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The European IoT Hub

Growing a sustainable and comprehensive ecosystem

for Next Generation Internet of Things

D4.7: Report on IoT business model innovation patterns and acceleration support activities

Version 2

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Abstract

This deliverable accounts for the outcome produced by the EU-IoT project to support and accelerate business model innovation in the European IoT landscape. The report describes the state of play of novel and disruptive IoT business model practices in different industries and, based on the patterns of best practice, presents a toolbox dedicated to stimulating a higher degree of innovation-driven thinking and exploitation in the Internet of Things. The toolbox has been assembled, tested and validated, and is now available in the complete version as a digital learning platform to help innovators succeed in building IoT business models and lower the barriers for adoption of IoT-empowered solutions. The report will give an account of the most recent business model innovation pattern findings and the updated contents of the toolbox, and it will provide an impact assessment of the generated results along with an outlook for the European IoT landscape.

Deliverable D4.7 reports the work carried out by the EU-IoT COACH in the scope of Task 4.3 under Work Package 4 in the period from October 2021 to March 2023.

Keywords: IoT, Use Case, Best Practice, Business Model, Business Model Innovation, Business Model Pattern, E-learning, Toolbox

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Disclaimer

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Nature of the deliverable:	Report on IoT business model innovation patterns and acceleration support activities - 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

European stakeholders are mobilising forces to ensure the foundation of a digital transformation continuum able to strengthen the European data economy and society towards the next generation internet. This requires the growth of a sustainable ecosystem structured as a community of communities for European actors to join forces and align on core initiatives to nurture successful European sovereignty. The EU-IoT guiding principle is to build a vibrant and impactful European IoT ecosystem, and within this context, the EU-IoT COACH ambition is to foster the development of business models, innovation activities, and skills building toward lowering the barriers for adoption of IoT-empowered solutions.

To reach the ambition, this deliverable reports on business model patterns in the European IoT landscape, as well as the outcome of activities conducted by EU-IoT to support and accelerate IoT business model innovation. This deliverable is a renewed version of the preliminary D4.6 “IoT BMI patterns and acceleration support activities - Version 1”, and thus to elude repetitive information, this renewed version will merely provide updates to the activities carried out and present the resulting outcome. The core of the deliverable is an e-learning platform built to accelerate IoT business model innovation and support practitioners in gaining the related distinctive skills. This resource shall stimulate a higher degree of innovation-driven thinking and exploitation among practitioners. Complementary information to the results presented in this report was released in October 2022 in the D4.6 report, which provides broad findings on business model innovation patterns, and outlines the strategy and draft version of the e-learning platform as well as activities performed to validate it and test new content.

To properly support and accelerate IoT business models and skills building for optimal utilisation of novel technologies, it is necessary to provide tools that stimulate innovation-driven thinking and exploitation. The purpose of the activities leading up to this deliverable has therefore been to facilitate knowledge on best practices for IoT business model innovation and to provide the tools and guidance needed to enable innovators to adopt these best practices and build business models accordingly. The concrete outcome of these activities is a toolbox that fosters IoT business models that support the ecosystem to overcome barriers and enable practitioners to successfully adopt IoT-empowered solutions. Further development activities and impact assessment has been performed during the past half year, leading to the results presented in this report:

- An account is given on the state of play of novel and disruptive IoT business models. Patterns that are characteristic of best practices indicate that successful IoT innovation generally involves significant change on two or three business model dimensions and that the value proposition and the value chain are the typical dimensions of change. However, patterns vary across different industry verticals, indicating that the support needed to accelerate IoT business models may need specific amendments for specific industries.
- A complete version of the e-learning platform is presented along with the activities performed to test and validate the ability of its contents to treat all steps in the business model innovation process and build the related distinctive skills. The toolbox has been updated, assembled and made available in digital learning format to ensure the best combination of tools, templates and methods needed to lower the barriers for adoption of IoT-empowered solutions.
- An assessment of the impact is performed upon the result of support and acceleration activities, evaluating the immediate and potential value of the e-learning platform towards supporting practitioners in succeeding to adopt best practices for business model innovation and to build business models in the fast-changing IoT landscape.

- Finally, an outlook for the European IoT landscape is offered to understand the need for business model innovation support and acceleration activities in the future, outlining also the viability of the e-learning platform to stimulate a higher degree of innovation-driven thinking and exploitation among practitioners.

To this end, the EU-IoT COACH remains committed to maximising the impact and sustainability of the work and results presented in this deliverable. By making the e-learning platform available in alignment with the European vision, it shall contribute to converging digital autonomy and technological sovereignty, boosting industrial competitiveness, and promoting 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
CAGR	Compound Annual Growth Rate
CC	Creative Commons
CSA	Coordination and Support Action
DMAT	Digital Maturity Assessment Tool
EC	European Commission
ELP	E-learning platform
ESG	Environmental, Social, and Governance.
EU	European Union
EV	Electric Vehicles
GDPR	General Data Protection Law
HVAC	Heating, ventilation, and air conditioning
ICT	Information and Communications Technology
IoT	Internet of Things
KPI	Key Performance Indicator
MWC	Mobile World Congress
NGIoT	Next Generation Internet of Things
RIA	Research and Innovation Action
R&D	Research and Development
T	Task
VC	Venture Capital
WP	Work Package

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.

Industry, innovators and policy makers are facing a world where technology is changing the landscape around them. 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, relies heavily on the optimal utilisation of technology.

Efforts driven by the European Commission push for an evolution of the Next Generation Internet, so that - thanks to the utilisation of increasingly decentralised architectures that automate 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 properly support and accelerate IoT business models and skills building for optimal utilisation of novel technologies, it is necessary to provide tools that stimulate innovation-driven thinking and exploitation. Hence, dedicated tools and guidance are significant enablers for European actors to adopt best practices towards achieving success in the fast-changing IoT landscape. The Commission embraces several initiatives that focus on increasing the adoption of novel technologies across verticals that allow for the proliferation of new IoT solutions. EU-IoT is one of these initiatives.

This report is a deliverable of the EU-IoT Coordination and Support Action under grant agreement no 956671. EU-IoT is part of the Next Generation IoT initiative and has received funding from the European Union's Horizon 2020 Research and Innovation Programme.

A pillar of the EU-IoT project and this 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 outcome and results presented in this deliverable aim to become a lodestar in facilitating knowledge on best practices for IoT business model innovation and providing the tools and guidance needed to enable innovators to adopt these best practices and build business models accordingly. The challenge is to overcome fragmentation in a broader perspective of the Next Generation Internet ecosystem and identify the ideal set of impactful tools that are key to fostering IoT business models that enable practitioners to successfully adopt IoT-empowered solutions.

In alignment with the overall efforts of the EU-IoT consortium, this deliverable 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. The unfolding of this principle relies on the efforts of the consortium to aid the ability of the ecosystem to overcome the barriers for adopting IoT-empowered solutions. To this end, this particular deliverable strives to effectively COACH practitioners towards success in the IoT landscape, by assembling and offering tools and recommendations that enable them to adopt best practices for business model innovation. Purposively to support innovators, learners and policy makers in building the IoT business models and skills needed to accelerate ecosystem innovation and manifest European excellence in the Next Generation Internet.

1.1 Purpose of deliverable

This deliverable reports the results of activities performed by the EU-IoT COACH on IoT business model innovation patterns and acceleration support. In this regard, it outlines the outcomes of the dedicated deliverable task and provides updated information on relevant matters that have emerged during the six months period since the initial reporting on the task. Specifically, this deliverable builds on the outcomes of the first version and some reporting may therefore summarise or repeat results. Nevertheless, most contents are enhanced, updated or completely new in this final report on the coordination and support activities of the EU-IoT COACH.

The reported results are underpinned by an intention to offer business model acceleration support. Thus, the EU-IoT consortium has set itself the goal of accelerating the adoption of IoT-empowered solutions by lowering barriers in the IoT ecosystem; by supporting industry, innovators, learners and policy makers to build and enhance IoT skills and IoT business models for optimal utilisation of the novel technologies; thru providing a toolbox that offers the tools, templates, methods and recommendations needed for practitioners to unlock successful IoT business model innovation. Hence, as illustrated in Figure 1, it all starts with the toolbox.

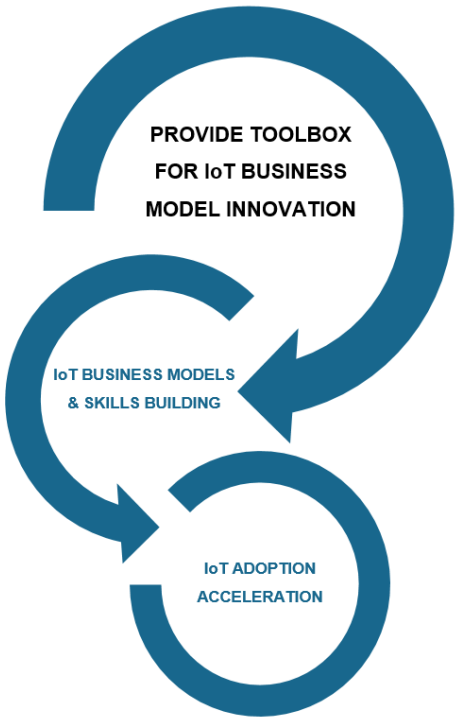


Figure 1: Purpose statement

The purpose of our activities has therefore been to provide a toolbox for IoT business model innovation. This toolbox offers a validated selection of (self-evaluation) tools, templates and methods in combination with a set of recommendations on how to apply the toolbox and adopt best practices for IoT business model innovation. It targets industry stakeholders and addresses both innovators that are active users of IoT technologies already, but also learners that are late bloomers in leveraging the innovation potential of digital technologies.

The toolbox and recommendations are made available in structured learning modules and provided in digital format on an e-learning platform. Each learning module covers the business model innovation process step by step and builds the related distinctive skills for practitioners. When a learning module is completed, the practitioner is one step closer to unlocking a novel and disruptive business model that accelerates IoT adoption.

Contents of the toolbox have been developed on a continuous basis based on consensus from community stakeholders and best practice case companies. To this purpose, the task has

leveraged consortium partners and liaisons across the European IoT ecosystem for scenarios to test, update and validate the toolbox.

The main objective of our activities towards providing the toolbox has been to effectively support European stakeholders and initiatives that foster the Next Generation Internet while stimulating innovation-driven thinking and exploitation. With this toolbox and recommendations, industry, innovators, learners and policy makers are enabled to leverage the best practices of IoT frontrunners and build the skills and business models needed to successfully utilise novel technologies.

1.2 Scope of deliverable

Aarhus University (AU) holds the role of EU-IoT COACH, which is the lead beneficiary on work package 4 (WP4). In this role, AU contributes to the project with specific assets related to IoT business model innovation support and acceleration.

The premises behind the results presented in this report - the draft version of the e-learning platform and its development strategy, including clarification of the underlying patterns explored and tests conducted to identify, validate and further update the contents of the toolbox - was presented in the intermediate version deliverable D4.6. Only the introduction section and information that is essential for general understanding will be repeated in this deliverable, hence, it is assumed that the reader has knowledge of the premises presented in deliverable D4.6.

While aiming to offer an online platform that supports practitioners to achieve success in the diverse and ever-growing IoT landscape, our selection of suitable content for the toolbox and development of appertaining recommendations, is underpinned by results and knowledge derived from prior work of the EU-IoT COACH. Hence, further premises for the activities and results presented in the deliverables related to T4.3 can be found in former deliverables related to T4.1 “Success stories and best practice use cases”, with the deliverable D4.1 that covers the methodology for collection and analysis of best practice use cases, including clarification of the scientific and theoretical frame of reference, and the deliverable D4.2 that covers the results of analysis, including a use case catalogue that documents IoT success stories, and a use case study that explores archetypical factors of IoT success.

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.

VISIONS

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 setting up a self-sustaining European IoT community.

1.3 Structure of activities

The activities of T4.3 “Business models and acceleration support”, under the EU-IoT WP4, have followed an agile approach towards achieving the previously defined purpose. The unfolding of activities was structured only by a starting point and an ending point defined by time. Outcomes generated between these points mutually affect and depend on each other, and all activities have therefore been repetitive in nature as illustrated in Figure 2.

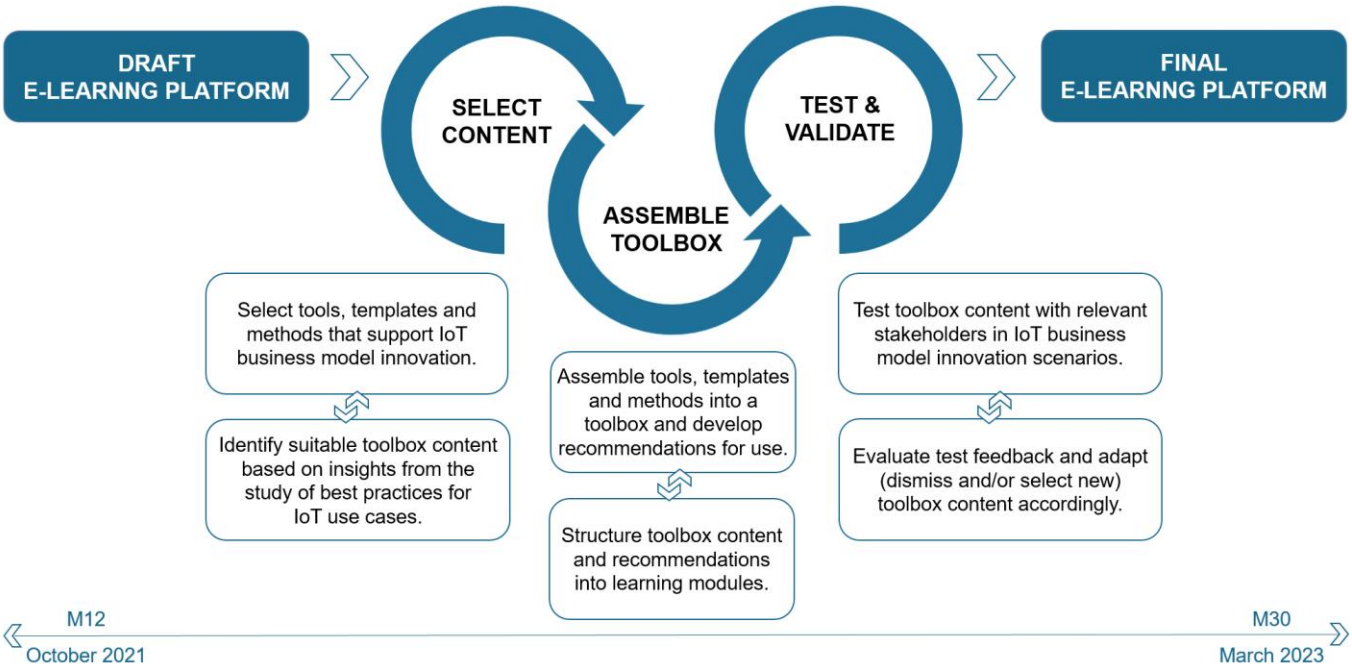


Figure 2: Structure of business model and acceleration support activities

The starting point was marked by the initiation of T4.3 in M12 of the EU-IoT project, with the draft version e-learning platform. The iterative activities hereafter included:

- Selection of content to the toolbox in terms of specific tools, templates and methods that support IoT BMI. In order to identify suitable toolbox content, we leveraged insights from our study of best practices in the IoT area conducted across 30 successful use cases (results presented in D4.2, T4.1 under WP4).
- Assembling the toolbox and developing recommendations for practitioners on how to use the selected tools, templates and methods towards successfully innovating IoT BMs. In order to support the entire BMI process, the toolbox and recommendations have been structured into user-friendly learning modules.
- Testing the toolbox content in relevant scenarios, such as workshops, master classes and classroom teaching, to ensure that it adds value to the IoT BMI process. Stakeholder feedback from testing activities was collected when possible and toolbox content has been evaluated and updated accordingly – some content was dismissed, some were modified and some were replaced with alternative content – and with that, replicating the line of activities.

