Grant Agreement No. 767498
Innovation Action Project
H2020-FOF-12-2017

D2.2. Requirements Engineering Methodology and Tools 2

WP2 - Scenarios and Requirements for DIHs and Experiments

Version: 1.0.
Due Date: 30/06/2019
Delivery Date: 04/11/2019
Type: Report (R)
Dissemination Level: PU
Lead partner: POLIMI
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Disclaimer

MIDIH has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement no. 767498.

Version Control:

Version	Date	Author	Author's Organization	Changes
0.1	28/05/2019	Cecilia Angioletti	POLIMI	TOC
0.2	26/07/2019	Cecilia Angioletti	POLIMI	First version of D2.2
0.3	02/09/2019	Cecilia Angioletti	POLIMI	Changes in the structure to get aligned with the advancements of D2.5
0.4	16/09/2019	ALL contributors	ALL contributors	Contributions in chapter 2 and 3
0.5	01/10/2019	ALL contributors	ALL contributors	Contribution to chapter 2 from D2.5
0.6	07/10/2019	ALL contributors	ALL contributors	New contribution to chapter 2
0.7	14/10/2019	ALL contributors	ALL contributors	Contribution to chapter 4
0.8	31/10/2019	Cecilia Angioletti	POLIMI	Final review
1.0	04/11/2019	Susanne Kuehrer Emanuel Skubowius	EIT Digital IML	Final internal review, Submission to EC

Annexes:

№	Title
1	Questionnaire for the collection of feedback on the adoption of the MIDIH RE Methodology 1

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Deliverable Title: Requirements Engineering Methodology and Tools 2

Deliverable Number D.2.2.

Keywords: DIH/CC, Industrial Experiments, Open Digital Platform, Feedbacks form Requirements Engineering Methodology, Digitalization, Industry 4.0

Executive Summary:

D2.2 is part of MIDIH Project WP2 "Scenarios and Requirements for Digital Innovation Hubs and Experiments" and verifies the accurateness of the MIDIH RE Engineering Methodology 1 adopted by Digital innovation Hubs (DIHs), Competence Centers (CCs), Industrial Experimenters, Technology providers and systems integrators to identify, specify and validate their business scenarios, requirements and objectives.

The analysis proposed in Chapter 2 provides the information to verify the suitability of the MIDIH RE Methodology 1 delivered in D2.1 by using two fonts of data: the indirect feedback retrieved from the socio-business assessment performed in T2.5 and specified in D2.5, and the feedback collected through ad-hoc interviews with different representatives of WP3 (CCs/DIHs), WP4 (Technology providers and integrators) and WP5 (industrial experimenters).

To this end, the investigation of the concepts, details, relevance, challenges and mitigation actions related to the definition of business scenarios and the acquisition, analysis, specification and validation of business requirements served as inputs for Chapter 3, where conclusions on the adoption of the MIDIH RE Methodology 1 are presented and the second version of the methodology is presented as a consequence of the feedback analysis.

Finally, Chapter 4 provides recommendations to be taken into account when undergoing the activities foreseen to shape D2.4 "Scenarios, Use Cases and Requirements for MIDIH 2". Recommendations are given to properly validate the scenarios and requirements initially elicited inside the different WPs respectively by CCs and DIHs (WP3), Industrial Experimenters (WP5), Technology Providers and Systems Integrators (WP4). Moreover, recommendations on how to overcome difficulties and threats declared in Chapter 2 and declared in Chapter 3 as well are given, together with indications pertaining a new mind-set to deal with the collection of new business scenarios and requirements in cohesion with the MIDIH project vision.

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1 Introduction

This section is intended to clarify the purpose of this deliverable and of the activities carried out to perform the validation of what specified in D2.1 “Requirements Engineering Methodology and Tools 1” and to provide the inputs to shape the MIDIH Requirement Engineering Methodology 2. The structure of the deliverable is presented as well as the impact of the content of this deliverable on other tasks and work packages.

1.1 Objectives and structure of the deliverable

The main purpose of WP2 is the definition of scenarios, requirements’ identification and verification & validation (V&V) by use of MIDIH-tailored Requirement Engineering (RE) framework (also referred to as “methodology”). The definition and specification of the MIDIH RE Methodology was firstly presented in M3 in D2.1 “Requirements Engineering Methodology and Tools 1”.

The MIDIH RE methodology 1 supported the process of requirements definition and validation involving different MIDIH entities: Digital Innovation Hubs (DIHs) and Competence Centres (CCs), and Industrial Experiments. By use of the MIDIH RE Methodology 1, business scenarios have been specified and then instantiated in specific requirements for DIHs/CCs and Industrial Experiments in the smart manufacturing environment related to the CPS/IoT domain, then translated into requirements, business objectives and KPIs. The collection of requirements, objectives and KPIs was presented in D2.3 “Scenarios, Use Cases and Requirements for MIDIH 1”.

The purpose of this deliverable is to present the feedbacks and impressions derived from the application of the MIDIH RE Methodology 1 during the first iteration of the MIDIH project and to provide the specifications of the MIDIH RE Methodology 2. Therefore, chapter 2 describes the process of feedback collection on the adoption of the MIDIH RE Methodology 1 and reports the impressions collected from the field. This is the starting point to shape the MIDIH RE Methodology 2 presented in Chapter 3, where the details of the step-based methodology for the definition of business scenarios, business requirements’ elicitation, analysis, specification and validation are provided. Chapter 4 is meant to support the adoption of the MIDIH RE Methodology 2 in the next iteration of the MIDIH project to facilitate the work to be done in D2.4 “Scenarios, Use Cases and Requirements for MIDIH 2”. Finally, Chapter 5 aims at drawing conclusions from the activities carried out and described in this deliverable.

1.2 Contribution to other WPs and deliverables

Building the RE Methodology for the definition of scenarios and requirements for Task 2.2 (requirements for CCs/DIHs), Task 2.3 (requirements for industrial experiments) and Task 2.4

(requirements for Digital Manufacturing Platforms) is the main goal of T2.1 "Requirements Engineering and Industrial Verification and Validation Method".

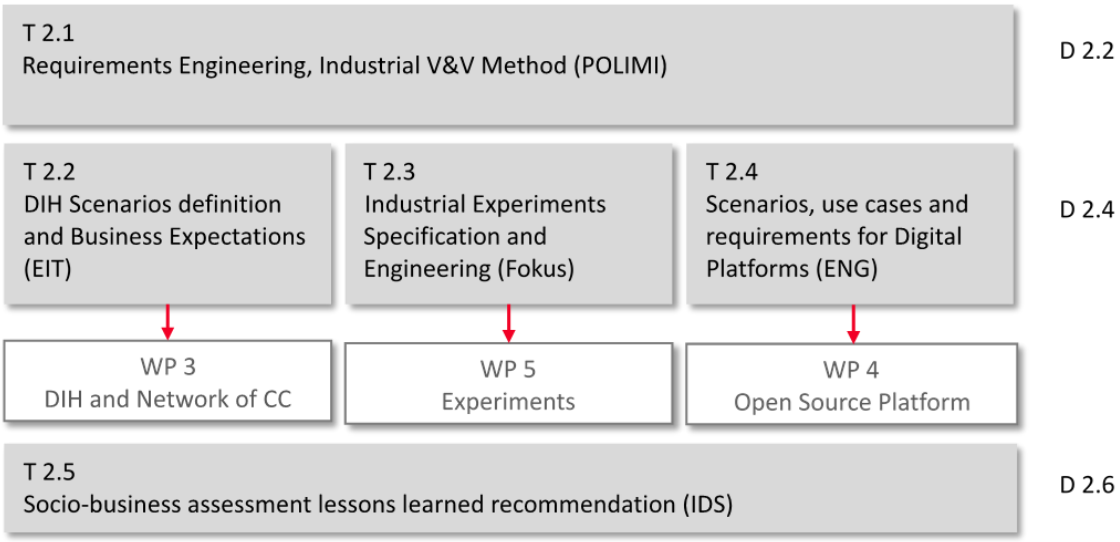


Figure 1 T2.1 impact on other tasks and work packages

WP2 "Scenarios and Requirements for DIHs and Experiments"

According to **Error! Reference source not found.**, T2.1 is intended to provide T2.2, T2.3 and T2.4 with a methodology to define and describe the business scenarios of a DIH (T2.2 "DIH Scenarios definition and Business Expectations"), of the Open Source platform (T2.3 "Industrial Experiments Requirements Specification and Engineering") and the Lighthouse Experiments (T2.4 "Business scenarios, use cases and requirements for CPS/IOT Digital Platforms"), as well as the respective business requirements, objectives and KPIs. This is going to facilitate the work to be done in D2.4 that is intended to result in a collection of information from the WP2 activities in the tasks mentioned above.

