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The European IoT Hub

Growing a sustainable and comprehensive ecosystem for Next Generation Internet of Things

D4.1: Report on best practices for IoT use cases

Version 1.0

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Abstract

Deliverable D4.1 of EU-IoT relates to the work under development in WP4 – COACH, Task 4.1, focussed on reporting best practices for IoT use cases. This report outlines the EU-IoT strategy regarding collection, documentation and analysis of best practices for IoT use cases, while reporting on the activities carried out during the initial project year in this respect. Activities include selection of methodology, including planning of research approach and data collection process, identification of and liaison with relevant use case companies, preparation and organization of use case interviews, assessments and surveys, interim analysis of results, and documentation and online publishing of cases. Finally, a preliminary use case catalogue is presented along with steps proposed for future development.

Keywords: IoT, Use Case, Best Practice, Success Story, Digital Maturity, Business Model, Business Model Pattern

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Disclaimer

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Nature of the deliverable:	Report on best practices for IoT use cases Version 1	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 EU-IoT project and Commission Services	

EXECUTIVE SUMMARY

In order to support and accelerate the IoT business models and IoT skills development, this deliverable D4.1 “Best Practices for IoT Use Cases - Version 1”, due on month 12, September 2021, seeks to identify the practices that are key in fostering successful development and deployment of IoT-empowered solutions, and enable European actors to adopt these best practices in the fast-changing IoT landscape.

D4.1 corresponds to an intermediate version report, motivated to generate a full catalogue of best practices for IoT use cases. The final and complementary report to D4.1 is D4.2, to be publicly released in month 24 (Oct 2022) of the EU-IoT project.

Focus of this intermediate D4.1 is on the methodology for the collection of best practice use cases including clarification of the scientific and theoretical frame of reference: A wide selection of companies with interesting IoT use cases have been identified and recruited from various communities that operate in the scope of IoT, of which the majority is associated with relevant ongoing EC funded Research and Innovation Actions. Qualitative data has been collected via interviews with key people that are technically and strategically involved in the use cases of the respective companies, and quantitative data has been collected through assessments of the corporate digital maturity on various dimensions, business model configuration and business model patterns that characterize the use case.

We aim to present a use case catalogue of 30 IoT use cases in total. At present, data has been collected from 17 use cases, and 12 of those are consolidated and documented as written success stories. The methodology and interim results of the data collection will be presented in this D4.1 report. The full catalogue of IoT use cases and data analysis results will be presented in the D4.2 report.

During the next year, the activities related to recruitment, collection and consolidation of further use cases will continue and the multi-case analysis will be initiated. It is further expected that activities related to online dissemination of the use case catalogue will intensify. The EU-IoT COACH remains committed to collecting and sharing the successful stories of best practice IoT use cases in alignment with the EU vision, thereby contributing to ensure European digital autonomy and technological sovereignty; Boost industrial competitiveness; and Promote sustainable development in the European landscape.

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ABBREVIATIONS

AI	Artificial Intelligence
BM	Business Model
BMI	Business Model Innovation
BMP	Business Model Pattern
CSA	Coordination and Support Action
DMAT	Digital Maturity Assessment Tool
EC	European Commission
EU	European Union
ICT	Information and Communications Technology
IoT	Internet of Things
IP	Internet Protocol
KPI	Key Performance Indicator
NB-IoT	Narrowband Internet of Things
NGIoT	Next Generation Internet of Things
RIA	Research and Innovation Action
R&D	Research and Development
TRL	Technology Readiness Level

1. INTRODUCTION

Over the past decade, the Internet of Things (IoT) has undergone rapid and extensive changes becoming a key enabler of digital transformation as well as it has evolved into a paradigm that integrates a broad set of technologies, each of which are in themselves advancing at a rapid pace.

Businesses of all sizes and in all sectors are facing a world where technology is changing the surrounding landscape. Transitioning from the back-end offices of organisations into the hands of customers, employees and society. Faster development cycles, disruptive business models and increased competition are highlighting the increasingly vital role that technology and data take in business. This means that the success of businesses, now and in the future, rely heavily on the optimal utilisation of technology.

Efforts driven by the European Commission (EC) push for an evolution of the Next Generation Internet (NGI), so that - thanks to utilisation of increasingly decentralised architectures automating processes at the edge - a variety of semi-autonomous and real-time IoT applications can be offered and new business opportunities can arise. Key drivers of this evolution include edge computing, distributed AI and analytics, augmented reality, tactile Internet, data-centric/secure architectures, 5G/6G networks, etc.

However, to support properly and accelerate the needed IoT skills development and optimal utilisation of the novel technologies in the European landscape, it is necessary to create an understanding and alignment that enables European actors to adopt best practices for achieving success in the fast-changing IoT landscape. The EC embraces several initiatives that focus on the increasing number of novel technologies across verticals that allow for the proliferation of new IoT solutions. EU-IoT is one of them.

This report is a deliverable of the EU-IoT Coordination and Support Action (Grant Agreement no 956671), which is part of the NGIoT initiative. EU-IoT has received funding from the European Union's Horizon 2020 Research and Innovation Programme.

A pillar of this EU-IoT deliverable is the vision to grow and consolidate the NGIoT initiative and establish a competitive advantage for Europe, by overcoming the current fragmentation of efforts to succeed in the IoT landscape. In this respect, the outcomes of this deliverable aims to become a lodestar that facilitates knowledge, guidance, and promotes accordingly the stories, outcomes and lessons of successful IoT frontrunners. The challenge is to overcome the diversity and identify a set of commonly agreed upon practices that are key to foster the successful development and deployment of IoT-empowered solutions in a broader perspective with the large community.

This deliverable, as part of the work carried out by the EU-IoT consortium (consultations, surveys, events, strategic road mapping, skills development/training, business analysis and acceleration, standards/open-source mapping, etc.), has the ambition to help converge and join forces around some essential core principles:

- Ensure European digital autonomy and technological sovereignty.
- Boost industrial competitiveness and sustain the economic recovery and growth.
- Promote sustainable development of our society in the respect of the environment.

The EU-IoT guiding principle is to build a vibrant and impactful European IoT ecosystem. In this respect, the success of the EU-IoT consortium's effort builds upon the ability of the ecosystem to overcome the barriers for developing and deploying IoT-empowered solutions – and to do it successfully! Hence, an ambition of this EU-IoT deliverable is to effectively amplify the results and impact of various IoT initiatives represented by practical examples (hereinafter referred to as use cases) that defines the Next Generation Internet, in order to define aligned practices for the

successful development and deployment of IoT solutions. This, for other European actors such as industry, innovators, IoT learners and policy makers to leverage from best practice in order to support and accelerate the adoption of new business models and skills.

1.1 Purpose of Deliverable

This deliverable presents the project's overall strategy for reporting on best practices for IoT use cases. In this relation it outlines the specific activities that were conducted during the first year of the EU-IoT project lifetime.

The EU-IoT consortium has set itself the goal of understanding the business dynamics of companies that have successfully developed and/or deployed IoT-empowered solutions and their business models, and based on the findings provide recommendations for others to leverage from best practice (rf. Figure 1).

We have selected, evaluated and systematically analysed 17 IoT use cases (NB note that the goal is 30 use cases in total) that reflect best practice for successful IoT development and/or deployment from a variety of industry verticals and geographical origin. These use cases illustrate real-world examples of how SMEs, Start-ups and Innovators have successfully developed and/or deployed IoT-empowered solutions. These examples resemble successful frontrunners in the field of IoT, and we explore them to better understand the dynamics underlying their business models and in order to identify the key factors accountable for their success.

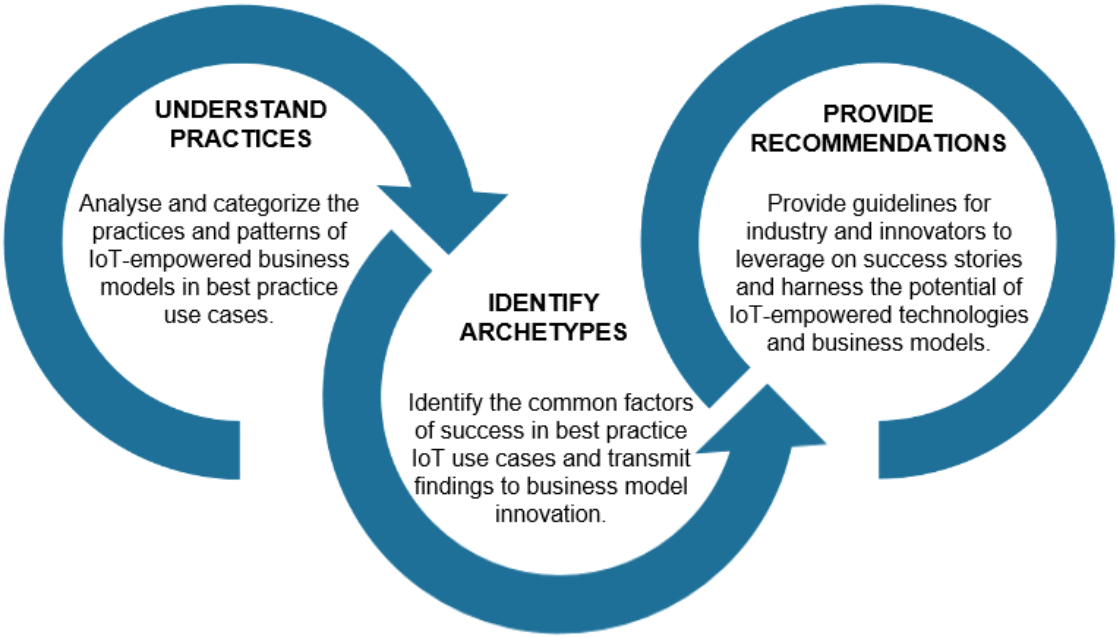


Figure 1: Purpose statement

The main objective of our analysis is to encourage European companies to evaluate their business model and expose them to relatable IoT use cases, as well as to stimulate transparency of the practices and business model compositions shared by IoT frontrunners, including significant factors of their success. While aiming to offer a guiding set of best practices for achieving success in the diverse and ever-growing IoT landscape, our analysis will also consider the individualities of prosperous use cases.

The intended outcome of this deliverable is an online use case catalogue that effectively amplifies the results and impact of successful IoT initiatives that defines the Next Generation Internet. By offering a catalogue of best practices, stakeholders of the European IoT ecosystem will be able

to find inspiration and general guidelines on how IoT can be successfully developed and/or deployed. With this catalogue, industry, innovators, IoT learners and policy makers are offered a guide to learn the best practices for utilising novel technologies to achieve success with their IoT-empowered solutions as well as to leverage the knowledge of frontrunners in the IoT field. Starting from the collection of best practice IoT use cases and documentation of the success stories, this deliverable will increase the impact of subsequent activities related to business modelling and acceleration support, leading to IoT skills development through training and mentoring. Ultimately, to lower the barriers for developing and deploying IoT-empowered solutions and thereby inspire stakeholders to contribute towards growing and intensifying the European IoT ecosystem

1.2 Structure of Deliverable

This deliverable represents a preliminary step to build and ensure the growth of a vibrant European IoT ecosystem as well as support and accelerate IoT business models and skills building. The following topics will be discussed in the subsequent sections:

- Section 2 is dedicated to: The scientific frame of reference, outlining the methodology and tools deployed for collection of data in the work on reporting best practices for IoT use cases. The chosen combination of qualitative and quantitative data sources are clarified and key empirical concepts are defined and justified.
- Section 3 is dedicated to: The theoretical frame of reference, outlining the conceptual basis for the results presented by this deliverable. Establishing a common understanding of essential general concepts; digital maturity, business model (innovation), business model pattern, technology domain, and how these are applied.
- Section 4 is dedicated to: An IoT Use Case overview, providing an overview of the use cases that are currently collected and consolidated, including an interim multi-case analysis and all written IoT success story presented in a short version format.
- Section 5 is dedicated to: Status and next steps, offering a status quo on the EU-IoT Task 4.1 in relation to the KPIs defined by the EC, as well as an outlook towards project month 24, accounting for the planned activities of the next year.

The activities accounted for in this initial deliverable are progressing at present, and no conclusive outcomes are therefore presented. The contents will be further enriched and elaborated, leading to a more consolidated version that is planned to be delivered in October 2022.

1.3 Process and Scope of Deliverable

The process for reporting on best practice use cases is designed to unfold in three steps, in order to achieve the previously defined purpose. The process follows a value chain approach and is composed of the steps as illustrated in Figure 2.

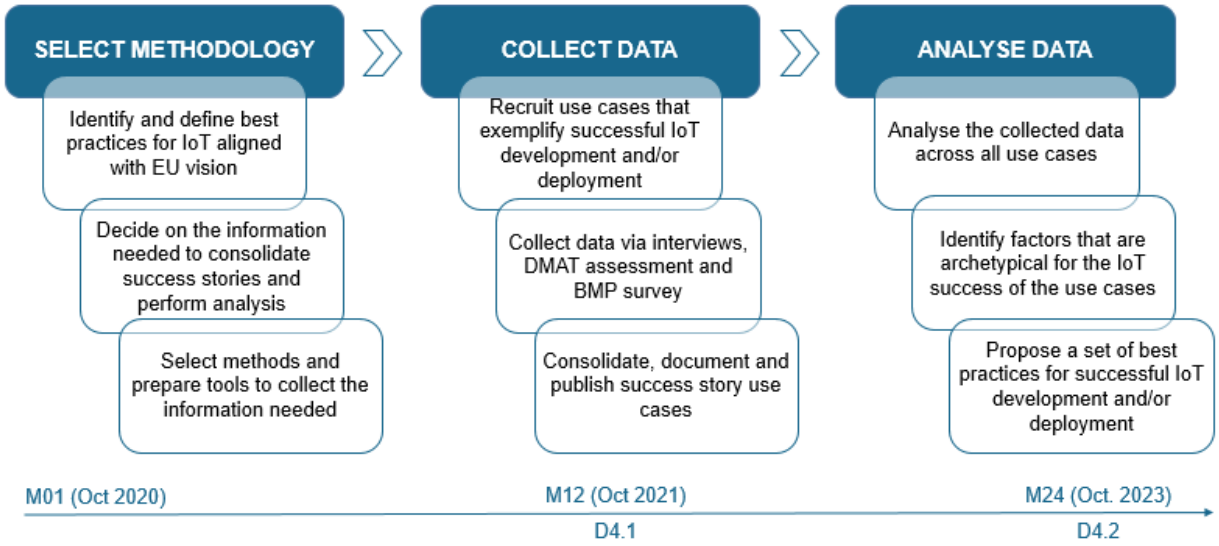


Figure 2: Process for reporting on best practices for IoT use cases

Intended outcomes of the process will include:

- written success stories that introduce the investigated IoT use cases, which are expected to cover experiences across >10 countries and 7 domains and in the scope of 18 different advanced technologies
- results from analysis across all cases to identify and define archetypical factors for achieving success with IoT-empowered solutions (factors such as digital maturity levels on various dimensions, business model configuration and business model patterns).
- guiding overview that aligns the 'X best practices for successful IoT development and deployment'.

Completed outcomes of the process will be presented in the D4.2 report. The methodology and interim results of the data collection are presented in this D4.1 report.

At the heart of the deliverables D4.1 and D4.2 is an analysis of 30 IoT use cases (see Appendix A for overview and status). The consortium wants to emphasize that this collection does not claim to be exhaustive and does not constitute a special distinction for the named practical examples. For a detailed overview of all the data governed by this deliverable, we refer to the initial Data Management Plan of the EU-IoT project. 30 IoT use cases will be carefully selected, from a backlog of ~50 relevant cases, to be documented in the catalogue and included in our analysis. As illustrated by Figure 3, the results presented in this D4.1 report reflects that, at present, data has been collected from 17 of the 30 use cases, 12 of those are consolidated and documented as written success stories, and 6 of those are published online.

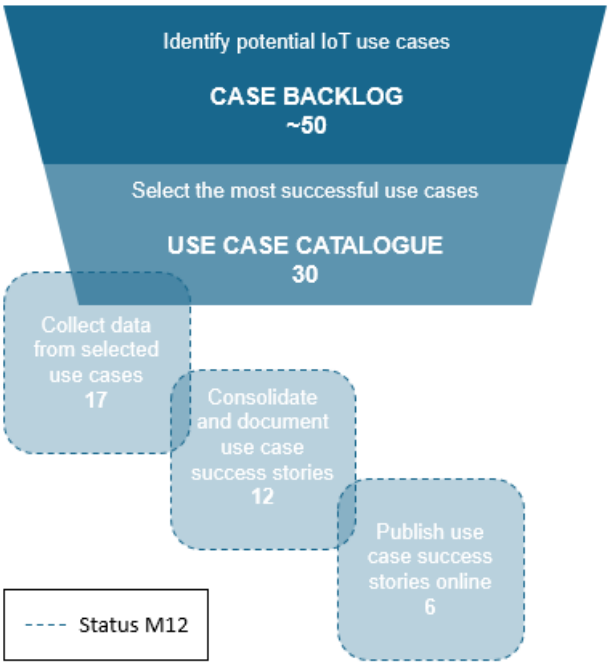


Figure 3: Use case catalogue status M12

SCOPE OF DELIVERABLE

The phenomenon 'best practice of IoT' is considered holistically: we analyse upon organisational digital maturity and patterns of IT business models and as well as contextual factors of each use case company and their IoT-empowered solution, including the process of development and/or deployment, the achieved outcomes and lessons as practice for success.

The rapid development in the IoT landscape brings in the need to rethink technology interfaces to integrate and adapt to human behaviour and human activities (EU-IoT Scope area 1: *Human / IoT-interfaces*). It also requires rethinking computational and networking architectures (EU-IoT Scope areas 2-3: *Far edge (device) and Near edge (gateway)*, taking into consideration behaviour learning; the need for data and user privacy; the larger volumes of sensitive data to be analysed, and the requirements to handle such data. Then, it requires addressing interconnection and networking aspects (EU-IoT Scope area 4: *Infrastructure*) and data sovereignty aspects across decentralised data spaces (EU-IoT Scope area 5: *Data Spaces*).

All the work presented in this deliverable is to be considered within the scope of the EU-IoT project under the NGIoT initiative, and in alignment with the visions of those.

At the core of the NGIoT vision is the ambition to enable a major shift: from digitally enabling the physical world towards automation and augmentation of the human experience with the connected world thanks to secure, resilient, safe, and trustworthy IoT.

At the core of the EU-IoT vision is the ambition to act as an accelerator for the whole European IoT ecosystem towards transforming the current IoT community of researchers and innovators in Europe into an increasingly cohesive, dynamic, participatory and sustainable ecosystem, as an essential part of the Next Generation Internet initiative. It assists stakeholders to engage and create value, as well as set up a self-sustaining European IoT community.

2. SCIENTIFIC FRAME OF REFERENCE

This section outlines the approach applied by the EU-IoT project to report on best practices for IoT use cases, and thereby the scientific frame of reference for collection of qualitative and quantitative data sources. Please note that the approach is long-term and reflects intentions that cover the outcome of both the first and second version deliverable D4.1 and D4.2.

2.1 General Approach

We want to analyse best practice of IoT as a 'contemporary phenomenon in its real-world context', and for that purpose, a case-based approach with many IoT use cases is found to be the most appropriate [1]. A qualitative multiple case study is applied to gain in-depth understanding as well as generalizable, cross-sectional analyses, and further, because evidence created from a multiple case study is measured strong and reliable [2].

We have set up a case backlog comprising ~50 IoT use cases. The unit of analysis of these cases is a specific IoT-empowered solution, considered in the context of the respective business model and case company at the level of a strategic business unit, to ensure a delineated focus on those parts of business that are significantly impacted by the specific IoT solution developed and/or deployed (i.e. when analysing an IoT use case in a large corporation, we do not study the overall BM of that company but only the one of the strategic business unit that has developed and/or deployed the IoT solution, whereas for smaller companies, the level of analysis will correlate with the BM of the overall company).

In our recruitment of IoT use cases, we have set up metrics that define an IoT success and metrics that distinguish between two case types, classifying the data as either a technological or a business use case. The use cases are then sorted into four levels, which clarify to what extent the technology of a use case is proven, implemented, commercialised and operational, whether it is novel and whether it positively impacts business of the case company.

2.2 Research Structure

Our research of each individual use case will unfold in three steps:

1. First, we will conduct interviews to derive key information about the IoT-empowered solution that has been developed and/or deployed as well as the contextual setting of it.
2. Second, we will conduct a digital maturity assessment to evaluate the level of digital maturity of the case company.
3. Third, we will conduct a survey of the business model and potential IT driven business model patterns deployed by the use case.

Findings throughout the three phases are to be correlated with the specific IoT solution developed and/or deployed and individually documented as a success story for each use case.

When all individual use cases are collected and documented, our research will proceed into a multiple case study, qualifying us to analyse the data not only within each IoT use case but also across all the cases [3]. This, to understand differences and similarities between the cases and for the findings to be correlated with the cases' experienced success of IoT. Ultimately, this enables us to report on best practices for successful IoT development and deployment, and to make inferences upon archetypical levels of digital maturity, business model composition and business model patterns for successful IoT stories, in order to inspire and create a list of recommendations to be leveraged by the industry and innovators of the European ecosystem. These findings from analysis will be presented in the version 2 of this deliverable (D4.2).

2.3 Methodological Tools

Our research will employ the following methodological tools for the collection and analysis of data, and hence the assessment of IoT use cases depicted by Table 1.

Table 1: Methodological tools

Tool	Description
Interviews	To cover all relevant aspects of the IoT use case, and to ensure several perspectives, interviews are conducted with two employees from each case company. Their roles in developing and/or deploying the IoT solution represent both a technical and a business perspective, and they are/or have been severely involved in the IoT use case. The interviews are semi-structured, and further information, including an example of the interview frame, may be found in Appendix D.
Digital Maturity Assessment	The Digital Maturity Assessment is an online tool in terms of a questionnaire, which can be accessed via the link: https://dbd.au.dk/dmat/ or in Appendix B. The DMAT assessment is developed by the Interdisciplinary Centre for Digital Business Development, Aarhus University, and copyrighted by Annabeth Aagaard, PhD, Associate Professor and Centre Director.
Business Model Pattern survey	The Business Model Pattern Survey is an online questionnaire, which can be accessed via the link: https://survey.au.dk/LinkCollector?key=9492NPF6LPCK or in Appendix C. The survey is developed for the specific purpose of the EU-IoT project by the Interdisciplinary Centre for Digital Business Development, Aarhus University, and based on research by Weking et al. 2020 [4].