These iterative activities proceeded until an ideal toolbox was assembled and validated. This was manifested by the launch of the final version e-learning platform, illustrated by the ending point that formally marks the completion of T4.3 in M30 of the EU-IoT project.

Since the intermediate reporting for T4.3 in M24, main focus has been on back-end activities for building the e-learning platform and assessing its impact. In brief, specific key activities leading up to this final deliverable have included:

- Mapping of novel and disruptive IoT BMs for individual domains, for insights of best practices to be leveraged in the further selection of content to the toolbox
- Developing recommendations for practitioners on how to use the selected tools, templates and methods
- Structuring the toolbox and recommendations into the defined learning modules
- Further testing of the ELP and toolbox content in IoT BMI scenarios
- Adapting the ELP and toolbox content to feedback collected from testing
- Implementation and monitoring of analytics for impact assessment
- Setting up the technical transformation from draft platform to ready-to-launch platform, including the transfer of online content to the official EU-IoT / NGIoT website.

With the EU-IoT project going into M30, not only the activities related to T4.3 are reaching termination, ALL activities of the project are. However, beyond this termination, the EU-IoT COACH will seek to collaborate in a joint effort with the consortium towards possible scenarios for applying the gathered knowledge and resources to accelerate the adoption of IoT business models in the European landscape.

1.4 Structure of deliverable

This deliverable is to be seen as a resource in building and ensuring the growth of a vibrant European IoT ecosystem by supporting and accelerating IoT business models and skills building. The following topics will be discussed in the subsequent sections:

- Section 2 is dedicated to outlining the state of play for novel and disruptive business model practices in different industry verticals. Knowledge on patterns that are characteristic of best practice IoT BMI is introduced to underpin the e-learning platform.
- Section 3 is dedicated to presenting the e-learning platform in its final and validated version, including its content in terms of updates on the toolbox and appertaining recommendations.
- Section 4 is dedicated to outlining the current and potential impact of the resources produced to support and accelerate IoT business model innovation, including how the results contribute to the EU-IoT vision.
- Section 5 is dedicated to providing an outlook for the European IoT landscape, and with that the viability of the e-learning platform.
- Section 6 is dedicated to outlining a proposal for ensuring continuity of the efforts and results presented in this and former WP4 deliverables.

2. PATTERNS OF BEST PRACTICE BMI

This section outlines the state of play for novel and disruptive business model practices in different industry verticals found by the EU-IoT COACH in the scope of T4.3 under WP4. The insights to be presented leverage results of T4.1 “Success stories and best practice use cases” to introduce and disseminate knowledge on patterns that are characteristic of best practice IoT BMI. This knowledge underpins the e-learning platform and has indirectly served as a basis for selecting suitable content for a toolbox that is able to stimulate innovation-driven thinking and exploitation.

2.1 IoT best practice premises

To develop consensus on best practices for achieving success in the diverse and ever-growing IoT landscape, a cluster of successful IoT use cases across different industry verticals and geographical origins was explored in T4.1 under WP4. Results include an IoT use case catalogue that exemplifies best practices for IoT by documenting the use cases as success stories, and a study that provides insight into a range of factors that are archetypical for their success in the IoT area.

USE CASE CATALOGUE

The use case catalogue consists of 30 IoT success stories that aim to inspire industry, innovators, IoT learners and policy makers by demonstrating best practices for developing and/or deploying IoT solutions. This catalogue offers practical examples that lower the barriers for adoption of IoT technologies, eventually helping practitioners to understand how they can create the most optimal premises for themselves and for the ecosystem to succeed with IoT.

The use case catalogue is made available as an online resource on the official website of EU-IoT / NGIoT, and can be accessed via the link: https://www.ngiot.eu/use-cases/. Results in terms of this catalogue are derived largely from semi-structured interviews as methodological basis to explore IoT best practices and document the success story of each individual use case

USE CASE STUDY

The use case study takes an in-depth look at business dynamics and technological dynamics of relevance to IoT success. Analysis unfolds as a multiple case study conducted across the cluster of 30 use cases, and findings thereby constitute a collective exemplification of best practices that provides insight on collective factors that characterize the successful development and/or deployment of IoT solutions.

The use case study is made available in the deliverable D4.2 , which was released in September 2022 on the official website of EU-IoT / NGIoT, and can be accessed via the link: https://www.ngiot.eu/deliverables/. Results in terms of this study are derived largely from a theoretical frame of reference that consists of; assessment of digital maturity of the case companies [1]; exploration of BM patterns [1]; evaluation of the configuration of BMs for innovation [1]; and study technological trends, as methodological basis to explore IoT best practices and generate insights on IoT successes across the cluster of cases.

Findings of the study presumes a BM to be novel and disruptive when it represents a use case that 1) demonstrates high digital maturity, 2) employs an IoT BMP, 3) qualifies as BM innovation, and where 4) IoT plays a constitutive or value increasing role. Please take note of this theoretical frame of reference for prior understanding towards the coming section.
(For further elaboration on the points of measurement and theoretical frame of reference for the use case study, see D4.2 - Best practices for IoT use cases).

Hence, the presented results of T4.1 are leveraged by T4.3 to introduce knowledge on the patterns of best practices that are relevant to fostering and accelerating IoT BMI. This knowledge has been useful in our selection of appropriate tools, templates and methods to shape the best toolbox possible, and in developing pertinent recommendations that increase the applicability and impact of the learning modules.

The cluster of use cases covers a broad representation of industry frontrunners in the European IoT landscape. Each use case is based on the development and/or deployment of a specific IoT-empowered solution, and the use case owner, most often being a company, is studied at the level of a strategic business unit. For the purpose of the study, the traditional designation of industry verticals was converted into a categorisation more suitable in an IoT perspective, containing the seven key domains illustrated in Figure 3, deducted from the praxis of the European IoT ecosystem. (For elaboration on the domains, see D4.1, appendix E)

Figure 3: Use case domains

2.2 The state of play of IoT BMs

Novel and disruptive business models are the desired outcome of IoT BMI, and an outcome that is likely for practitioners to achieve when adopting best practices throughout the innovation process. But what are best practices? And are best practices the same across different industries? The lack of dissemination of this knowledge poses a challenge for practitioners to successfully build IoT BMs, and for the EU-IoT consortium to provide assets that support and accelerate the efforts. To this purpose, patterns that are characteristic for best practice IoT BMI, are documented as novel and disruptive business models with mappings for each specific domain, and a mapping across all domains.

The mappings reflect best practices for IoT-driven innovation toward a novel and disruptive BM (cf. Impact 15, sec. 6). However, the insights presented in this section must be considered only as indicative patterns of best practices due to the limited amount of use cases in the study. Nevertheless, the insights do provide a knowledgeable basis from practical examples derived from the industry.

2.2.1 Individual domain BMs

The mappings to be presented illustrate the distribution of the BM dimensions in successful companies' BMs that are archetypically subject to significant change in an IoT-driven innovation process. The mappings further reflect the frequency that specific dimension(s) are impacted by the development and/or deployment of an IoT solution. For elaboration on the dimensions, see D4.2, sec. 2.3 and sec. 5.3)

Based on the study of the cluster of best practice use cases, the below Figure 4 illustrates per domain, the distribution of BM dimensions impacted by the development and/or deployment of the IoT solution. Hence, each mapping reflects a domain-specific novel and disruptive BMs.

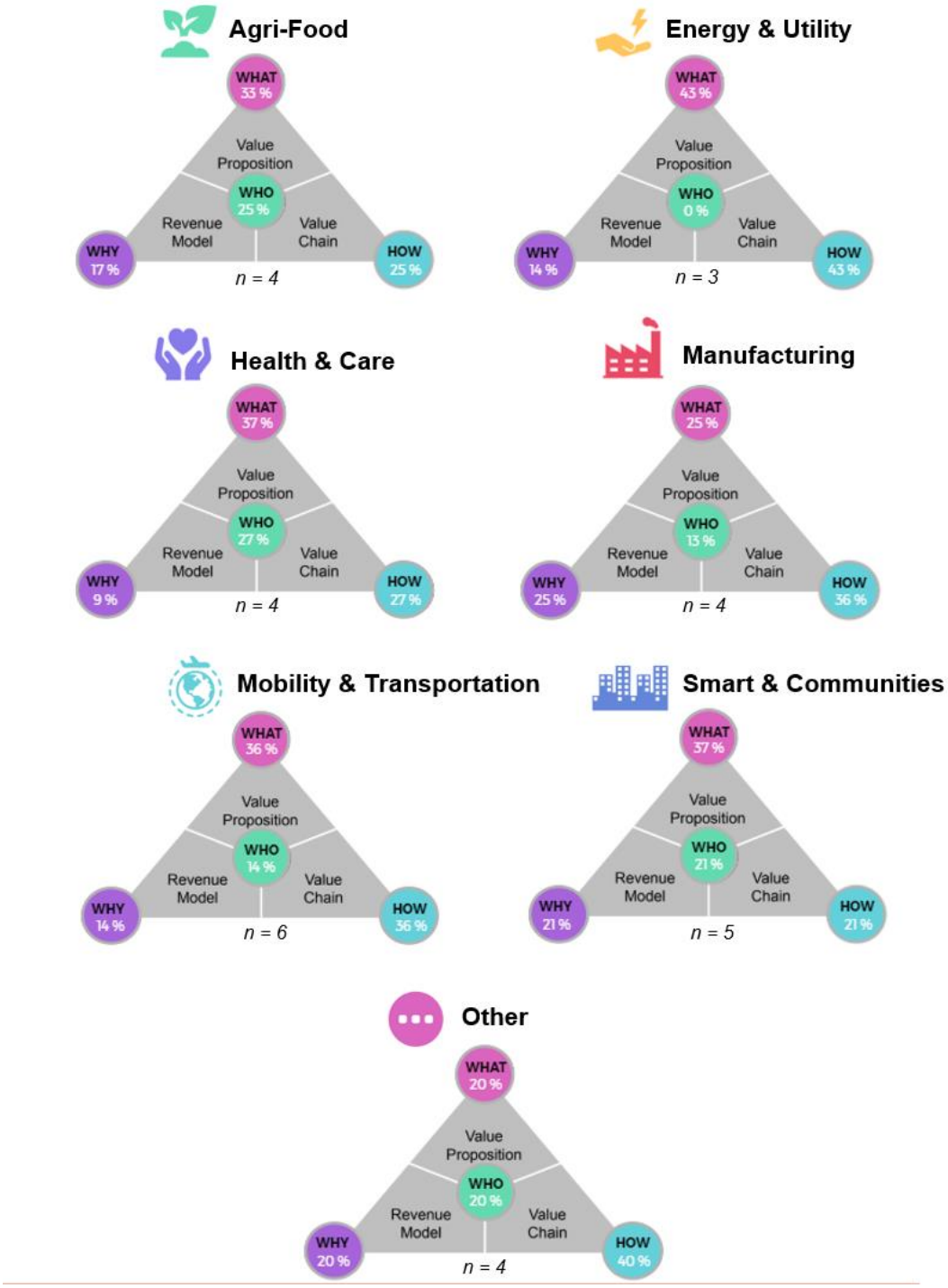


Figure 4: Domain-specific best practice BMs

To condense the information into a more cross-domain comparable insight, the below Figure 5 sums up per domain, the distribution of BM dimensions impacted by the development and/or deployment of the IoT solution.

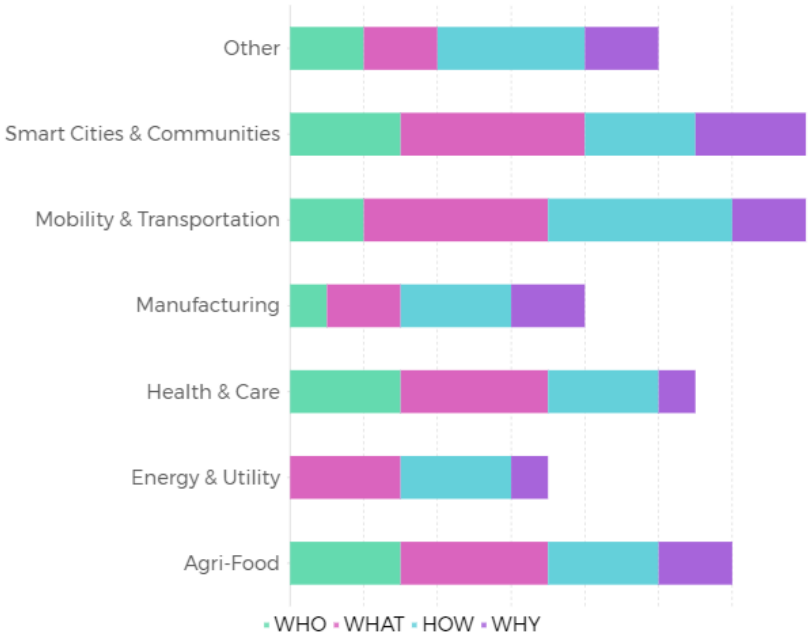


Figure 5: Domain-specific BM dimensions of impact

Hence, from observing, per domain, the best practices for innovation towards building novel and disruptive IoT BMs, findings indicate that:

- The value proposition is typically the dominating subject of significant change in the domains Agri-Food, Health & Care, and Smart Cities & Communities.
- The value chain is typically the dominating subject of significant change in the domains Manufacturing and Other.
- The four dimensions are never equally impacted by the development and/or deployment of the IoT empowered solution. Only one or two dimensions can be simultaneously dominating subjects of significant change.
- The WHO and WHY dimension are rarely subjects of significant change. These are either equally or less impacted than the WHAT and WHY dimensions.

For an overview of the impacts of innovation on the business models of each individual case in the study (equivalent to those presented in the EU-IoT use case catalogue), see appendix A – BMI impacts of IoT use cases.

2.2.2 BM across domains

Based on the study of the cluster of best practice use cases, the below Figure 6 illustrates across domains, the distribution of BM dimensions impacted by the development and/or deployment of IoT solutions. Hence, the mapping reflects a novel and disruptive BM that is domain-general.

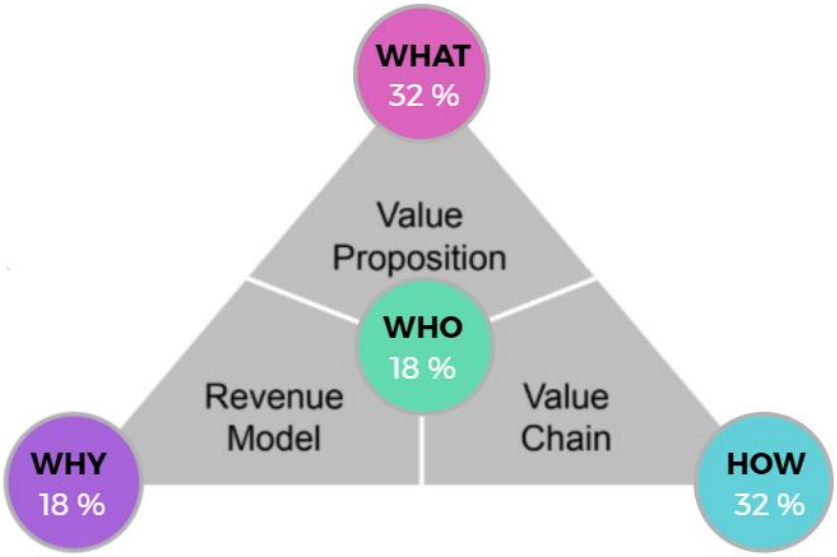


Figure 6: Best practice BM across domains

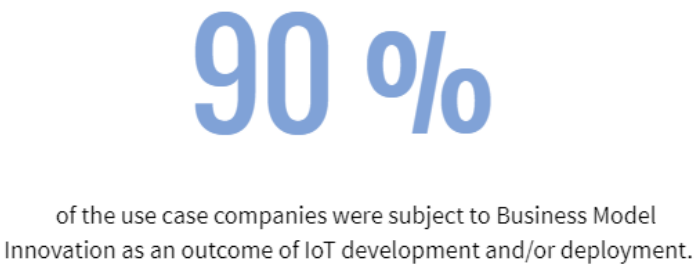
Across domains, findings indicate that best practice for innovation, towards building a novel and disruptive IoT BM, the impact is distributed among the dimensions as follows:

- The value proposition is impacted with a frequency of 32 % due to IoT development and/or deployment. Insight from the use case study of T4.1 further demonstrates that the WHAT of the BM changed significantly for 25 of the 30 case companies.
- The value chain is impacted with a frequency of 32 % due to IoT development and/or deployment. Insight from the use case study of T4.1 further demonstrates that the HOW of the BM changed significantly for 25 of the 30 case companies.
- The target customer is impacted with a frequency of 18 % due to IoT development and/or deployment. Insight from the use case study of T4.1 further demonstrates that the WHO of the BM changed significantly for 14 of the 30 case companies.
- The revenue model is impacted with a frequency of 18 % due to IoT development and/or deployment. Insight from the use case study of T4.1 further demonstrates that the WHY of the BM changed significantly for 14 of the 30 case companies.

