project stages and decide from early stages the offering so the exploitation strategy can be adapted to each specific project needs.
- External stakeholders should be involved from the beginning of the project in order to gather feedback that can be used to improve project results, but also to create a community of interest about these results.
- Liaisons with external initiatives, such as GAIA-X, BDVA, EOSC or any DIH is strongly recommended to support dissemination, but also for sustainability issues.
- Consider that a real success story starts after the end of the project, e.g., with further commercialisation of project results.
- Provide training activities as a mean of disseminating project results.
- Organise more interactive workshops, including hand-on sessions or even hackathons among others, to identify weakness or innovations not initially contemplated.
- Use the European Commission services to get support on impact-related activities.
- Manage IP from the beginning in order to identify patents or deal with ownership, but also to support exploitation strategy developing the offering.

# 6 CONCLUSIONS

The overall objective of this activity was to measure the impact of ICT-15 and ICT-40 projects and how they are dealing to maximise it. Several projects were surveyed by HUB4CLOUD and a few more considered that they have a success story that can be shared with other projects.

The main conclusion after analysing the information provided is that there is still work to do in order to reach the maximum potential for having a significant impact out of the scientific community. As projects are very active developing innovations and publishing them, results are well known by other researchers. However, the impact on industry is very little while the impact on society is almost inexistent.

Projects should invest more time and efforts on traying to attract and engage external stakeholders from the beginning of the project so potential users, end users or even early adopters know more about what the project is developing and when it will be market ready. Also, it is important to develop simple messages that can be easily understood by citizens, public administrations or any other non-technical audience as they can be a lobby supporting their interests.

On the other hand, exploitation seemed to be a weak work in many of the projects just performing the activities they are expected but sometimes in a slightly incoherent way. In this sense, there is a lack of information about basic activities that can be performed and how and some training activities will be useful for them.

In general, all participants have results with potential to have a significant market impact but lack of support for doing so. Although some of them, as reflect in the provided success stories, are one step beyond the others in terms of impact. Thus, it is recommended that their activities are used as an starting point for future projects and continue their work far beyond it.

# APPENDIX A: SURVEY QUESTIONS

As a continuation of the work performed during the first half of the project, the consortium has prepared a second questionnaire to be fulfilled by ICT-15 and ICT-40 projects in order to measure any progress on their impact during this time.

The questionnaire follows the same structure of the preliminary one, but questions are slightly different in order to be more precise on the answers content. The survey was available online to easiest the participation [1]. Below the list of questions:

## HUB4CLOUD Survey

*The objective of this survey is to collect feedback from ongoing cloud/edge computing research projects about the different activities performed to maximise their impact. Results of the survey will be further analysed to develop a set of best practices and guidelines to support future research projects developing their impact strategy.*

*The survey takes around 30 minutes to be fulfilled. Results will be shared by the HUB4CLOUD consortium. If you may know more about this initiative, please check Horizon Cloud website* [2].

### General Information

**Project name**

**Which period of execution is your project in?** Year 1 / Year 2 / Year 3

**Which general cloud/edge topics are mainly addressed in your project?** (Compositional) Cloud certification / Cognitive cloud / AI for the cloud / Self-healing cloud / Legislation aware cloud / Cloud federation / Green Cloud / Other(s)

**Please specify Other(s)**

**Which cloud research domains are addressed in your project? (E.g., energy efficiency, load balancing, security, etc.)**

**Which sectors are represented by your use cases?** Manufacturing / Telco / Agrifood / Retail / Smart cities / Logistics / Construction / Robotics / Health / Media / Smart home / Transport / Other

**Please specify Other(s)**

**From your project perspective, rank the foreseen relevance for the following cloud/edge topics (from 1 Very low relevance to 5 Very high relevance)** (Compositional) Cloud certification / Cognitive cloud / AI for the cloud / Self-healing cloud / Legislation aware cloud / Cloud federation / Green cloud

**From your project perspective, which research domains do you consider that must be addressed in the future?**

### Innovation

**Please indicate the number of PMs devoted to innovation and the total amount of PMs in your project**

**Are you planning to file any patent during or after the project lifespan?** Yes / No / Not decided yet

**If yes, how many patents are you planning to file, or already filed?**

**Please specify the overall TRL of your project results**

**According to your estimations, when will project results be market-ready?** Just right after the project end / 1-3 years / 3-5 years / 5-10 years

**Will you need further investments to have your results market-ready?** Yes / No / Don't know yet

**If yes, please explain how you plan to get funds (e.g., internal investment, other research projects, venture capital, etc.)**