The methodological tools, and their theoretical basis are describes in further detail in sec. 3.

To augment the above described primary case data (interview, assessment and survey) and to support data triangulation [5], we will manually search for additional information on the websites of case companies, in public available articles, press releases and other online sources and we will seek to access internal corporate materials of relevance to present the use case (such as technical specifications, images, videos etc. of the developed and/or deployed IoT solution).

2.4 Use Case Definition

An IoT success story is reflected in a best practice case for IoT use. To further specify this, our research takes its point of departure in the following definition of a best practice IoT use case:

An IoT solution with proven technology is

- developed and/or deployed;
- and proves a positive impact on the bottom line;
- and/or a high impact potential due to the novelty of the technology.

A perfect IoT success story combines technological success (novel IoT technology) and business success (bottom line impact), while contributing positively to the planet addressing the sustainable development goals. However, perfect success stories are still rare in the current state of the Next Generation Internet, and aiming solely to collect these would be unrealistic and result in a uniform and subtle reflection of the extant IoT landscape. Therefore, to pursue a more candid and

representative reflection, we consider an IoT use case an IoT success story if: it proves best practice for IoT through either business success OR technological success. Hence, the consortium considers the following two types of IoT use cases as depicted by Table 2.

Table 2: Definition of use case types

Case type	Definition	
Business use case	*An IoT solution with proven technology is…*	*…deployed (and operational), and proves a positive impact on the bottom line.*
Technology use case		*…developed (and tested), and proves a high impact potential due to the novelty of the technology.*

To distinguish between the two types of use cases, a range of inclusion criteria depicted by Table 3 are deployed:

Table 3: Inclusion criteria for distinct use case types

	Business use case	Technology use case
Use case significance	Business impact	Technological novelty
Use case selection criteria	• Proven IoT technology • Technology is deployed and operational Positive impact on the bottom line is proven	• Novel IoT technology • Technology is developed and proven Positive impact potential is expected
Success story metrics	• Bottom line effect e.g. pct. progression b/a implementation of IoT solution. • Business model innovation enabled by the IoT solution e.g. significant changes in value capture, creation or delivery.	• Autonomy of the IoT solution e.g. degree of human interaction needed and AI deployed. • Decentralization of data spaces and data processing activities e.g. significance of cloud and edge in the architecture of the IoT solution.

In the evaluation, we consider the above defined success story metrics related to the respective case type (rf. Table 1) and we further sort the use cases into four levels, which determine the conformity of the IoT use case with the definition of an IoT success story (rf. sec 2.2.1) as well as the TRL of the case. As depicted in Table 4, the four levels are:

Table 4: Use case levels - classification for identification of IoT success stories

Case level	Case level description	*Does the use case qualify as an IoT success story?*
1. Edge	Proven novel technology and proven business impact	*Preferred*
2. Industrial	Proven technology and proven business impact	*Accepted*

3. Pilot	Proven novel technology	
4. Lab	Nothing proven yet	*Dismissed*

The four case levels clarify *to what extent the technology of a use case is proven, implemented, commercialised and operational*, *whether it is considered novel and whether it is considered to impact positively business of the case company*. The distinction between the four case levels and the two case types is illustrated in the Figure 4 below.

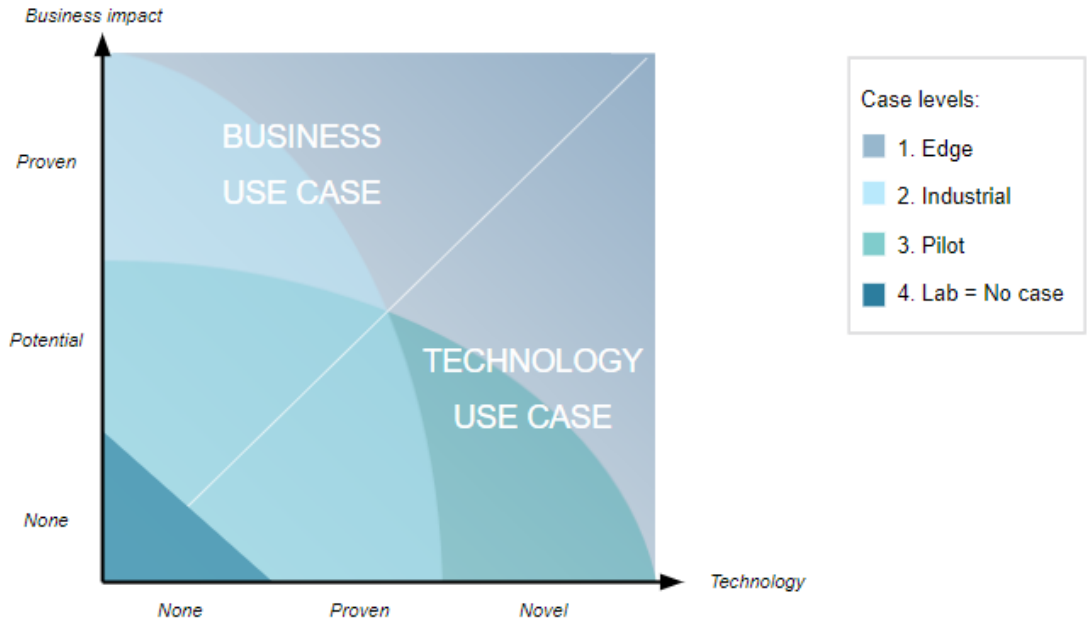


Figure 4: The four levels and the two types of use cases

For further clarification on how the IoT use cases are accessed given the described distinction of case levels and case types, see appendix A.4, and for a complete overview of the case level and type of each use case, see appendix A.3.

2.4.1 Use Case Recruitment

Data, in terms of potential use cases are identified and collected through bottom-up exploitation of synergies across relevant H2020 projects, established networks and collaboration partners that operate in the scope of the Next Generation Internet and novel IoT technologies.

Majority of the use cases that are present in the case backlog are recruited by direct contact, referrals or snowball effect, due to their affiliation to the IoT ecosystem. These sources are depicted by Table 5 below.

Table 5: Use case recruitment sources

ICT56 RIA-projects	The most recent research and innovation efforts within the NGIoT initiatives are channelled through the six ICT-56 Research and Innovation Action (RIA) projects: ASSIST-IoT, iNGENIOUS, IntellIoT, IoT-NGIN, TERMINET & VEDLIoT. The aim of these projects is to develop and demonstrate novel IoT concepts and solutions in line with the NGI vision, proved through specific use cases, with the goal of better serving end-users. Started late 2020.

IoTAC	IoTAC (Security By Design IoT Development and Certificate Framework with Front-end Access Control) is an SU-ICT Research and Innovation Action (RIA) project on the topic 'Building blocks for resilience in evolving ICT systems'. The aim of the project is to deliver a novel, secure and privacy-friendly IoT architecture that will facilitate the development and operation of more resilient IoT service environments. Started early 2020.
IoT Next Club	IoT Next Club is a reference platform for SMEs and start-ups within the European IoT ecosystem. The aim of the platform is to connect different stakeholders, helping them to boost their business and to find potential joint collaborations. The platform is a vital link between the NGIoT initiative and the beating heart of the European IoT.
Nordic IoT Centre	The Nordic IoT Centre is an IoT knowledge hub in the Nordic countries, and an ecosystem of partners and collaborators in the field of electronics, software developers and contract manufacturers. The aim of the Centre is to support companies in developing IoT systems and services, offering an entry point to leading IoT development and integration specialists.

Based on the above sources, we have, in the case backlog, obtained a database of ~50 companies that are potential units of analysis. To ensure relevance and sufficient information of the IoT use case as well as perpetuate participatory readiness of the case company, we contact each of them.

When it is made sure that the case company complies with the defined inclusion criteria and is able to demonstrate an IoT use case that is fit with the above definition of an IoT success story, they are recruited for project participation. The evaluation process will result in the identification and selection of 30 use cases that are suitable for analysis (of which 17 are selected at the present project month 12).

3. THEORETICAL FRAME OF REFERENCE

This section outlines the conceptual frame of reference for the approach and results presented by this deliverable (and the results to be presented by the final version), and thus elaborates on the theoretical basis for the collection and analysis of data. This frame is assembled by EU-IoT COACH and closely interlinks with the methodological tools applied (rf. table 1).

The theoretical frame of reference should establish a common understanding of essential general concepts, and how these are applied and assessed by this deliverable: digital maturity, business model (innovation), business model pattern, and technology domain.

3.1 Digital Maturity

The term digital maturity refers to a measure of an organization's ability to create value through the implementation of digital solutions. Digital maturity is a key predictor of success for companies that initiate a digital transformation. Businesses with high levels of digital maturity have a competitive advantage along multiple performance dimensions (including revenue growth, time to market, cost efficiency, product quality, and customer satisfaction), whereas businesses with low levels of digital maturity struggle to achieve these benefits. [6].

Maturity models offer a methodology to assess and evaluate the effects of digital interventions, such as IoT use cases. Practitioners can benefit from assessing their digital maturity, as it can help them identify digital development areas and measure and evaluate the readiness of their existing business models to initiate IoT development and deployment. The application of maturity models is not limited to any particular domain [7] and they can be used both as an assessment tool and as an improvement tool [8].

**It should be noted that maturity assessment is a self-assessment process influenced heavily by the case companies' own digital self-perception.*

The concept and act of assessment is essential in this report, for us to understand *how* successful IoT development and deployment interlinks with the digital maturity of a company.

As part of our analysis, we therefore assess the digital maturity of the selected case companies to institute a quantifiable insight and deepen our overall understanding on the impact of a successful IoT use case across different performance dimensions of the case company.

By determining the level of digital maturity archetypical for the best practice of IoT use cases, inspiration seekers will become educated about the state of digital competition in their domain, and enabled to benchmark and determine the durability of their own digital capabilities. The assessment will point out the digital development areas and digital competitive advantages at individual company level and at sectoral level, and finally, offer points of reference for desirable levels of digital maturity in the context of ensuring successful IoT interventions.

APPLIED THEORETICAL FRAME OF REFERENCE

In this report, the assessment of digital maturity is facilitated by The Digital Maturity Assessment Tool (DMAT) by Aagaard et al. [9]. The DMAT is an online tool that measures and evaluates the digital maturity of an organisation. The tool is often applied as a framework in supporting the organisational adoption of technologies during intervention processes, and serves as a practice tool for organisations to identify digital development areas before and after interventions.

The key elements of the DMAT tool and of a company's digital maturity are derived from an extensive literature review, which revealed the following six dimensions: Strategy, Culture, Organisation, Processes, Technology and Customers & Partners. Each of these dimensions is key in evaluating a company's digital maturity and ability to transform digitally and to adopt

technology. The DMAT is able to measure digital maturity on each dimension and provide scores that indicate digital development areas, digital competitive advantages and position in the respective sector. This is illustrated in the Figure 5 as depicted below.

Figure 5: Digital Maturity Assessment Tool (DMAT) result

The DMAT will serve as a tool of simplification and accessibility for the assessment of use case companies, supporting the evaluation and documentation of digital maturity.

The DMAT can be accessed via the link: https://dbd.au.dk/dmat/ or in Appendix B.

3.2 Business Model and Business Model Innovation

A BM describes the rationale of how an organization creates, delivers, and captures value [10]. Ultimately, it is a plan for the successful operation of a business and it provides the conceptual structure that supports the viability of the business. BM innovation is the process of reinventing or enhancing the BM by making simultaneous - and mutually supportive - changes to the value dimensions. In the context of digital BM innovation, IT and IoT can either play a role that is constitutive, value increasing or irrelevant for the general BM of the organisation [11].

The concepts are essential in this report for us to explore prevailing BM's of IoT and to facilitate a common understanding of the practices that underlie these models. This exploration will seek to clarify:

- How are traditional business models impacted by development and deployment of IoT empowered solutions (i.e. are any specific dimensions subjected)?
- Is it possible to determine archetypical configurations or characteristics of the BM's that make up best practice in the IoT arena?
- Is business model innovation an indisputable outcome of IoT development and deployment in best practice?

Hence, the intention of exploring the concept of business model (innovation), is to create insight on the latitude of engaging with IoT, as well as to offer a responsiveness foundation for innovators, by shedding light on the dimensions of traditional business models that should be subject to increased digital focus. Ultimately, this knowledge shall offer guidance and inspiration for industry, innovators and IoT learners to harness the potential of successful IoT business models.

APPLIED THEORETICAL FRAME OF REFERENCE

In this report, the general concept of business model and business model innovation is assessed by the theoretical framework of St. Gallen University [12], which is illustrated in Figure 6 below.

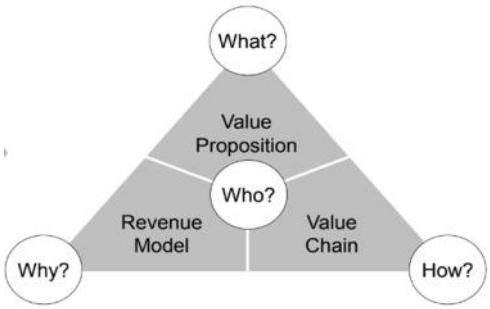


Figure 6: Business Model Framework by St. Gallen

We analyse the business model of each individual IoT use case based on St. Gallen's theoretical framework by considering the impact of the IoT solution on four vital business model dimensions. Hence, by asking the following four questions:

- Customer: Who are the target customers of the IoT solution?
- Value proposition: What does the company offer the customers?
- Value chain: How does the company, together with other partners, create this solution?
- Revenue model: How does the company create value as revenue?

In order to determine the correlation between an IoT solution and business model innovation, we define business model innovation if the IoT solution has caused a significant change in the way a company answers at least two of the four questions. The business model of each use case is visualized with highlighting of those of the dimensions that have changed significantly as a result of the IoT development and/or deployment.

3.3 Business Model Patterns

A business model pattern is defined as *"a definite configuration of four core elements (who are the customers? What is being sold? How is it produced? How is revenue earned?) that have proven successful in different companies and industries"* [13]. Hence, a pattern represents a repeatable configuration of the four core elements to strengthen a company's overall business model.

According to the University of St. Gallen, a BMP provides a practical template to help build new business models from scratch and supercharge existing business models. Similar to the patterns considered in our analysis, is that they are all using the internet – or IT - as a fundamental source for building and innovating BMs. The emergence of an IT BMP is inevitable in any significant use case revolving development and/or deployment of an IoT solution.

**It should be noted that the business model pattern survey is a self-assessment process influenced heavily by the case companies' own self-perception.*

The concept is essential in this report, not only to understand the factors of the IoT business models that make up the best practice, but to identify also the specific factors of success. Those factors may be classified into archetypical business model patterns, which are then possible for inspiration seekers to transmit onto their own initiatives in business model innovation.

Hence, the intention of analysing IT business models patterns is to derive well-grounded guidance, both theoretical and practical, for building successful IoT business models. These

patterns should inspire and we aim to provide them on a level of abstraction that will facilitate their application across different industry sectors, while remaining concrete enough to be actionable for innovators and IoT learners. This will enable the IoT ecosystem to leverage on the patterns of the best practice business models.

APPLIED THEORETICAL FRAME OF REFERENCE

In this report, the general concept of business model patterns is assessed by the theoretical taxonomy of Weking et al. [14], which focuses solely on patterns in the IT arena. The taxonomy offers a framework for classifying, describing and analysing patterns of IT business models.

Through analysis of 32 case studies of firms that have undergone various transformations driven by IT, the taxonomy was developed and three super-patterns and 10 sub-patterns of IT BMs were identified. These are illustrated in Figure 7 below. The super-pattern Integration innovates its BM around new processes, Servitization around new products, and Expertization around a hybrid of products and processes.

SUPER-PATTERN	SUB-PATTERN			
Integration	Crowd-sourced innovation	Production as a service	Mass customization	
Servitization	Life-long partnerships	Product as a service	Result as a service	
Expertization	Product-related consulting	Process-related consulting	Product-related platformization	Process-related platformization

Figure 7: IT Business Model Patterns by Weking et. al

The taxonomy shapes an easily replicative basis for exploring the BMPs of best practice companies, which is assessed through an online survey developed by the EU-IoT consortium for the specific purpose.

Results from the survey, due to its theoretical origin of Weking et al.'s taxonomy, provides a structured overview of the configuration of BMs in various IoT use cases, and ultimately, enables us to identify which patterns are archetypal for the cases' successful leverage of technologies and concepts of IoT.

The Business Model Pattern Survey can be accessed via the link:
https://survey.au.dk/LinkCollector?key=9492NPF6LPCK or in Appendix C.

3.4 Technology Domains

IoT has come to be understood as a paradigm that integrates a broad set of technologies, each of which are in themselves advancing at a rapid pace. IoT has already become a significant enabler of digital transformation across many sectors and will have a far-reaching impact on the future of European technological dominance.

While the idea of IoT has existed for a long time, it is the collection of several technologies that makes it practical. Sensor technology, connectivity, cloud computing platforms, machine learning and analytics as well as artificial intelligence are basic technologies needed to enable physical things to share and collect data, and digital systems to facilitate the interaction between connected things.

Hence, IoT reaches across the traditional sensor-network-server coupling and relies on more advanced technologies for connecting and exchanging data with devices and systems over the internet. The domain terminology in the perspective of technology refers to a delimited

technological field of thought.

The concept is essential in this report, to ensure a focus on the archetypes of novel technology that will define the next generation of IoT in the European landscape. By exploring the technological domains in which single use cases are organized, we will be able to conclude whether specific technologies prove to be repetitive for IoT success. As a frame of reference, the findings may further serve as a compass for industry and innovators to leverage on successful IoT stories and harness the technologies and solutions used by the best practice cases.

APPLIED THEORETICAL FRAME OF REFERENCE

In this report, the general concept of technology domains is assessed by a framework inspired by activities of the NGIoT community, and developed by the EU-IoT consortium for the specific purpose.

No other framework sufficiently addresses the technologies of the Internet of Things (IoT), as it is continuously subjected to rapid and extensive development. EU-IoT has conceptualised an overarching framework that identifies the principal technological domains that dominate the development and provides a viewpoint for the future of IoT.

The framework incorporates a set of defined contexts, within which challenges and opportunities of the IoT domain arise, while still providing flexibility and agility. The framework addresses the points of interaction between the physical elements making up the human to cloud continuum, as illustrated in Figure 8 below.

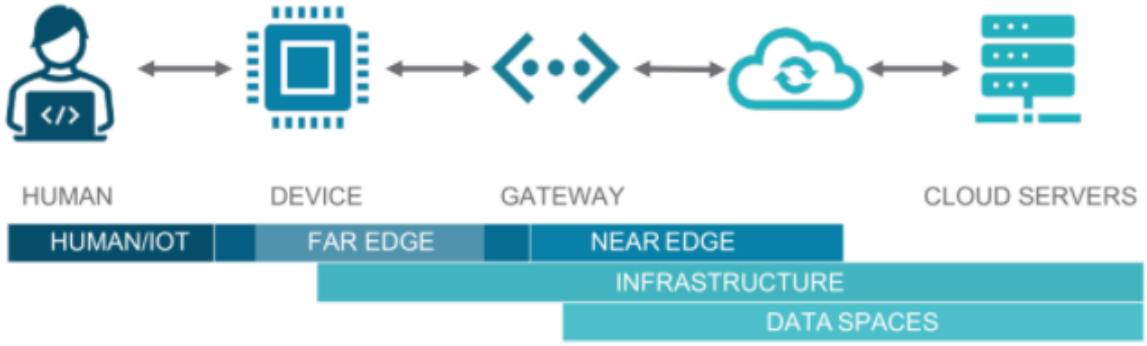


Figure 8: Technology domains framework

The key research and innovation areas / technological contexts, which can overlap and have a reach across the continuum that this deliverable will focus on are:

- Technology: to identify novel and advancing enabling technologies.
- Market: to identify applications, services, and models enabled by the technologies (both individual and varied combinations).

With the above continuum as a point of reference, the framework presents a broad classification of technological domains that are considered formative for next-generation IoT, as illustrated by Figure 9 and 10 below.