Furthermore, best practices for IoT BMI indicate that existing BMs on average are impacted on 2.65 dimensions towards becoming novel and disruptive IoT BMs. This indicates that best practice for IoT innovation typically includes significant change on two or three BM dimensions.

Finally, to determine the correlation between BM innovation and the development and/or deployment of an IoT solution, we have explored the concept in alignment with the theory proposed by the University of St. Gallen [1], defining the occurrence of BM innovation with the occurrence of significant change in at least two of the four BM dimensions. This led to the conclusion:

[1] Gassmann, O., Frankenberger, K., & Csik, M. (2013). *The St. Gallen business model navigator.*



Pattern application for IoT BMI acceleration

With the novel and disruptive BMs documented, sufficient knowledge is introduced to recognise patterns that are characteristic for best practice IoT BMI. Although the insights cannot be considered definitive, they are definitely indicative in clarifying – and thereof increasing understanding - of the impact on specific BM elements caused by IoT-driven innovation toward building a novel and disruptive IoT BM.

This knowledge injects into the thinking of the consortium and has effectively served as a knowledgeable frame of reference in the selection of suitable content for the toolbox and in the development of appertaining recommendations. Hence, insights into the state of play of novel and disruptive BMs thereby underpin the composition of learning modules and the final e-learning platform.

Furthermore, the insights may be useful for innovators and learners as a point of reference for best practice IoT BMs, and as a framework to perform BM self-evaluation prior to initiating the IoT BMI process. Hence, knowledge dissemination of these insights holds the potential to support practitioners in successfully adopting best practices for building novel and disruptive business models that enable them to achieve success in the IoT area.

3. E-LEARNING PLATFORM

This section outlines the e-learning platform that has been built by the EU-IoT COACH, in the scope of T4.3 under WP4, to support and accelerate IoT BMs in the European landscape. The platform is introduced along with the activities conducted to test and validate it, leading to the discovery of needs for additional tools, templates and methods to support the innovation process. To alleviate these needs, certain content elements of BMI toolbox have been updated and will be presented accordingly.

3.1 ELP presentation

The ELP is an online platform for facilitating new knowledge on best practices for IoT business model innovation, and for providing the assets that enable innovators and learners to adopt these best practices and build novel and disruptive business models accordingly.

The platform assembles a toolbox and appertaining recommendations with the ambition to support practitioners through the entire BMI process while building up the skills for optimal utilisation of the novel IoT technologies. The platform targets industry stakeholders, and addresses both innovators that are active users of IoT technology already, but also learners that are late bloomers in leveraging the potential of digital technology. The assets for IoT BMI consist of:

- Toolbox that provides tools, templates and methods that support practitioners in building novel and disruptive business models for next generation IoT applications.
- Recommendations that provide guidance that supports practitioners to adopt best practices in the innovation process.

The toolbox, along with appertaining recommendations, are structured into a range of learning modules that support the entire BMI process. Each learning module treats one distinctive step in the BMI process, and builds the related distinctive skills. Hence, this modular composition of the ELP helps innovators and learners to build or enhance their BMs one step at a time. For an overview of the learning modules and further information on recommendations, see appendix B – Learning modules overview. 12 learning modules in total guide practitioners towards unlocking the success of a novel and disruptive business model that accelerates IoT adoption.

With the title ‘The e-learning platform for digital business development’, the complete version is made available online as an integrated resource at the official EU-IoT / NGIoT website: https://www.ngiot.eu/business-development/ (along with complementary resources such as a training catalogue, webinars and skills surveys). The content is hosted back-end on the domain of Aarhus University, Interdisciplinary Centre for Digital Business Development: https://dbd.au.dk/models-tools/. Throughout the EU-IoT project, this domain has served as a draft for development, testing and validation, and will serve as a warrant of continuity in providing assets that stimulate innovation-driven thinking and exploitation. Ultimately, this extends and prolongs the support to accelerate IoT BMI and enable practitioners to achieve success in the European IoT landscape also beyond the EU-IoT project.

The final version of the ELP is illustrated in the below Figure 7.

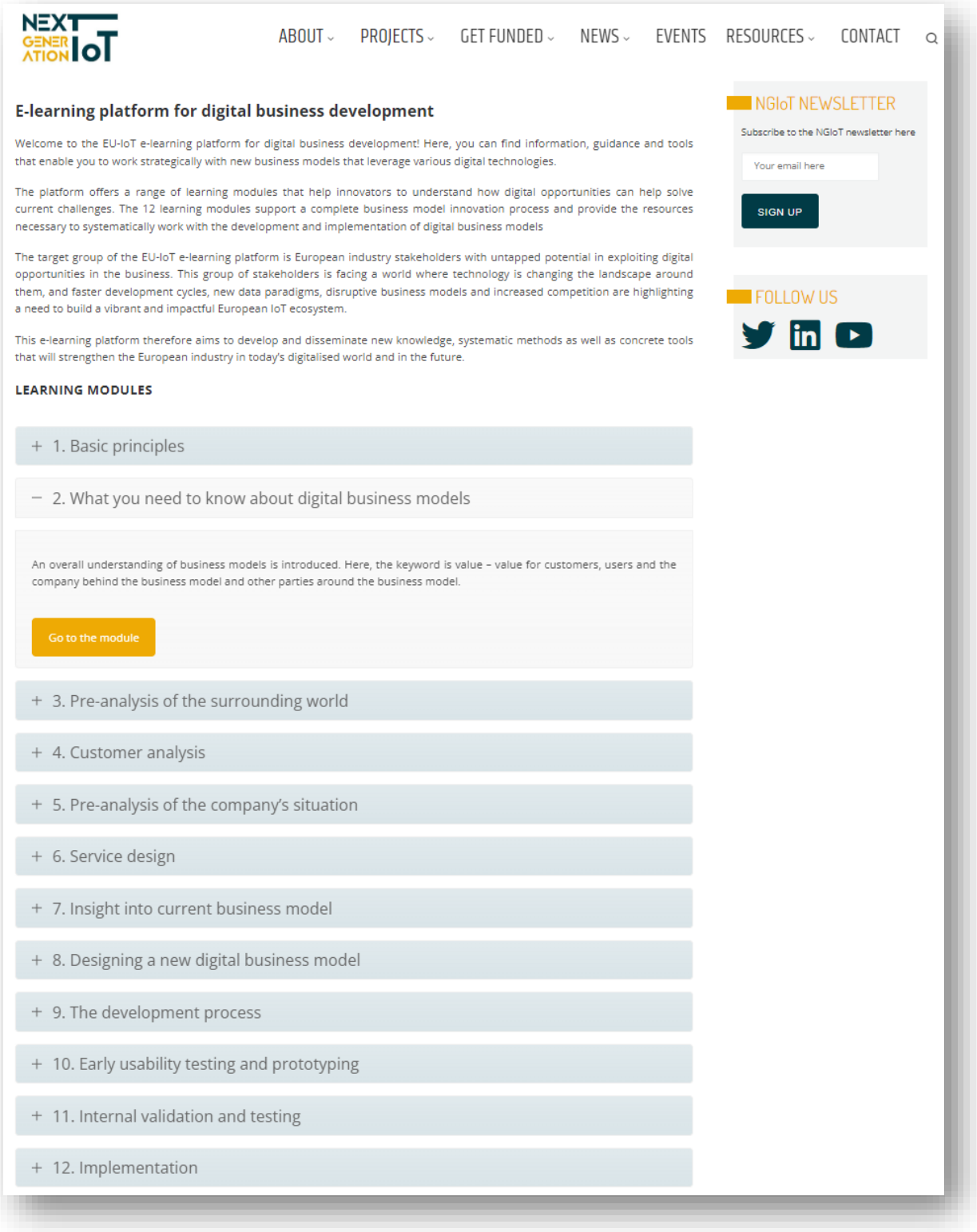


Figure 7: E-learning platform - Final version

APPLICABILITY EXAMPLE

To make clear the vision for application of the ELP, the EU-IoT project organised a BM co-design event in May 2022 in collaboration with the complementary CSA project Open DEI. The event

gathered H2020 projects that address the topic of digital platforms with the aim to support them in designing BMs that can commercialise their technical solutions and thereby realise the value of the results generated by each of the projects. The ELP served as the framework for a BM co-design exercise that took place throughout three parallel sessions focusing on various domains.

This event proves a compelling applicability example for the ELP that demonstrates the ability of the platform to support the development and adoption of IoT BMs in alignment with its vision. Also insights from our study of domain-specific BM patterns (cf. sec. 2.2.1) was confirmed valuable in differentiating the innovation process across the parallel sessions, and with that, enabling it to be adapted towards best practices for the individual domains. For information on the methodology for business modelling applied during the exercise and the main findings of the event, please see the REPORT OF BUSINESS MODEL CO-DESIGN.

3.2 Testing and validation activities

The ELP and its contents have continuously been subjected to testing in innovation scenarios prior to the launch of the final platform within the European IoT ecosystem. These testing activities have been conducted to refine and validate the structure of the platform, the composition of the learning modules, and the quality of the toolbox.

For the purpose of validation, the EU-IoT COACH has put effort into engaging individuals in alignment with the target group of the ELP in terms of innovators and learners from projects, business and academic communities. A variety of testing scenarios have been applied, including example workshops, master classes, webinars, user observations, expert discussions, applicability simulations etc. For an account of the testing scenarios and activities carried out until October 2022 and the overall validation strategy, see deliverable D4.6. During the recent period leading up to this deliverable, the EU-IoT COACH has prioritised quality over quantity in the testing activities, with the following scenarios included:

EXERCISE-ORIENTED TEACHING

Exercise-oriented teaching of students enrolled in the study programme Master of Science in Engineering - Technology-Based Business Development at Aarhus University has secured a certain volume of participants to test the toolbox and the usability of the ELP, and allowed us to collect instant and continuous feedback. Hence, the classroom has served as a controlled environment for testing activities, and the students an avenue for validation in terms of observation and feedback upon tools applicability, BMI working process and output. The specific programme aims at providing graduates with a strong insight into engineering practices, the relationship between theory and practice and skills to generate new knowledge and technology-based business opportunities for companies. Leveraging the course Technological Business Model Innovation (TBMI) for the purpose, we had an exercise-oriented and structured frame for conducting testing activities with up to 70 students. The aims of the programme and course align well with aims of IoT innovators and learners, which further enabled us to physically observe how the various tools, templates and methods are being practically used with the incentivised perspective of the target group.

WEBINARS AND WORKSHOPS

Webinars and workshops with stakeholders from complementary CSAs, RIAs and other relevant European initiatives ensured that the content of the toolbox and general usability of the ELP was tested by stakeholders in the European IoT ecosystem representing the target group. To this purpose, we leveraged several of the relations to projects and companies that were established by WP4 under T4.1 during the documentation of 30 IoT success stories (deliverables 4.1 and 4.2) and under T4.2 during the training activities and exploration of skills (deliverables 4.3 and 4.4). These relations include NGIoT, OPEN DEI, ICT-56 RIAs (IntellIoT, VEDLIoT, Ingenious, IoT-NGIN, ASSIST-IoT), AIOTI, IoTAC, ACTIVAGE, Startup3, DIATOMIC, MERMISS, Nordic IoT

Center, Eclipse Foundation, LoRa Alliance, and The Things Network. During the latest reporting period in particular, The IoT Next Club and The Danish Industry Foundation, hava been helpful in funnelling relevant stakeholders for IoT business model testing and interaction and to facilitate synergies in the board community of innovators and learners in academia as well as in industry.

During any testing scenario, AU has systematically collected feedback from the test groups and encouraged reflective interaction at human-centric as well as business-centric levels. For documentation and feedback examples on content testing scenario, see appendix C and deliverable D4.6. The impact and consequence of our testing and validation activities have differentiated across the different content elements of the toolbox. Based on the feedback given by the test groups throughout these activities, all content elements have been evaluated and reorganised accordingly. Some of the original tools, templates and methods from the draft ELP have been dismissed, some have been modified and some have been replaced with alternative content.

DISCOVERIES

The testing and validation efforts have contributed immensely to evaluating and refining the contents of the ELP, ultimately creating consensus on the best tools, templates and methods to support and accelerate IoT BMI. Among the most remarkable discoveries from the scenarios described above, was a need among practitioners for further support in the innovation process regarding:

- **IoT business model development**. Throughout many testing scenarios, we found that insights into the technological aspects of a business is a valuable addition to the simple and general mapping suggested by the St. Gallen Magic Triangle framework (available in modules 7. INSIGHT INTO CURRENT BUSINESS MODEL and 8. DESIGNING A NEW DIGITAL BUSINESS MODEL). Hence, a more specific framework designed for IoT business models will be a helpful tool to support the innovation process.
- **Change management**. Moving from theory to practice has shown to be a prevalent concern among practitioners. Feedback from testing made apparent that although several of the learning modules offer guidance on this part of the BMI process (modules 9. THE DEVELOPMENT PROCESS, 10. EARLY USABILITY TESTING AND PROTOTYPING, 11. INTERNAL VALIDATION AND TESTING, 12. IMPLEMENTATION), further support to deal with the transition imposed by the implementation of a new BM is in demand. Hence, a framework capable of offering a systematic approach for strategically managing the changes will be a helpful tool to support the innovation process.
- **Network collaboration**. Digital business models require practitioners to work more closely with their customers, suppliers, competitors and other network stakeholders. Discussions during testing scenarios often pointed out the ability to generate revenue from intelligently managing the network they are part of as an essential source of success. However, without a systematic approach to assessing networks, practitioners find themselves incapable of positioning themselves in alignment with the value proposition of that network. Hence, a framework capable of supporting value network analysis will be a helpful tool to support the innovation process.

Following these discoveries, the most impactful updates to the toolbox will be presented in the following section. (Please notice that the updates account for content elements published in the period between October 2022 and March 2023. For an account of content element updates prior to this period, see deliverable D4.6).

Beyond the obvious outcome of testing and validating, we find it worth noting that these activities have contributed, not only to make industry, innovators, IoT learners and policy makers aware of the new ELP, but to drive actual impact in terms of real changes leading to adoption of the best practices for building IoT skills and BMs in the European landscape.

3.3 Updated BMI toolbox

The updated toolbox assembles selected tools, templates and methods that are found suitable for practitioners to apply in the process of innovating IoT BMs. The suitability of the content is now validated to an extent that allows us to confidently proclaim that the ELP can be an asset in effectively stimulating innovation-driven exploitation by supporting practitioners in building novel and disruptive business models for next-generation IoT applications.