Moreover, this deliverable is connected with other activities pertaining the MIDIH project at large and that specifically interest other WPs such as WP3 "Network of Competence Centers and pan-EU DIHs in CPS/IOT", WP4 "Open Platform architecture, development, integration and testing" and WP5 "Cross-Border Industrial Experiments".

***WP3 "Network of Competence Centers and pan-EU DIHs in CPS/IOT"* (POLIMI)**

CPS-IoT oriented DIH and CC are the heart of the wave of digitalization in Europe, exploiting the opportunities given by ecosystem networks and knowledge specialization in the field of I4.0 technologies and competences. In that light, the MIDIH project aims at specifying the portfolio of services a DIH should offer in line with the needs for digitalization of the European manufacturing industry, especially SMEs. Customers need support to accomplish the steps required to achieve a higher level of digital maturity and gain competitiveness. From this point of view, the definition of business objectives and requirements is supported by the MIDIH RE methodology, a step-based approach that guides the 16 MIDIH entities in adopting an

ecosystem perspective of networks that collaborate to push technological innovation to a step forward. Starting from the background experience of the 16 MIDIH entities, the RE Methodology guides them to define the premises and basis to design the MIDIH DIH characterised by a specific and unique service offer to be a model for the European DIHs network.

***WP4 "Open Platform architecture, development, integration and testing" (*ATOS/ENG)**

Aiming to provide a methodology to define and describe the business scenario of the MIDIH Open Source Platform Task 2.1 provides, thanks to the collaboration with WP4 activities targeting the definition of the Open platform Architecture, the means to get closer the new requirements (mainly customer and system requirements) coming out from the Task 2.4.

The MIDIH RE methodology, following an iterative approach starting from the scenario analysis to the verification and validation though the requirement analysis defining functional and non-functional requirements, allowed to design of the first version of the Open Platform Architecture.

The first release of the MIDIH Open Platform aimed to achieve an Open Platform based on the most common Reference Architectures targeting the Industry 4.0 domain, paving the way to obtain an open source reference implementation being able to satisfy common needs coming from the industry, starting from Industrial Experiments (WP5) and Open Call winners (WP1).

WP5 "Cross-Border Industrial Experiments" (IML/FOKUS)

This deliverable provides relevant methods of requirement engineering to support the ongoing development and implementation of the respective use cases and experiments of WP5. Task 2.1 selects suitable RE methods and modifies them towards customized methods and tools, which was reported in the D2.1 as an initial version of customization. The resulting procedure models, guiding questions, examples, questionnaires or tables, used to collect requirements and specifications, are applied in D2.4. The supply of customized methods supports WP5 indirectly by various tasks and processes within the MIDIH project. Therefore, D2.2 should provide well-structured and clearly addressed methods and tools that are capable of firstly collecting the different requirements and secondly structuring them so that the addressee is well supported in the further progress of the project.

2 Analysis of the MIDIH RE Methodology and Tools 1

This chapter provides a resume of the validation activity intended to test and verify the suitability of the MIDIH RE Methodology 1 presented in M3 in D2.1. The take away of this chapter are expected to be lessons learnt for the revision of the appropriateness of the MIDIH RE Methodology 1 (chapter 3) and recommendations for its effective adoption (chapter 4).

2.1 Methods for collecting feedback on the MIDIH RE Methodology 1

WP2 "Scenarios and Requirements for DIHs and Experiments" focuses on the provision of tools and the analysis of the support they provide in the realization of sustainable projects' results from a socio-business perspective. In particular, T2.1 "Requirements Engineering and Industrial Verification and Validation Method" is expected to design a methodology to support DIHs and CCs on the one side and industrial experimenters on the other to define business scenarios, objectives and KPIs they expect to satisfy by the end of the MIDIH project. Due to the focus area of MIDIH, which is the digitalization of the manufacturing industry (especially SMEs) by use of CPS/IoT technology solutions, the information collected by use of the RE Methodology is going to impact the development of integrated technological solutions and OS platform inside the project itself. In other words, the business objectives and requirements elicited by MIDIH partners is WP3 and WP5 are the starting point to define a plan of activities inside WP4. For that reason, feedback from the first iteration of the MIDIH RE Methodology was collected from WP3 (DIHs and CCs) and WP5 (industrial experimenters) and cross-checked with WP4 (technology and OS platforms providers, developers and integrators) to assure the alignment between the providers and recipient of the information.

According to the structure of WP2 as represented in **Error! Reference source not found.** and coherently with the other WPs that T2.1 is supposed to impact, a selected group of MIDIH partners was interviewed to collect feedback on the understanding and applicability of the RE Methodology 1. This can be considered the point of validation of the RE Methodology 1 based on the work performed during the first 18 months of the project. Both indirect and direct feedback was collected.

Indirect feedback comes from the resume of the activities and goals achieved during the first half of the projects, which is the outcome of T2.5 "Socio-business assessment, lessons learned and recommendations". WPs leaders and core partners have been asked to answer some focused questions in online teleconferences. The panel of MIDIH partners interviewed is representative of the variety and heterogeneity of the figures and the different specific focuses of the MIDIH project: DIHs and CCs (connected to activities within WP3), system developers and integrators (connected to activities within WP4), manufacturing companies (connected to activities within WP5). More specifically, all the DIHs and CCs, were interviewed using a structured online questionnaire. This activity was run as part of the plan of actions scheduled to achieve the goals of T2.5, which returns interesting perspectives and impressions to be taken as

inputs for this deliverable. The content of the interviews was rationalised, and the interesting information was reinterpreted in the context of D2.2.
Direct feedback was collected during further interactions with a selected sample of MIDIH partners that is representative for the variety of entities involved in the MIDIH project from WP3, WP4 and WP5. The questionnaire used to capture the information from the MIDIH partners is available in Annex I: Questionnaire for the collection of feedback on the adoption of the MIDIH RE Methodology 1.

The inputs have been then analysed to facilitate the comprehension and harmonization of the information collected. The following chapter shows the result of the moments of interaction and verification of the RE Methodology 1 within the MIDIH consortium.

2.2 Feedback from the first iteration of the MIDIH RE Methodology

This chapter shows the feedback collected from the adoption of the MIDIH RE Methodology 1 with the aim of understanding its applicability and fitness to the scope of the MIDIH project. More specifically, Chapter 2.2.1 presents the feedbacks retrieved from the investigation done in D2.5, opportunely selected and translated in a way that could be of use of the evaluation of the MIDIH RE Methodology 1. Chapter 2.2.2 shows the results of the feedback collection done by use of a common structure to capture the impressions of DIHs and CCs on the one side, and industrial experimenters on the other. These inputs have been collected specifically addressing questions about the adoption and suitability of the MIDIH RE Methodology 1.