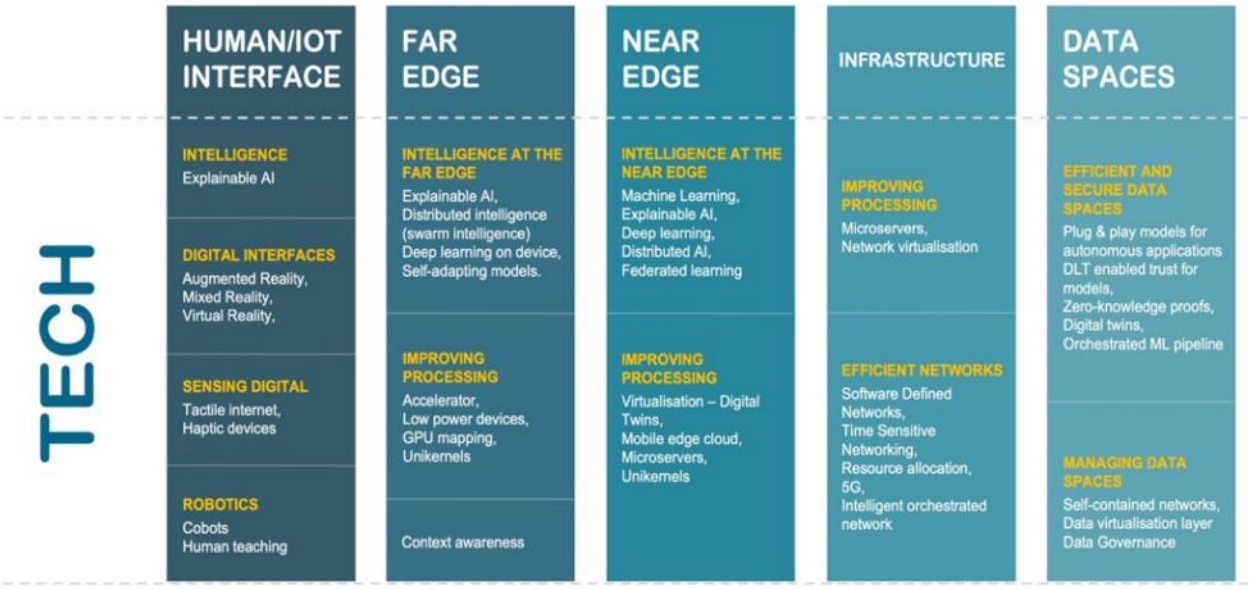


Figure 9: Technology priorities in the NGIoT landscape

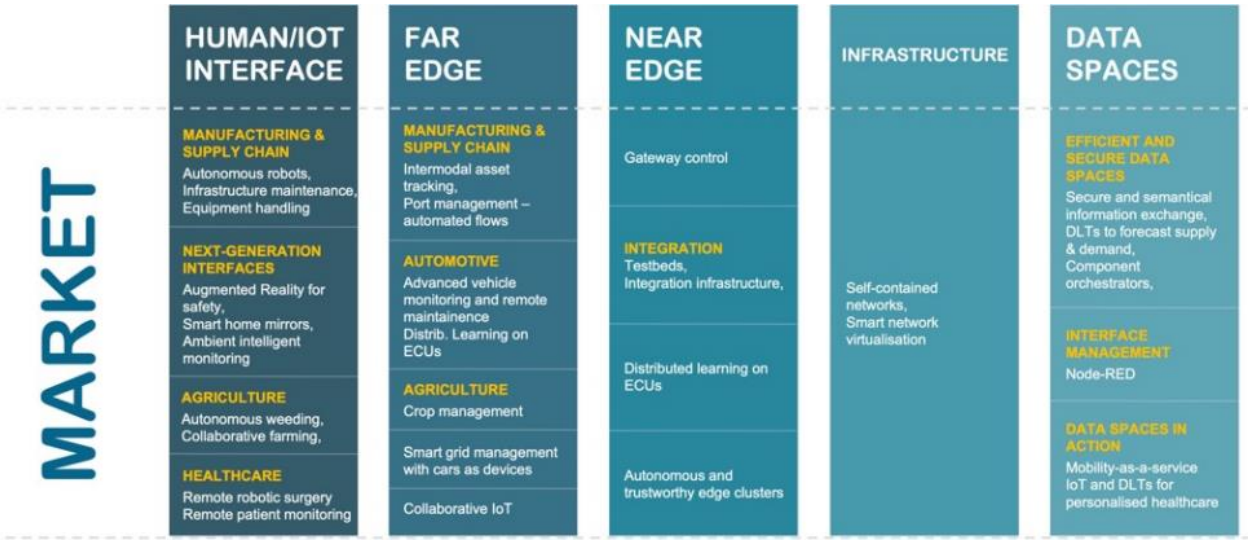


Figure 10: Market applications priorities in the NGIoT initiative

The framework provides a non-exhaustive overview as the technology constantly evolves and the sphere of IoT expands. Nonetheless, our research will be based upon the present knowledge presented by this framework, hence our assessment of use cases will include the following domains of technology:

Artificial Intelligence - Digital Twins - Fog Computing - High Performance Computing - Ledger Technology (for example block chain) - Machine Learning - Mixed Reality - Nano Electronics - Open Source software and/or hardware - Quantum Computing – Robotics - Satellites (for example micro, nano or pico) - Search Technology - Sensors and/or cameras - Virtual and/or Augmented Reality - 5G - 6G - Other.

For further elaboration on the technology domains, a full version of the strategy white paper "Towards a vibrant European IoT Ecosystem" can be accessed via the link: EU-IoT D2.1.

4. USE CASE OVERVIEW

This section will provide the interim results of data collection and analysis within the scope of the EU-IoT Work Package 4 - Task 4.1, and hence provide an overview of the IoT use cases that have been identified and selected as suitable for analysis.

Again, please note that only immediate results are presented here, and that the full catalogue of best practices for IoT use cases, as well as analysis across all cases, will be presented in the version 2 deliverable. At the time of submission for this deliverable, data has been collected from 17 IoT use cases, and 12 of those are consolidated and documented as IoT success stories. Find below in Table 5 an overview of the case companies.

Table 5: Overview of use case companies

No.	Case company	Size (no. of employees)	Domain	Geography
1	**Troldtekt**	148	Manufacturing	Denmark
2	**Herning Water**	63	Energy & Utility	Denmark
3	**Aqua Robur**	10	Energy & Utility	Sweden
4	**Synelixis**	18	Agri-food	Greece
5	**See.Sense**	14	Mobility & Transportation	Ireland
6	**HOPU**	34	Smart Cities & Communities	Spain
7	**Tecnalia**	1,472	Mobility & Transportation	Spain
8	**Emotion**	14	Mobility & Transportation	Italy
9	**ASM Terni**	350	Energy & Utility	Italy
10	**CERTH**	700	Smart Cities & Communities	Greece
11	**Aloxy**	15	Manufacturing	Belgium
12	**AllThingsTalk**	25	Other (Cross-domain)	Belgium
13	**ASTI Mobile Robotics**	215	Manufacturing	Spain
14	**Cumucore**	10	Other (Telecommunications)	Finland
15	**Awake AI**	28	Mobility & Transportation	Finland
16	**Fivecomm**	11	Other (Telecommunications)	Spain
17	**Quadible**	10	Other (Security)	United Kingdom
…				
30				

The list of use case companies provided shall not be considered as exhaustive.

4.1 Interim Analysis Results

Based on the available 12 IoT use cases that are currently collected and consolidated, a minor interim analysis was conducted to summarize the immediate information and offer an indicator for the progression of the task.

4.1.1 Use Case Distribution

Find below in Table 6 some general information about the distribution of the currently collected and consolidated IoT use cases and how these are distributed among domain and geography, as well as the defined case types and case levels.

Table 6: Analysis summary – general case information

Case domain	Agri-food (1), Energy & Utility (3), Manufacturing (2), Mobility & Transportation (3), Smart Cities & Communities (1), Other (1)
Case geography	Belgium (2), Denmark (2), Greece (2), Ireland (1), Italy (2), Spain (2), Sweden (1)
Case type	Business use case (7), Technology use case (5)
Case level	Level 1 Edge (3), Level 2 Industrial (7), Level 3 Pilot (2)

4.1.2 Technology Trends

The technological domains covered by the analysed IoT use cases are as follows:

Artificial Intelligence (5), Digital Twins (5), Fog Computing (2), High Performance Computing (1), Ledger Technology (2), Machine Learning (4), Mixed Reality (1), Nano Electronics (0), Open Source software and/or hardware (8), Quantum Computing (1), Robotics (2), Satellites (0) - Search Technology (1), Sensors and/or cameras (12), Virtual and/or Augmented Reality (2), 5G (5), 6G (0), Other (1).

The distribution indicates that the most archetypical technology trends among the analysed IoT use cases is *Sensors and/or cameras,* which is applied to all the case companies, and *Open Source software and/or hardware,* which is applied to more than half of the case companies. Also *Artificial Intelligence, Digital Twins* and *5G* are prevalent technology trends among the case companies.

4.1.3 Digital Maturity

Majority of the analysed IoT use cases assume a high level of digital maturity with an *average overall score of 3.97.*

The highly ranked scores may be explicated by the origination of many of the case companies as born digital. The score indicates that the digital capabilities of the case companies are vastly mature, and that they perform above average for their sector.

The average digital maturity for the analysed IoT use cases is mapped out on each of the six dimensions of the DMAT as demonstrated below:

Dimension	Strategy	Culture	Organisation	Processes	Technology	Customers & Partners
Score	4.10	4.08	3.90	3.73	4.10	3.92

The scores indicate that the case companies, on average, consider themselves the most digital mature on strategy and technology, and least digital mature on processes.

4.1.4 Business Model Innovation

Majority of the analysed IoT use cases are causes of business model innovation, as the IoT development and/or deployment has significantly affected two or more of the four dimensions on the business model of the case company. This is the case for 10 of the 12 analysed IoT use cases.

The business model dimensions that have been affected in the analysed IoT use cases are mapped out as illustrated in Figure 11 below.

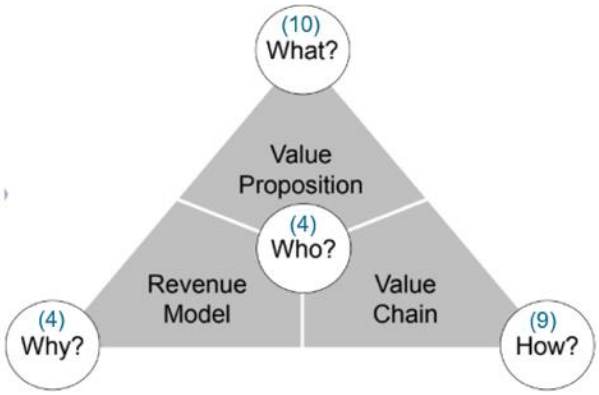


Figure 11: Analysis summary – business model innovation

The distribution indicates that the most archetypical business model dimension to be significantly affected by the IoT development and/or deployment of the analysed use cases are the value proposition and the value chain i.e. WHAT value the firm offers and HOW it is put into effect, whereas the dimensions that are least affected are the profit mechanism and the target segment, i.e. WHY the value is eligible for profit, and WHO it is offered to.

4.1.5 Business Model Patterns

Majority of the analysed IoT use cases are characterised by the overarching business model super-pattern *Expertization*. The super-pattern Expertization indicates that more than half (7 of 12) has a combined process- and product-focus.

The business model patterns that have been active in characterising the analysed IoT use cases are mapped out as illustrated by Figure 12 below.

SUPER-PATTERN	SUB-PATTERN			
Integration (2)	Crowd-sourced innovation (1)	Production as a service	Mass customization	
Servitization (3)	Life-long partnerships (3)	Product as a service (1)	Result as a service (1)	
Expertization (7)	Product-related consulting (1)	Process-related consulting (1)	Product-related Platformization (2)	Process-related Platformization (4)

Figure 12: Analysis summary – business model patterns

The distribution indicates that the most archetypical business model sub-pattern among the analysed IoT use cases are Process-related Platformization and life-long partnerships.

4.2 Use Case Catalogue

In this section, we present the IoT success stories that are generated based on the data collected from our list of IoT use cases. The individual use case is presented as a story that reflects the successful IoT development and/or deployment made by a specific company. The use cases, as a collective group, are presented as a catalogue that reflects the best practices for achieving success in developing and/or deploying IoT solutions.

Find below a summary version of the 12 IoT success stories that are currently collected and consolidated.

TROLDTEKT

The use case in brief: Operations are made more efficient through leverage of data from production processes of acoustic panels

Full case study: https://dbd.au.dk/blog/case-studies/troldtekt-a-s/

Domain	Manufacturing
Geography	Denmark
Technologies	Sensors and/or cameras
SDG engagement	#3 Good Health and Well-being. #12 Sustainable Consumption and Production. #15 Life on land. #17 Partnerships for the Goals.

Challenge

- Severe product defect rate causing substantial costs due to demolition and waste
- Machine operations driven by 'gut feeling' and intuition of the operators

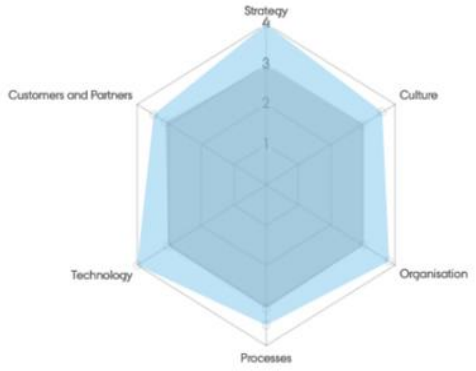
Solution

- Wireless PLC sensor in a plug and play format, enabling the collection and merging of data across machines, production environment and manual configurations

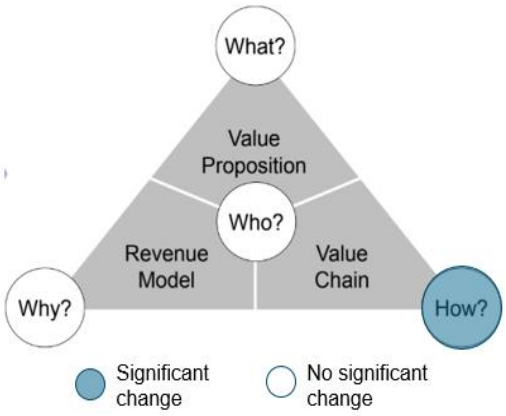
Outcome

- Overview and insights on cause-and-effects in production performance
- Increased operational performance and identification of optimisation potentials
- Implementation of data-driven decision-making and quality management

Digital maturity, business model and business model pattern



Overall digital maturity: **3.73**



SUPER-PATTERN	SUB-PATTERN			
Integration	Crowd-sourced innovation	Production as a service	Mass customization	
Servitization	Life-long partnerships	Product as a service	Result as a service	
Expertization	Product-related consulting	Process-related consulting	Product-related platformization	Process-related platformization

HERNING VAND

The use case in brief: Intelligent water metering is enabling new service business model and service add-on for citizens

Full case study: http://dbd.au.dk/blog/case-studies/herning-vand/

Domain	Energy & Utility
Geography	Denmark
Technologies	Machine Learning, Open Source software and/or hardware, Sensors and/or cameras
SDG engagement	#6 Clean water and sanitation. #7 Affordable clean energy. #11 Sustainable cities and communities.

Challenge

- Existing water meters failed to meet technical standards during a control
- Desire to make customers more engaged in their water usage

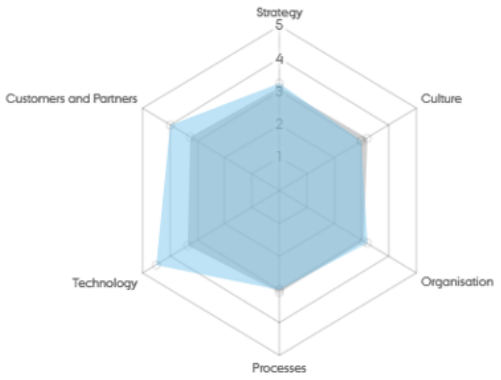
Solution

- Smart water metering; Digital water meters, supported by a software platform, are installed to replace the old obsolete devices

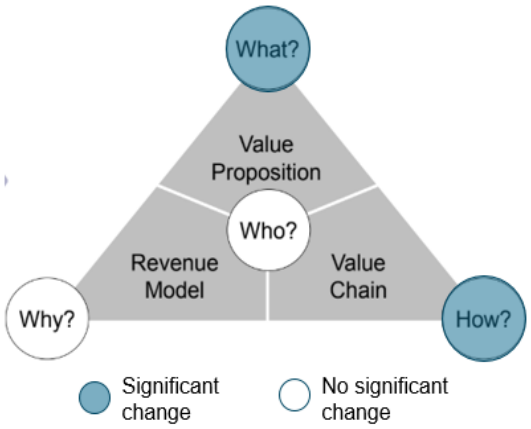
Outcome

- Remote and automated readings of water usage and waste increases internal efficiency and saves costs
- Data collected by the meters offers customer control and insight.
- Platform enables new customer service with automated billing, water consumption overview and leakage alters

Digital maturity, business model and business model pattern



Overall digital maturity: **3.49**



SUPER-PATTERN	SUB-PATTERN			
Integration	Crowd-sourced innovation	Production as a service	Mass customization	
Servitization	Life-long partnerships	Product as a service	Result as a service	
Expertization	Product-related consulting	Process-related consulting	Product-related platformization	Process-related platformization

AQUA ROBUR

The use case in brief: Smart water infrastructure is enabled by NB-IoT and energy harvesting technology

Full case study: https://dbd.au.dk/blog/case-studies/aqua-robur-technologies-ab/

Domain	Utility
Geography	Sweden
Technologies	Digital Twins, Open Source software and/or hardware, Sensors and/or cameras, 5G
SDG engagement	#6 Clean water and sanitation. #7 Affordable clean energy. #11 Sustainable cities and communities. #15 Life on land.

Challenge

- Insufficient water networks contribute to resource scarcity
- Leakage levels about 20-25% in public fresh-water pipelines

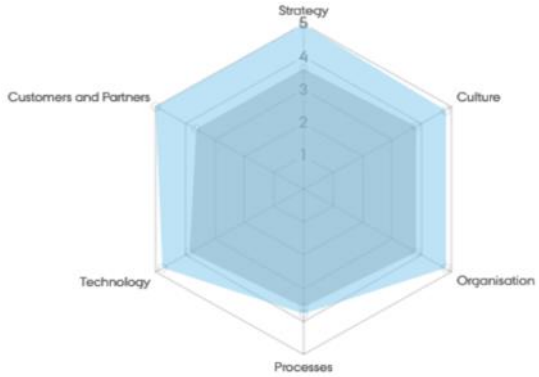
Solution

- Smart water infrastructure on the edge:
- plug-and-play IoT solution with integrated software solution enables monitoring and management of water networks
- micro-hydro-system converts water flow into a stable power supply

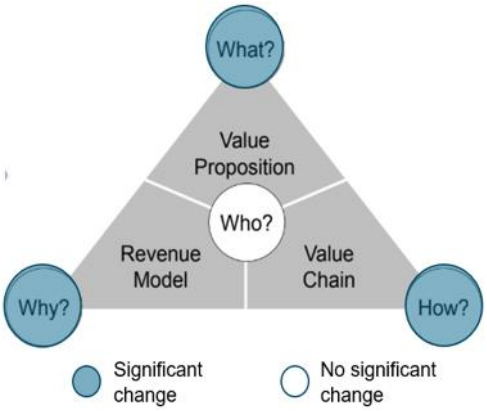
Outcome

- Increased control over water networks incl. reduced leakage levels
- Improved cost and performance due to enabled abnormality identification, automated preventive actions and predictive maintenance.

Digital maturity, business model and business model pattern



Overall digital maturity: **4.68**



SUPER-PATTERN	SUB-PATTERN			
Integration	Crowd-sourced innovation	Production as a service	Mass customization	
Servitization	Life-long partnerships	Product as a service	Result as a service	
Expertization	Product-related consulting	Process-related consulting	Product-related platformization	Process-related platformization

SYNELIXIS

The use case in brief: Precision agriculture is enabled by federated machine learning and autonomous farming procedures

Full case study: Not yet published online

Domain	Agri-Food
Geography	Greece
Technologies	Artificial Intelligence, Ledger Technology, Machine Learning, Sensors and/or cameras, 5G
SDG engagement	#2 Zero hunger. #12 Responsible consumption and production. #13 Climate action. #15 Life on land.

Challenge

- Heavy climate impact and resource consumption of cultivation
- Sectoral obsoleteness of the agricultural domain in Greece

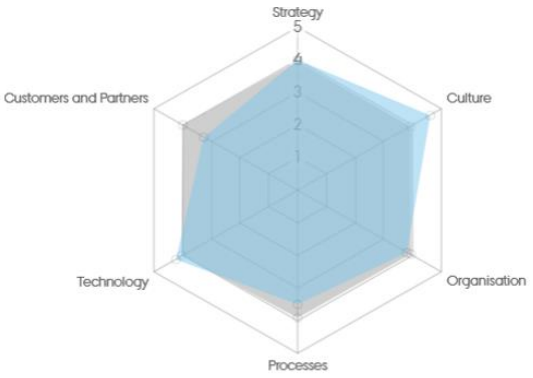
Solution

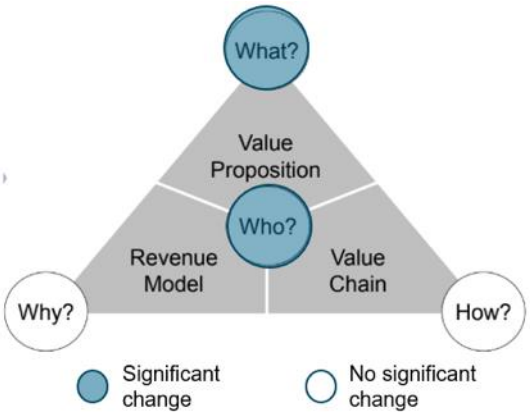
- Intelligent precision agriculture; Automation of farming procedures, enabled by a variety of sensors and actuators, a client platform and federated machine learning

Outcome

- Reduced spending of resources, effort, time and money due to enabled remote and fact driven management of the fields
- More optimal cultivation (enabled by irrigation water management, precision fertilization, climate monitoring and prediction of diseases in the crops)

Digital maturity, business model and business model pattern





Overall digital maturity: **3.90**

SUPER-PATTERN	SUB-PATTERN			
Integration	Crowd-sourced innovation	Production as a service	Mass customization	
Servitization	Life-long partnerships	Product as a service	Result as a service	
Expertization	Product-related consulting	Process-related consulting	Product-related platformization	Process-related platformization

SEE.SENSE

The use case in brief: Reactive bike lights utilise sensor technology to protect cyclists and help cities improve infrastructure

Full case study: Not yet published online

Domain	Mobility & Transportation / Smart Cities & Communities
Geography	Ireland
Technologies	Artificial Intelligence, Open Software and/or hardware, Sensors and/or cameras
SDG engagement	#3 Good Health and Well-being. #9 Industry, Innovation and Infrastructure. #11 Sustainable cities and communities. #13 Climate Action.