Each tool, template and method represent a fraction of the knowledge needed to undergo the entire BMI process. The knowledge offered through the toolbox covers a range from basic principles and concepts of BMI, throughout BM frameworks, innovation process support, market and customer-focused approaches, BM testing and validation and reoccurring 'health checks' of the elements. The intent is to support the iterative and explorative approach to BMI that industry studies indicate to have the highest impact on smaller and midsized organisations.

In the final version platform, the 12 learning modules are complemented by a range of tools, templates and methods developed for more specialised application. These are elective add-ons to the general BMI process and are therefore provided separately to the learning module format.

3.3.1 IoT Business Model Innovation Tool

The IoT Business Model Innovation Tool (IoT BMIT) can assist practitioners in mapping and designing BMs using the IoT as a key technology enabler. Thus, the tool represents the outside-in perspective on developing new solutions and services with a focus on customer needs, while it also embodies the integral aspects of the technology into the BM.

The tool is developed by Mansour & Presser (2018) for the purpose of mapping IoT BMs, and it builds on top of the concepts known from the Business Model Canvas by Osterwalder et al. (2010) and the St. Gallen Business Model Navigator by Gassmann et al. (2013).

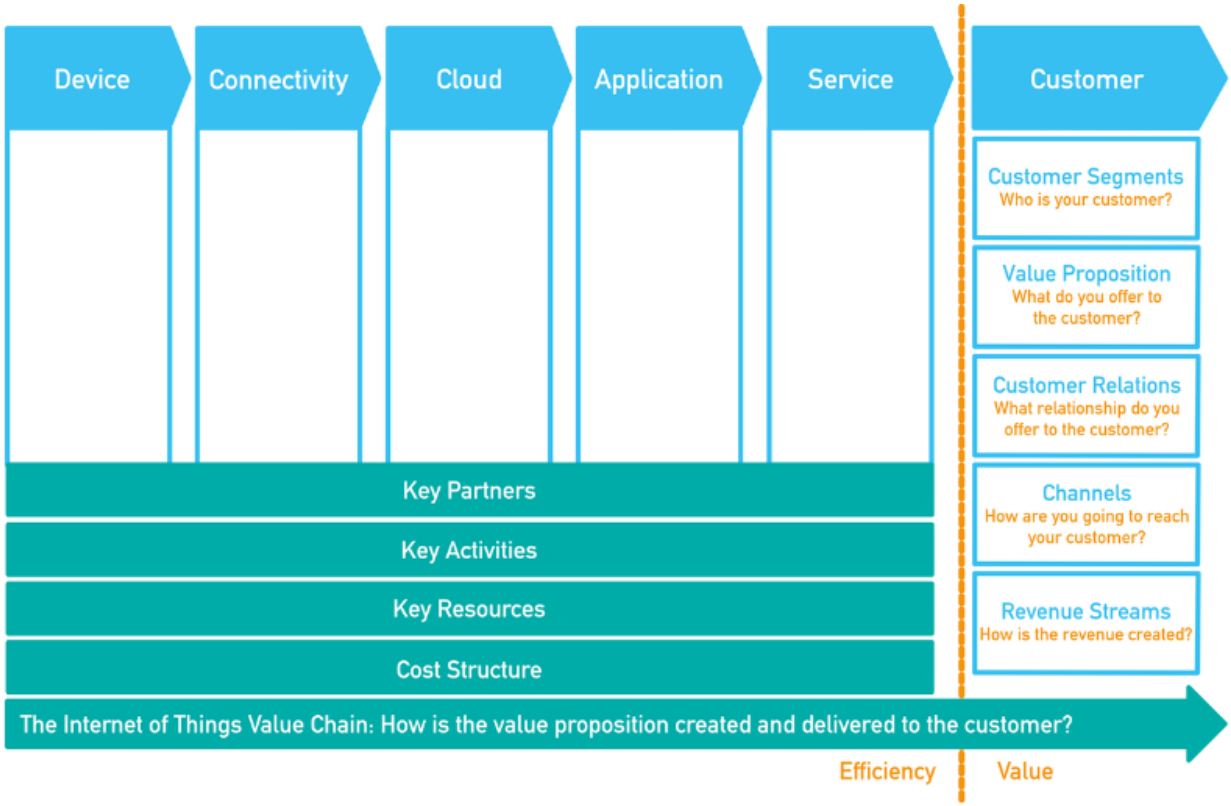


Figure 8: The IoT Business Model Innovation Tool

The mapping is an alternative to the classic business plan, as the idea behind it is that it can be completed quickly and condensed to one page to create an overview of the BM. As part of the toolbox, the tool facilitates a deeper understanding of the technology in the BMI process.

The IoT BMIT has broad applicability and is useful both to design a new digital BM as well as to map an existing digital BM. Hence, it captures innovation as a transitional move from one business model to another, as a starting point for building a business model on top of technology, and as an instrument to further optimise a digitally empowered business model.

The IoT BMIT is available on the ELP as a stand-alone tool (serving as an add-on to the modules 7. INSIGHT INTO CURRENT BUSINESS MODEL and 8. DESIGNING A NEW DIGITAL BUSINESS MODEL).

3.3.2 The 7 Ss of Mutual Effect

The 7 Ss of Mutual Effect offers a structured methodology for analysing and aligning elements of the internal organisational. These elements are essential in preparing and positioning a company strongly for times of change. By managing the elements methodologically, practitioners can optimise the mutual effects that a change, such as the implementation of a new digital BM, may cause, and thereby ensure the optimal conditions for the BM to be adopted, put into effect and positioned to achieve its goals.

The 7 Ss of Mutual Effect is developed for the purpose of the EU-IoT project and is based on an experimental combination of known change management theories that commonly focus on navigating transformation processes, and ensuring that changes are accepted and put into practice.

Figure 9: The 7 Ss of mutual effect

As part of the toolbox, the methodology enables practitioners to examine the likely effects of future change initiatives and assess what it requires of the company to implement a new digital business model, process, solution or technology as well as how to avoid inconsistencies in the internal organisation in the BMI process.

The 7 Ss of Mutual Effect is available on the ELP as a methodology integrated into the modules 11. INTERNAL VALIDATION AND TESTING and 12. IMPLEMENTATION.

3.3.3 Value Network Mapping

Value network mapping shows the set of connections between the stakeholders that exchange value in a network and how the individual business models contribute to the shared value proposition of the network.

A conceptual methodology to analyse practical examples has been developed by an AIoTI Working Group, based on the paper "Digital business models for Industrie 4.0" by the Federal Ministry for Economic Affairs and Energy (BMWi) in 2019. The methodology sets out a systematic approach for conducting an in-depth analysis that enables any actor to illustrate and describe their value network in simple terms.

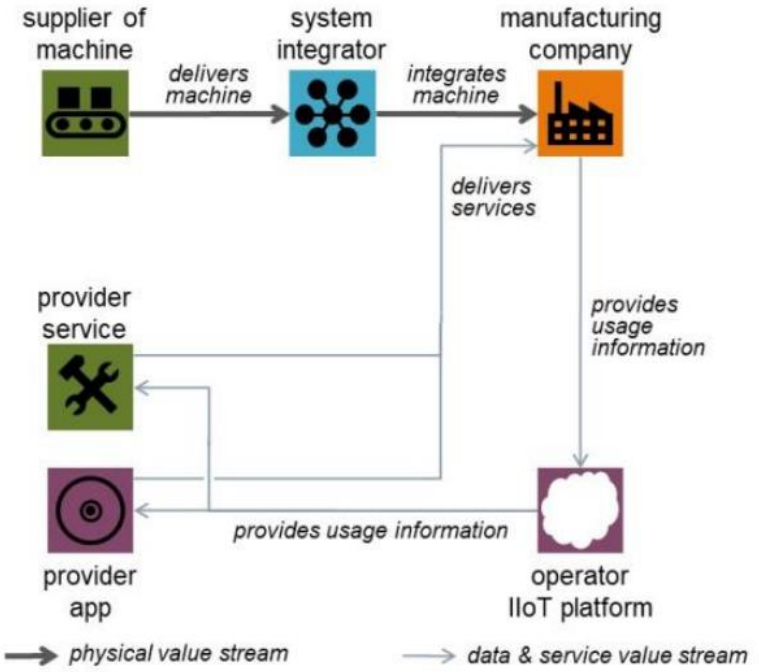


Figure 10: Value network mapping example

The methodology for value network mapping builds on the premise that in today's digitalised world, it is typically not enough to consider a single provider-customer relationship. Instead, practitioners must consider the overall value network and going forward, a stronger focus must be placed on redesigning value networks. As part of the toolbox, the value network mapping methodology supports practitioners to understand the value network they are part of and how their business model contributes to it.

The Value Network Mapping methodology is available on the ELP as a stand-alone tool (serving as an add-on to the modules 3. PRE-ANALYSIS OF THE SURROUNDING WORLD and 5. PRE-ANALYSIS OF THE COMPANY'S SITUATION).

Contents of the toolbox have been developed on a continuous basis based on consensus from community stakeholders both in academia and industry. To this purpose, the task has leveraged consortium partners and liaisons across the European IoT ecosystem toward scenarios for testing and validating the toolbox.

3.3.4 IoT use case catalogue

The IoT use case catalogue, which is integrated as a subpage to the ELP, has been updated with a number of new success stories and now reached the target of 30 best practice IoT use cases.

Updates to the use cases are relevant to the ELP for two purposes:

- Serving as practical examples: The application of tools, templates and methods are illustrated with best practice use cases as practical examples. To this purpose, the success stories are leveraged to demonstrate the theoretical application in a real-world scenario. Examples include references to the specific use cases that offer the practitioner to seek further inspiration and further guidance from relatable companies.
- Offering recommendations: IoT frontrunners from the industry offer recommendations based on their own experience and learnings. These recommendations include: Learnings made by the innovator that accounts for do's and don'ts throughout the IoT BMI process, and in general when engaging in IoT development and/or deployment; IoT solution experience that accounts for the enabling technologies, and the hardware and software features of a specific IoT solution; and Outcomes achieved by the innovator that accounts for the effects and the value generated by the IoT use case both internally by the case company end externally in the ecosystem.

The final version of the IoT use case catalogue is illustrated in the below Figure 11 (Notice the tagging mechanism, which allows users to filter the IoT use cases on domain, location and technology, and thereby easily find those of greatest relevance and matching interest. The green box illustrates how the tagging mechanism appears on the individual page of a use case).

For an overview of the 30 IoT use cases available in the catalogue, see appendix D that offers an outline of the case companies and their respective domain, along with descriptions of the use cases and their source of origin.

Figure 11: IoT use case catalogue – final version

4. IMPACT ASSESSMENT

This section outlines the impact of the work conducted by the EU-IoT COACH, in the scope of T4.3 under WP4. Key performance indicators provide a status on task activities in alignment with the project vision. Analytics results are presented to track and measure the early success of the ELP to reach industry, innovators, learners and policy makers in the European IoT landscape, along with an assessment of the results presented by the EU-IoT COACH towards stimulating a higher degree of innovation-driven thinking and exploitation.

4.1 Key performance indicators

To assess the impact of the efforts made with regard to T4.3 under WP4 “IoT BMs and Acceleration Support”, the EC has provided measures in terms of key performance indicators. These measures have served as a guide for the EU-IoT COACH and a vision towards the finalisation of the EU-IoT project. Find in the below Table 1, documentation that all impact measures for T4.3 under WP4 “IoT BMs and Acceleration Support” are met.

Table 1: KPI measures related to T4.3

	KPI measures	Target (M30)	Status (M30)	Comments
Impact 03	Business models for human-centred IoT applications	>=3	3	3 learning modules that support business models for human-centred IoT applications will be offered via the e-learning platform.
Impact 14	Number of different projects that will be coordinated and supported in producing and articulating novel and disruptive business models	>=12	>20	Minimum 12 projects across complementary CSAs, RIAs and other relevant European initiatives will be supported in producing and articulating novel and disruptive business models through testing scenarios and/or free access to the e-learning platform.
Impact 15	Number of novel and disruptive business models to be documented by EU-IoT	>=8	8	8 novel and disruptive business models will be documented through a mapping of best practice BMs – overall and domain-specific – based on insights from the use case study of T4.2.

IMPACT 03: The term “human-centred IoT applications” refers to the development of IoT technology for designing useful applications that enable user-friendly experiences. T4.3 intend for all 12 learning modules on the e-learning platform to be designed from the perspective of BMI for human-centric IoT, and for three of them to focus specifically on accelerating business models for human-centred IoT applications: 04. Customer Analysis, 06. Service Design and 11. Early Usability Testing & Pretotyping (cf. appendix B). All three modules are available online via the ELP.

IMPACT 14: A large amount of projects, along with public and private associations and entities, formal and informal alliances, coalitions and membership organisations, are offered support in producing and articulating novel and disruptive business models through introduction and free access to the e-learning platform.

The following have been supported in the BMI process through testing and validating activities:

- Projects: OPEN DEI large-scale-pilots (SmartAgriHubs, SYNERGY, INTERCONNECT, ADLIFE, PHARAON, Digiprime, Kyklos, EFPF, Qu4lity), and the AIoTI Manufacturing WG.
- Network actors: IoT Next Club, Danish Industry Foundation and Danish IT Society

The following have coordinated BMI trough project collaboration activities:

- Projects: ICT-56 RIAs (IntellIoT, VEDLIoT, Ingenious, IoT-NGIN, ASSIST-IoT, NGIoT), IoTAC, ACTIVAGE, Startup3, DIATOMIC, MERMISS.
- Network actors: Nordic IoT Center, Eclipse Foundation, LoRa Alliance, The Things Network.

IMPACT 15: T4.3 documents eight novel and disruptive BMs by mapping patterns that are characteristic for best practice IoT BMI (cf. sec 2.2). Each mapping reflects the BM of a specific domain (Agri-Food, Energy & Utility, Health & Care, Manufacturing, Mobility & Transportation, Smart Cities & Communities, and Other), and one overall mapping reflects BMI best practices across all domains.

It can further be argued that 30 novel and disruptive BMs have been documented with the best practice IoT cases presented in the EU-IoT use case catalogue. For an overview of the BMs of the individual use cases and how they were impacted by IoT innovation, see appendix A.

4.2 Key analytics

The impact of the results presented by the EU-IoT COACH determines the success of the efforts to provide BM acceleration support. To this end, we find a desirable impact in the knowledge resources of the ELP being applied and that value for European IoT practitioners are generated from it. For the consortium, to ensure such impact, measurable metrics were implemented that enabled sophisticated tracking through analytics. The analytics assesses impact based on user engagement and toolbox application on the ELP. All website content has been analysed based on data from activity tracking*[2] and, based on the capabilities of the applied web analytics solution, the consortium has focused on the following metrics:

PAGE VIEWS AND UNIQUE PAGE VIEWS

Page views and unique page views are set up to monitor the traffic to the websites and thus interest in the offered modules and content elements. Page views are the total number of pages viewed (i.e. repeated views of the same page are counted in). Unique Page views are the number of sessions during which a specific page is viewed at least once (i.e. how many times each user has visited the page), serving as an indicator for the reach of the ELP and the IoT use case catalogue.

Tracking period

All analytics across all domains have been tracked up to March 2023.

The period of tracking vary across domains because the sites and its content were launched at different times along with the EU-IoT project unfolding. The tracking periods were marked with the implementation of analytics as follows:

E-learning platform

- NGIoT: 5 months (start Oct. 2022)
- DBD.AU: 5 months (start Oct. 2022)

Use case catalogue

- NGIoT: 14 months (start Jan. 2022)
- DBD.AU: 16 months (start Nov 2021)

NB. The tracking periods does NOT solely cover the sites in their final versions, but also the content development processes.

NGIoT sites were promoted (on LinkedIn and Twitter) from Jan. 2023 to Mar. 2023

DBD.AU sites were subject to test and validation activities from Apr. 2022 to Feb. 2023.