2.2.1. Indirect feedback from D2.5

This chapter specifies the feedback retrieved from D2.5, inherently the adoption of the MIDIH RE Methodology 1 by DIHs and CCs, Industrial experiments and feedback from the system integrators and developers.

2.2.1.1. Summary of the feedbacks from CCs, DIHs and Pan-Eu DIH

The ongoing feedback collection within T2.5 showed that all MIDIH CCs and DIHs have their running service portfolio on CPS/IOT in manufacturing, but the nature of each CC varies from university, public owned RTO, private owned RTO, consultancy as a PPP and a private consultancy. Accordingly, the ways how to offer services towards the “customer” including the definition, who is the customer, etc. varies.

Additionally, the feedback showed that it was not always clear in which role the beneficiaries answer and act within MIDIH. The interpretation of the indirect feedback to the RE method is that the adapted RE Framework should take into account the different perspectives and business requirements combining them together. Furthermore, the feedback showed that the first iteration of requirements engineering started without a clear definition about which role a CCs has within a DIH and what is the target group of the CC. The target group / customer should not be created because of MIDIH but because of the running operations of the CC.

Finally, it can be summarized that the target for the requirement engineering for the CCs and DIHs should be clarified more. Some CCs saw the running services and existing target group /

customer including the existing “assets” as core of the requirement engineering, some saw the future services and maybe a future target group / customer as a role or potential new role of the CC within a DIH as core, and some others saw the network of MIDIH CCs / DIHs and thus the new services among them as core of the requirement engineering.

2.2.1.2. Summary of the feedbacks from the cross-border industrial experiments

The feedback from WP5 in D2.5 has shown that the RE method could be applied. In the first iteration of the scenario definition and requirement engineering the lighthouse experiment followed the methodology provided by the D2.1. A few aspects in the feedback still refer to the requirement engineering, less to the method than to the timing and scope of D2.3 in the project. One aspect is that the industry also had to be involved in the requirements analysis and that the specification was performed more frequently later in the project. This means that parts of the requirements were collected during the work in WP5. The business scenario description, business requirements elicitation and the business requirements analysis were well addressed and followed in D2.3 as well as D5.1. The scenario definition and business requirements were especially important and suitable for field operations of the experiments themselves. However, the requirements defined by the experiments targeted mainly their experiment individual objectives and did not provide much input for other work packages such as WP4. The collection of business scenarios and requirements was run separately for the three lighthouse experiments at M6 (D2.3), but in the second iteration a closer cooperation and an earlier sharing of requirements between experimenters should be considered.

2.2.1.3. *Summary of the feedbacks from the system developers and integrators*

With regard to the MIDIH Open and Modular Reference Architecture, the main objective has been business requirements the gap between Requirements Engineering inputs from WP3 and WP5 and the MIDIH Open platform Software Architecture.

In this context, the elicitation of requirements has not been totally aligned to the one specified in the overall RE framework defined for MIDIH, mainly because the architecture was already conditioned by well-known requirements and functionalities required by the CPS/IoT systems. The approach followed for the MIDIH Open Reference Architecture tries to avoid the problem to elicit, analyse and specify requirements in isolation without considering the impact of architecture artefacts. This allows that the requirements and software architecture evolve together. Therefore, to carry out the essential activity of defining the MIDIH Reference Architecture, several requirements have been identified based on a detailed review and analysis of the reference models and architectures for IIoT systems (such as IIRA, IVRA, and RAMI4.0), as well as an analysis of IoT standard technologies applied in manufacturing domain. In parallel, several architectures of Digital Platforms developed in other EU funded projects have been considered in order to exploit the most recent and already available results in such a task. Therefore, the requirements in this initial phase have been extracted based on identifying commonalities, both at the level of functionalities and technologies, covering standards, interoperability, connectivity, analytics, security and mechanisms to access information.

2.2.2. Feedback from DIHs/CCs, Industrial Experimenters, System Integrators and developers

This chapter collects the feedback coming from DIHs and CCs, Industrial experiments and feedback from the system integrators and developers who were asked to reply specific questions about their comprehension of the MIDIH RE Methodology 1 terminology, its structure, ease of use and suitability.

The MIDIH RE Methodology 1 followed a spiral approach (for more details refer to Chapter 3.2 or to D2.1) based on a five step process that goes from the identification of the business scenario to the validation of the business requirements related to each scenario.

In a simplified way, the MIDIH RE Methodology 1 is constituted by sequential building blocks for business requirements development activities and cross-sectional requirements management tasks to allow transparency, traceability and coherence of requirements development and analytic activities along the whole project. Figure 3 is an analytical representation of the MIDIH RE Methodology 1 presented in Figure 2.

The main steps guiding the MIDIH project to achieve the expected outcomes are five:

1. Business scenario description
2. Business requirements elicitation
3. Business requirements analysis
4. Business requirements specification
5. Business requirements validation.

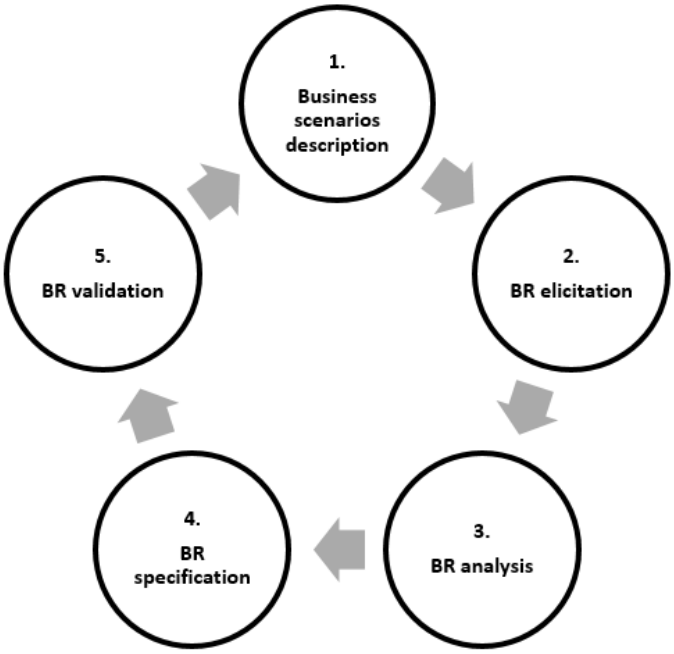


Figure 2 MIDIH RE Methodology 1 – Five steps

After the collection process, the received feedback was analysed according to the aim of the analysis. Therefore, the feedback will be presented according to their reference to each of the

five steps of the MIDIH RE Methodology 1. The feedback was collected by interviewing partners playing different roles in the MIDIH project. Therefore, the impressions of DIHs/CCs, Industrial Experimenters and technology developers and integrators are presented simultaneously, to allow cross-comparison between the different WPs (respectively WP3, WP5 and WP4). The reason for that is the need to verify the alignment between different parts of the MIDIH project with overlapping and dependencies one with the others.

2.2.2.1. Feedback on Business Scenario Description

The first step of the MIDIH RE Methodology 1 was verified with the aim to investigate the level of alignment in understanding what a business scenario is, the specifications that should be explicated to exhaustively represent it by means of words, threats that might have occurred in these activities and the actions that have been put in place to reduce the negative impacts of a verified threat.

2.2.2.1.1. Understanding the Concept

DIHs and CCs interpreted a business scenario as the description of the future shape of a business activity with regard to a specific problem. It is intended to envision the system and its surrounding environment, including the roles of each stakeholder and encompassing the outcomes of proper business activities that are strongly depending on both the business strategy of the CC/DIH and the technological advancements and trends. Due to the fact that CCs and DIHs are meant to offer services to support the industrial growth of SMEs by adoption of the most advanced technologies, a business scenario should also take into account the high-level interaction between a service provider and a service consumer (e.g. customer journey).