Challenge

- High safety risk of cycling on metropolitan roads due to visibility
- Non-optimal cycling infrastructure and poor road conditions cause poor cycling experiences and increase risk of collusions and accidents

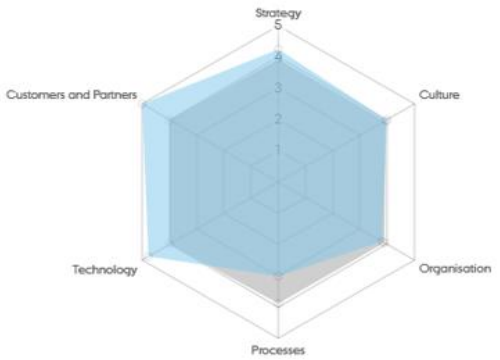
Solution

- Reactive bike lights; Sensor technology in the bike light monitors the environment (up to 800 times per second) and the behavior of the cyclist

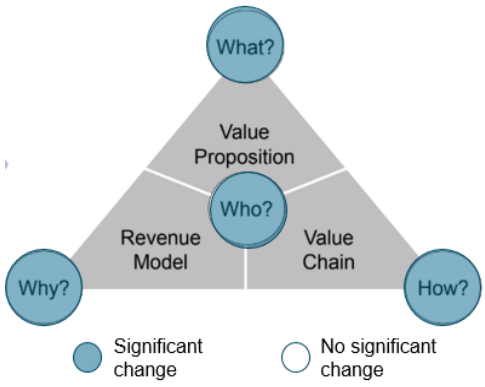
Outcome

- Increased cycling safety due to automated visibility in risky encounters (brighter and faster flashing e.g. at roundabouts)
- Information about infrastructure networks is passively collected and made available to city planners and engineers to support decision-making
- Sustainable transport is promoted, contributing to better health of citizens, while reducing exhaust emissions in cities.

Digital maturity, business model and business model pattern



Overall digital maturity: **4.13**



SUPER-PATTERN	SUB-PATTERN			
Integration	Crowd-sourced innovation	Production as a service	Mass customization	
Servitization	Life-long partnerships	Product as a service	Result as a service	
Expertization	Product-related consulting	Process-related consulting	Product-related platformization	Process-related platformization

HOPU

The use case in brief: Smart urban development and improved liveability is enabled through data-driven environmental monitoring

Full case study: https://dbd.au.dk/blog/case-studies/hopu/

Domain	Smart Cities & Communities
Geography	Spain
Technologies	Artificial Intelligence, Fog computing, Machine Learning, Open Source software and/or hardware, Search Technology, Sensors and/or Cameras, 5G
SDG engagement	#11 Sustainable cities and communities. #15 Climate Action.

Challenge

- Climate change's negative impact on human health and environment
- Cities find it difficult to navigate and select the most cost efficient and sustainable mitigation actions

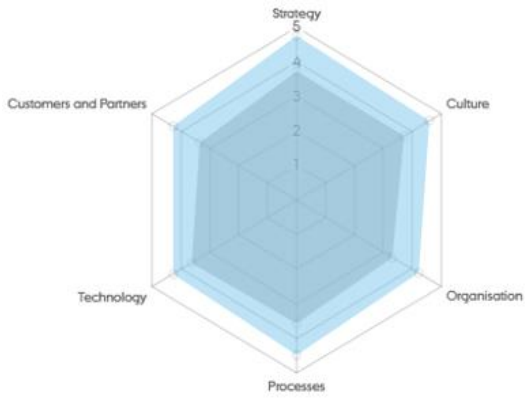
Solution

- Smart urban development; data-driven environmental monitoring enabled by sensorial detection of situational anomalies and irregularities (via 35 different parameters), and autonomous elicitation of mitigation actions

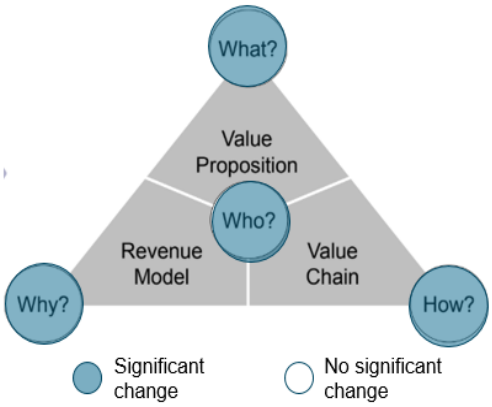
Outcome

- Environmental insight and forecasting is enabled for cities and urban planning
- Decision-making support is provided for actions to improve liveability index, quality of life of the citizens and sustained environment

Digital maturity, business model and business model pattern



Overall digital maturity: **4.43**



SUPER-PATTERN	SUB-PATTERN			
Integration	Crowd-sourced innovation	Production as a service	Mass customization	
Servitization	Life-long partnerships	Product as a service	Result as a service	
Expertization	Product-related consulting	Process-related consulting	Product-related platformization	Process-related platformization

TECNALIA

The use case in brief: Automated Driving (AD) systems enable sustainable and safe mobility in urban connected environment

Full case study: Not yet published online

Domain	Mobility & Transportation
Geography	Spain
Technologies	Artificial Intelligence, Digital Twins, Machine Learning, Robotics, Sensors and/or Cameras, Virtual and/or Augmented Reality, 5G
SDG engagement	#9 Industry, Innovation and Infrastructure. #11 Sustainable cities and communities.

Challenge

- Public request for AD technology to achieve more efficient and safe driving
- Desire to drive the transition towards mobility of the future: lower environmental impact, more inclusive, connected and smart

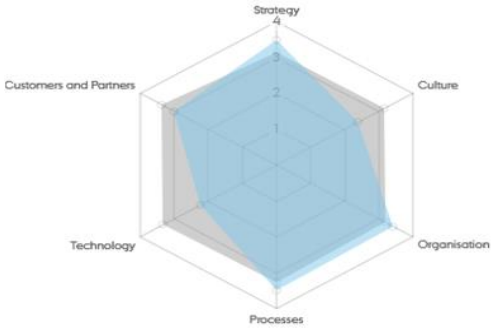
Solution

- AD systems based on standardized and easily deployable architecture (driver assistance and shared control systems), enabled by perception sensors, cameras and real time trajectory generations of data, which adds dynamic, sensorial and cinematic knowledge to vehicles

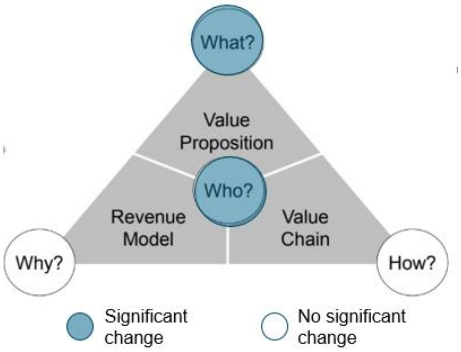
Outcome

- Improved driver experience in regards of safety, comfort, inclusion, time, efficiency, environmental sustainability
- Detection of obstacles and danger (e.g. other vehicles, pedestrians, driver distraction, unexpected elements) and automated activation of decision, control and actuation manoeuvres

Digital maturity, business model and business model pattern



Overall digital maturity: **3.00**



SUPER-PATTERN	SUB-PATTERN			
Integration	Crowd-sourced innovation	Production as a service	Mass customization	
Servitization	Life-long partnerships	Product as a service	Result as a service	
Expertization	Product-related consulting	Process-related consulting	Product-related platformization	Process-related platformization

EMOTION

The use case in brief: Smart e-mobility charging stations with remote control and edge capability

Full case study: Not yet published online

Domain	Mobility & Transportation
Geography	Italy
Technologies	Open Source software and/or hardware, Sensors and/or Cameras
SDG engagement	#7 Affordable clean energy. #9 Industry, Innovation and infrastructure. #11 Sustainable cities and communities.

Challenge

- Public request for increased sustainable driving and promotion of electric mobility
- Desire to integrate IoT into charging solutions for electric mobility

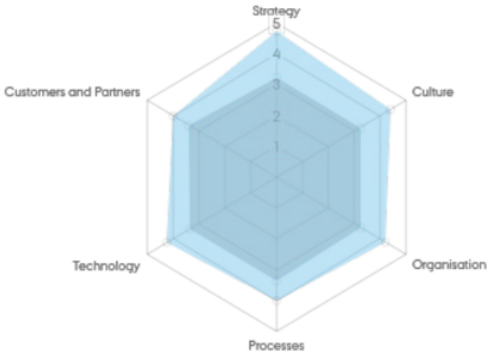
Solution

- Smart e-charging stations; charging stations modules integrated with SpotLink software and a dedicated application, collecting *remotely* readable flows of *real-time* information.

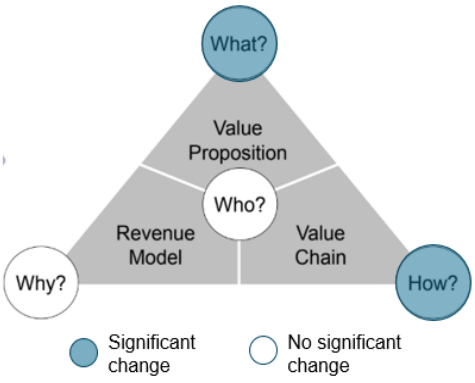
Outcome

- Remote monitoring, control and actuation of the stations (for station owners)
- Increased customer service in terms of geo-localization, secure payment, coupon management and consumption overview (for station users)
- Fostering intelligent sustainable infrastructure by balancing energy output with input from renewable energy resources

Digital maturity, business model and business model pattern



Overall digital maturity: **4.27**



SUPER-PATTERN	SUB-PATTERN			
Integration	Crowd-sourced innovation	Production as a service	Mass customization	
Servitization	Life-long partnerships	Product as a service	Result as a service	
Expertization	Product-related consulting	Process-related consulting	Product-related platformization	Process-related platformization

ASM TERNI

The use case in brief: Smart metering enables energy management and flexibility of Smart Grids

Full case study: Not yet published online

Domain	Energy & Utility
Geography	Italy
Technologies	Open Source software and/or hardware, Sensors and/or Cameras
SDG engagement	#7 Affordable clean energy. #11 Sustainable cities and communities. #12 Responsible consumption and production.

Challenge

- Societal ambition to increase penetration of renewable energy sources (RES) and transitioning the electricity towards a future-proof and 'clean' domain
- Distribution System Operators (DSOs) are challenged in securing, supplying and providing balance in the grid when incorporating RES.

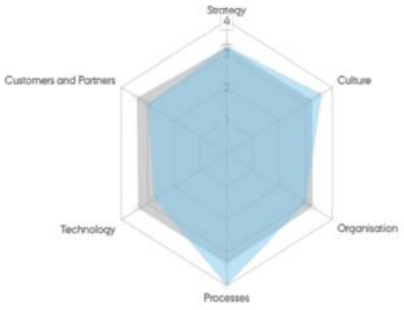
Solution

- Smart Grids; energy metering devices measure the amount of electricity consumed by users, offering near real-time data and algorithms that enables forecasting and immediate awareness about the status of the grid

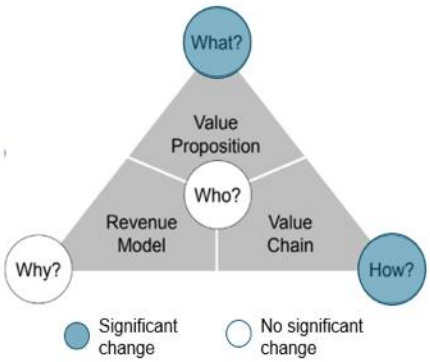
Outcome

- Improved grid management in general terms of energy flexibility alteration, demand response, asset management and predictive maintenance
- Increased security of supply and quality input (RES) and minimized risk of imbalance and overvoltage in the grid
- Decision support system for DSOs with abnormality detection based on ML algorithms and AI functionalities

Digital maturity, business model and business model pattern



Overall digital maturity: **3.27**



SUPER-PATTERN	SUB-PATTERN			
Integration	Crowd-sourced innovation	Production as a service	Mass customization	
Servitization	Life-long partnerships	Product as a service	Result as a service	
Expertization	Product-related consulting	Process-related consulting	Product-related platformization	Process-related platformization

CERTH

The use case in brief: The near Zero Energy Building (nZEB) Smart House is a catalyst for an IoT innovation hub, testbed and ecosystem

Full case study: Not yet published online

Domain	Other (Cross domain: Health & Care, Energy & Utility, Mobility & Transportation, Smart Cities & Communities, Cybersecurity)
Geography	Greece
Technologies	Artificial Intelligence, Digital Twins, Fog Computing, High Performance Computing, Ledger Technology, Machine Learning, Mixed Reality, Open Source software and/or hardware, Quantum Computing, Robotics, Sensors and/or cameras, Virtual and/or Augmented Reality, 5G, Other (Cybersecurity, Additive Manufacturing, Software Defined Network Technology)
SDG engagement	#3 Good Health and Well-being. #7 Affordable and Clean Energy. #9 Industry, Innovation and Infrastructure. #11 Sustainable Cities and Communities. #12 Responsible Consumption and Production.

Challenge

- Ambition to support the development of novel IoT-empowered solutions for emerging domains and challenges identified at regional, national and European levels
- Lack of facilitation for research and industry to evolve solutions collectively and generate long term sustainable collaborations

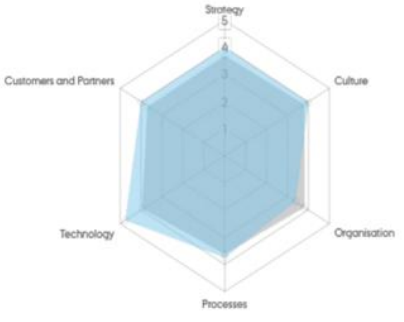
Solution

- Smart House; building with an open digital infrastructure and ecosystem for novel technologies and IoT solutions to be prototyped, developed and validated before introduced to the market

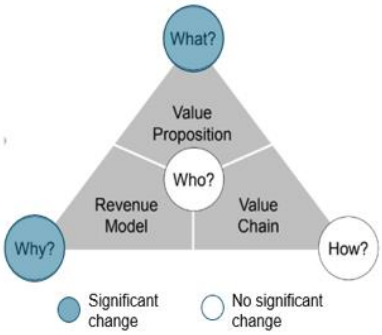
Outcome

- Unique set of data (collected by the building's multi-sensorial network that measures in real-time practically all parameters) for R&D
- Feasibility studies, proof of concept validations and Minimum Viable Product designs, for industrial third-party solutions
- Driving regional and national development while promoting digital transformation of entire civilisations

Digital maturity, business model and business model pattern



Overall digital maturity: **3.98**



SUPER-PATTERN	SUB-PATTERN			
Integration	Crowd-sourced innovation	Production as a service	Mass customization	
Servitization	Life-long partnerships	Product as a service	Result as a service	
Expertization	Product-related consulting	Process-related consulting	Product-related platformization	Process-related platformization

ALOXY

The use case in brief: End-to-end IoT solutions makes asset smart, automate processes and deliver actionable insights into industrial operations

Full case study: https://dbd.au.dk/blog/case-studies/aloxy/

Domain	Manufacturing
Geography	Belgium
Technologies	Digital Twins, Open Source Software and/or Hardware, Sensors and/or Cameras
SDG engagement	#8 Decent Work and Economic Growth. #9 Industry, Innovation and Infrastructure.

Challenge

- Insufficient processes of safety operations in industrial contexts, with manual checking of valve positions as a key factor
- Lack of wireless technologies at operational level, preventing monitoring of various important factors for optimising and streamlining daily procedures.

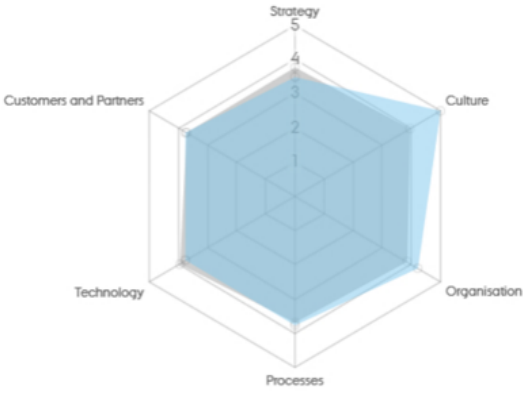
Solution

- IoT valve monitor: plug-and-play low power device combines a variety of sensors that facilitates automated monitor and control of valves, reducing the need to carry out manual tasks.

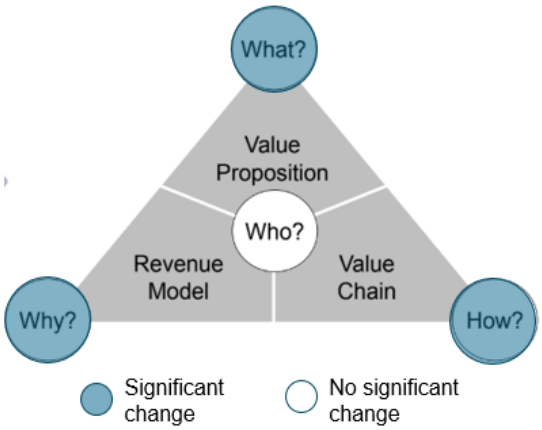
Outcome

- Reduced amount of time spent on valve checks and emergency monitoring
- Improve risk management, valve maintenance and process safety
- Contribution to the transition of the domain towards Industrial IoT and smart factories

Digital maturity, business model and business model pattern



Overall digital maturity: **3.99**



SUPER-PATTERN	SUB-PATTERN			
Integration	Crowd-sourced innovation	Production as a service	Mass customization	
Servitization	Life-long partnerships	Product as a service	Result as a service	
Expertization	Product-related consulting	Process-related consulting	Product-related platformization	Process-related platformization

ALLTHINGSTALK

The use case in brief: IoT application enablement platform and citizen science meteorological system

Full case study: https://dbd.au.dk/blog/case-studies/allthingstalk/

Domain	Other: Cross-domain
Geography	Belgium
Technologies	Digital Twins, Open Source Software and/or Hardware, Sensors and/or Cameras
SDG engagement	#9 Industry, Innovation and Infrastructure. #17 Partnerships for the Goals.

Challenge

- Commoditization of application development poses a general request for solutions to build and manage IoT initiatives
- Current solutions are complex and difficult to incorporate in existing organisational systems, requiring expensive expert help.

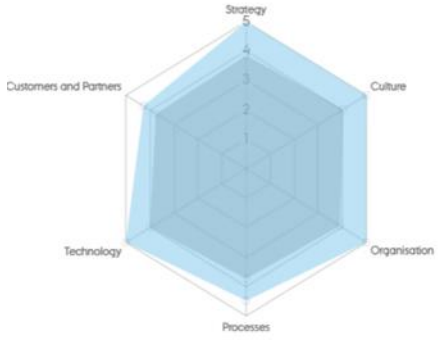
Solution

- End-to-end application; Cloud platform offering specific app services, to build and manage IoT products, both Maker and Product spaces, complementing by Rapid Development Kits that enables quickly built MVPs.

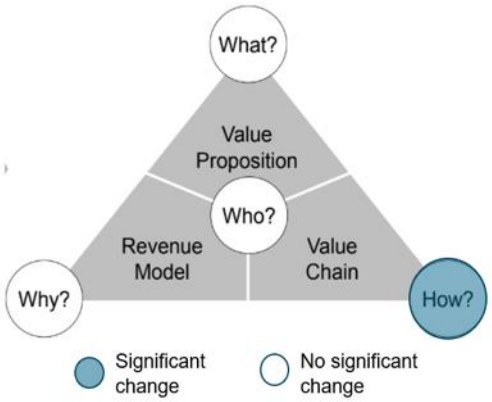
Outcome

- End-to-end solution that is logic and easy to use, regardless of the complexities of the physical sensors and network of an organisation.
- Enabled transformation towards data-driven business, through equipment provided to build physical use cases and aggregate data from existing and upcoming data networks, facilitating logic development of applications and reduced time to implement.

Digital maturity, business model and business model pattern



Overall digital maturity: **4.79**



SUPER-PATTERN	SUB-PATTERN			
Integration	Crowd-sourced innovation	Production as a service	Mass customization	
Servitization	Life-long partnerships	Product as a service	Result as a service	
Expertization	Product-related consulting	Process-related consulting	Product-related platformization	Process-related platformization

4.3 Use Case Catalogue Online Presentation

The complete use case catalogue will be made available at the official EU-IoT / NGIoT website: https://www.ngiot.eu/. The online presentation is to be designed and developed within the following year of the EU-IoT project and will be presented as a direct outcome of the final version 2 of this deliverable scheduled for October 2022.

At present, the IoT success stories are made available online as they are documented on a continuing basis, at the website of Aarhus University, Interdisciplinary Centre for Digital Business Development: https://dbd.au.dk/case-studies/. The online IoT success stories generally follow the same outline:

- **Short** introduction that introduces the case company and the context of the use case
- IoT incentive that reveals the cause and motivation of the case company for initiating development and/or deployment of an IoT solution
- IoT solution that describes technology architecture and features of the specific IoT solution of the case
- Outcome that accounts for the effects and value generated by the IoT use case both internally by the case company end externally in the ecosystem
- Learnings **and recommendations** that offer advice and inspiration to other actors that consider engaging in IoT development and/or deployment.

All stories include image material, and some include video material and/or additional text sections.

Find below in Figure 13, 14 and 15 early drafts illustrating the online presentation of the complete use case catalogue on the official EU-IoT / NGIoT website.