*[2] *Across the consortium websites the universal Google Analytics are currently applied. This ensures a coherent capture of data for analytics across domains, however, the project partners are planning to implement an alternative analytics solution that is better in alignment with European values - the Matomo open source web analytics have been chosen [https://matomo.org/].*

E-learning platform

For the main page of the ELP[3] (across domains), **total page views are 636** and **unique page views are 378**, as illustrated in the below Figure 12. This implies that more than 75 people have visited the ELP each month (over the past 5 months) on average.

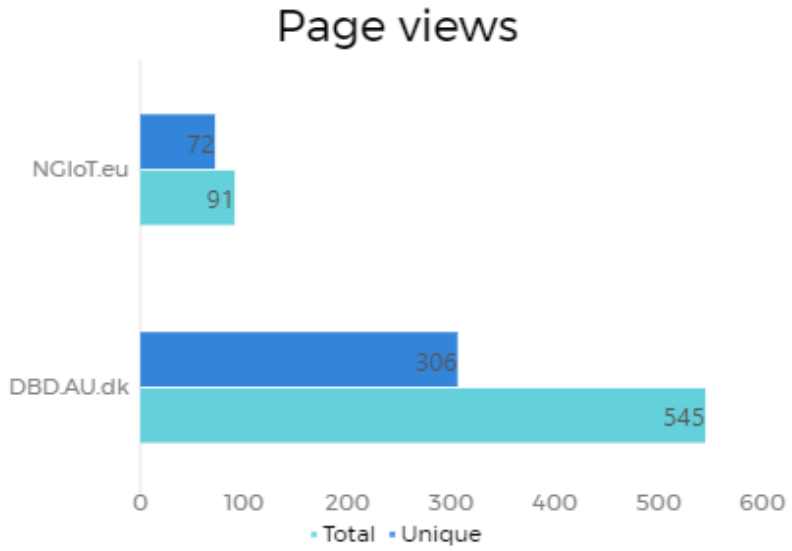


Figure 12: Page views on ELP main page

Considering the individual business development learning modules and tools on the ELP (based on unique page views across domains), the top three most popular content are:

Table 2: Page views on top three learning modules

	Learning module or tool	Unique page views
1	St. Gallen Magic Triangle [tool]	536
2	Basic principles [learning module 01]	90
3	What you need to know about digital business development [learning module 02]	55

As Table 2 illustrates, the St. Gallen Magic Triangle, was used frequently over the past five months, with more than 107 people clicking the tool each month on average. The popularity can be explained by a rapid use of the tool both for teaching, workshop exercises and other testing activities in the period.

IoT use case catalogue

For the main page of the EU-IoT Use Case Catalogue[4] (across domains), **total page views are 2,487** and **unique page views are 1,589**, as illustrated in the below Figure 13. This implies that more than 105 people have visited the use case catalogue each month (over the past 15 months) on average.

[3] [https://www.ngiot.eu/business-development/ and https://dbd.au.dk/models-tools/]

[4] [https://www.ngiot.eu/use-cases/ and https://dbd.au.dk/case-studies/]

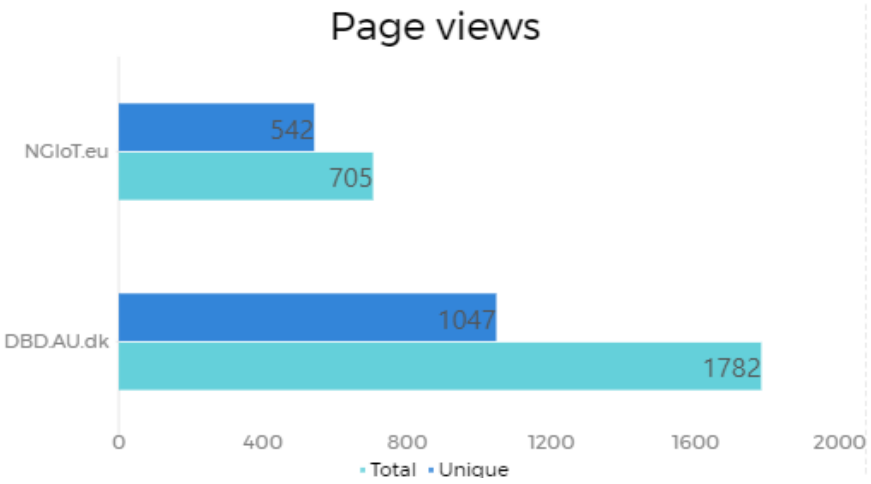


Figure 13: Page views on IoT use case catalogue main page

Considering the individual cases in the IoT use case catalogue (based on unique page views across domains), the top five most popular cases are:

Table 3: Page views on top five use cases

	Use case	Unique page views
1	ASTI Mobile Robotics	796
2	Veoneer	543
3	Fivecomm	314
4	Aqua Robur Technologies	223
5	Emotion	185

As Table 3 illustrates, in particular the cases of ASTI Mobile Robotics (published Dec. 2022) and Veoneer (published Nov. 2022) have received great interest from the public, with respectively 56 and 181 people clicking the cases each month on average. Although all cases have been promoted via NGIoT channels, the popularity of ASTI Mobile Robotics and Veoneer can be explained by additional efforts made by the companies to communicate and link to the use cases.

EVENT TRACKING

Event tracking, in terms of time spent on a page, is the metric set up to investigate how the users invest time in reading and engaging with the content. Statistically, an average user reads one page (300 words) in one minute. The metric '60 seconds spent on a page' was therefore chosen to account for a positive result in assessing the number of users that engage with the content.

E-learning platform

The average time spent on the main page of the ELP (across domains) is 01:00, or 60 seconds, as illustrated in the below Figure 14. This is a reasonable period of time since the main page is light on text elements and users are therefore able to quickly navigate to the learning module of interest.

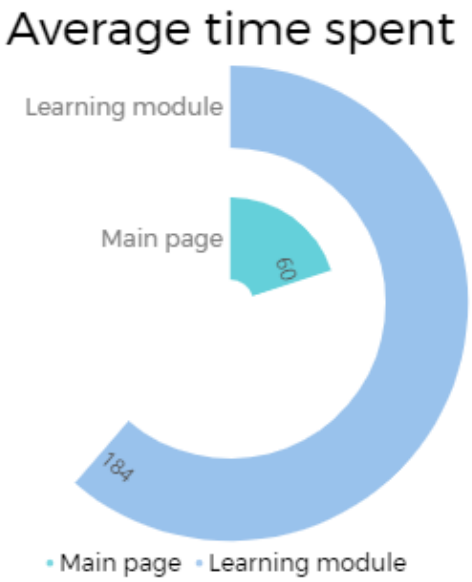


Figure 14: Average time spent on ELP main page vs. individual learning modules

The average time spent on individual learning modules and tools (based on the top three) is 03:04, or 184 seconds. The period of time confirms that the users *do* engage with the content, however, it is not possible to conclude whether they complete the suggested exercises.

Table 4: Average time spent on top three learning modules

	Learning module or tool	Unique page views
1	St. Gallen Magic Triangle [tool]	04:34
2	Basic principles [learning module 01]	02:12
3	What you need to know about digital business development [learning module 02]	02:25

Considering the top three individual business development learning modules and tools on the ELP, the distribution of the time spent (c.f. Table 4) may indicate that the learning modules have primarily been read, whereas the St. Gallen Magic Triangle has been read *and* actively used.

Use case catalogue

The average time spent on the main page of the IoT use case catalogue (across domains) is 01:16, or 76 seconds, as illustrated in the below Figure 15. This is a reasonable period of time since the main page of the use case catalogue, quite similar to the ELP, is light on text elements and users are therefore able to quickly navigate to the specific use case of interest. It is very likely the filtering mechanism (see sec. 3.3.4) that takes up the additional seconds.

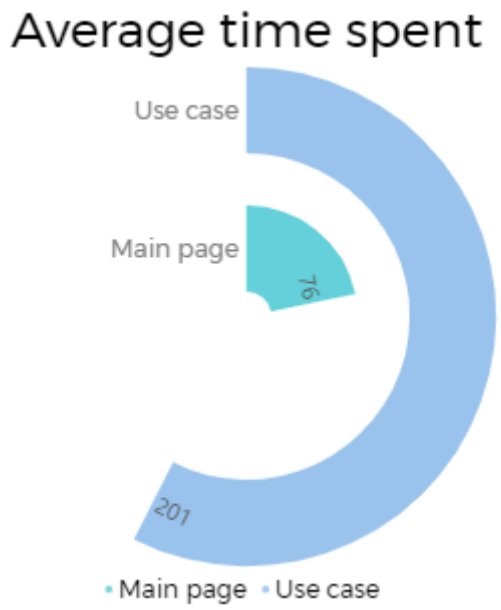


Figure 15: Average time spent on IoT use case catalogue main page vs. individual use cases

The average time spent on individual use cases (based on the top five) is 03:21, or 201 seconds. The period of time confirms that the users *do* read the text and engage with the various sections of the cases.

Considering the top five individual cases in the IoT use case catalogue, the distribution of the time spent (c.f. Table 5) is a combined indicator for the ability of the individual case to catch the interest of the reader, as well as for the volume of text elements.

Table 5: Average time spent on top five use cases

	Use case	Average time spent
1	ASTI Mobile Robotics	02:39
2	Veoneer	02:48
3	Fivecomm	02:34
4	Aqua Robur Technologies	04:17
5	Emotion	04:27

WEBSITE FUNNELS

Website funnels (behaviour flows) offer insight into the needs and wants of the users. As previously mentioned, practitioners can enter any module on the ELP that matches their status in the BMI process and level of experience with IoT technologies, and equally, they can follow the flow between the modules as an ongoing process. Likewise, they can read any case in the IoT use case catalogue that matches their area of interest and relatability on domain, geography and technology. Hence, by tracking the website funnels, the consortium can harvest information regarding the status of the innovators and learners based on their entry point and journey through the modules and use cases.

E-learning platform

The top 10 funnels, starting from the ELP main page, is illustrated in the below Figure 16. Hence, the illustration reflects what (e.g., learning module, tool, website subpage, etc.), and to what extent, the user clicks on when proceeding from the ELP main page.

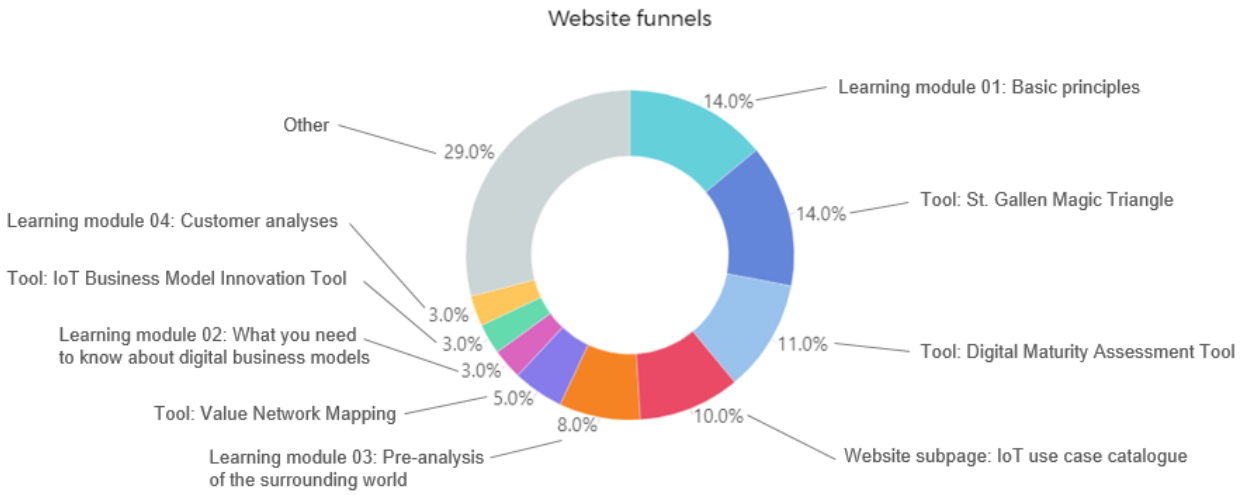


Figure 16: Website funnels fro, ELP main page

It seems that the *Learning module 01: Basic principles* is the natural first click for users. In general, users tend to click the early modules, which perfectly align with the desired behaviour to follow the BMI process step-by-step. We can further see that the additional tools offered by the ELP are popular first clicks for the users. This was expected because practitioners often are attracted by practical tools and because they are located easily accessible on the ELP main page. The measure of website funnels has in particular been useful to support the ongoing testing, refinement and development of the toolbox, and in understanding what parts of the content users find immediately interesting.

Use case catalogue

The top 10 funnels, starting from the IoT use case catalogue main page, is illustrated in the below Figure 17. Hence, the illustration reflects what (e.g., use case, website subpage, etc.), and to what extent, the user clicks on when proceeding from the IoT use case catalogue main page.

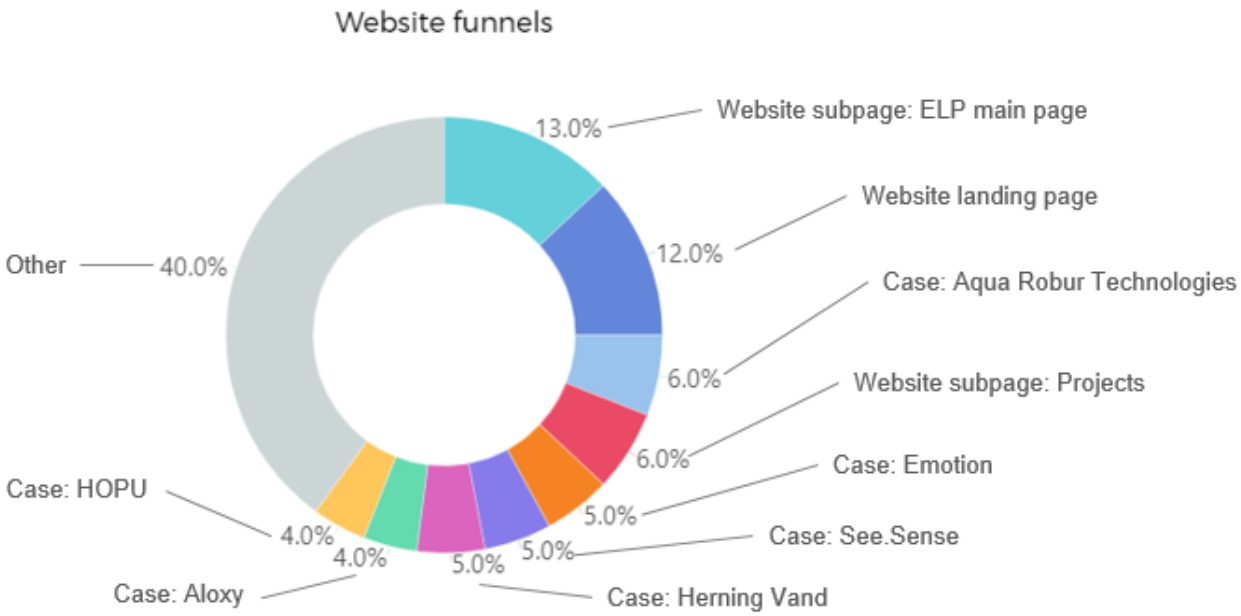


Figure 17: Website funnels from IoT use case catalogue main page

It seems that users most often tend to proceed to the ELP main page or to the website landing page. Presumably, this behaviour reflects that this group of users visit the IoT use case catalogue main page to 1) check if new use cases have been added, or to 2) get a general overview of all the available cases, without intending to explore them in detail. Subsequently, we see that users' first click varies across the many use cases – hence, the category *other* mainly entails the remaining use cases in the catalogue, with a relatively even distribution of clicks. This indicates that all the 30 IoT use cases are found interesting and relevant to some extent by the users.