Industrial Experimenters see a business scenario as the set of features that are taken into account in the experiment in relation to a business problem that needs to be addressed and solved. It depicts the context in which the project has an application, and that will be improved from a business point of view including for instance the business process and its actors.

From the perspective of technology developers and systems integrators, a business scenario could be defined as a set of new applications in a product, process or service that could be enabled by the architecture of a certain technical development inside a project. It is a way to identify how both business and architectural features should work to solve a business problem and to support understanding the business requirements that the architecture development must address.

2.2.2.1.2. Defining specifications

CCs and DIHs suggested that a business requirement should include a clear definition of a problem and the anticipation of the objectives to be achieved in a specific, measurable and realistic way. The description should focus on the system the CC/DIH belongs to or is inserted into and the environment including involved parties/stakeholders, their role and how they interact with each other.

Industrial experimenters faced business requirements as the statement of the initial business problems and business objectives. It should be constituted by an overall explanation of the

business process and that the derived business requirements can be understand in the overall context in a specific, measurable, realistic and time-bound way. Some recommendations are given when defining the focus of a business scenario, which should be limited to the general business and technology environment rather than in the possible improvements itself; it is less particular than, for instance, a business process.

Technology developers and systems integrators see a business scenario as the description of a business process, application or set of applications that can be enabled by the IT Open Source architecture. It must include the business and technology environment, the system actors, comprising people and computing components, the main steps involved in the business process showing interaction between the business and system actors and the desired outcome of proper execution.

2.2.2.1.3. Challenges

DIHs and CCs encountered some obstacles when describing the business scenario, such as different levels of granularity may impact on the clarity of a business scenario. A CC/DIH identified "problem" might not be the actual problem of the business. A CC/DIH does not describe its own business scenario; instead, it describes an industry business scenario. There is a danger to describe a scenario that only theoretically exists. The risk is to stay on a too general level. Moreover, as DIHs and CCs are complex organization composed by different partners, it is difficult to imagine a business scenario related to the MIDIH outcomes exploitation that could fit all and targets are not always measurable, especially when TRL levels tend to be lower than on a competitive market.

Industrial Experimenters found sometimes difficult to distinguish between technical and business aspects, since they are much related to each other. The main difficulties would be to know what is the company able to offer in the market at a particular moment. A Business Scenario should also be divisible in one or more business processes. In that light, a clear parallelism could be established here (between business scenario and business process) with two concepts actually more related to Exploitation than to Technical development. The first one out of them is “Business Model” (its equivalent being Business Scenario), which defines “What?”, the mechanism through which the company generates its profit, which is really a description of the company position in the industry and its relation to customers, suppliers and/or partners. The second one is “Business Plan” (comparable to Business Process), which would answer to “How?, covering the company’s more particular strategy, the action plans and the expected results for the coming years to be achieved through their application.

For technology developers and systems integrators, business scenarios are addressed based on the business scenarios coming from both industrial experimenters and CCs/DIHS, and then the issue is more how to interpret and translate business features in technical specifications for the deployment of the IT Open Source Architecture.

2.2.2.1.4. Mitigation actions

DIHs and CCs tended to describe generalized representative business scenarios based on the CC/DIH experience, by making aware all partners of the CC/DIH about the impact MIDIH could

have on their business scenarios and having a close collaboration between the industry and the CC/DIH.

Industrial experimenters tried to clearly link the current business situation (AS-IS) with a potential future business panorama (TO-BE), making sure that going from the AS-IS to the TO-BE was supported by proper business objectives. Of relevant impact is the relation of the CC/DIH with its stakeholders, including the other partners of the MIDIH consortium.

Technology developers and systems integrator focused on extracting information from industrial experiments, where the business scenarios and their business processes are described.

2.2.2.2. Feedback on Business Requirements Elicitation

2.2.2.2.1. Understanding the concept

From the perspective of DIHs and CCs a business requirement is mainly intended to understand the business needs to ensure that the CC/DIH is delivering the highest value to its customer: who needs what and for what purpose. Moreover, a business requirement is relevant to depict the characteristics a system should have representing the essence of their business (usually does not change often and rapidly) from the point of view of the customer/user.

For the industrial experimenters, **a** business requirement is intended to identify the characteristics for the solution to be developed, needed by the final user in order to satisfy his/her business needs, to understand the elements that explain what the developed solution should be able to do and to specify concrete features the solution needs to address. Business requirements were perceived as a quite high-level statement, describing what is required from the business perspective both for the present and the future. They are related to business objectives and constitute the most basic needs in terms of stakeholder satisfaction. A similar parallelism to the one mentioned in the Business Scenario description could be traced between Business Requirements and Functional/Non-functional Requirements of a product/system/service: the first ones answer to “What?”, while the second ones provide the idea of “How?”.

Technology developers and systems integrators see business requirements as the description of what a system or a solution should do. They constitute a high-level statement describing what is required from the business’ perspective to achieve its objectives, vision, and goals, and they identify and establish the basis to define and develop the functional requirements.

2.2.2.2.2. Defining specifications

From the perspective of DIHs and CCs, a business requirement should encompass some key aspects. Business scenarios where described starting from the needs that were derived from the CC/DIH specific experience according to what customers are demanding. The availability and possibility to leverage on the existing assets of the CC/DIH to deliver suitable solutions and services (existing, under development or new ones) to customers is fundamental to uncover the analysis of the weak points in the service offer of the CC/DIH. The identification of the CC/DIH

constraints with respect to the CC/DIH strategy in satisfying the customers' need through the achievements of the MIDIH project is at the basis of requirements elicitation.

Industrial experimenters detailed business requirements based on the need behind the stated business problem and what the solution to be developed should enable in order to satisfy the identified business need. A business requirement ends up in guidelines during the development process so that the result is serving/solving the initial business problem.

For technology providers and systems integrators business requirements should constitute a comprehensive way to understand business goals and objectives in detail based on the inputs and discussions from business and IT stakeholders. They help understanding the objective environment and the affected commercial areas of the new product or service that will be implemented within the new business landscape.

2.2.2.2.3. Challenges

DIHs and CCs mainly struggled in aligning internal (to the CC/DIH) and external (customers of the CC/DIH) business needs, because they are heterogeneous. Thus, experiences are extremely important in order to find communalities that will end up in services that can be offered to multiple customers. The CC/DIH role and thus the scenarios were not always easy to identify, as well as to relate the business objectives to a specific business scenario. Moreover, it was hard to manage to include the MIDIH scenario in the CC/DIH own business scenario or, in other words, to couple business objectives and MIDIH project expected outcomes and to understand how the business requirements could really describe the CC/DIH objectives and the business needs as a part of a collaborative new ecosystem.

Industrial experimenters found challenging to have the internal knowledge on the adopted components and planned technical developments affecting the specification of business requirements that are coherent with the IT reference architecture. The risk here is not to miss any of the most basic requirements that should be satisfied through the developed platform.

Technology developers and systems integrators found sometimes not clearly identified scope from CC/DIH and experimenters. Moreover, great attention was payed to recognize and document system events and responses, to identify relevant user stakeholders, and to elicit and identify user requirements from stakeholders who directly or indirectly utilize the products/services within the impacted business areas.

2.2.2.2.4. Mitigation actions

DIHs and CCs tried to assure a clear definition of the objectives, a defined project scope and more interaction with the customers also by selecting a limited number of requirements meant to be the most relevant for the customers and that matched the actual activities of the CC/DIH. To assure the reliability of the elicitation process and the outcome, CCs and DIHs involved experts inside the CC/DIH in the elicitation process in order to leverage on the expertise of the CC/DIH ecosystem.