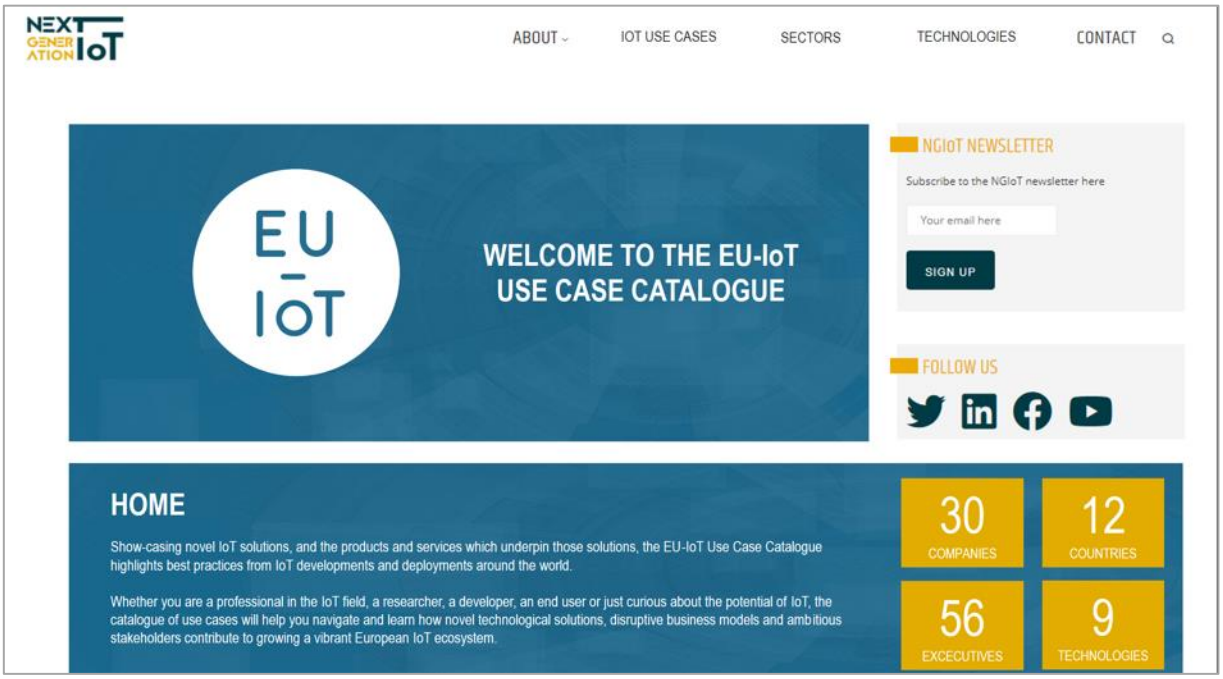


Figure 13: Online presentation draft 1 of 3

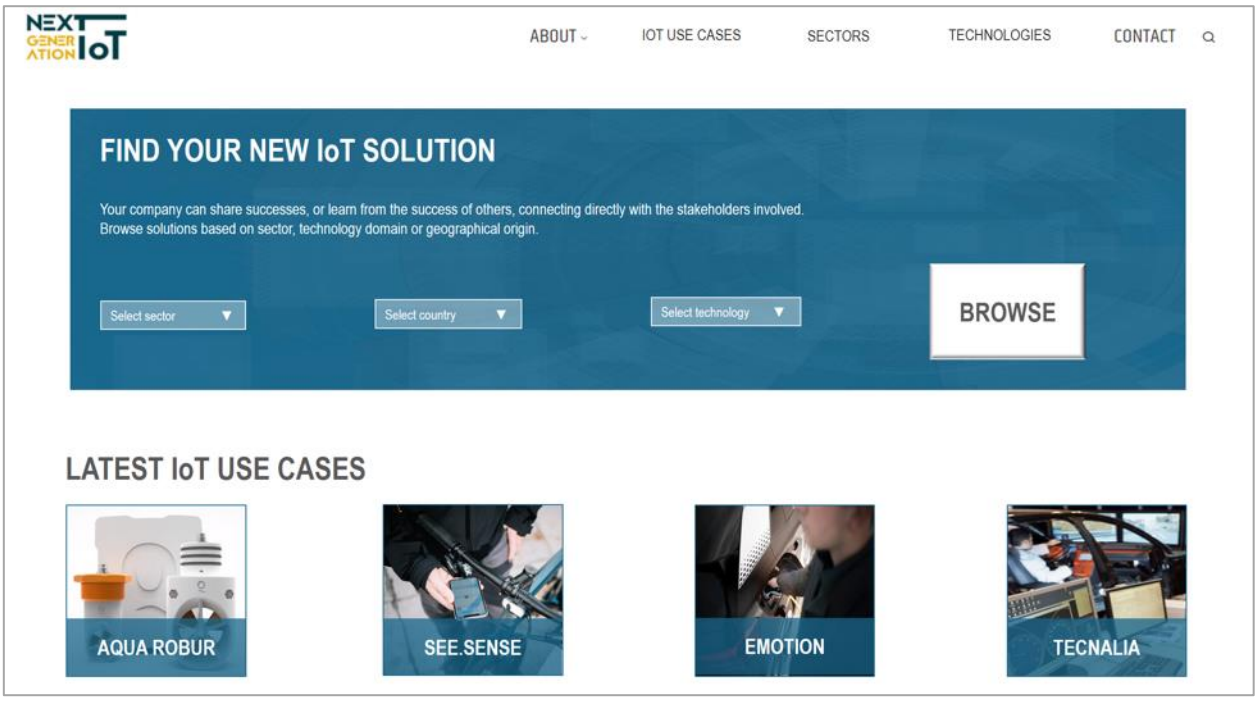


Figure 14: Online presentation draft 2 of 3

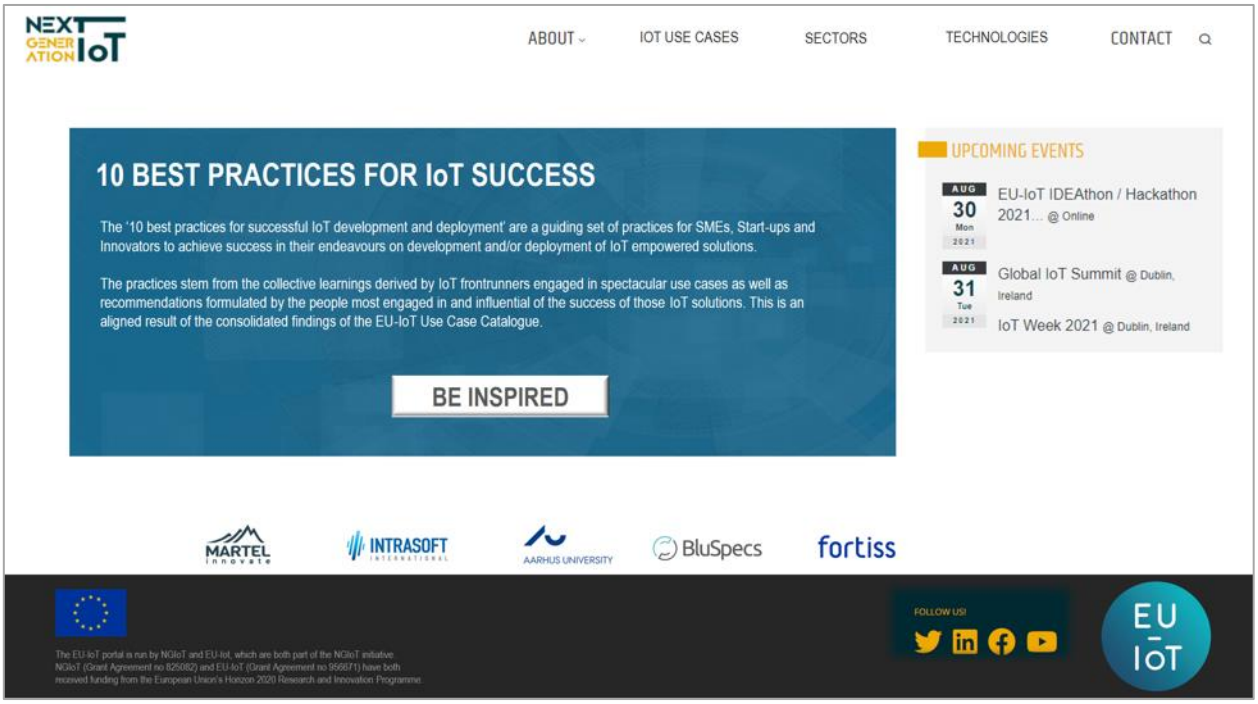


Figure 15: Online presentation draft 3 of 3

It is anticipated that the inclusion of the IoT use case catalogue to the official EU-IoT / NGIoT website will be an enriching contribution to its overall content, increasing the web site projection and extending its outreach in the ecosystem.

5. RECOMMENDATIONS AND NEXT STEPS

As previously accounted for, this report is an intermediate version deliverable, and the results presented are progressing work and therefore changeable in nature. The version 2 deliverable D4.2 will be submitted in month 24 (Oct 2022) of the EU-IoT project.

Target measures have been provided by the EC to be achieved within the period towards month 24. Find in Table 7 a status quo on the measures for the task related to this deliverable D4.1 "Collection and Documentation of Success Stories and Best Practice Use Cases" (Task 4.1).

Table 7: KPI measures related to deliverable 4.1

KPI measures	Target (M24)	Status (M12)	Comments
Number of success stories to be collected and consolidated.	>=30	12	30 success stories will be documented (based on interviews and surveys). These are selected from a backlog of identified best practice IoT use cases.
Documentation of use cases and success stories where novel and disruptive business models can be applied	>=20	10	20 of the 30 documented success stories will illustrate how novel and disruptive business model patterns are being applied.
Number of on-line showcases and case studies (in multimedia format)	>=12	6	12 of the 30 documented success stories will include multimedia format.

12 IoT success stories are currently consolidated and documented as IoT success stories (of which 6 are published online), and data has been collected from further 5 use cases (rf. Figure 3). All the planned activities in the period towards project month 24, will focus on achieving the KPI target measure of collecting and consolidating 30 IoT success stories, while complying with the targets for application of novel and disruptive business models and multimedia format in the selected use cases.

RECOMMENDATIONS

Based on the preliminary data collection and analysis of D4.1, we derive a set of recommendations that will be further explored towards D4.2.

The planned activities in the period towards project month 24 shall increasingly focus on centralising the tasks of the EU-IoT COACH (i.e. the entire Work Package 4 of the EU-IoT project), making sure that the Success stories and best practice use cases (Task4.1) eventually feeds into the planned Training and mentoring IoT skills development (Task4.2) and Business models acceleration support (Task4.3).

Hence, the continuation of the ongoing work that was presented in this deliverable is essential as a foundation for subsequent deliverables of the EU-IoT COACH to come. Not only in reporting on best practices for use cases, but on training activities and programmes (D4.4) and IoT BMI patterns (D4.6) as well.

As illustrated by Figure 16, current work focuses primarily on the collection and initial analysis of data. This work will continue until meeting the KPI targets set.

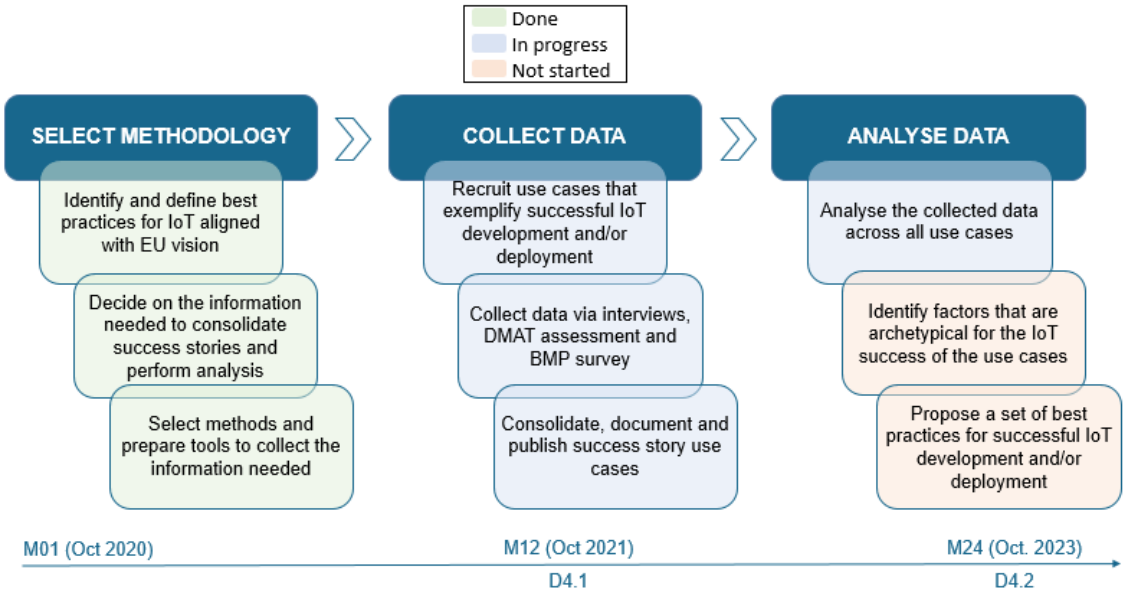


Figure 16: Status for reporting on best practices for IoT use cases

In the activities to liaise, identify and recruit the remaining IoT use cases, the three focus areas of the E4 Unit (i.e. Energy, Mobility and Agriculture) will receive special attention as requested by the EC. When all data has been collected, focus will shift towards analysing the data in more details. Additionally, the intention is to present, in D4.2, a complete catalogue of IoT success stories based on 30 best practice use cases and a streamlined overview on *'X best practices for successful IoT deployment and development'*.

NEXT STEPS

In brief, the key activities of the period towards month 24 (Oct 2022) of the EU-IoT project, and for the final version 2 deliverable D4.2, will include:

- Extension of the case backlog through further focus on leveraging key contact points for the identification and aggregation of best practice use cases
- Further data collection incl. planning and conduct of the remaining interviews
- Documentation and further refinement of IoT success stories
- Processing and analysis of (quantitative) survey data collected from use cases, in order to identify archetypical factors for achieving IoT success
- Multiple case study of (qualitative) interview data from use cases, in order to formulate a set of best practices for achieving IoT success
- Establish an online use case catalogue on the official EU-IoT / NGIoT website
- Establish templates for mapping of success stories to business model innovation methodologies and tools.

The EU-IoT consortium acknowledges the importance of ensuring the sustainability of its reporting outcomes on best practices for IoT use cases. To this end, the project is aiming at producing results with potential for extensibility and wider use. The use case catalogue is a step in this direction, as we envisage that the entire IoT community will use the catalogue as a directory of best practices for IoT beyond the end of the EU-IoT project. Likewise, our intention to conduct a meta-analysis on the use cases is one more result with significant sustainability potential. It can allow industry, innovators, IoT learners and policy makers to understand how they can create the most optimal premises for succeeding with IoT.

6. SUMMARY

This deliverable has illustrated the strategy of the EU-IoT project to report on best practices for IoT use cases, including the approach to guide and impact the future European IoT ecosystem. It has also specified the methodology for *how* to collect, consolidate and disseminate use cases that are capable of exemplifying best practices for IoT, as well as offered the intermediate results in a structured and easily accessible catalogue.

As an intermediate version 1 of 2 deliverables, this report focused on the methodology selected for the collection of best practice use cases, including clarification of the scientific and theoretical frame of reference. A wide selection of companies with interesting IoT use cases have been identified and recruited from various communities that operate in the scope of IoT, Qualitative data has been collected through interviews and quantitative data has been collected through assessments of the corporate digital maturity on various dimensions, business model configuration and business model patterns that characterize the use case.

Methodology and interim results were presented in this D4.1 report, whereas final results of the data collection and analysis will be presented in the complementary report D4.2 (to be publicly released in month 24, Oct 2022), where outcomes will include: (1) case catalogue of 30 written success stories that introduce the investigated IoT use cases, (2) results from analysis across all cases to identify and define archetypical factors for achieving success with IoT-empowered solutions, and (3) a guiding overview that aligns the *'X best practices for successful IoT development and deployment'*.

It is expected that these outcomes will provide industry, innovators, IoT learners and policy makers with insights on factors that are archetypical for successful development and deployment of IoT-empowered solutions, offer inspiration and general guidelines on how novel technologies can be optimally utilised in business, and ultimately, enable European actors to adopt the best practices for achieving success with IoT in the fast-changing landscape. During the next year, the underlying activities related to recruitment, collection and consolidation of further use cases will continue and the multi-case analysis will be initiated. It is further expected that activities related to online dissemination of the use case catalogue will intensify.

Finally, the EU-IoT COACH will remain committed to the ambition of this deliverable to amplify effectively the results and the impact of various IoT initiatives that define the Next Generation Internet. As an inspirational hub, the full use case catalogue will lower the barriers for developing and deploying IoT solutions by supporting and accelerating the IoT business models and IoT skills development. Fostering synergies in the ecosystem and supporting efforts within H2020 and beyond the efforts will help to shape the digital future of Europe in the ongoing transition towards Horizon Europe.

APPENDIX A – USE CASE OVERVIEW

A.1: USE CASE OVERVIEW

No.	Case company	Use case outline
1	**Troldtekt**	Operations made more efficient through leverage of data from production processes of acoustic panels
2	**Herning Water**	Intelligent water metering enabling new service business model and service add-on for citizens
3	**Aqua Robur**	Smart water infrastructure enabled by NB-IoT and energy harvesting technology
4	**Synelixis**	Precision agriculture enabled by federated machine learning and autonomous farming procedures
5	**See.Sense**	Reactive bike lights utilise sensor technology to protect cyclists and help cities improve infrastructure
6	**HopU**	Smart urban development and improved liveability through data-driven environmental monitoring
7	**Tecnalia**	Automated driving systems enable sustainable and safe mobility in urban connected environment
8	**Emotion**	Smart e-mobility charging stations with remote control and edge capability
9	**ASM Terni**	Smart metering enables energy management and flexibility of Smart Grids
10	**CERTH**	The near Zero Energy Building (nZEB) Smart House is a catalyst for an IoT innovation hub, testbed and ecosystem
11	**Aloxy**	End-to-end IoT solutions makes asset smart, automate processes and deliver actionable insights into industrial operations
12	**AllThingsTalk**	IoT application enablement platform and citizen science meteorological system
13	**ASTI Mobile Robotics**	Intelligent industrial intralogistics enabled by automated guided vehicles with unified mobile robotics
14	**Cumucore**	Enablement of next generation mobile networks through Network Function Virtualization and Software Defined Networking
15	**Awake AI**	Maritime digitalization optimises sea-port-land operations through a collaborative open data platform
16	**Fivecomm**	Facilitation of the adoption of 5G technologies by industry vertical
17	**Quadible**	Authentication of end-users with autonomously working AI-platform
…		
30		

A.2: USE CASE OVERVIEW: CASE COMPANY TIME INFORMATION

No.	Case company	Year of est.	Year of IoT use case
1	**Troldtekt**	1935	2018
2	**Herning Water**	2010	2019
3	**Aqua Robur**	2015	2018
4	**Synelixis**	2007	2013
5	**See.Sense**	2013	2015
6	**HopU**	2014	2014
7	**Tecnalia**	2010	2016
8	**Emotion**	2014	2014
9	**ASM Terni**	1960	2015
10	**CERTH**	2000	2017
11	**Aloxy**	2017	2017
12	**AllThingsTalk**	2013	2013
13	**ASTI Mobile Robotics**	1982	
14	**Cumucore**	2014	
15	**Awake AI**	2018	
16	**Fivecomm**	2019	
17	**Quadible**	2015	
…			
30			

A.3: USE CASE OVERVIEW: CASE LEVEL AND TYPE

No.	Case company	Case level	Case type
1	**Troldtekt**	2. Industrial	Business
2	**Herning Water**	2. Industrial	Business
3	**Aqua Robur**	1. Edge	Business
4	**Synelixis**	2. Industrial	Business
5	**See.Sense**	2. Industrial	Business
6	**HopU**	1. Edge	Business
7	**Tecnalia**	3. Pilot	Technology
8	**Emotion**	2. Industrial	Business
9	**ASM Terni**	3. Pilot	Technology
10	**CERTH**	1. Edge	Technology
11	**Aloxy**	2. Industrial	Technology
12	**AllThingsTalk**	2. Industrial	Technology
13	**ASTI Mobile Robotics**	3. Pilot	Technology
14	**Cumucore**	3. Pilot	Business
15	**Awake AI**	2. Industrial	Business
16	**Fivecomm**	1. Edge	Business
17	**Quadible**	2. Industrial	Business
…			
30			

A.4: USE CASE OVERVIEW: CASE LEVEL AND TYPE ASSESSMENT

Find below an explanatory figure that clarifies how the IoT use cases are accessed, given the described distinction of case levels and case types:

For a complete overview of the case level and type of each use case, see appendix A.3.

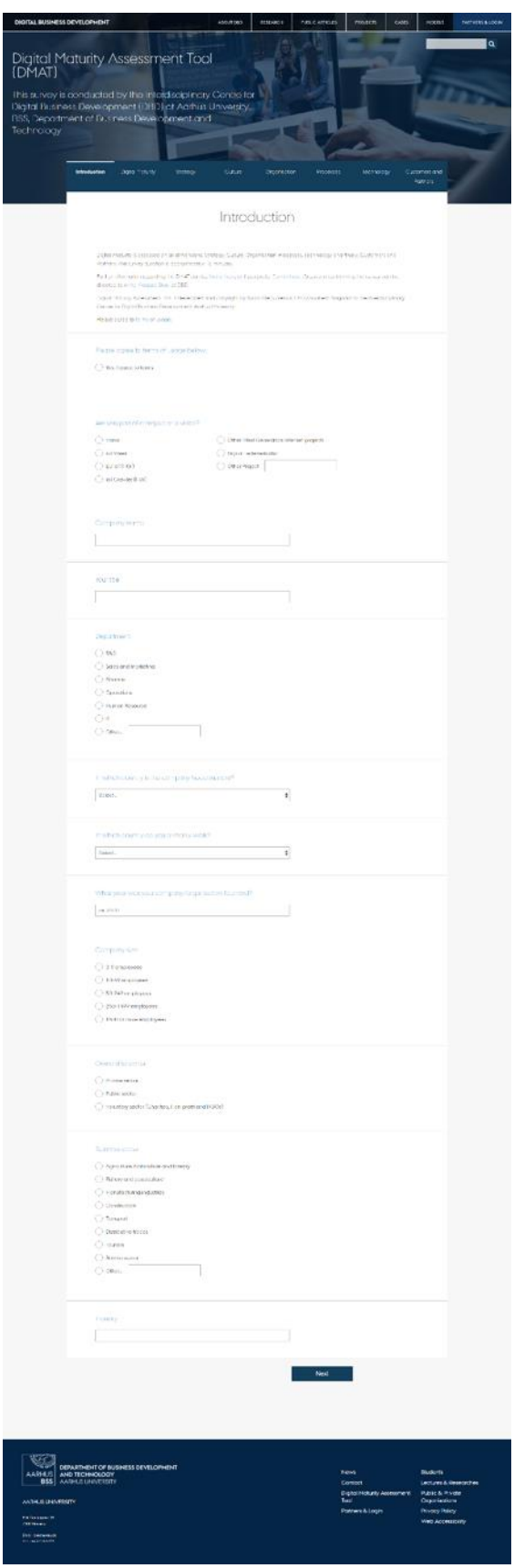
Figure 17: Distinction framework for levels and types of use cases

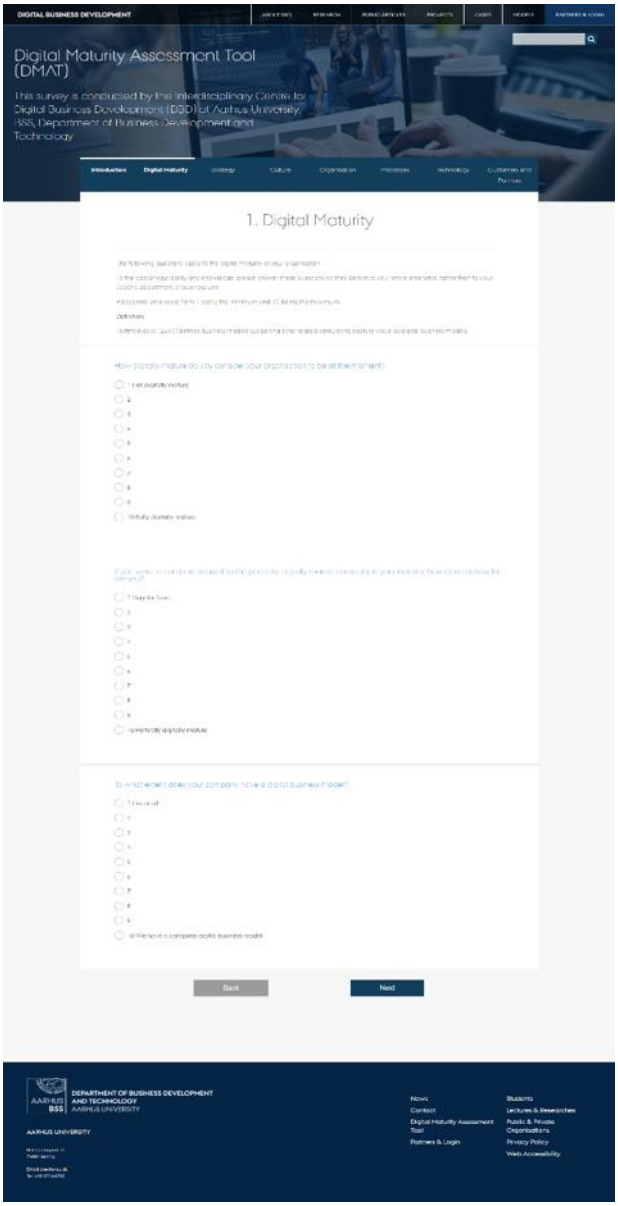
IoT use cases on level 1. Edge are the preferred cases, as they are the ones that best conform to the definition of an IoT success story. Cases on this level constitute the perfect IoT success story as referred to in sec. 2.4. IoT use cases on level 2. Industrial and 3. Pilot, are the cases we accept, as they conform to one of the two case types, and thus represent an IoT success story in terms of best practice for IoT through either business success or technological success. IoT use cases on level 4. Lab, are dismissed as no aspects of success can be documented – these are referred to as 'No case', in the above figure.