DOWNLOADS

Tools and templates are offered in a downloadable version that can be printed to support physical workshops. The number of downloads is being tracked to assess this use situation. We are aware that all content is primarily designed for application and utilisation in the digital form online. Thus, we will not be able to draw any conclusions regarding usage based on this number, but rather to which extent the toolbox is applied as blended learning.

Over the tracked 5-month period, 597 downloads were made from the ELP, covering tool templates and related step-by-step guides and case examples. Based on the summarisation of these downloads, the Table 6 illustrates the top five most popular tool templates.

Table 6: Top five tool templates based on downloads

	Tool template	Originating from learning module
1	Value Design	06 Service design
2	The IoT Business Model Innovation Tool	Additional tool: The IoT Business Model Innovation Tool
3	The Surrounding World	03 Pre-analysis of the surrounding world
4	B2C Customer Segmentation	04 Customer analysis
5	Value Chain	03 Pre-analysis of the surrounding world

PURPOSE OF USE

Feedback questions (as shown in figure 18) have been implemented at the end of all IoT use cases to enable assessments of the purpose of use. This, to gain an understanding of WHY and on WHO the specific use case has an impact.

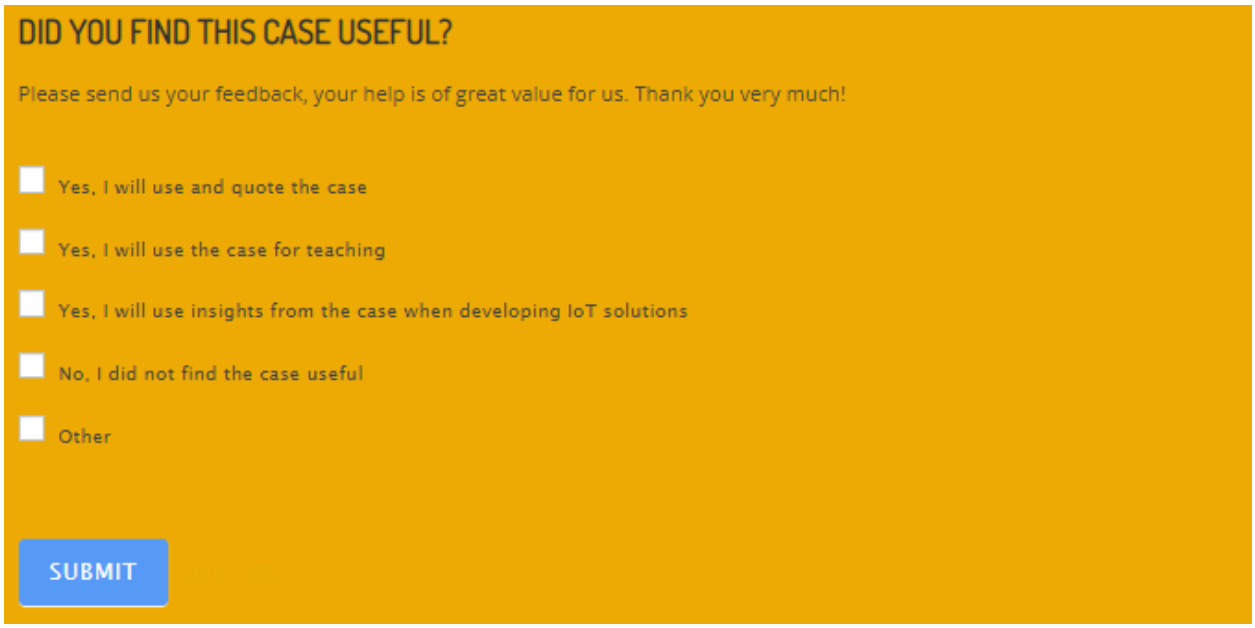


Figure 18: Feedback question on IoT use cases

Answers to the question first and foremost indicate whether the user finds the IoT use case useful, secondly answers indicate the intended purpose of use, and with that also who the users are (e.g., academics, teachers, consultants or companies in the industry).

Unfortunately, we have received only five answers to the feedback question (across the cases ASTI Mobile Robotics, Veoneer and Bielefeld University). Hence, we are not able to derive any representative conclusions, but we would like to share the answers after all to offer an indicative insight. 100 % of the respondents have answered that they intend to use the case, and with that, that they find it useful.

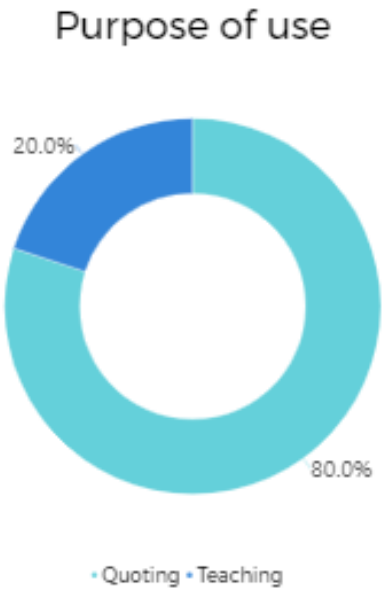


Figure 19: Feedback on the purpose of use for IoT use cases

As illustrated in Figure 19, 80 % of the respondents intend to quote the case, indicating that the users are likely to be academics that use the case for the purpose of their research, and 20 % of the respondents intend to use the case for teaching, indicating that the users are likely to be teachers or consultants that use the case for the purpose of exemplifying theory in classroom teaching, illustrating real-world IoT scenarios in workshop exercises, and alike.

Since the ELP was launched in its final version just recently, and the tracking across the various sites was initiated before all contents were fully released, the above numbers indicate relatively limited activity on and use of the sites. However, it is important to note that these analytics metrics do not reflect the ELP and the IoT use case catalogue in their final versions. It has only been possible to track the final version of the sites over short periods of time, which offers an incomplete representation to convey the impact potential. However, AU will continue to track activity and use analytics insights beyond the EU-IoT project, to increase the application and impact of the toolbox.

4.3 Impact of the results presented by the EU-IoT COACH

The above analytics are useful in indicating the early success of the ELP to reach industry, innovators, learners and policy makers in the European IoT landscape. However, when assessing impact through metrics we must be careful not to focus on what is measurable at the expense of what is important. The impact of the results presented by the EU-IoT COACH can and should not be reduced only to metrics. Hence, a short account is given below to assess the unmeasurable impact of the results towards stimulating a higher degree of innovation-driven thinking and exploitation.

4.3.1 Impact of EU-IoT use case catalogue (incl. study results)

The IoT use case catalogue offers inspiration by demonstrating best practices for developing and/or deploying IoT solutions. These practical examples lower the barriers for adopting IoT technologies, eventually helping practitioners to understand how they can create the most optimal premises for themselves and for the ecosystem to succeed with IoT. The practical and relatable stories of the IoT use case catalogue are also leveraged in illustrating the application of tools, templates and methods on the ELP through best practice examples. Hence, the success stories have valuable impact to demonstrate theoretical application in a real-world scenario.

The study across IoT use cases has generated new knowledge on patterns in business dynamics and technological dynamics of relevance to IoT success. The insights are useful for innovators and learners as a point of reference for conceptualising best practice IoT BMs, and as a framework to perform BM self-evaluation prior to initiating an IoT BMI process. Eventually, this knowledge will support practitioners in successfully adopting best practices for building novel and disruptive business models that enable them to achieve success in the IoT area.

To sum up, the EU-IoT use case catalogue and study results stimulate innovation-driven thinking, by providing inspiration and concretise best practices for practitioners to build novel and disruptive business models for next generation IoT applications.

4.3.2 Impact of EU-IoT e-learning platform (incl. toolbox)

The ELP translates the new knowledge on best practices for IoT business model innovation into action by providing the toolbox needed for innovators and learners to adopt these best practices and build novel and disruptive business models accordingly. The platform is easy to access, easy to use and easy to custom to the level of innovation, novelty of technology, complexity of the

ecosystem and composition of BM elements represented by different companies and the products and services within them.

The toolbox assembles tools, templates and methods that support practitioners through the entire BMI process, while offering appertaining recommendations that build up their skills for optimal utilisation of novel IoT technologies. Eventually, this asset will educate both innovators that are active users of IoT technologies already, but also learners that are late bloomers in leveraging the innovation potential of digital technologies.

To sum up, the EU-IoT e-learning platform, along with its contents of toolbox and recommendations, will stimulate innovation-driven exploitation by directly supporting practitioners in building novel and disruptive business models for next-generation IoT applications.

Hence, the above results presented by the EU-IoT COACH are complementary to each other and hold great potential to support and accelerate IoT BMI for industry, innovators, learners and policy makers. Utilised together, they are an impactful resource to effectuate real change by increasing the adoption of best practices for building IoT skills and BMs in the European landscape.

5. OUTLOOK AND CONCLUSION

This section offers an outlook for the European IoT landscape to understand the need for business model innovation support and acceleration activities in the future while outlining the viability of the e-learning platform, and with that the ability of EU-IoT COACH, in the scope of T4.3 under WP4, to stimulate a higher degree of innovation-driven thinking and exploitation among industry, innovators, learners and policy makers.

5.1 Trends and challenges of IoT BMI

As part of our outlook, we have taken a look into how the development of the European IoT ecosystem is influenced by major macro trends in the areas of economics, political developments, environmental factors, and technological advances going forward. These trends outline the significant challenges that practitioners will face when innovating IoT BMs, along with the opportunities that arise. We want to highlight the following key macro themes, many of which are interrelated:

ECONOMIC

- **Inflation.** Global growth forecasts are declining as inflation intensifies in most major economies of the world, raising expectations of a cooling down of the economy. Rising prices for energy, raw materials, and food have started to hit businesses. Because these rising input prices have a negative effect on profits, companies have limited room to invest, which has a negative effect on the adoption of new technologies, such as IoT. Nonetheless, there is a silver lining for IoT. A recent report from IoT Analytics [5] found that IoT use cases related to improving a company's operations are among the most adopted. As margin pressure due to inflation increases, companies will look to IoT as a tool to improve operations and invest in cost-saving activities.
- **Lower valuations for disruptive technologies**. Central banks around the world are expected to increase interest rates substantially in the coming months to fight inflation. This increase is bad news for high-growth technology firms and startups because it puts their overall company valuations under pressure. Valuations of VC-funded companies are already down 20% this year, according to some insiders. It might get harder for market-disrupting business ideas and technologies to collect fresh funding in the future.
- **Unstable supply chains.** Supply chain disruption rose as a concern throughout 2021 due to a number of factors, including COVID-19 lockdowns, container shortages, and the blocked Suez Canal. The chipset supply chain in particular is of major concern for the growth of IoT. However, supply disruptions have also shown to be a major tailwind for some IoT initiative, as companies are investing heavily in smart solutions that make supply chains more resilient (e.g., track-and-trace IoT solutions or warehouse automation).

The ability of governments and central banks to mitigate the disruptions and ensure a soft landing will largely determine the ultimate impacts of current economic factors going forward. The most urgent challenge is the chip shortages which are now expected to extend well into 2024 and possibly even beyond.

[5] IoT Analytics. (2023, February 07). Global IoT market size to grow 19% in 2023—IoT shows resilience despite economic downturn. Retrieved February 13, 2023, from https://iot-analytics.com/iot-market-size/

POLITICAL

- **Nearshoring/Reshoring**. As a result of unstable supply chains, many companies are moving from a single-source supplier strategy to a multiple-source strategy to provide more options in case of future disruptions. Considering the comparably high labor costs in the US and Europe, companies need to invest in state-of-the-art manufacturing facilities and Industry 4.0 to stay competitive. This drive will lead to investments into new, state-of-the-art manufacturing facilities in countries with relatively high average wages.
- **Russian invasion of Ukraine.** The war in Ukraine is adding to supply disruptions and inflation concerns. Since large shares of neon and palladium are produced in Russia and Ukraine, the semiconductor shortage is expected to get worse, thereby impacting the IoT market growth further.
- **European Data Act.** The European Data Act, which is likely to go into effect in 2023, could have positive implications for competition in the tech space. The EC is planning to introduce a directive allowing customers (businesses and consumers) to switch between different cloud data-processing services providers and establishing safeguards against unlawful data transfer. Moreover, it would allow users of connected devices to gain access to data they generate, which as of now are mainly accessible by manufacturers. End users would then be allowed to share that data with third parties, which could offer additional services. This opportunity could help startups and other actors grow their customer base.
- **Skill/Labor shortage.** Many companies are facing a massive challenge finding skilled labor to move ahead full force with digital transformation, AI, IoT, and cloud projects. IoT Analytics tracks online job ads on an ongoing basis. The number of job ads that included “IoT” grew by +32% between July 2021 and April 2022. Job ads including “AI” (+48%), “Edge Computing” (+53%), and “5G” (+52%) were in even higher demand. Moreover, a recent study published by Inmarsat identified a lack of in-house skills as the top barrier to IoT deployments [6].

The war in Ukraine adds to the challenge of chip shortage and reshoring activities might put further pressure on the already existing skill/talent gap. The launch of European Data Act may however contribute positively to grow the IoT ecosystem going forward.

ENVIRONMENTAL

- **Sustainability goals.** Many companies have committed to ambitious climate goals, striving to reach net-zero carbon emissions within the coming decades. To reach these goals, companies will need to measure and reduce carbon emissions. Sustainability-focused use cases, such as IoT-based energy management, renewable energy management, and connected HVAC, are expected to be in high demand. Software tools are also required to measure sustainability footprints and achieve ESG goals.
- **Reducing fossil fuel dependence.** Governments, companies, and individuals are increasingly moving to alternative energy sources. Investments in EVs and EV charging infrastructure are increasing and heavy industries and transportation are looking to hydrogen to replace fossil fuels. The investments into new and greener energy sources in all major economies will likely trigger investments into smart grid and smart city solutions and a general increase in IoT spending from the energy industry.

All environmental factors are considered tailwinds for IoT growth. Extreme weather events will

[6] Inmarsat Corporate Website. (2022, March 15). Skills shortages remain the top barrier to industrial IoT adoption, Inmarsat Research reveals. Retrieved February 13, 2023, from https://www.inmarsat.com/en/news/latest-news/enterprise/2022/skills-shortage-iot-adoption-research.html

ensure that climate change continues to get attention and will lead to further investments in energy efficiency and carbon neutrality to limit the effects. It will be interesting to see whether companies and governments meet their ambitious goals in the coming years and decades.

TECHNOLOGICAL FACTORS

- **Maturing artificial intelligence.** A 2021 survey on IoT adoption showed that only 16% of companies have fully adopted AI as part of IoT projects, while 70% are rolling it out or have a pilot. The importance of AI for the IoT is still increasing. The availability of new software tools, the development of simplified AI solutions, the infusion of AI into legacy applications, and advances in AI hardware are expected to boost the Artificial Intelligence of Things (AIoT), and we estimate that the AIoT market will reach $102.2 billion by 2026.
- **Cloud vendor focus on IoT**. As enterprise workload migration to the cloud continues, the three main hyper scalers—Microsoft, AWS, and Google—continue to invest significantly in IoT. They enable communication services, offer industry-specific services, and implement digital twins as a core element of their IoT cloud. In many ways, the hyper scalers have become the backbone of the IoT, and their continued strong commitment is expected to boost overall IoT market size growth for years to come.
- **Maturing Connectivity**. 5G is a hot topic now and in the coming years! The ability to get more powerful connectivity at lower prices continues to fuel the IoT market and is bringing new concepts to customers, such as the ability for enterprises to set up their own private 5G networks.
- **Increasing cybersecurity incidents**. The number of cybersecurity attacks has been high for a couple of years. Headlines about high-profile security incidents have become frequent, emphasising the risks facing the IoT. These incidents will be a barrier to the growth of the industry for some time to come while being a boost to those offering cybersecurity solutions.
- **Chip shortage.** In 2021, 20 million cellular IoT chips were missing due to a global supply shortage. The shortage continues to be the most significant pain point for the semiconductor industry and many of its customers. At MWC 2022, we learned that chip lead times of 40–50 weeks have become the new industry average, that redesigning and pre-ordering chips with an upfront payment has become a standard business practice for the industry, and that the industry is unable to determine whether the demand surge for chips reflects panic or the new normal. With lead times still increasing, many IoT projects will not be feasible given rising prices and limited supply. The shortage is likely to limit growth in 2022 and 2023 at least. However, in the long run, investments into additional capacities could increase the supply and lead to lower prices.