**In general, what is the market potential of your proposed solution?** Not analysed / Very demanding market but no similar solutions / Very demanding market but some similar solutions / Very demanding market but many similar solutions / Little demanding market but some similar solutions / Not demanding market

**Are the consortium members willing to maintain project results? Specify why and how**

**Do you have a plan for engaging external stakeholders?** Yes / No

**If yes, do you already materialised your plan? And how many stakeholders have been engaged (independently of their profile)?**

**How many startups are involved in the project? Please specify how many are part of the consortium and how many external ones have been engaged**

**Will the assets developed be reusable after the end of the project?** No, they are project specific / Yes, but requires significant customisation / Yes, but few adaptations are required / Yes, direct plug and play in new projects/scenarios

**How many of the project assets will be reusable? And where and when will they be available?**

**How many of your project uses cases are being, or will be, deployed in real-world environments?**

**Are you measuring the benefits brought by the project use cases?** Yes / No

**If yes, specify which ones. If no, explain why.**

**How many innovations are being developed within the project? Please briefly explain them.**

**Do you find any difficulty while performing innovation activities? Please provide a brief explanation.**

**Will you consider useful to have an initial set of recommendations about the activities that can be performed and how before starting your project? What kind of information do you expect?**

## Exploitation and business development

**Please indicate the number of PMs devoted to exploitation and business development and the total amount of PMs in your project.**

**How are you developing the value proposition of your project?** No project value proposition / Only for the project in general / Only for specific results / For the project in general and for specific results

**Is your value proposition adapted to the targeted stakeholders?** Yes / No

**Which are the targeted stakeholders of your project?** Cloud/edge service providers / Infrastructure operators / System integrators / Early adopters / End users / Other(s)

**Please specify Other(s)**

**Are you doing a market analysis within your project activities?** No / Yes, in general / Yes, for specific results / Yes, in general and for specific results

**Are you doing a competitor analysis within your project activities?** No / Yes, in general / Yes, for specific results / Yes, in general and for specific results

**Have you identified any business model to be applied to your project results?** No / Yes, in general / Yes, for specific results / Yes, in general and for specific results

**Which of the following business models do you think better apply to your project?** PaaS – Platform as a Service / SaaS – Software as a Service / IaaS – Infrastructure as a Service / APIaaS – API as a Service / AaaS – Analytics as a Service / BaaS – Backend as a Service / DaaS – Data as a Service / DBaaS – Database as a Service / DaaS – Desktop as a Service / FaaS – Function as a Service / SECaaS – Security as a Service / Other(s)

**Please specify Other(s)**

**Does your project have an exploitation strategy?** No / Yes, only individual ones / Yes, only a joint one / Yes, individual and joint ones

**Does your project have a sustainability plan?** No, it is not clear what a sustainability plan is / No, it relies only on individual exploitation / Yes, there are some activities identified at individual partner level / Yes, there are some activities identified at consortium level

**Do you know your position in the cloud/edge value chain? Please provide a brief explanation.**

**Do you find difficult to proper develop an exploitation/sustainability strategy? Please justify your answer.**

**Will you consider useful to have an initial set of recommendations and guidelines before starting your project activities? What kind of information do you expect in such a list?**

## Impact

**Please indicate the number of PMs devoted to dissemination and communication and the total among of PMs in your project.**

**How many social networks and which ones are you using to spread project information?**

**What is the penetration rate (number of followers, impact rate and engagement rate) in each of them?**

**How many publications have you done so far in the project? Please specify the type of publication (e.g., journal paper, conference paper, white paper, etc.) and the amount of each of them.**

**Do you plan to perform any training activity within your project? If yes, please specify which ones.**

**Did you participate in any event (or are you planning to do so)? Please specify in how many and the type of event (e.g., scientific, industrial, etc.).**

**Are you collaborating with any other project or initiative to reach a wider audience? Please provide a brief explanation of your answer.**

**Will you consider useful to have a set of recommendations and guidelines about how to better communicate/disseminate project results before starting your activities? And what kind of recommendations do you expect to see?**

**Please indicate the number of PMs devoted to standardisation and the total amount of PMs in your project.**

**Do you have a standardisation plan in your project?** No / Yes, a dedicated deliverable / Yes, as part of other deliverables

**Which cloud/edge standards in general do you consider as the most relevant ones?** OASIS TOSCA / OSCAL / ISO 19086 / ETSI-NFV / EUCS / Other(s)

**Please specify Other(s)**

**Are you adopting any standard within your project? If yes, specify which ones.**

**Are you already contributing to any cloud/edge related standard or planning to do so? Please explain your answer.**

**Do you find difficulties reaching standardization bodies? Please briefly explain your answer.**

**Please indicate the number of PMs devoted to open source activities and the total amount of PMs in your project.**

**How many already existing OS software tools are you using within your project (not developed by project partners)?** None / Between 1 and 5 / Between 6 and 10 / More than 10