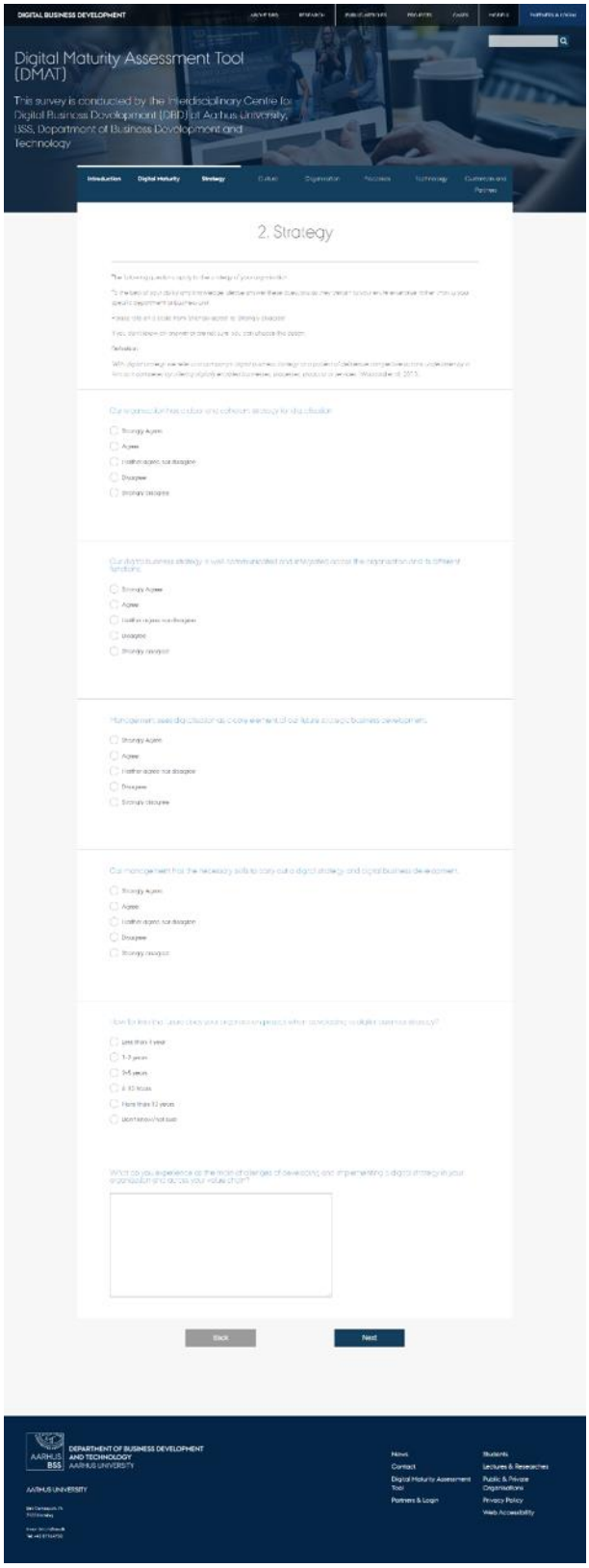
For a complete overview of the case level and type of each use case, see appendix A.3.

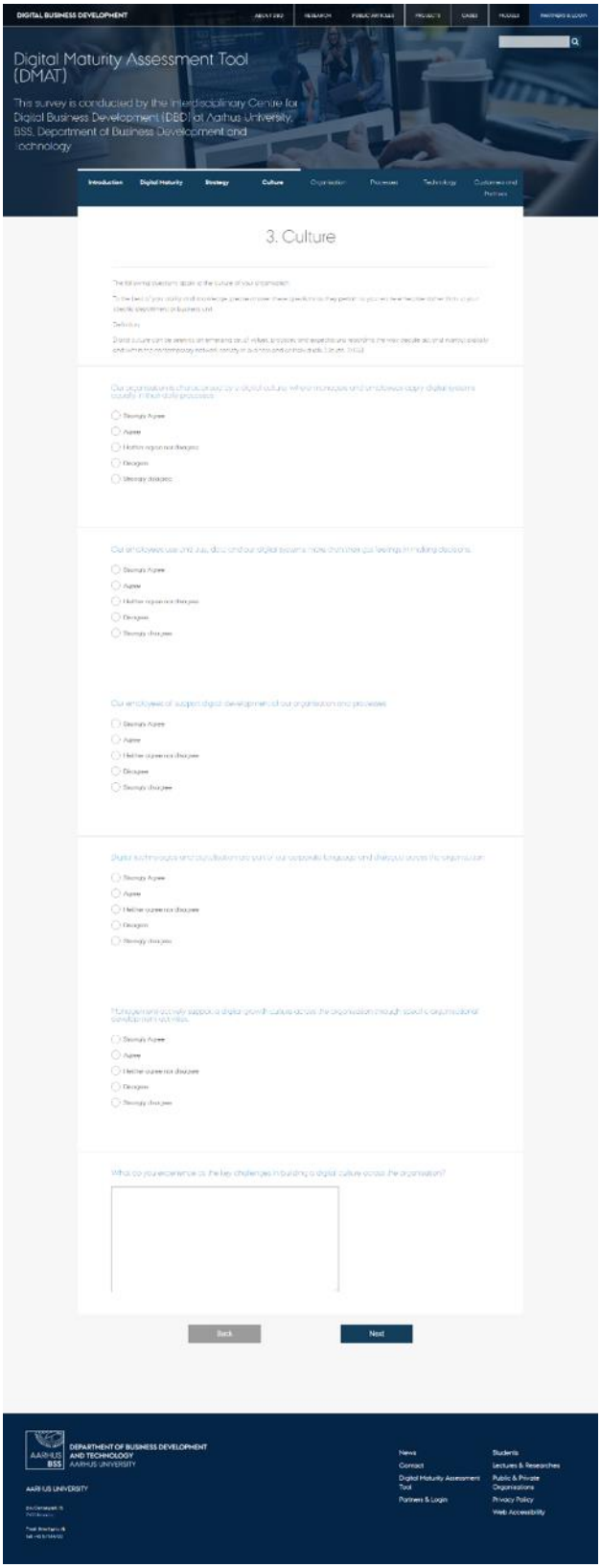
APPENDIX B – DIGITAL MATURITY ASSESSMENT TOOL

DMAT ASSESSMENT (Can be accessed online via the link: https://dbd.au.dk/dmat/)






DIGITAL BUSINESS DEVELOPMENT
Digital Maturity Assessment Tool (DMAT)
This survey is conducted by the Interdisciplinary Centre for Digital Business Development (IDBD) at Aarhus University, BSS, Department of Business Development and Technology
Introduction
Digital Maturity
Strategy
Culture
Organization
Processes
Technology
Customers and Partners
2. Strategy
Back
Next
DEPARTMENT OF BUSINESS DEVELOPMENT AND TECHNOLOGY
AARHUS UNIVERSITY
News
Contact
Digital Maturity Assessment Tool
Partners & Login
Students
Lectures & Researches
Public & Private Organisations
Privacy Policy
Web Accessibility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Digital Maturity Assessment Tool (DMAT)
This survey is conducted by the Interdisciplinary Centre for Digital Business Development (IDBD) at Aarhus University, BSS, Department of Business Development and Technology
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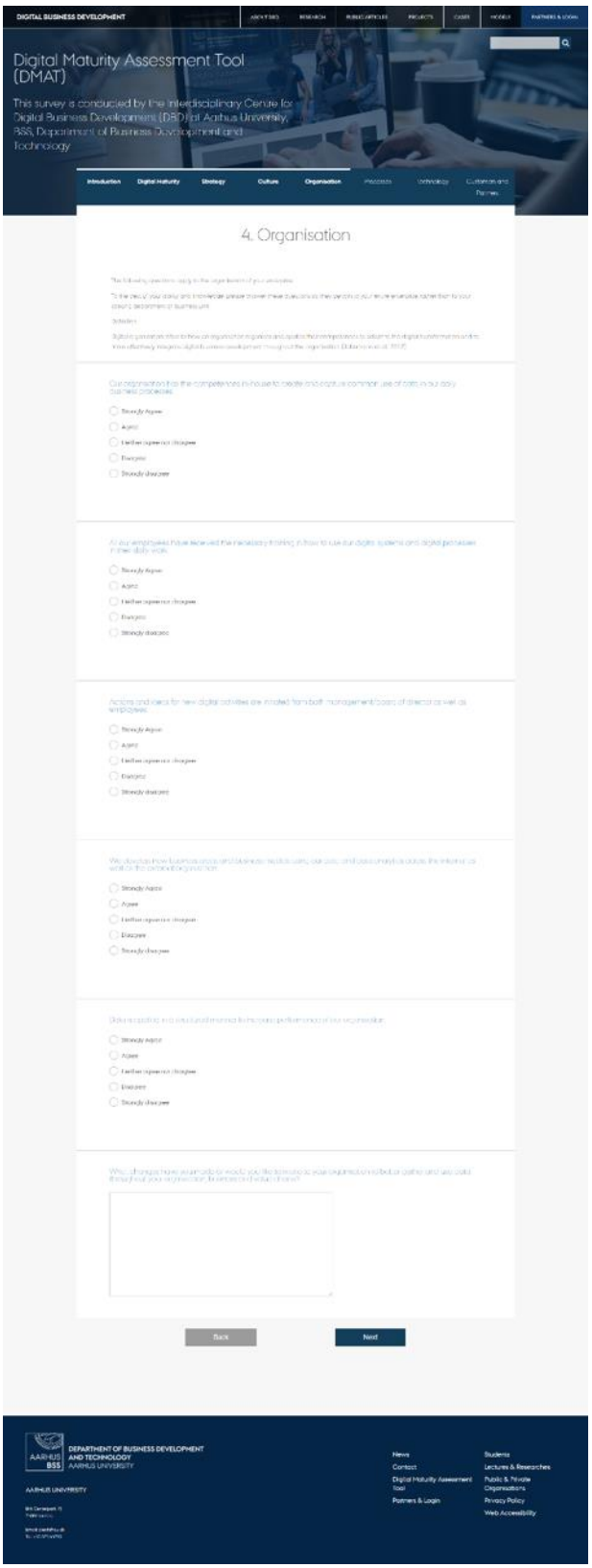
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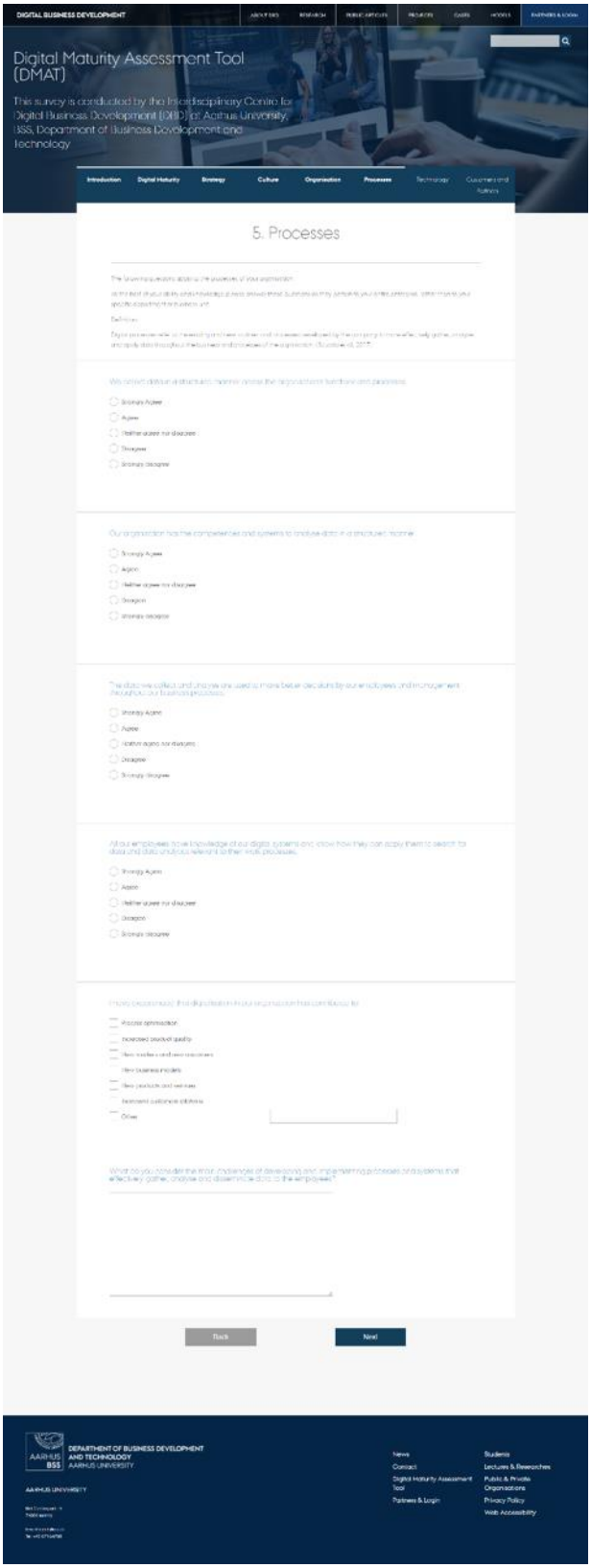
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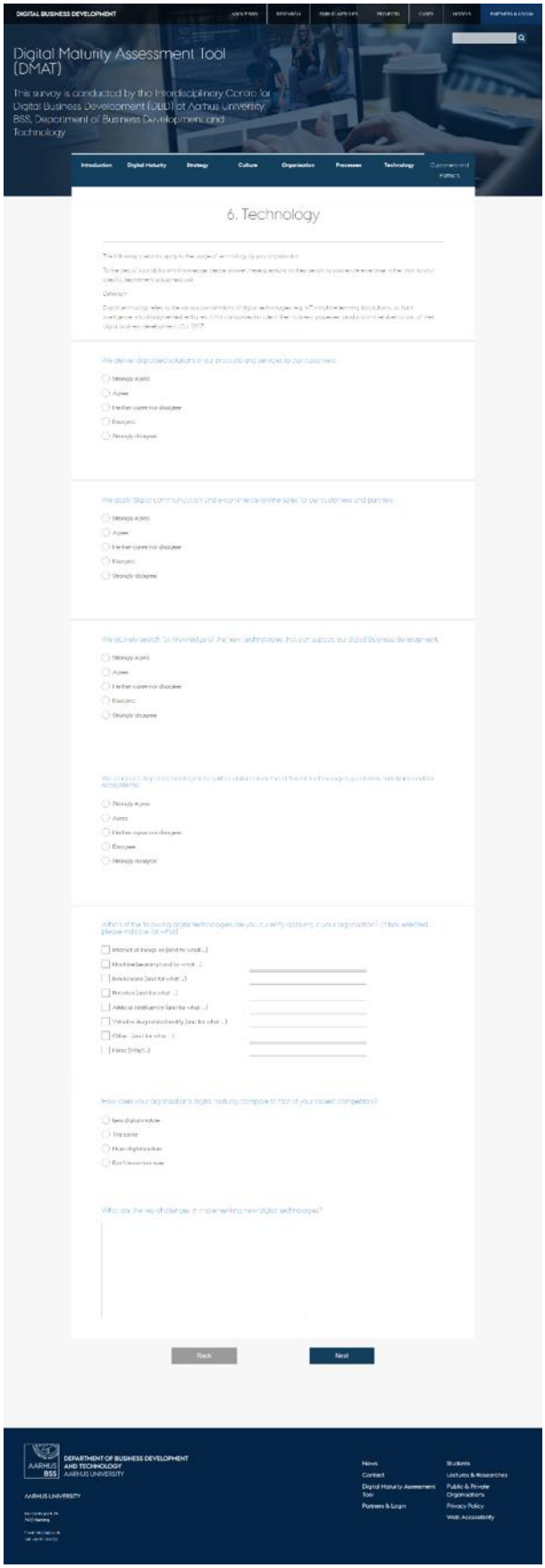
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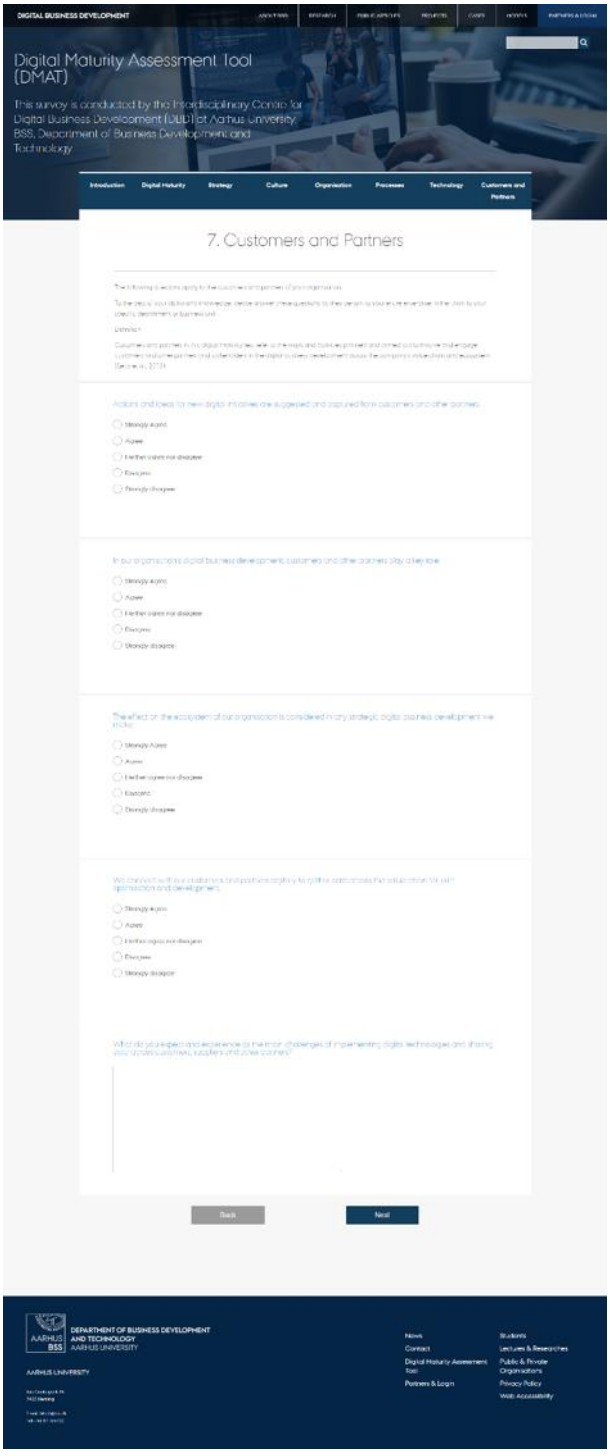
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DMAT REPORT (EXAMPLE)

Report #[redacted]

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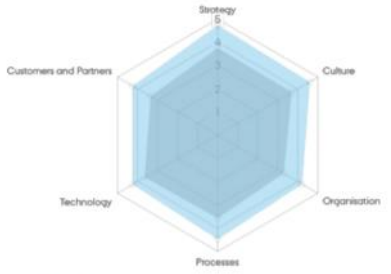
Mini Report
Digital Maturity Assessment Tool

The radar chart to the right illustrates the digital maturity equal to the information you have entered in the Digital Maturity Assessment Tool.