Technological developments are usually always advantageous for technology markets, and thus IoT market growth, but we are in a peculiar situation in which the demand for chipsets has become so large that the supply shortage is limiting the rollout of IoT projects.

5.2 IoT BMI going forward

As a result of some of these macro factors, particularly inflation, companies are forced to focus more on digitalisation towards operational efficiency to neutralise cost pressures and ensure supply to customers. Despite the many challenges, IoT remains a very hot topic and the number of connected IoT devices is estimated to have reached 14.5 billion globally by the end of 2022 [7].These trends immensely contribute to the growth of the European IoT ecosystem, however, it

[7] IoT Analytics. (2022, June 14). State of IoT 2022: Number of connected IOT devices growing 18% to 14.4 billion globally. Retrieved February 13, 2023, from https://iot-analytics.com/number-connected-iot-devices/

also brings in a need for support initiatives to accelerate IoT BMI accordingly.

Unfortunately, skills shortages are putting a brake on IoT innovation, inhibiting the adoption of the technology and the potential effectiveness of IoT BMs. According to research based on interviews with 450 global respondents, a lack of in-house skills remains the top barrier to IoT deployment for well over a third of the innovative companies questioned [3]. The EU-IoT project has conducted a skills survey that involved over 100 experienced IoT professionals to explore the IoT skills shortage issue. Findings of the survey are presented in a whitepaper released end November 2021, along with a clustering of the skills that are currently high in demand in the global market, appertaining IoT skills profiles, and a taxonomy that serves as basis for defining education activities and learning paths to alleviate the problem. The whitepaper with the title "The EU-IoT Framework for Internet of Things Skills: Closing the Talent Gap" is available with the DOI:10.13140/RG.2.2.15421.38886 at ResearchGate, In alignment with these insights, the learning modules that are made available via the ELP are addressing the IoT skills shortage issue by offering a complete toolbox that supports the IoT skills building needed to foster the development, deployment, and operation of modern IoT BMs.

Beyond the skills shortage issue, 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*). With the selection of tools, templates and methods, the ELP serves as a platform that helps practitioners to not only rethink these scope areas but to build BMs that effectuate them.

The current business sentiment for companies engaging in digitalisation remains predominantly positive and there is widespread acknowledgement that especially the Covid-19 pandemic has had an overall positive effect on the accelerated adoption of IoT technologies. The IoT market size is forecasted to grow, from $201 billion in 2022, at a CAGR of 22% to $525 billion over the next five years [2]. However, with a market that is facing the current trends and challenges while growing at this pace, the need to accelerate innovation-driven thinking and exploitation is more profound than ever. For industry, innovators, learners and policy makers the lack of IoT skills and BMs is a major concern and barrier to leverage market growth. For IoT to be a sustained success, support to overcome this barrier is necessary. Support in terms of access to the relevant tools, templates and methods for building skills and innovating BMs is needed at all levels. Without all these resources in place, businesses will continue to struggle to make optimal use of the data they gather, to integrate IoT technologies into the wider organisation and benefit from the transformative role that IoT can play in the global supply chain.

6. INITIATIVES FOR CONTINUITY

This section provides an account for initiatives of the EU-IoT COACH that stretches beyond project closure, to ensure continuity of the efforts to support and accelerate business model innovation in the European IoT landscape.

Although the EU-IoT project is soon reaching termination - and with that also the activities of WP4 and the authority of the EU-IoT COACH – AU will persistently seek to increase and manifest the impact of the results presented in this and previous WP4 deliverables towards IoT skills development, business modelling and acceleration support. Eventually, to lower the barriers for developing and deploying IoT-empowered solutions and thereby inspire and enable stakeholders to contribute towards growing the European IoT ecosystem.

Several initiatives have already been implemented throughout the project activities to ensure that the knowledge and resources presented by the EU-IoT COACH will continue to be available, to be used and to generate value beyond project closure. Examples include:

- **Free and public resources**: The ELP and the use case catalogue are offered online and free of charge as publicly accessible resources. This availability offers all stakeholders in the European IoT landscape the opportunity to access BMI support and inspiration, as well as potential for widespread proliferation. All content is released over time e.g. when a new module is designed, an additional case is documented or video media is ready, thus offering as much new knowledge as soon as possible.
- **Creative Commons (CC) licensing**: A simplified licensing system is implemented on the ELP to support BM innovators and learners in the application of the tools, templates and methods. The CC licensing system indicates when users can freely download, print, copy and share content, as well as when they have permission to stream or view the video media from their original location, ensuring personal data protection in alignment with the GDPR. The CC thereby provides continuity for the validity of the contents of the ELP, while supporting the project's effort to fuse knowledge and action with the maximum availability to the users, while still respecting intellectual property and personal data.
- **Replicated online hosting**: The ELP and the use case catalogue are offered online both via the NGIoT domain and the DBD.AU domain. With the closure of the EU-IoT project, a closure of the NGIoT domain may not be far into the future due to the end of allocated funding. However, in this scenario, the results generated through the project will remain available on the DBD.AU domain. Over time, the results will be complemented with new content e.g. when additional modules are designed, stand-alone tools are developed or use cases are documented, as part of AU's engagement and efforts in future digital business development projects, thus offering as much new knowledge as soon as possible.

Hence, several continuity initiatives and strong project closure are contributing to ensure impact of the results and realisation on the potential of IoT BMI acceleration support to foster the growth of a sustainable European ecosystem.

Although AU is leading the IoT BMI support and acceleration activities, the consortium has collaborated in joint effort towards generating the results presented in this deliverable. The EU-IoT COACH has leveraged the partners to progress and amplify the activities of WP4, for example by advantaging from the consultation activities and strategic outcomes of WP2 and the community-building activities of WP3 to gather the necessary additional knowledge and expertise that the involved stakeholders bring, and from the tools and mechanisms of WP5 to outreach activities and outcomes to the IoT community. For further information on the contribution of AU to create consortium synergies, see appendix E.

AU intends to continually liaise with the partners of the consortium as well as with other stakeholders in the European IoT ecosystem such as CSAs, ICT-56 RIA projects and other relevant European initiatives beyond project closure. Close contact and continuous collaboration shall be leveraged towards further disseminating the new knowledge and valuable resources to

accelerate the adoption of IoT technology and the building of IoT skills and BMs. One concrete initiative toward this, is the final event planned for the 30. March 2023, where the EU-IoT consortium will showcase the results, pass on resources and assets, and engage with relevant projects to follow on from the activities. Hence, persistent liaison with the ecosystem is considered key to manifesting and further increasing the impact of the results presented in this and previous WP4 deliverables. Results that hold the potential to maximize IoT BM exploitation and acceleration, both in academia as well as in industry and also in governmental entities dedicated to the pursuit and acceleration of the IoT BMI in the European landscape.

EU-IoT COACH or not, AU will remain committed to the ambition of the project to effectively amplify the achievements of the EU-IoT project, and the impact of various IoT initiatives that define the Next Generation Internet. Fostering synergies in the ecosystem and supporting efforts within H2020 and beyond, these efforts will help to shape the digital future of Europe in the ongoing transition towards Horizon Europe.

APPENDIX A – BMI IMPACTS OF IOT USE CASES

Find in the below table 7, an overview of the impacts of innovation on the business models of the 30 individual cases presented in the EU-IoT use case catalogue.

Table 7: BMI impacts of IoT use cases

DOMAIN	CASE COMPANY	BUSINESS MODEL DIMENSION				BUSINESS MODEL INNOVATION
		WHO	WHAT	HOW	WHY	
Agri-Food 	Fauna Smart Technologies		X	X		√
	DunavNET _agroNET	X	X	X	X	√
	DunavNET _poultryNET	X	X	X	X	√
	Synelixis	X	X			√
Energy & Utility	ASM Terni		X	X		√
	Aqua Robur		X	X	X	√
	Herning Vand		X	X		√
Health & Care 	GoodLife Technology	X	X	X	X	√
	MySphera	X	X			√
	Technosens	X	X	X		√
	NTT Data		X	X	X	√
Manufacturing 	QiO Technologies	X		X	X	√
	ASTI Mobile Robotics	X		X		√
	Aloxy		X	X	X	√
	Troldtekt			X		
Mobility & Transportation 	Veoneer		X	X		√
	Terminal Link			X		
	Awake.AI		X	X	X	√
	Emotion	X		X		√
	Tecnalia	X	X			√
	See.Sense	X	X	X	X	√
Smart Cities &	FoldAI	X	X	X	X	√

Communities	CITEC, University of Bielefeld	X	X			
	Aguardio		X	X		√
	CERTH		X		X	√
	HOPU	X	X	X	X	√
Other	Quadible	X	X	X	X	√
	Fivecomm		X	X	X	√
	Cumucore	X		X		√
	AllThingsTalk				X	

APPENDIX B – LEARNING MODULES OVERVIEW

The toolbox, along with recommendations, is structured into a range of learning modules that support the entire BMI process. Each learning module treats one distinctive step in the BMI process, and builds the related distinctive skills. When a practitioner completes a learning module, he is one step closer to unlocking the success of a novel and disruptive business model that accelerates IoT adoption.

The format of the learning modules offers a user-friendly structure for IoT BMI, where the specific tools, templates, methods, and recommendations, needed at any point of time in any BM innovation process, can be found as one bundle among the modules. This modular composition of the ELP helps innovators and learners to build or enhance their BMs one step at a time. From a practitioner perspective, this module structure of the toolbox enables support throughout the BMI process regardless of how far into the process the user has reached on their own - the practitioner can simply skip to the module representing the key challenges they are facing at the moment in their individual BMI process.

The learnings modules are listed in the below Table 8:

Table 8: Overview of learning modules

Learning module	Introduction
1. BASIC PRINCIPLES	When working with the development of digital BMs and with digital transformation in general, some basic principles are worth applying. All tools, templates and methods presented in subsequent modules are based on one or more of the principles.
2. WHAT YOU NEED TO KNOW ABOUT DIGITAL BUSINESS MODELS	An overall understanding of business models is introduced. Here, the keyword is value – value for customers, users and the company behind the business model and other parties around the business model.
3. PRE-ANALYSIS OF THE SURROUNDING WORLD	An analysis of your surrounding world and your value chain explores the context in which the new digital business model is to be implemented. By analysing your surroundings, you will find opportunities, which you can seize, or threats, of which you must be aware.
4. CUSTOMER ANALYSIS	Your customers are the most important actors when it comes to ensuring the future survival of your business. A customer analysis enables you to understand who your customers are and what their wishes and dreams are.
5. PRE-ANALYSIS OF THE COMPANY'S SITUATION	An analysis of your business situation offers an overview of the digital maturity of the organisation, as well as assesses your internal strengths and weaknesses in relation to your external surroundings.
6. SERVICE DESIGN	Service design starts by analysing customers' needs and from there outlining one or more possible value propositions that meet these needs. This helps you to translate knowledge about the customer's tasks, problems and unfulfilled dreams into ideas for new BMs.
7. INSIGHT INTO CURRENT BUSINESS MODEL	A company's BMs, current as well as new ones, all contribute to the overall ability to create value. This module provides an overview that can be used to assess possible synergies across BMs, as well as to

	explore whether elements in an older BM can be updated to the advantage of the new BM.
8. DESIGNING A NEW DIGITAL BUSINESS MODEL	Based on the previous analyses of your current and/or future customers and outside in-principle, this module illustrates how to design a BM. This offers an overview of what your future digital BM might look like.
9. THE DEVELOPMENT PROCESS	The BMI process must ensure that the model you end up with supports your business strategies and ensures that you can make optimal use of the business opportunities that lie in the digitisation and market in which you are operating.
10. EARLY USABILITY TESTING AND PROTOTYPING	The quality of the various elements in the BM needs to be tested. This module presents test methods that can help to validate, further develop and qualify a new digital BM so that it becomes ripe for implementation.
11. INTERNAL VALIDATION AND TESTING	The ability of the company to create and deliver the value on which the new BM is based needs to be validated. This module helps you to evaluate that your company can handle the task of implementing a new BM and that all pros and cons have been considered.
12. IMPLEMENTATION	The value of a new BM only becomes real once it is implemented. This module teaches you what it takes to successfully implement and run the components of your new digital BM.

The learning modules provide a process framework that supports practitioners in successfully building IoT-driven business models. All learning modules are designed from the perspective of BMI for human-centric IoT, but are extendable to other digital technology offerings, where a network of actors offers value jointly and hence a strong degree of sharing in terms of revenue, data, responsibilities, and ethics is characteristic. *The term "human-centric IoT" refers to the development of IoT technology for designing useful applications that enable user-friendly experiences (cf. Impact 03, sec. 6).* Particularly three of the 12 learning modules will focus on accelerating business models for human-centred IoT applications: 4. Customer Analysis, 6. Service Design and 10. Early Usability Testing test and Pretotyping.

All the 12 learning modules are available online via the ELP, where they are complemented by a range of tools, templates and methods for more specialised application. These are elective add-ons to the general BMI process, and are therefore provided separately to the learning module format.

Equally, the communication of the toolbox is designed with a practitioner focus, where all modules are based on repetitive elements, for fast overview, easy understanding and candid practical implementation:

- The module in brief. An introduction with focus on the intended and expected learning outcomes of the module.
- Description of key concepts and definitions of the module.
- Introduction to each tool or template including a visual representation.
- A suggested method to work with the tool or template that includes practical information regarding who should be involved, the expected timeframe of the activity and what other resources are needed e.g. paper, post-it's and markers for a workshop.
- The step-by-step guide for the specific tool or template. This includes how to approach the tool or template through a logic process from the first parameter or question to raise and though all elements to finalisation.

- Reflective sections to support that the users fully understand what they have created, learned, decided or innovated.
- Output lists that articulate the learnings outcomes that are expected to derive from working with the tools, templates and methods presented in the module. This frames the module with the first introduction in the module in brief.
- Expert advice that covers the main elements from best practices in the domain of the tools, templates and methods applied in the module.
- Next steps that relate the specific module to the following or other parallel steps in the logic process of BMI.

The learning modules are dedicated to supporting the ability of the ecosystem to overcome the barriers for adopting next generation IoT technologies, by supporting and accelerating the innovation of novel and disruptive business models, and stimulating innovation-driven thinking and exploitation in the European IoT landscape.

RECOMMENDATIONS

The recommendations are dedicated to stimulating innovation-driven *thinking*, by supporting practitioners to adopt best practices in the process of building novel and disruptive business models for next generation IoT applications. These recommendations will be developed to guide practitioners through the process of innovating IoT BMs in the best possible way. This guidance will include both recommendations on the optimal application of the toolbox, as well as more general recommendations from experts on BMI and IoT.

TOOLBOX APPLICATION RECOMMENDATIONS

Recommendations are developed on how to use the specific tools, templates and methods towards successfully innovating IoT BMs. These include step-by-step guides and case examples.

STEP-BY-STEP GUIDES

Practitioners will be guided through the application of each individual tool, template and method. Very much like a user manual, an illustration along with dedicated information defines what to do and how to do it in detailed steps.

CASE EXAMPLES

The application of tools, templates and methods are illustrated with best practice use cases as practical examples. To this purpose, the success stories presented in the use case catalogue (generated by T4.1 under WP4) are leveraged to demonstrate the theoretical application in a real-world scenario. Examples include references to the specific use cases, and the catalogue is made available as a subpage to the ELP, offering the practitioner to seek further inspiration from relatable companies.