**Will you be able to develop project results without using any of these tools? Please provide a brief explanation.**

**How many of your project results will be released under an open source licensing scheme?** None / Only a few / Most of them / All of them

**What are your plans for your open source results after the end of the project?** Contribute to an existing OS project / Create a new project within an OS community / Create a new OS community / Publish the source code in a public repository (e.g., GitHub) / Other(s)

**Please specify Other(s)**

**If you plan to contribute to an existing project or create a new one within an OS community, how are you approaching the community? Please explain which community(ies) you are targeting and how you are doing so.**

**If you plan to creae a new OS community, please explain why and how you are doing so.**

**Do you find any difficulty reaching already existing OS communities? Please briefly explain your answer.**

**Will you consider useful to have a set of recommendations and guidelines for contributing to standards and/or OS communities before starting the project activities? What kind of information do you expect in such a list?**

# APPENDIX B: SUCCESS STORIES

**Project name:** An open, trusted fog computing platform facilitating the deployment, orchestration and management of scalable, heterogeneous and secure iot services and cross-cloud apps

**Project acronym:** RAINBOW

**Project call:** Information and Communication Technologies (H2020-ICT-2018-20) / Topic ID: ICT-15-2019-2020 - Cloud computing

**Start - End date:** 01/01/2020 - 31/12/2022

**Type of success story:** Technological need

## 1. Problem Overview

The Internet of Things (IoT) has the potential to change the way we monitor, understand, and interact with our physical world, bringing it closer to cyberspace. Data collected by and retrieved from IoT devices are essential in building online, delay-sensitive services in various application domains, such as public transportation, industrial manufacturing and autonomous robotic swarms. However, as the number of IoT devices keeps increasing at a rigorous rate, the IoT market tracker[1] indicates a 13% annual growth with more than 30 billion devices by 2025, the amount of data generated outside traditional data centers significantly strain the IoT vision of responsive and low-latency services.

To overcome this, IoT services must utilize compute and network resources along the path that connects the Edge to the Cloud, often referred to as the Fog continuum. Still, the heterogeneity of the Fog continuum, the non-uniformity of mobile networks and the high resource variability that arises because of physical faults, bandwidth saturation, network uncertainty, energy consumption and device mobility must be taken into account in service placement as they affect the performance and reliability of IoT applications.

Consequently, the design, deployment, and evaluation of IoT applications becomes a complex and costly endeavor for IoT developers and service operators, since it requires the exploration of numerous conditions and parameters through repeatable and controllable experiments on a potentially plethora of geo-distributed devices via a combination of physical and virtual testbeds that are hard to configure and scale.

## 2. Solution Description

Acknowledging the pressing challenges that developers and service operators face during the design and testing of their IoT applications, the Fogify framework[2] was spawned out of necessity from the RAINBOW project. In a nutshell, Fogify is an award-winning framework[3] that provides a toolset to model complex fog topologies comprised of heterogeneous resources, network capabilities and QoS criteria. It allows to deploy the modeled configuration and services using popular containerized infrastructure-as-code descriptions to a cloud or local environment; experiment, measure and evaluate the deployment by injecting faults and adapting the configuration at runtime to test different “what-if” scenarios that reveal the limitations of service

[1] https://iot-analytics.com/iot-market-data/cellular-iot-connectivity-market/

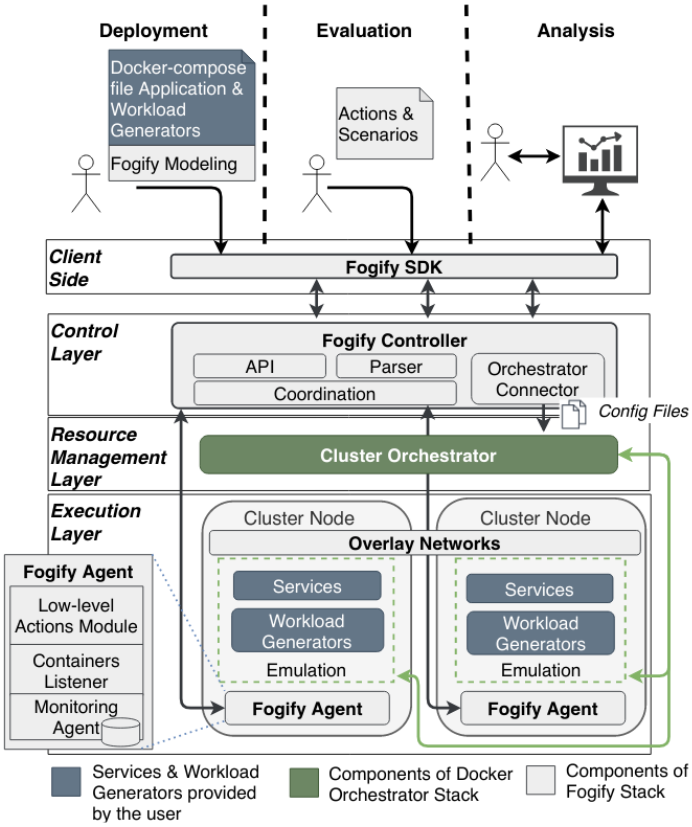
[2] https://ucy-linc-lab.github.io/fogify/