Industrial experimenters found of primary importance **t**o improve the collaboration with technological/developer partners. For elicitation, the most used methods – among many others

– are observation, market analysis, interviews with and questionnaires to the different stakeholders identified, and success stories, both periodical and specific and from other R&D projects.

As technology developers and systems integrators, business requirements must be provided by stakeholders and final users.

2.2.2.3. Feedback on Business Requirements Analysis

2.2.2.3.1. Understanding the concept

For DIHs and CCs the analysis of business requirements implies a creative process to business requirements brainstorm about potential functionalities or solutions to fulfil the requirement. It encompasses gaining a deeper understanding of the system/service to be engineered and the identification of the problems of the customer to solve the right business need. For these reasons, the analysis should cover the detailed description of a requirement, the documentation, the assignment to an actual objective and the definition of how this can be measured and achieved.

Industrial Experimenters exploited the analysis of the business requirements collected to decide if the business requirement is necessary, verifiable and achievable, in relation to the business objectives. The main aim was to revise the defined business requirement to create a catalogue of valid requirements that all fit the solution with regard to the initial business problem.

Technology developers and systems integrators conducted the analysis of business requirements to clearly agree on what is going to be delivered, defining the scope or what is included and excluded in the project. Business requirement analysis was included in a phase of the project that covers a business requirements and general description of what is required to be done, often a business need or problem description. The aim was to capture detailed requirements from business stakeholders and dividing them into categories of functional and non-functional requirement, which impact the system architecture such as: business rules, quality expectations, performance, etc. Finally, they delve into details of how to implement with solution requirements, investigating functional gaps and duplication of requirements which are out of scope through the business requirement analysis.

2.2.2.3.2. Relevance

DIHs and CCs perceived the relevance of conducting an analysis of the elicited business requirements to check if they include all relevant information to properly proceed with their analysis and to solve issues related to missing of crucial data/information, potential rework, frustration and disappointment, which is fundamental to understand if a business requirement offers an adequate basis for designing and implementing a service or a solution. Analysing requires specifying evaluation criteria to analyse the business requirements and eliminate the ones that are unclear, vague or not measurable, the ones with a weak connection with business needs, etc. The final aim was to assure that the needs of the CC/DIH are satisfied once the needs of business requirements and objectives are achieved. In the case of the MIDIH project, this evaluation was intended to allow CCs and DIHs to verify if being part of an ecosystem of CC/DIH

enabled by an Innovation and Collaboration Platform (DIHIWARE) each CC/DIH could maintain or improve its service offer compared to the level of service delivery achievable with the current processes/partnerships/organizational features of the CC/DIH.

For the industrial experimenters the analysis of business requirements was relevant to understand the relation between the business requirements and business objectives, and to avoid misleading cornerstones, which verifies when the solution is not coherent with the initial scenario. By making a global and complete analysis of the current situation ("As-Is"), with particular focus on its limitations and improvement opportunities, the future situation to be achieved ("To-Be") was evaluated and confirmed to be in line with the project's ambition, and tracing both the master lines and narrower paths to achieve this second scenario. Documenting the process all along and making the whole process multi-party and multi-disciplinary was also important.

2.2.2.3.3. Challenges

DIHs and CCs found the main challenges in unclear business needs and imprecise business requirements, due to the fact that the CC/DIH expected to set requirements is not necessarily the one who will implement them. Moreover, unclear responsibility was to be managed as there was not always clear evidence of product ownership.

Industrial Experimenters found difficult to evaluate all the business requirements at an early phase of the project. They tried to find consensus on the elicitation and prioritization of the business requirements with respect to the different partners and to collect feedback from external partners involved in the experimentation to align the business requirements with the business scenario. The main barrier is the fact that, always, the architecture to be developed, business services to be provided or skills building services, depend on the needs of other parties; so constant communication with them is necessary and their feedback is essential, as their importance as a stakeholder is high in this case. One of the typical risks of not performing the business requirements analysis, specification and re-assessment through the project is that we may miss the scope of the more general business requirements while prioritising lower-level functional or non-functional system requirements, or the interests of or functions assigned to either the technology provider or the end user may not be coordinated enough and this could cause problems later on in the project.

Technology developers and systems integrators involved selected stakeholders and consequently it was sometimes difficult to prioritize business requirements correctly because of the multitude and heterogeneity of the stakeholders.

2.2.2.3.4. Mitigation actions

DIHs and CCs focused on defining the business requirements not with the point of view of the single CC/DIH, but imaging it as a part of a wider ecosystem, and taking into account that in such context some new stakeholders could be seen as final customers (e.g. other CCs or DIHs). They tried to abstract from the actual level of business needs and imagining new business scenarios.

Industrial experimenters relied on a more generic initial definition of a business requirement to be then better specified in a second cycle of business requirements definition in relation to the

progress of the MIDIH project and planning discussions to finding compromises between the stakeholders involved in the experiment. Some partners used structured tools for both the Analysis and the Specification of business requirements, such as the "Trial Handbook". Across this document, which consists in a series of short but difficult-to-answer questions, three aspects are recorded: requirements to be fulfilled, steps to be followed and impact indicators. This is a tool to be used in the first few months of a project in order to align as much as possible every partner's approach on the path to the solution, as it is a multi-disciplinary, collaborative (relative to both the technology provider and the end user) work to be done, at least, for each of the use cases, like in MIDIH. The Trial Handbook methodology is composed by three main steps: the description of the present ("As-Is") Scenario to identify the weaknesses and bottlenecks, the definition of a future ("To-Be") Scenario to integrate the desired functionalities, and the Business Experiment itself (Requirements and Scenarios, as identified in the previous two steps).

From a technical perspective, for technology developers and systems integrators the analysis of business requirements is about incorporating Unified Modelling Language (UML) /Requirements Modelling Language techniques which would provide system and requirements viewpoints of the technology environment. This is meant to perform analysis and allocate requirements which identify all the third-party applications and components and subsystems.

2.2.2.4. Feedback on Business Requirements Specification

2.2.2.4.1. Understanding the concept

DIHs and CCs saw the specification of business requirements as a way to provide a high-level description of the requirements from customers and how to fulfil the corresponding requirements.

For the industrial experimenters the specification of requirements implied the explanation of the requirements in terms of functionalities that must be met when developing the solution. The specification of business requirements is, aside from their identification, the full description of the Business Scenarios that represent the real situations in the context of the trial. It should define the goal-oriented set of interactions between external users and the system under development.

From the perspective of technology developers and system integrators, the specification of requirements implies structuring and collating the requirement in a coherent structured manner by defining and translating the requirements in textual descriptions (writing down into a document) and high-level diagrams that is easily understood by the target audience. In other words, it is about defining and documenting all business rules.

2.2.2.4.2. Relevance

For DIHs and CCs the specification of requirements is relevant to understand the tasks deriving them from the high level descriptions of the business requirements, to make sure that no misunderstandings have occurred by acting in a feedback loop manner, to avoid the confusion between requirements and features of the solution (architecture, platform, software etc.), and to describe how to implement something to fulfil a business requirements.

Industrial experimenters found it relevant to give indications and guidelines to the developers and to divide the tasks into reasonable work packages and to set KPIs. The participation of both technology providers and end users is necessary. As already mentioned, some experimenters found important to make a thorough documentation of the work to be carried in order not to disregard any important point related to methodology and planning.

Technology developers and systems integrators found the specification of business requirements important to allow customers and developers come to a consensus about what should be implemented and how. They tried to achieve a reference and global vision of all requirements to understand the capabilities needed in the architecture to finally deliver a solution and to enable requirements' traceability.