The radar chart to the right illustrates the digital maturity equal to the information you have entered in the Digital Maturity Assessment Tool. Your score is illustrated as the blue star, with the grey star as a reference point. The selected reference point is described next to the grey square below the radar chart. Your company's digital maturity is assessed on six dimensions: Strategy, Culture, Organisation, Processes, Technology and finally, Customers and Partners. Each of the dimensions is measured on a scale from 1 to 5. A score between 3 and 5 equals a high level of digital maturity within the dimension and below 3 equals a low digital maturity. No answer equals zero. In the section below, you will find the definitions of each dimension and your current score.



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The benchmark is based on your working location e.g., Denmark, Scandinavia or the continent if located outside Scandinavia.

Strategy

With digital strategy we refer to a company's digital business strategy as a pattern of deliberate competitive actions undertaken by a firm as it competes by offering digitally enabled businesses, processes, products or services.

Your Score
4.75

Culture

Digital culture can be seen as an emerging set of values, practices, and expectations regarding the way people act and interact digitally and within the contemporary network society in business and as individuals.

Your Score
4.60

Organisation

Digital organisation refers to how an organisation organise and apply their competences to adapt to the digital transformation and to more effectively integrate digital business development throughout the organisation.

Your Score
4.20

Processes

Digital processes refer to the existing and new routines and processes developed by the company to more effectively gather, analyse, and apply data throughout the business and processes of the organisation.

Your Score
4.50

Technology

Digital technology refers to the various combinations of digital technologies (e.g. IoT, Machine learning, Blockchains, Artificial Intelligence, Virtual/augmented reality etc.) that companies include into their business, processes, products, and services as part of their digital business development.

Your Score
4.25

Customers and Partners

Customers and partners in this digital maturity test refers to the ways and activities planned and carried out to involve and engage customers and other partners and stakeholders in the digital business development across the company's value chain and ecosystem.

Your Score
4.25

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Impact of Results

This section describes the known characteristics and impacts of having either a high or low maturity level on each variable. The characteristics will be less pronounced the closer the score is to the mean of 3. The results of the test are based on your answers for the questions posed in the digital maturity test, and the report generated from these answers is captured in a generic feedback on the six dimensions of digital maturity as stated below.

Your digital maturity test scores high/medium on digital strategy

A high/medium score on digital strategy indicates that your company has worked on formulating a strategy for your digitalisation and use of digital technologies. You should apply your digital strategy as a guide for the activities you set in motion and make sure that the digital strategy is implemented and integrated throughout your internal as well as external organisation to be able capture the full business and development potential. Make sure that you also support a strong digital culture and organisation to have the proper platform and resources for the digital endeavours you have planned in your digital strategy.

Your digital maturity test scores high/medium on digital culture

A high/medium score on digital culture emphasises that your company has worked on growing an organisational culture prone to digitalisation and the use of digital technologies throughout the company's processes and routines. To get the optimal business effects of a high digital culture, you should build on a digital strategy and emphasise developing your digital processes and routines as well as your digital organisation to make sure that you have the proper resources, structures and processes to materialise the digital development and business potentials of your organisation.

Your digital maturity test scores high/medium on digital organisation

A high/medium score on digital organisation reveals that your company has worked on building an organisation with the necessary digital competences and structures to be able to harvest the digital development your organisation may pursue. To ensure the full business potential of your company's digital development, make sure to build a strong digital culture and digital processes and implement a clear digital strategy to support the results of your digital organisation.

Your digital maturity test scores high/medium on digital processes

A high/medium score on digital processes indicates that your company has worked on developing the digital processes and routines throughout your organisation. Making use of digital technologies in your processes requires a strategic objective and a digital

culture and digital organisation to back it up for further developments. Thus, a digital strategy helping to prioritise how to further develop your internal and external processes digitally is key. Also, a strong digital culture combined with close digital collaboration with your customers and partners can help leverage the business potentials of your digital development.

Your digital maturity test scores high/medium on digital technology

A high/medium score on digital technologies suggests that your company has worked with digital technologies in a number of contexts. Digital business development requires an optimal prioritisation and use of selected digital technologies to be applied in your business processes and routines. It is therefore vital that your organisation has a clear digital strategy to guide the investments, prioritisation and integration of selected digital technologies in developing your digital business and that you use the digital technologies to build effective digital processes and strong and digital collaborations and processes with your customers and partners to harvest the full business potentials of your use of digital technologies.

Your digital maturity test scores high/medium on customers and partners

A high/medium score on customers and partners indicates that your company has worked on engaging your customers and other partners and stakeholders in your digitalisation. Although it is suggested to carry out digital transformation in the internal organisation first, the full business and development potentials of digital business development can only be reached through inclusion and interconnectivity of your value chain and your customers Digital Maturity Assessment Tool copyright Associate professor, PhD Annabeth Aagaard, Aarhus University and partners. This also requires a clear digital strategy, good digital processes and digital organisation to provide the right prioritisation of joint initiatives, effective joint/interconnected digital processes for the collaboration to work effectively and a strong digital organisation to provide the necessary competences for the further and joint digital development.

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Concluding Remarks

Digital technologies are transforming business strategies, business processes, firm capabilities, products and services and key interfirm relationships in extended business networks (Bharadwaj et al., 2013). Through the use of digital technologies, viewed as combinations of information, computing, communication and connectivity technologies, new and existing businesses can transform and identify, create and capture value in totally new ways.

The business potential of digital transformation is enormous, as stressed by several major consultancies (e.g., Accenture, 2015; McKinsey, 2015) and researchers (e.g., Bort, 2013). However, each company has to tailor their digital transformation process to their existing business and business strategy to reap the many benefits and business potentials of using digital technologies in (digital) business development (Aagaard, 2018). The digital maturity assessment mini-report illustrates the stronger and weaker dimensions of a company's digital maturity and can therefore indicate which dimensions to develop further. However, as all companies are unique, the report has to be complemented by individual feedback based on the specific characteristics of the company.

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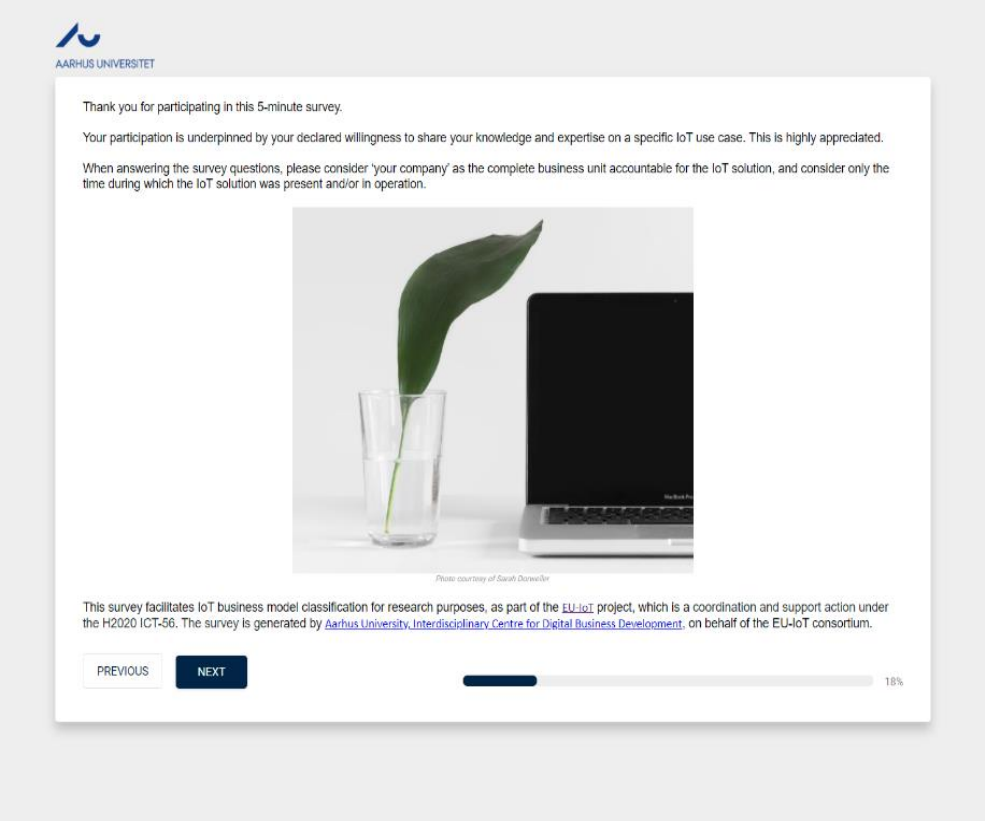
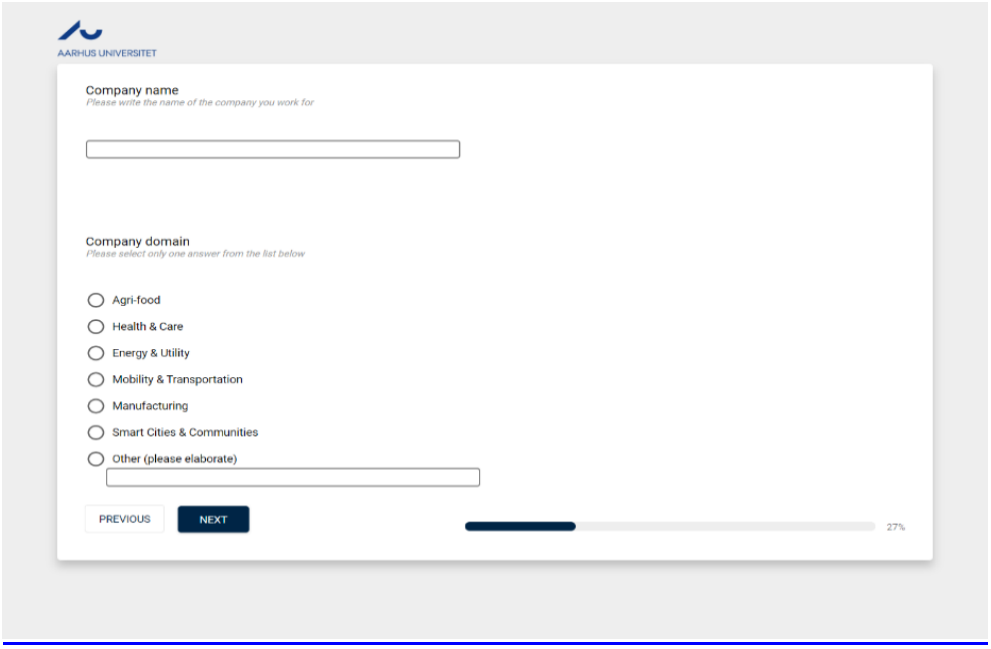
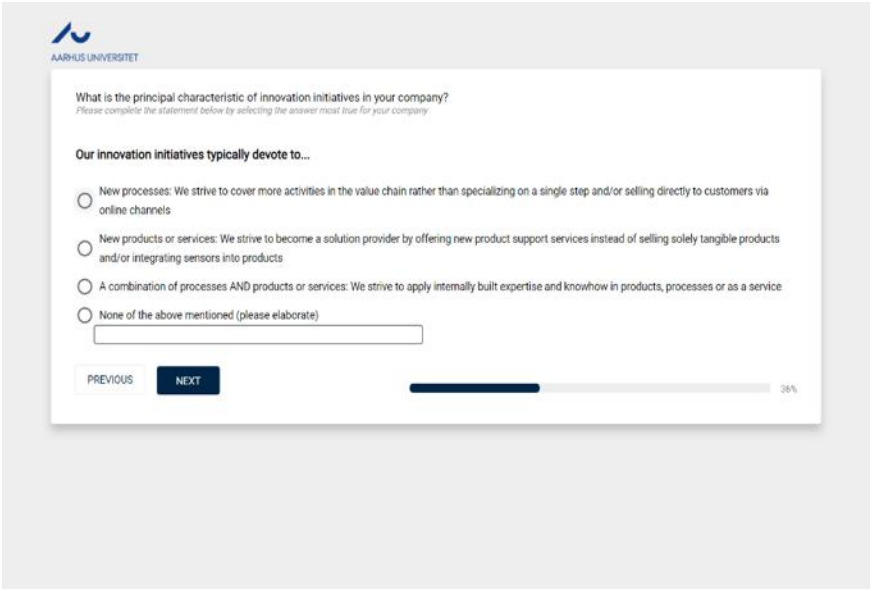
APPENDIX C – BUSINESS MODEL PATTERN SURVEY

(Can be accessed online via the link: https://survey.au.dk/LinkCollector?key=9492NPF6LPCK)







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What is the principal characteristic of innovation initiatives in your company?

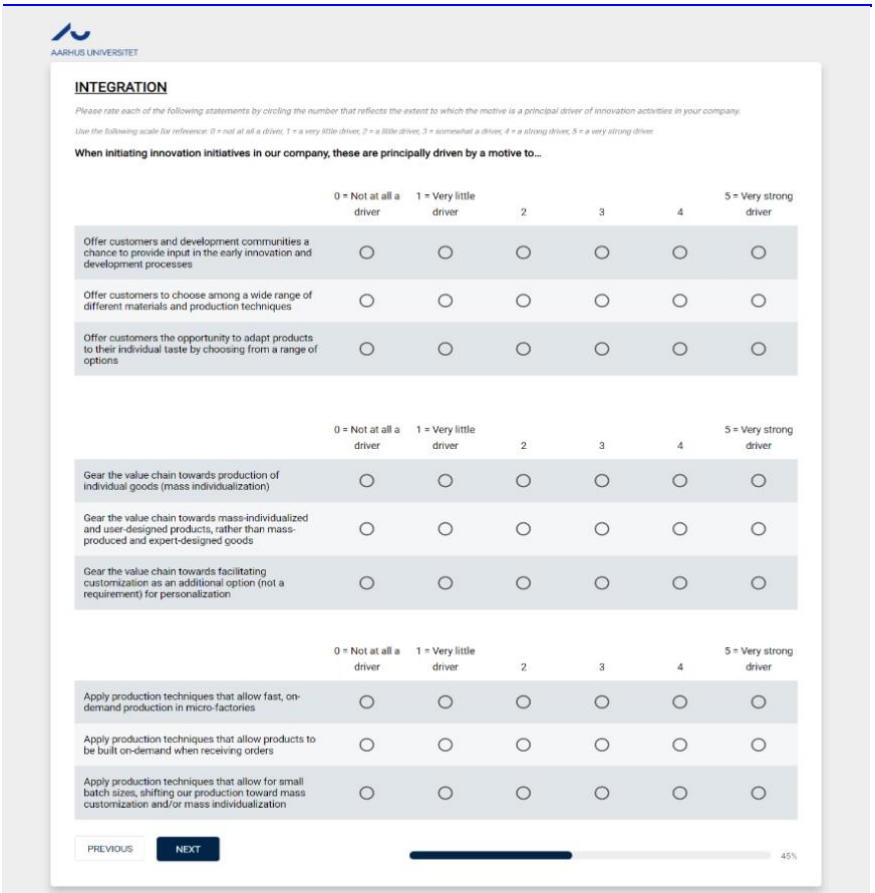
Please complete the statement below by selecting the answer most true for your company

Our innovation initiatives typically devote to...

- ○ New processes: We strive to cover more activities in the value chain rather than specializing on a single step and/or selling directly to customers via online channels
- ○ New products or services: We strive to become a solution provider by offering new product support services instead of selling solely tangible products and/or integrating sensors into products
- ○ A combination of processes AND products or services: We strive to apply internally built expertise and knowhow in products, processes or as a service
- ○ None of the above mentioned (please elaborate)

PREVIOUS NEXT

36%



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INTEGRATION

Please rate each of the following statements by circling the number that reflects the extent to which the motive is a principal driver of innovation activities in your company.

Use the following scale for reference: 0 = not at all a driver, 1 = a very little driver, 2 = a little driver, 3 = somewhat a driver, 4 = a strong driver, 5 = a very strong driver.

When initiating innovation initiatives in our company, these are principally driven by a motive to...

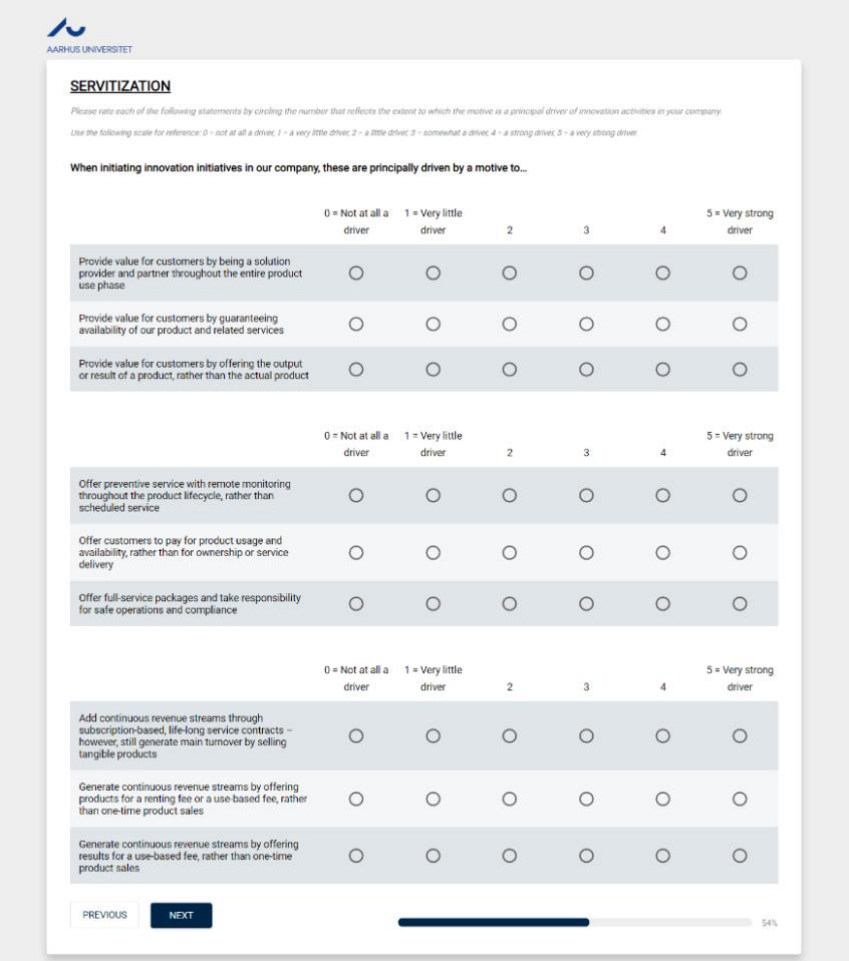
	0 = Not at all a driver	1 = Very little driver	2	3	4	5 = Very strong driver
Offer customers and development communities a chance to provide input in the early innovation and development processes	○	○	○	○	○	○
Offer customers to choose among a wide range of different materials and production techniques	○	○	○	○	○	○
Offer customers the opportunity to adapt products to their individual taste by choosing from a range of options	○	○	○	○	○	○

	0 = Not at all a driver	1 = Very little driver	2	3	4	5 = Very strong driver
Gear the value chain towards production of individual goods (mass individualization)	○	○	○	○	○	○
Gear the value chain towards mass-individualized and user-designed products, rather than mass-produced and expert-designed goods	○	○	○	○	○	○
Gear the value chain towards facilitating customization as an additional option (not a requirement) for personalization	○	○	○	○	○	○

	0 = Not at all a driver	1 = Very little driver	2	3	4	5 = Very strong driver
Apply production techniques that allow fast, on-demand production in micro-factories	○	○	○	○	○	○
Apply production techniques that allow products to be built on-demand when receiving orders	○	○	○	○	○	○
Apply production techniques that allow for small batch sizes, shifting our production toward mass customization and/or mass individualization	○	○	○	○	○	○

PREVIOUS NEXT

45%



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SERVITIZATION

Please rate each of the following statements by circling the number that reflects the extent to which the motive is a principal driver of innovation activities in your company.

Use the following scale for reference: 0 = not at all a driver, 1 = a very little driver, 2 = a little driver, 3 = somewhat a driver, 4 = a strong driver, 5 = a very strong driver.

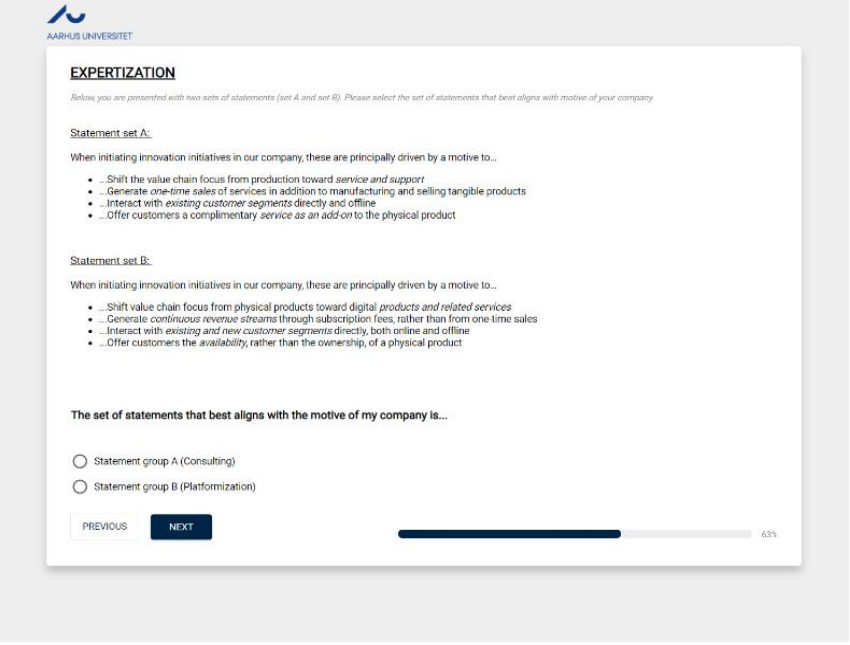
When initiating innovation initiatives in our company, these are principally driven by a motive to...