[3] Best Paper at IEEE/ACM IoTDi 2022 and Best demo at IEEE/ACM SEC 2020

before introduced to end-users.

*Design large-scale IoT testbeds*: Fogify embeds a rich set of modeling abstractions where during the modeling phase users can describe the capabilities of their IoT services and the underlying infrastructure. Most importantly, no changes are required to the business logic of an application with the only assumptions that they adopt a micro-services architecture and that services are containerized using Docker technology. Hence, a typical workflow starts by annotating application services with infrastructure requirements and configuring network connectivity between infrastructure offerings.

*Deploy IoT applications as a virtual lab*: With an IoT testbed description in hand, users can take advantage of the Fogify SDK, to deploy the description in a virtual environment where the IoT application actually runs but with the infrastructure emulated on either the user's laptop or a computing cluster. This is possible thanks to the research backing Fogify where novel techniques have been designed for enforcing compute limits on host environments and extending overlay mesh with network rule chaining. The Fogify SDK, as a python library, can be imported in notebook environments to interact at runtime with the Fogify Controller that is in charge of translating the model specification to underlying orchestration primitives. Fogify supports both Docker Swarm and Kubernetes in Docker (KIND).




*Execute repeatable and reproducible "what-if" scenarios:* Fogify users can experiment with scenarios and apply ad-hoc actions to deployed testbeds that will enable users to assess application performance and QoS. Supported actions include a wide range of chaos testing tooling, including changes to the infrastructure, network QoS, injecting faults, vertical and horizontal scaling. The combination of monitored metrics with the analytical capabilities of the Fogify SDK permits users to produce hidden insights about fog-oriented concepts such as Quality of Service, deployment cost and system reliability.

## 3. Main Outcomes

Without proper testing during application design, when the costs are still low, deployments become error-prone due to several unexpected overheads not initially envisioned in the design phase and underwhelming testing conditions not resembling the end environment. Through the RAINBOW project, Fogify is put to test over three very demanding pilot applications in the area of urban transportation (Centro Ricerche FIAT, Italy), industrial manufacturing (BIBA-Bremer Institut für Produktion und Logistik, Germany) and autonomous drone swarms (MSP Marcin Szender , Poland). Such pilots require wide-area testing over a plethora of devices while testbed design is a slow, labor-intensive and safety-critical process. All these hamper time-to-market and pose significant costs for SMEs. As an example, BIBA designs software and machinery for industrial IoT where human-robot collaboration are optimized while still obeying strict safety protocols. Testing optimization techniques during application prototyping is risky and can endanger personnel. However, through Fogify, developers design IoT testbed blueprints to configure their infrastructure needs and share with colleagues and clients experiment scenarios

to test various safety-critical functions, while at the same time, monitor and assess real-time performance metrics. This is the innovation Fogify brings to the IoT landscape.

# REFERENCES

[1] “PLEDGER project,” [Online]. Available: http://www.pledger-project.eu/.

[2] “RAINBOW project,” [Online]. Available: https://rainbow-h2020.eu/.

[3] “PHYSICS project,” [Online]. Available: https://physics-faas.eu/.

[4] “CHARITY project,” [Online]. Available: https://www.charity-project.eu/en.

[5] “AI-SPRINT project,” [Online]. Available: https://www.ai-sprint-project.eu/.

[6] “Prometheus,” [Online]. Available: https://prometheus.io/.

[7] “Kubernetes,” [Online]. Available: https://kubernetes.io/.

[8] “Apache OpenWhisk,” [Online]. Available: https://openwhisk.apache.org/.

[9] “OASIS TOSCA,” [Online]. Available: https://www.oasis-open.org/committees/tc_home.php?wg_abbrev=tosca.

[10] “HUB4CLOUD second survey,” [Online]. Available: https://ec.europa.eu/eusurvey/runner/HUB4CLOUDSurvey.

[11] “Horizon Cloud website,” [Online]. Available: https://www.h-cloud.eu/.