2.2.2.4.3. Defining specifications

For DIHs and CCs the specification of requirements should encompass what is the expected functionality of a system, which scenario the CC/DIH wants to fulfil, for whom and which objectives are expected to be met, what is the expected functionality of a system, all relevant information describing features and behaviour of a system or the workflow of a service.

For the industrial experimenters the specification of requirements should encompass business functionalities that should be included in the MIDIH solution in order for the final user to be able to use it for his/her own needs. First of all, the definition of business requirements should include information relevant to the Legal, Social and Economic framework of the experimentation. This means the following inputs are to be included: description of each Business Scenario within each trial, explaining in detail, explanation of the current situation/scenario in the company ("As-Is"), directives and regulations, standards and Certifications, description of the future scenario ("To-Be"), business objectives, expected benefits and business indicators.

From the perspective of technology developers and systems integrators, the specification of requirements should include accurate, clear, easy to understand, complete and consistent information as they will facilitate and drive the development of the MIDIH Reference Architecture. All the information collected must support establishing and specifying non-functional requirements.

2.2.2.4.4. Challenges

DIHs and CCs did not find trivial to assure that the aims of the business requirements are clearly understood by the persons who need to further specify the requirements, to identify business requirements that fits with the CC/DIH strategies and at the same time could be adopted by another CC/DIH to create real impact. There is the need for a joint effort in defining specifications, and not to leave each CC/DIH alone in this process. Requirements specification can be collected in a living document that has to be updated several times during the project in a very agile way.

Industrial experimenters found challenging translating a business need into a requirement. Considering that the technical development is feasible, at the time of defining the framework in

which the trials are to be carried out, as well as possible barriers and difficulties, all the three fields mentioned above shall be taken into consideration: legal, social and economic.
Legal: regulations and legislation must be considered (personal data protection, labour security, quality, work conditions) at international, EU, national and regional/local level to either the technology to be implemented, the company or industrial sector, the specific products and services to be validated, or the trial itself. Standards and certifications and legal implications are to be taken into account, too.
Social: to describe all aspects of this class (social relations, gender issues, equality and diversity, Globalisation, privacy, security, health, sustainability, culture, tradition and customs, etc.) that affect the activity performed at the trial, describing the impact and identifying their causes.
Economic: description of the economic framework that characterises the current situation of the companies' sector and the technology related to the trial, including also both impact and causes.

For technology developers and systems integrators, the main difficulties came from the previous phases, from elicitation and from the analysis of the requirements where relevant requirements have not been identified or considered.

2.2.2.4.5. Mitigation actions

DIHs and CCs put in place a feedback loop mechanism to make sure that there are no misunderstandings, tried to go over the actual CC/DIH positioning imaging to enlarge the service portfolio by adopting some of the services provided by the other MIDIH partners still remaining in the strategy and objectives that the CC/DIH has foreseeing for the future. In order to have some communication, the parts of the business requirements specification were moved into each work package or tasks. This specified, but the link to the overall MIDIH objectives became fuzzy.

Industrial experimenters tried to collaborate with the partners responsible for the development of the solution in order to better clarify the meaning of the business requirements specified. Also, the "Trial Handbook" tool supported the specifications of business requirements for the experimenters that adopted it.

Technology developers and systems integrators identified the expected functionality of the software, covering external interfaces, required performance levels, quality attributes (non-functional factors that are used to evaluate the performance of the software, such as security, safety, portability etc.) and designing constraints such as operating system, implementation language, etc.

2.2.2.5. Feedback on Business Requirements Validation

2.2.2.5.1. Understanding the concept

For DIHs and CCs the validation of business requirements is intended to judge if the outcomes (e.g. service/system) are fulfilling the customer's needs, to confirm the correctness of the business requirements, the achievement of the business objectives and the alignment with the

customer expectation, and to check whether the implementation meets the stakeholder expectations described in the business requirement.

Industrial experimenters saw the validation of business requirements as a way to **c**onfirm that the business requirement is measurable and allows the achievement of the business objective and to verify that the business requirement is met by the achievements by use of metrics (KPIs). The Business Requirements evaluation or validation is a periodical assessment of whether the business requirements defined at the very beginning of the project are needed and sufficient enough (correctness and completeness checking) in order to fulfil with the global objectives of any project for each and every agent. Validation ensures that the previously specified requirements achieve established business objectives, meet the needs of stakeholders and are clear and understood by the developers.

Technology providers and systems integrators used the validation phase to review the requirements for quality control purposes ensuring all relevant details and notes are captured from the workshops, interviews, etc., and to create user acceptance testing criteria which define the scenarios and requirements in alignment to customer, business needs and business objectives. They perform an iteration which is critical for requirements development success; a business analyst should plan multiple cycles of requirements collating, reviewing and validating before circulating to the development teams.

2.2.2.5.2. Means of validation

DIHs and CCs used metrics ideally defined in the specification phase to measure the results, field test, observations, results measurement and comparison with the defined KPIs such as: “Against which criterion I test (KPI)?”, “What do I test?”, “How do I test?”

Industrial experimenters identified KPIs to clearly indicate which business requirements are confirmed and will be measured at the end of the project to evaluate the achievement of the objectives. The validation of requirements ensured that each individual requirement is correct, clear, feasible, modifiable, necessary, accurately prioritised, traceable and verifiable.

Technology developers and systems integrators focus on ensuring that the final software solution provides all the functionalities to solve the identified business requirements.

2.2.2.5.3. Challenges

DIHs and CCs stated that if there are no measurements or metrics defined it is impossible to justify if requirements are fulfilled or not. Moreover, business requirements may have different time horizons, so the validation time may vary. It might be necessary to validate the requirement at least in a “friend” environment and check if it goes in contrast with the CCs/DIH strategy.

Industrial experimenters found difficulties in ensuring that the business requirements will be measurable at the end of the project and possible changes in the business scenario should be taken into account, and in predicting if a KPI can be validated for real.

For technology developers and systems integrators, the greatest difficulty lies in the involvement of the end user, in our case the lighthouse experimenters. The issues here arise from a follow-up of the project not thorough enough. If any significant experiment conditions

or requirement changes have occurred along the project, for whichever reason, they must be reflected and considered in the evaluation/validation phase.

2.2.2.5.4. Mitigation actions

DIHs and CCs tried to define measurable specifications, and how they will be validated, as well as clear responsibilities and roles, such as product owner.

Industrial experimenters improved the analysis of the business requirements at an intermediate phase of the project making sure that the KPIs are “smart”, and will refine them in relation to the project progress during the second iteration of the MIDIH RE Methodology. In order to validate the requirements properly at the final stages of the project, this process shall be performed as agreed between all stakeholders, due to actually affecting them all.

Technology developers and systems integrators not managed directly the validation of the business requirements as they come from both CCs/DIHs and industrial experimenters.

3 MIDIH RE Methodology and Tools v2

This chapter proposes the features of the MIDIH RE Methodology 2. According to the feedbacks collected inside the MIDIH consortium on the usefulness and appropriateness of the MIDIH RE Methodology 1, it has undergone a process or evaluation and scanning intended to put in place modifications if needed to be incorporated in the MIDIH RE Engineering Methodology 2. In that light, Chapter 3.1 presents the conclusions from the analysis of the feedbacks collected and summarised in chapter 2. This constitutes the premise for structuring and defining how the MIDIH RE Methodology 2 should be modelled to meet the needs of the MIDIH project in the second half of its duration. This information is contained in Chapter 3.2.