	0 = Not at all a driver	1 = Very little driver	2	3	4	5 = Very strong driver
Provide value for customers by being a solution provider and partner throughout the entire product use phase	○	○	○	○	○	○
Provide value for customers by guaranteeing availability of our product and related services	○	○	○	○	○	○
Provide value for customers by offering the output or result of a product, rather than the actual product	○	○	○	○	○	○

	0 = Not at all a driver	1 = Very little driver	2	3	4	5 = Very strong driver
Offer preventive service with remote monitoring throughout the product lifecycle, rather than scheduled service	○	○	○	○	○	○
Offer customers to pay for product usage and availability, rather than for ownership or service delivery	○	○	○	○	○	○
Offer full-service packages and take responsibility for safe operations and compliance	○	○	○	○	○	○

	0 = Not at all a driver	1 = Very little driver	2	3	4	5 = Very strong driver
Add continuous revenue streams through subscription-based, life-long service contracts – however, still generate main turnover by selling tangible products	○	○	○	○	○	○
Generate continuous revenue streams by offering products for a renting fee or a use-based fee, rather than one-time product sales	○	○	○	○	○	○
Generate continuous revenue streams by offering results for a use-based fee, rather than one-time product sales	○	○	○	○	○	○

PREVIOUS NEXT 54%



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EXPERTIZATION

Below, you are presented with two sets of statements (set A and set B). Please select the set of statements that best aligns with motive of your company.

Statement set A:

When initiating innovation initiatives in our company, these are principally driven by a motive to...

- ...Shift the value chain focus from production toward *service and support*
- ...Generate *one-time sales* of services in addition to manufacturing and selling tangible products
- ...Interact with *existing customer segments* directly and offline
- ...Offer customers a complimentary *service as an add-on* to the physical product

Statement set B:

When initiating innovation initiatives in our company, these are principally driven by a motive to...

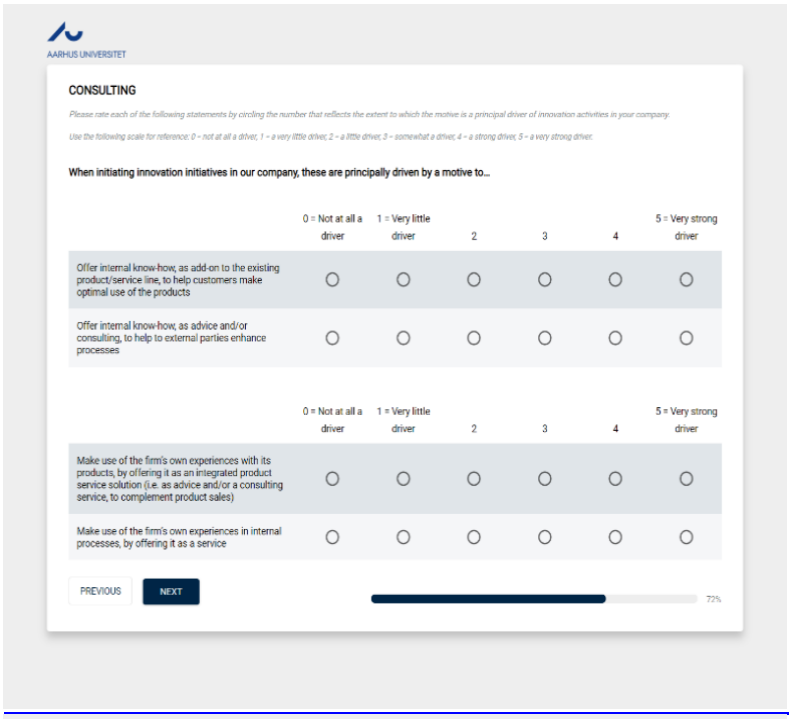
- ...Shift value chain focus from physical products toward digital *products and related services*
- ...Generate *continuous revenue streams* through subscription fees, rather than from one-time sales
- ...Interact with *existing and new customer segments* directly, both online and offline
- ...Offer customers the *availability*, rather than the ownership, of a physical product

The set of statements that best aligns with the motive of my company is...

○ Statement group A (Consulting)

○ Statement group B (Platformization)

PREVIOUS NEXT 63%



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CONSULTING

Please rate each of the following statements by circling the number that reflects the extent to which the motive is a principal driver of innovation activities in your company.

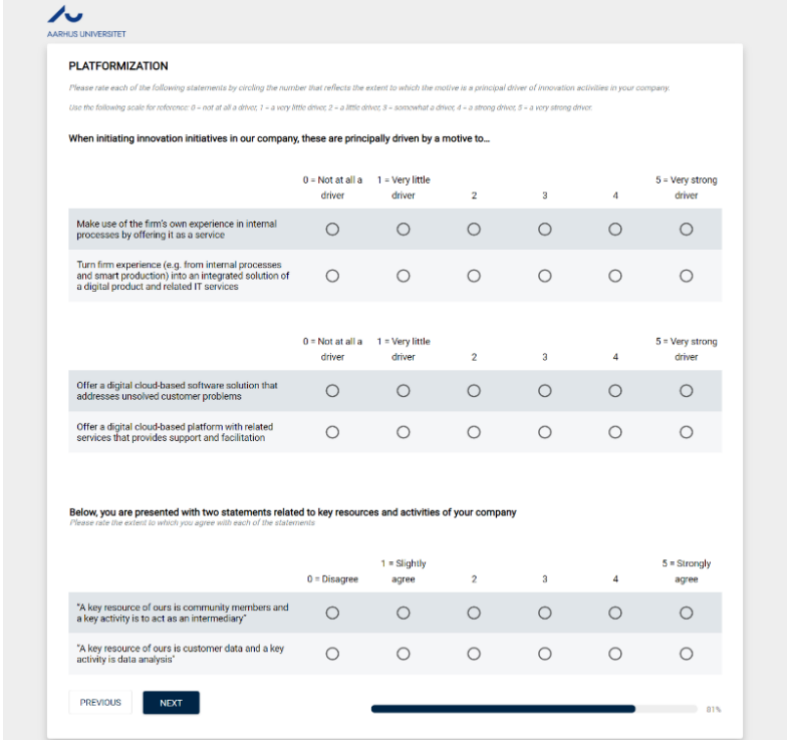
Use the following scale for reference: 0 = not at all a driver, 1 = a very little driver, 2 = a little driver, 3 = somewhat a driver, 4 = a strong driver, 5 = a very strong driver.

When initiating innovation initiatives in our company, these are principally driven by a motive to...

	0 = Not at all a driver	1 = Very little driver	2	3	4	5 = Very strong driver
Offer internal know-how, as add-on to the existing product/service line, to help customers make optimal use of the products	○	○	○	○	○	○
Offer internal know-how, as advice and/or consulting, to help to external parties enhance processes	○	○	○	○	○	○

	0 = Not at all a driver	1 = Very little driver	2	3	4	5 = Very strong driver
Make use of the firm's own experiences with its products, by offering it as an integrated product service solution (i.e. as advice and/or a consulting service, to complement product sales)	○	○	○	○	○	○
Make use of the firm's own experiences in internal processes, by offering it as a service	○	○	○	○	○	○

PREVIOUS NEXT 72%



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PLATFORMIZATION

Please rate each of the following statements by circling the number that reflects the extent to which the motive is a principal driver of innovation activities in your company.

Use the following scale for reference: 0 = not at all a driver, 1 = a very little driver, 2 = a little driver, 3 = somewhat a driver, 4 = a strong driver, 5 = a very strong driver.

When initiating innovation initiatives in our company, these are principally driven by a motive to...

	0 = Not at all a driver	1 = Very little driver	2	3	4	5 = Very strong driver
Make use of the firm's own experience in internal processes by offering it as a service	○	○	○	○	○	○
Turn firm experience (e.g. from internal processes and smart production) into an integrated solution of a digital product and related IT services	○	○	○	○	○	○

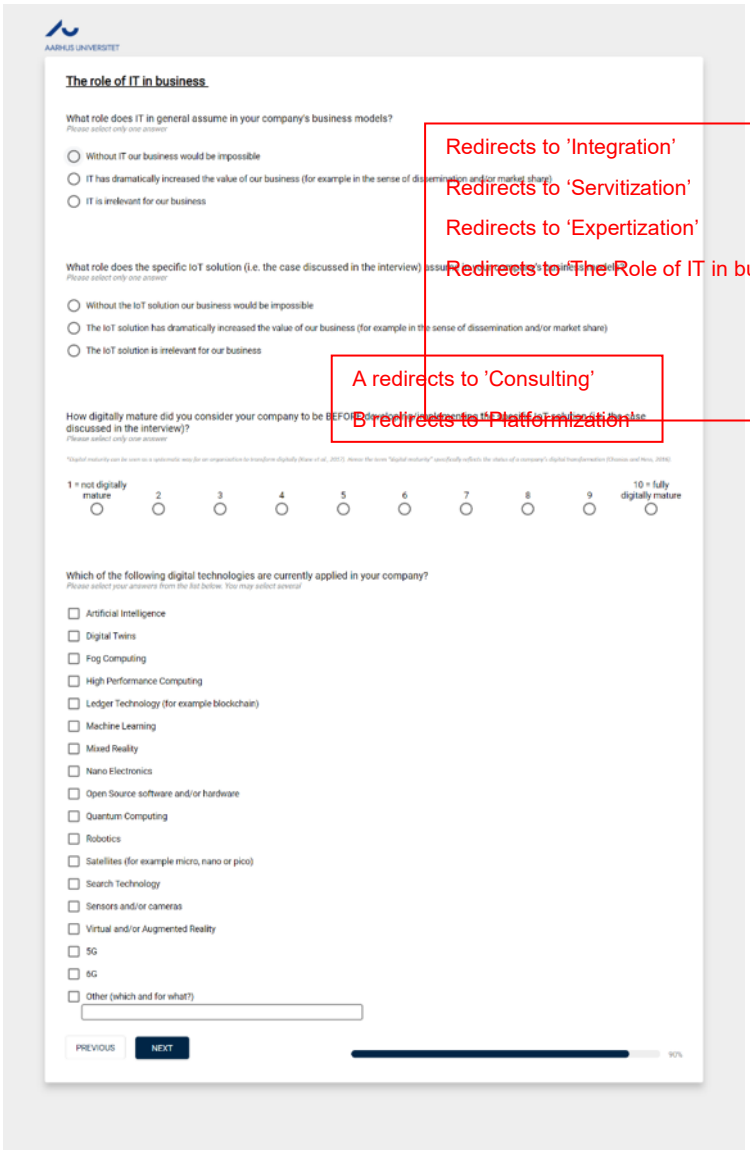
	0 = Not at all a driver	1 = Very little driver	2	3	4	5 = Very strong driver
Offer a digital cloud-based software solution that addresses unsolved customer problems	○	○	○	○	○	○
Offer a digital cloud-based platform with related services that provides support and facilitation	○	○	○	○	○	○

Below, you are presented with two statements related to key resources and activities of your company

Please rate the extent to which you agree with each of the statements

	0 = Disagree	1 = Slighly agree	2	3	4	5 = Strongly agree
"A key resource of ours is community members and a key activity is to act as an intermediary"	○	○	○	○	○	○
"A key resource of ours is customer data and a key activity is data analysis"	○	○	○	○	○	○

PREVIOUS NEXT 81%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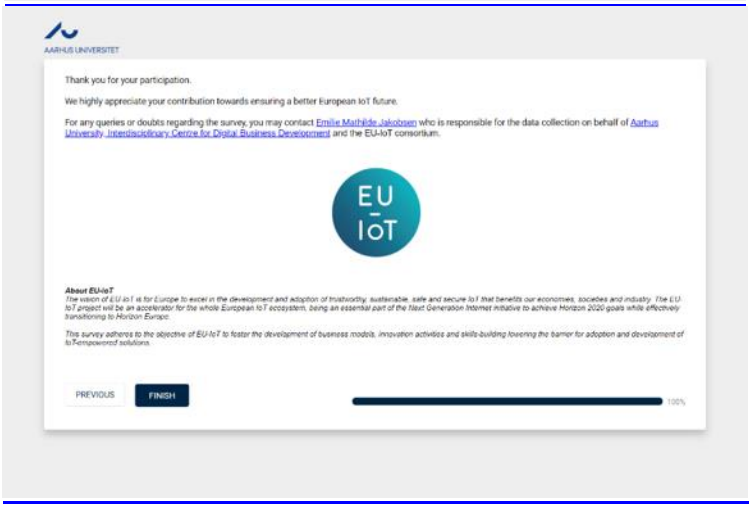
The role of IT in business
What role does IT in general assume in your company's business models?
Please select only one answer
Without IT our business would be impossible
IT has dramatically increased the value of our business (for example in the sense of dissemination and/or market share)
IT is irrelevant for our business
What role does the specific IoT solution (i.e. the case discussed in the interview) assume in your company's business models?
Please select only one answer
Without the IoT solution our business would be impossible
The IoT solution has dramatically increased the value of our business (for example in the sense of dissemination and/or market share)
The IoT solution is irrelevant for our business
How digitally mature did you consider your company to be BEFORE
discussed in the interview)?
Please select only one answer
1 = not digitally mature
10 = fully digitally mature
Which of the following digital technologies are currently applied in your company?
Please select your answers from the list below. You may select several
Artificial Intelligence
Digital Twins
Fog Computing
High Performance Computing
Ledger Technology (for example blockchain)
Machine Learning
Mixed Reality
Nano Electronics
Open Source software and/or hardware
Quantum Computing
Robotics
Satellites (for example micro, nano or pico)
Search Technology
Sensors and/or cameras
Virtual and/or Augmented Reality
5G
6G
Other (which and for what?)
PREVIOUS
NEXT
90%
Redirects to 'Integration'
Redirects to 'Servitization'
Redirects to 'Expertization'
Redirects to 'The Role of IT in business'
A redirects to 'Consulting'
B redirects to 'Platformization'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Thank you for your participation.
We highly appreciate your contribution towards ensuring a better European IoT future.
For any queries or doubts regarding the survey, you may contact Emilie Mathilde Jakobsen who is responsible for the data collection on behalf of Aarhus University, Interdisciplinary Centre for Digital Business Development and the EU-IoT consortium.
EU IoT
About EU-IoT
The vision of EU-IoT is for Europe to excel in the development and adoption of trustworthy, sustainable, safe and secure IoT that benefits our economies, societies and industry. The EU-IoT project will be an accelerator for the whole European IoT ecosystem, being an essential part of the Next Generation Internet initiative to achieve Horizon 2020 goals while effectively transitioning to Horizon Europe.
This survey adheres to the objective of EU-IoT to foster the development of business models, innovation activities and skills-building lowering the barrier for adoption and development of IoT-empowered solutions.
PREVIOUS
FINISH
100%

APPENDIX D – INTERVIEW FRAME EXAMPLE

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INTERVIEW GUIDELINE

Developed by Emilie Mathilde Jakobsen and Anita Krogsøe Skou at the Interdisciplinary Centre for Digital Business Development, Aarhus University.

Developed for the purpose of exploring and reporting best practice IoT use cases within the H2020 CSA project EU-IoT, Grant Agreement N° 956671.

1. Introduction to the informant/company

1.1 Can you please give a short presentation of what your unit/company does?

1.2 Can you please give a presentation of your role in the company?

2. Introduction to the IoT use case

1.1 Can you please give a short presentation to the IoT business solution?

What is the timeline of the solution?

1.2 Is the IoT solution implemented yet?

If yes: Where/in what context did you implement it?

If no: Where/in what context do you plan to implement it?

1.3 Why did you select the specific IoT solution that has been designed?

3. The role of IoT in the solution

3.1 Is the IoT used to develop new products / services (a), or to advance current (b)?

a. what is new and why are new products / services needed or desired?
b. what advancements are made and why?

3.2 How does the IoT drive the product / service?

3.3 Who are the potential users of the product / service?

3.4 Please describe the key (end user) features of the product/service?

3.5 Please describe the process-flow including points of human contact

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4. Verifying the IoT architecture / components of the IoT solution

4.1 Please describe the device domain of the IoT solution

What physical devices (sensors / actuators) are used to collect data e.g., accelerometer, GPS, camera etc.

What data does the IoT devices collect? e.g., ERP, PLS, BI, Excel, temperature, motion, location, video feed etc.

4.2 Please describe the network domain of the IoT solution

How are the IoT devices connected? / How is data transported to the cloud? e.g., WiFi, Bluetooth, satellite, gateway/router etc.

When and where is data analyzed and processed? [Cloud vs. Edge]

4.3 Please describe the application domain of the IoT solution

Does the IoT solution include any User Interfaces? e.g., smartphones, tablets, laptops

If yes... [client application]	*If no... [M2M application]*
• *What data does the interface visualize?* • *Does this include 'live' data?* • *Can the user 'interact' with the solution through the interface and if so, how?*	• *What data is exchanged between machines?* • *Does this include 'live' data?* • *Can the machines 'interact' with each other and if so, how?*
What is the data / results of data analysis used for? *e.g. trend identification, KPI determination, real-time error alerts*	

4.4 Please describe the level of autonomy enabled by the IoT solution?

Does the IoT solution act automatically? Is any human action needed?

What data schema and protocols run on the architecture to support autonomy?

5. Implementation / commercialization of the solution

5.1 Which internal departments and external partners were involved in the strategic roll-out and implementation the IoT solution?

5.2 How did you prepare for implementation and adoption the IoT solution across your organization, partners and users?

5.3 How did the technology implementation go? How did the market adapt the solution?

5.4 If going through the process of implementation and commercialization again - what would you do differently?

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6. Outcome and value

6.1 What has been the 2-3 most positive effects of implementing / commercializing the IoT solution?

6.2 Has the IoT solution influenced the way you do business? How?

e.g. new user groups, new markets, new revenue streams, new partner networks, new ways of interacting with customer etc.

6.3 To what extent has this IoT solution been able to create value internally in your organisation and/or externally in the business ecosystem?

6.4 Have you been able to capture (and measure) this value and how?

e.g. earn a profit, charge a premium price, lower material costs etc.

6.5 How do you expect or hope for the IoT solution to contribute more value in the future?

e.g. create new digital services/offerings, enter new markets, interact with new partners etc.

7. Learnings and success indicators

7.1 What has been your main managerial and organizational learnings from implementing / commercializing the IoT solution?

7.2 Do you consider the implementation / commercialization of the IoT solution a success and why?

7.3 What has been the 2-3 most essential causes for the successful implementation, adoption and use of the IoT solution?

7.4 Do you have any recommendations for companies similar to ASTI Mobile Robotics that consider implementing / commercializing an IoT solution?

If you have any questions, please contact me directly at email: emiliemj@btech.au.dk

APPENDIX E – INTERVIEW RECRUITMENT INFORMATION

To cover all relevant aspects of the IoT use case, and to ensure several perspectives, interviews are conducted with two employees from each case company (at all times possible). The two employees must be and/or have been severely involved in the IoT use case, and their roles in developing and/or deploying the IoT solution must represent diverse perspectives. Hence, from each company interviewees are selected as:

- One employee who is/has been involved in the technical setting of the IoT use case
- One employee who is/has been involved in the strategic business setting of the IoT use case

The duration of the interviews is between 30 and 45 minutes per person for an individual session, and between 40 and 60 minutes for a joint session. Before the interview, interviewees are provided with procedural participant information as well as information about GDPR and the legal basis for the consortium's collection, analysis and dissemination of data – and consent obtained with the interviewee's signature prior to the interview. When the written success story is composed, interviewees are offered to review factually it and approve the selection of quotes and images prior to publication.

The interviews are semi-structured and take point of departure in a range of questions about the specific IoT solution developed and/or deployed by the case company, achieved outcomes, learnings and recommendations.

INCLUSION CRITERIA

In addition to the criteria set for the different case types and the definition of IoT success story, further inclusion criteria were set up as a general filtering mechanism for all the use cases recruited to the backlog. These include:

- **Case company size**

  We aim to collect case companies for our analysis that are in the category of a small or medium-sized enterprise (SME), as these are the backbone of the European economy. They represent 99% of all businesses in the EU and employ around 100 million people, accounting for more than half of Europe's GDP, playing a key role in adding value in every sector of the economy [15].
  Hence implying that we aim to collect case companies that have between *10 and 250 employees*. To ensure this aim, the consortium has determined that a minimum of 80 % of the collected case companies must be in the category of a SME.

- Sectoral dispersion

  To ensure that best practices for development and deployment of IoT is explored across industry verticals and in environments of varying business activities, our analysis will take into account a relative sectoral dispersion of the case companies included. However, as sectors generally represent groups of similar industries, and the prevalence of IoT is not reflected by the traditional sector classification, we use an alternative classification of 'domains' in our analysis. These domains refer to specific groupings pertaining to similar business activities that are in alignment with the enduring penetration of IoT.
  The following domains are defined on a mutual basis from the standards and practices applied in active and recent European H2020 Coordination and Support Action initiatives that operate in the scope of the Next Generation Internet. The defined domains include: *Agri-food, Health & Care, Energy & Utility, Mobility & Transportation, Manufacturing, Smart Cities & Communities, Other.*

- **Geographical dispersion**

  To ensure that best practices for development and deployment of IoT is explored in varying national contexts, our analysis will take into account a relative geographical dispersion of the case companies included.
  The focus of our analysis is on European countries. From a total sample of 30 case companies, we do not aim for all European countries to be represented - this is a given constraint as well as a reflection of the imbalanced geographical penetration of IoT-empowered technologies in the European landscape.
  To ensure acceptable geographical dispersion, the consortium has determined that the number of case companies that originate from the same country must not exceed six, which corresponds to a geographically consolidated representation of maximum 20 %.

TERMINOLOGY DEFINITIONS

Term	Definition
Business use case	An IoT solution with proven technology is implemented, operational, and proves a positive impact on the bottom line.
Digital Twin	The digital representation of a physical object, a process or a system in the virtual world. This representation includes both the structure and the dynamic behavior of the object over its entire lifecycle. [16]
Edge Computing	Decentralized data processing based on the partial evaluation of sensor data on the fringe of the network (the „edge“) in preparation for uploading to the Cloud. [17]
Fog Computing	Decentralized data processing based on the partial evaluation of data in a local network in preparation for uploading to the Cloud. [18]
Internet of Things, (IoT)	An infrastructure of interconnected objects, people, systems and information resources together with intelligent services to allow them to process information of the physical and the virtual world and react. [19]
(IoT) Success story = Best practice IoT use case	An IoT solution with proven technology is developed and/or implemented, and proves a positive impact on the bottom line and/or a high impact potential due to the novelty of the technology.
(IoT) Use Case	The usage of a specific IoT solution, based on the setting of development and/or deployment.
Technology use case	An IoT solution with proven technology is developed and entails a high impact potential, due to the novelty of the technology.

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