EXPERT RECOMMENDATIONS

Recommendations are offered by a range of experts within the respective areas of BMI and IoT. To this end, the EU-IoT COACH collaborates with a variety of different stakeholders across the NGIoT ecosystem to cultivate consensus on best practices in the areas both when considered as isolated entities as well as when considered in symbiosis.

BMI EXPERTS

Academic professionals offer recommendations in terms of statements that have origin in two knowledge sources. The first source is the joint knowledge, learnings and conclusions of the consortium of the “Digitale Forretningsmodeller til Fremtiden” study. The second source is the collective knowledge of experienced researchers at Interdisciplinary Centre for Digital Business Development (DBD) at Aarhus University derived from years of intensive research in the area of business development, BMs, BMI processes and successful digital transformations. These studies represent a variety of methodologies and include literature studies, industry case studies, and research projects that analyse the state of art in industry, including both SMEs and large international enterprises.

The BMI expert advices are available across the different learning modules on the ELP. The same pool of expert knowledge from academic professionals frames the content and recommendations in the videos that are part of the BMI toolbox.

IOT EXPERTS

IoT frontrunners from the industry offer recommendations based on their own experience and learnings. These recommendations may be based on: Learnings made by the innovator that accounts for do’s and don’ts throughout the IoT BMI process, and in general when engaging in IoT development and/or deployment; IoT solution experience that accounts for the enabling technologies, and the hardware and software features of a specific IoT solution; and Outcomes achieved by the innovator that accounts for the effects and the value generated by the IoT use case both internally by the case company end externally in the ecosystem.

Recommendations from the IoT experts are provided across 30 success stories explored in T4.1 under WP4. The stories, in terms of the use case catalogue, is integrated as a subpage to the ELP, offering the practitioner to seek inspiration and further guidance from relatable IoT BMI processes of best practice companies.

APPENDIX C – TESTING SCENARIO EXAMPLE

Date: February 07 and 14, 2023.

Test activity: Teaching on the course Technological Business Model Innovation.

Test responsible: Madalina Pop, MSc, PhD and Lecturer at Aarhus University.

Test participants: Approx. 60 engineering students at master level on first and second semester.

Test elements: The tool Business Model Architect (learning module 07: Insight into current business model) was used to map the current business model of the company case "Emotion". The tool St. Gallen Magic Triangle was subsequently used to innovate the business model.

Please **describe the teaching / testing scenario** briefly.

In the first lecture, the students received an introduction into the multiple types of business model canvases (Osterwalder's Business Model Canvas, St. Gallen's Magic Triangle, The Lean Canvas and the Business Model Architect) out there plus an intro into the elements that go into a business model. Then the students had to work in groups to map the current business model of the company case "Emotion". They had read the case prior to coming to class.

In the second lecture, the students worked with innovating the business model of the company (learning module 08: Design of a new digital business model). Afterwards there was a discussion in class of what the students have done.

What challenges did the students experience working with the learning modules / tools / case?

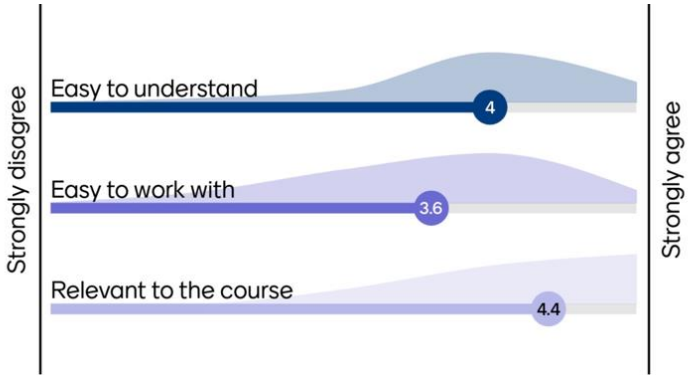
Not having enough data to be able to fully fill in a business model architect canvas. Canvas neglecting to include technology aspects of the business model.

What insights or new skills did the student achieve from working with the learning modules / tools / case?

In the first lecture, working with a business model, translating general case information into business model terminology, understanding where and how to make assumptions.

In the second lecture, they further worked with testing the assumptions as well.

Did the students find the learning modules / tools / case:



Did you do any interesting observations while the students were working with the learning modules / tools / case?

The case worked really well for its intended purpose. The St. Gallen Magic Triangle was good in translating the complexity of the Business Model Architect into more simple understanding.

What feedback did the students provide to the learning modules / tools / case?

Especially in the first lecture, there were a lot of comments that data was lacking. I do not see this as an issue because I wanted them to make assumptions and feel how difficult it is to figure out the business model when not everything is given to you. A selection of comments are included below:

Great case, however, it was lacking several aspects to the selling part of the product (E-station) and service (monitoring software). But they cannot be perfect, the cases, that's where we come in.
It was fun to work with
The Business Modeling exercise was nice and interactive itself, however I believe we could have come up with a better and more accurate business model if the Emotion case included some more details (ex. price, main consumers and other)
The case is fun and give some good discussions about the different elements in a BM
Nice case and a relevant topic to work with.
It was okay and fun to do the business model architect with cards.
I think there was way too little time to work with the case, but it was really interesting. Also, there was little data about the company and customers, compared to technical information.
By using the framework it was hard to establish what element were key business case parameters, and depending on the perspective, everything fit. But the case seemed to lack a clear answer to establish the specific business model.
Because it is kind of short and the business model architect model brings up a lot of topics making it easy for people to go off topic since most of the items are not defined.
Many assumptions had to be made to "answer" the BM fully as-is.
Nice with more time for group work! It is a good way to apply the learned knowledge and also discuss with others.

ELP content updates based on conclusions from the testing scenario:

The tool Business Model Architect is replaced by the St. Gallen Magic Triangle and the IoT Business Model Innovation Tool for further testing and validation.

APPENDIX D – IOT USE CASE OVERVIEW
[INCL. DOMAIN, COMPANY, USE CASE DESCRIPTION, AND SOURCE OF ORIGIN]

Find below in Table 9 an overview of the studied IoT use cases grouped by domain along with descriptions of the cases and their source of origin.

Table 9: Overview of use cases

Domain	Case company	Use case description and source of origin
Agri-Food 	Fauna Smart Technologies	Intelligent platform for pest and disease management in horticulture supports the transition to greener and more efficient farming practices
		H2020 call: ICT-33-2019 Startup Europe for Growth and Innovation Radar (IA); Project Startup3 871709; Period: 01-01-2020 to 31-12-2021; EC contribution 1.3 mil. EUR.
	DunavNET	Artificial intelligence platform for increased animal welfare and sustainability in livestock production
		H2020 call: DT-ICT-13-2019 Digital Platforms/Pilots Horizontal Activities (CSA); Project Open DEI 857065; Period: 01-05-2019 to 31-12-2022; EC contribution 2 mil. EUR.
	DunavNET	Artificial intelligence platform for optimised cultivation and supply chain transparency
		H2020 call: DT-ICT-13-2019 Digital Platforms/Pilots Horizontal Activities (CSA); Project Open DEI 857065; Period: 01-05-2019 to 31-12-2022; EC contribution 2 mil. EUR.
	Synelixis	Precision agriculture enabled by federated machine learning and autonomous farming procedures
		H2020 call: ICT-56-2020 Next Generation Internet of Things (RIA); Project IoT NGIN 957246; Period: 01-11-2020 to 30-09-2023; EC contribution 8 mil. EUR.
Energy & Utility	ASM Terni	Smart metering enables energy management and flexibility of Smart Grids
		H2020 call: ICT-56-2020 Next Generation Internet of Things (RIA); Project IoT NGIN 957246; Period: 01-11-2020 to 30-09-2023; EC contribution 8 mil. EUR.
	Aqua Robur	Smart water infrastructure enabled by NB-IoT and energy harvesting technology
		Network collaboration w. IoT Next Club (IoT community associated with the NGIoT initiative); Case period: 2021-2022.
	Herning Vand	Intelligent water metering enables new service business model and service add-on for citizens
		Projects MEREFF MST-141-01596 and MERMISS NST-404-00217; Period: 2014 to 2020; The Danish Environmental Protection Agency contribution 20 mil. EUR.
Health & Care	GoodLife Technology	Virtually engaging software facilitates interactive exercise for physical rehabilitation
		H2020 call: IoT-01-2016 Large Scale Pilots (IA); Project ACTIVAGE 732679; Period: 01-01-2017 to 30-09-2020; EC contribution 2.6 mil.

		EUR.
	MySphera	IoT solution to increase autonomy and quality of life of older adults, supporting and extending independent living in own homes
		H2020 call: IoT-01-2016 Large Scale Pilots (IA); Project ACTIVAGE 732679; Period: 01-01-2017 to 30-09-2020; EC contribution 20 mil. EUR.
	Technosens	Technology facilitates “senior ready” living environments to support residents, their families and care providers
		H2020 call: IoT-01-2016 Large Scale Pilots (IA); Project ACTIVAGE 732679; Period: 01-01-2017 to 30-09-2020; EC contribution 20 mil. EUR.
	NTT Data	Smart remote treatment supported by artificial intelligence enables personalised medication for bipolar disorder diagnosed patients
		Network collaboration w. IoT Next Club (IoT community associated with the NGIoT initiative); Case period: 2021-2022.
Manufacturing 	QiO Technologies	Artificial intelligence applications predict and prescribe actions to empower industrial efficiency and sustainability
		Network collaboration w. AIOTI - Alliance for IoT and Edge Computing Innovation (IoT community founded by the EC); Case period: 2021-2022.
	ASTI Mobile Robotics	Intelligent industrial intralogistics facilitated by automated guided vehicles unified with robotic arms
		H2020 call: ICT-56-2020 Next Generation Internet of Things (RIA); Project INGENIOUS 957216; Period: 01-11-2020 to 31-03-2023; EC contribution 8 mil. EUR.
	Aloxy	End-to-End IoT solutions make asset smart, automate processes and deliver actionable insights into industrial operations
		Network collaboration w. the Eclipse Foundation and the LoRa Alliance (OSS community and not-for-profit associations); Case period: 2021-2022.
	Troldtekt	Efficient operation through leverage of data from production processes of acoustic panels
		H2020 call: ICT-04-2017 Smart Anything Everywhere Initiative (IA); Project DIATOMIC 761809; Period: 01-19-2017 to 31-08-2020; EC contribution 8 mil. EUR.
Mobility & Transportation 	Veoneer	Distributed Ledger Technology for enabling vehicular collective perception on the road towards automated driving
		H2020 call: ICT-56-2020 Next Generation Internet of Things (RIA); Project VEDLIoT 957197; Period: 01-11-2020 to 31-10-2023; EC contribution 8 mil. EUR.
	Terminal Link	Digital platform connects all port industry equipment and systems for improvement of performance and efficiency
		H2020 call: ICT-56-2020 Next Generation Internet of Things (RIA); Project ASSIST-IoT 957258; Period: 01-11-2020 to 31-10-2023; EC contribution 6.3 mil. EUR.

	Awake.AI	Digitalising sea-port-land operations with an open data platform for intelligent maritime logistics H2020 call: ICT-56-2020 Next Generation Internet of Things (RIA); Project INGENIOUS 957216; Period: 01-11-2020 to 31-03-2023; EC contribution 8 mil. EUR.
	Emotion	Smart e-mobility charging stations with remote control and Edge capability H2020 call: ICT-56-2020 Next Generation Internet of Things (RIA); Project IoT NGIN 957246; Period: 01-11-2020 to 30-09-2023; EC contribution 8 mil. EUR.
	Tecnalia	Automated driving systems for sustainable mobility in urban connected environment H2020 call: SU-ICT-02-2020 Building blocks for resilience in evolving ICT systems (RIA); Project IoTAC 952684; Period: 01-09-2020 to 31-08-2023; EC contribution 5 mil. EUR.
	See.Sense	Reactive bike lights utilise sensor technology to protect cyclists and help cities improve infrastructure Network collaboration w. IoT Next Club (IoT community associated with the NGIoT initiative); Case period: 2021-2022.
Smart Cities & Communities	Fold.AI	Artificial sensing and intelligence for increased understanding and management of natural ecosystems Network collaboration w. IoT Next Club (IoT community associated with the NGIoT initiative); Case period: 2021-2022.
	CITEC, University of Bielefeld	Smart Mirror with deep learning algorithms and distributed AI serves as interface between residents and smart environments H2020 call: ICT-56-2020 Next Generation Internet of Things (RIA); Project VEDLIoT 957197; Period: 01-11-2020 to 31-10-2023; EC contribution 8 mil. EUR.
	Aquardio	Plug-and-play solution helps save water and energy by nudging people towards sustainable behaviour in the shower Network collaboration w. the Nordic IoT Center (IoT community supported by the Danish ministry for higher education and science); Case period: 2021-2022.
	CERTH	The near Zero Energy Building (nZEB) Smart House - an innovation hub, IoT testbed and ecosystem H2020 call: SU-ICT-02-2020 Building blocks for resilience in evolving ICT systems (RIA); Project IoTAC 952684; Period: 01-09-2020 to 31-08-2023; EC contribution 5 mil. EUR.
	HOPU	Smart urban development and improved liveability through data-driven environmental monitoring Network collaboration w. IoT Next Club (IoT community associated with the NGIoT initiative); Case period: 2021-2022.
Other	Quadible	Cybersecurity: Artificial intelligence platform increases cyber-security by authenticating users through behavioural patterns Network collaboration w. IoT Next Club (IoT community associated with the NGIoT initiative); Case period: 2021-2022.
		Telecommunications: 5G enabled autonomous and remote

	Fivecomm	controlled intelligent mobile robots
		H2020 call: ICT-56-2020 Next Generation Internet of Things (RIA); Project INGENIOUS 957216; Period: 01-11-2020 to 31-03-2023; EC contribution 8 mil. EUR.
	Cumucore	Telecommunications: Private 5G mobile networks enable industry verticals to adopt and deploy Next Generation technologies
		H2020 call: ICT-56-2020 Next Generation Internet of Things (RIA); Project INGENIOUS 957216; Period: 01-11-2020 to 31-03-2023; EC contribution 8 mil. EUR.
	AllThingsTalk	Cross-domain: IoT projects made into reality through IoT hardware design, manufacturing and consultancy
		Network collaboration w. The Things Network (IoT community for open source infrastructure owned by the users); Case period: 2021-2022.

APPENDIX E - EU-IOT CONSORTIUM SYNERGIES

AU is the lead beneficiary on WP4 and thereby accountable for the activities of T4.3. In this role as the EU-IoT COACH, AU and WP4 has contributed to the project with assets and services related to tools associated with IoT BMI as presented in this report. Beyond the contribution to the project, AU and the activities of WP4 have fostered synergies with partners across other WPs as depicted in Table 10:

Table 10: Consortium synergies contributed by AU

Work package	AU contribution
WP2 - GUIDE	Contribution in the dialogue within the CB and other initiatives to make the link with the activities under the WP4 (T2.1) Participation in the meetings with experts and coordinates dialogue based on the topic discussed and the expertise requested (T2.2) Contribution to policy recommendations and roadmaps (T2.2)
WP3 - CATALYST	Contribution to the organisation of the events mainly supporting the business modelling and acceleration aspects of the topics discussed under the agendas (T3.1) Participation in IoT community events, following the trends and news related to the success stories and best practices in the domain (T3.1)
WP5 - AMPLIFIER	Participation in the dissemination and communication activities through EU-IoT and own channels (T5.2) Contribution to the definition of the Impact Assessment indicators and the design of the framework, providing information gathered through best practices under the WP4 and linking the assessment results with the business modelling recommendations (T5.3)

Also in the scope of T4.3 under WP4, the activities led by AU has enjoyed contribution form the other partners and WPs, for example, MARTEL contributing to the promotion of the use case catalogue and e-learning platform, INTRA contributing to the mapping of skills profiles to business model innovation methodologies, and BLU and FOR contributing towards the identification of and the liaison to entities dedicated to the acceleration of digital technology.