3.1 Conclusions from the adoption of the MIDIH RE Methodology 1

According to the double-iteration structure of the MIDIH project, D2.2 is intended to provide the Requirements Engineering Verification and Validation Methodology 2 (MIDIH RE Methodology 2).

This second version of the methodology should take into consideration the impressions and lessons learnt from the adoption of the first version of the methodology. This feedback has been collected both during the activities carried out in T2.5 “Socio-business assessment, lessons learned and recommendations” and reported in D2.5 “Socio-Business Assessment & Lessons Learned 1” and from a structured collection of information conducted inside the MIDIH consortium to the sole aim of D2.2. Based on the inputs coming from T2.5 and from the collection of direct feedback with MIDIH partners’ representatives, and after several confrontations among WP2 task leaders, it came to the conclusion that the RE Methodology 1 fits the needs of the MIDIH project.

Chapter 2 highlights some criticalities connected to the adoption of the first version of the methodology in relation to the achievement of the objectives defined at the beginning of the project. Some barriers have been encountered in the running activities of the core operative WPs, but the obstacles could not have been directly linked to the lack of a supportive methodology for defining and specifying scenarios, business requirements and KPIs, but rather on a weak connection between the support that the MIDIH RE Methodology 1 was offering and the way in which it was adopted. In other words, the proposal of a defined step-based approach for the definition and validation of business objectives and requirements does not interfere with the content of the business objectives and elicited requirements. The reason for this is based on the purpose of a methodology as such.

Despite the suitability of the MIDIH RE Methodology 1 and the fact that no structural changes are foreseen, changes in business objectives and/or business requirements to be collected and presented in D2.4 “Scenarios, Use Cases and Requirements for MIDIH 2” could be verified compared to those collected in the first iteration and specified in D2.3 “Scenarios, Use Cases and Requirements for MIDIH 1”. This is due to the new activities foreseeing in the MIDIH project in

the second half of its duration and that might have impact on the expected new outcomes of the MIDIH project in WP3 “Network of Competence Centers and pan-EU DIHs in CPS/IOT” and WP5 “Cross-Border Industrial Experiments”., and consequently WP4 “Open Platform architecture, development, integration and testing”.

These aspects will be further explained in chapter **Error! Reference source not found.** intended to provide suggestions on how to properly perform the validation of the first wave of collection of the business requirements in D2.3 and how to support the second wave, both to be included in D2.4

Therefore, after having assured the appropriateness of the MIDIH RE Methodology 1, no need for changes arose, but attention should be paid in the adoption of this methodology where the elicitation and elaboration of the requirements and objectives should take into account their relevance for the project and the formulation should comply with a MIDIH-tailored vision.

3.2 Specification of the MIDIH RE Methodology and Tools 2

According to Chapter 3.1, the MIDIH RE Methodology is not going to change in the approach, but in the way in which it is implemented to support the definition of a set of business requirements, objectives and KPIs that is coherent with the envisioned intentions and mission of the MIDIH project.

Therefore, this chapter reassumes the main steps characterizing the RE Methodology 1 presented in M3 in D2.1 and that will still be the reference approach for the second half of the MIDIH project.

In D2.1, various Requirements Engineering (RE) methodologies were analyzed in a critical perspective resulting in a summary of the main advantages and criticalities in their respective implementation and in the identification of the field of application that is better suitable for each RE Methodology (for more details refer to D2.1). In order to find the right RE approach, the MIDIH features were cross-checked with the opportunities offered by a specific RE methodology or a combination of methodologies to create a “hybrid business requirements approach”. According to the State of the Art, the approach that better suits MIDIH features is the spiral approach because it allows the continuous check of all the steps undertaken to understand, plan and test the solutions developed to reach the desired business objectives. Figure 3 represents the MIDIH RE Methodology 1 shaped according to the spiral approach (for more details refer to D2.1).

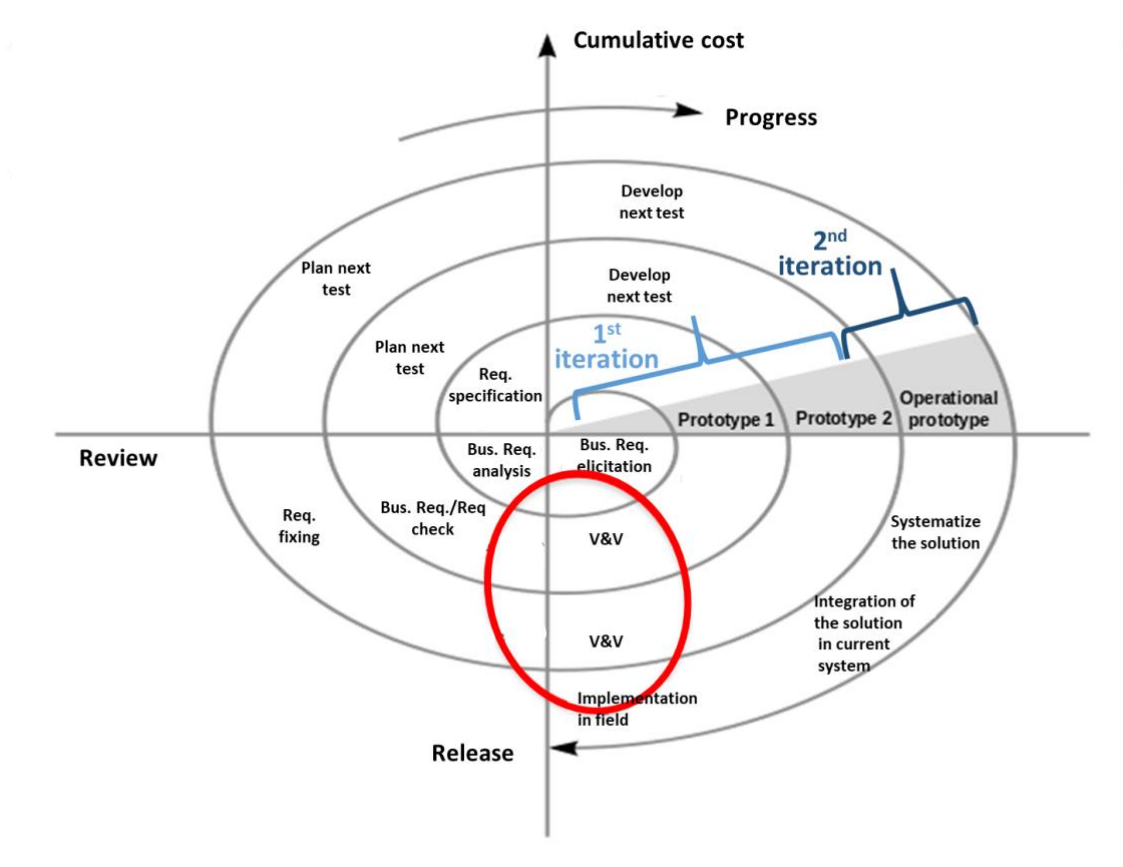


Figure 3 MIDIH RE Methodology 1 – Spiral approach

In the end, one of the major results of D2.1 was to establish the need to utilize a spiral RE approach properly adapted to work in a CPS/IOT-driven environment populated by different stakeholders and characterized by complexity and trans-discipline. In that light, the MIDIH RE Methodology 1 was intended to be a generic framework to support what will be subsequently specified for and instantiated in DIHs/CCs, Industrial Experiments and Open Digital Platforms.

As already mentioned in Chapter 2.2, the MIDIH RE Methodology 1 is constituted by five sequential building blocks.

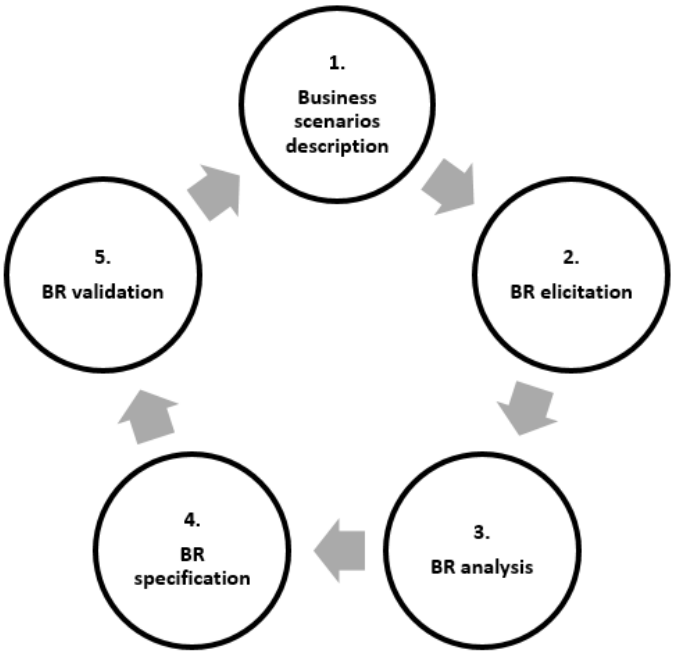
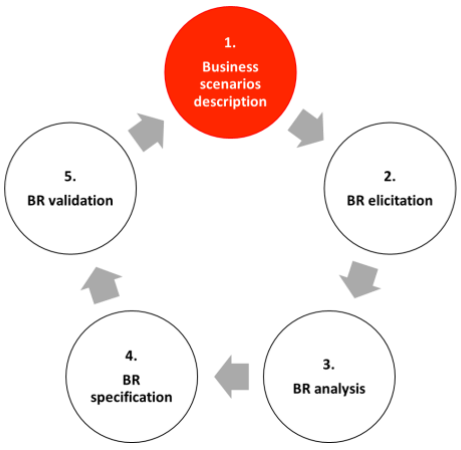


Figure 4 MIDIH RE Methodology 1 – Five steps

The following paragraphs are intended to recap the details and features of each step pf the MIDIH RE Methodology 1 that was confirmed and will be used in the second iteration of the description of business scenarios and collection, analysis and validation of business requirements.

1. Business scenarios definition



The analysis of the business scenario is the first step of RE processes.

Business scenarios can be defined as the future business circumstances envisioned on the basis of current state and assumptions, which may affect organizational performance.

The definition of a business scenario requires to envision the “new face” that the organization is expected to have, how it is going to look like on the basis of changes in the product-service offer, technological and operational changes, together with changes in the organizational and strategic structure.

When it comes to defining business scenarios, a simple question can be answered in order to start this creative process, which is "How will your company BE by the end of the project?" or “How do you see your organization (and therefore how it will BE) at the end of this innovation-oriented journey?”. Behind this simple question is a personification exercise which consists in

imagining the future state, in other words how the organization/company is expected to **"BE"** by the end of the project.
The TO BE scenario (foreseen future) should be defined starting from the AS IS scenario that is the current face of the company, trying to identify the technical areas of intervention, the tangible and intangible potential benefits of its realization.

In order to support the collection of the business scenarios in D2.4, the following tool should be used to collect and store the information in a dataset (e.g. spreadsheet).

Beside business scenarios, the **business objectives** capture the vision of the identity a company wishes to reach in the future in terms of betterment of actual performances and attended impacts on business performances. Business objectives require a personification exercise that states the **"HAVE"** a company or an organization would like to achieve in a near future. "HAVE" refers to the features and characteristics that shape the future face of the company in order to "BE" the innovative representation of itself.

The definition of both business scenarios and objectives have to respect MIDIH project vision. The idea is that each partner of the MIDIH consortium can benefit from the innovation opportunities in the field of technology and services / technological solutions, being part of the MIDIH project.

The paradigm **BE → HAVE** should support the MIDIH partners in defining business objectives that are coherent with the business scenarios.

For example, taking into consideration a generic Digital Innovation Hub within the MIDIH consortium, the envisioning of the "BE" could be summarized as follows.

"BE":

1) **Connected**: I wish to explore new communities and relevant entities in different DIH communities and be able to serve a variety of customers thanks to possible collaboration with other communities
2) **Multi-stakeholder**: I wish to enlarge the portfolio of services in order to raise the number of successful projects.
3) **Accelerator**: I wish to support my customers (particularly SMEs) in enlarging their business opportunities by accessing local funds/initiatives or by giving them access to private financial opportunities

According to the definition of the "BE", the "HAVE" should be specified. Following the example above, we here provide the "HAVE" specification for the "BE"→ "HAVE" paradigm.

"HAVE":

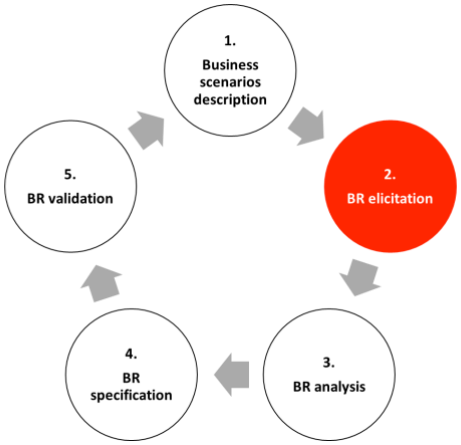
1) 1.1 Connection with several people of my interest in order to enlarge my network;
   1.2 Access to the state of the art of the work in the field of my competence (e.g. access to a catalogue of services or technological solutions);
   1.3 The opportunity to share my own projects/competencies/service offer to other experts or to new potential markets;

1.4 The opportunity to share business ideas with experts from complementary communities.

2) 2.1 Results from innovative projects to share with potential new customers as successful stories and demos;
2.2 Popularity in the manufacturing industry (at local/regional/national level);
2.3 Customers' loyalty.

3) 3.1 Visibility on public funds;
3.2 Relations with the local public authorities;
3.3 Partnerships with incubator/accelerators or large business companies with high investing capabilities and interest for the industrial-technical domain.

2. Business requirements elicitation



The **business requirements** (BUSINESS REQUIREMENTS) states the "why" for a project, their fulfilment allows to satisfy the business objectives. They also provide the scope of a business need or problem that needs to be addressed through a specific activity or project. Good BUSINESS REQUIREMENTS must be clear and are typically defined at high level. They must also provide enough information and guidance to help ensure that the project fulfils the identified need.

Functional requirements business requirements seek down the steps needed to meet the BUSINESS REQUIREMENTS. A functional requirement outlines the *"what"*. It essentially specifies something the system should do. Typically, functional requirements will specify a behaviour or function.

Non-functional or technical requirements specify *"how"* the system should perform a certain function (system quality attributes or characteristics). In other words, a non-functional requirement will describe how a system should behave and what limits there are on its functionality.

The gap analysis will constitute the basis for business requirements elicitation. The gaps identification between the AS IS and the TO BE business scenario allows defining the business requirements to be satisfied in order to facilitate the transition from the current to the desired situation. Business requirements are linked to business objectives and related impact.

The elicitation of the business requirements can be supported by asking the question "Which aspects of the business features should be modified/added to reach the desired scenario?".

Features that are commonly presented in a complex, trans-disciplinary and multi-stakeholder environment for requirements elicitation characterize the requirements elicitation process in MIDIH project:

- Complexity: Elicitation has to be able to handle a large number of interrelated requirements;
- Trans-discipline: Elicitation and requirements exchange process has to be supported in order to create a common view of the targeted complex system;
- Multi-stakeholder environment: Elicitation has to be applicable for a large number of stakeholders that are detached spatially and organizationally.

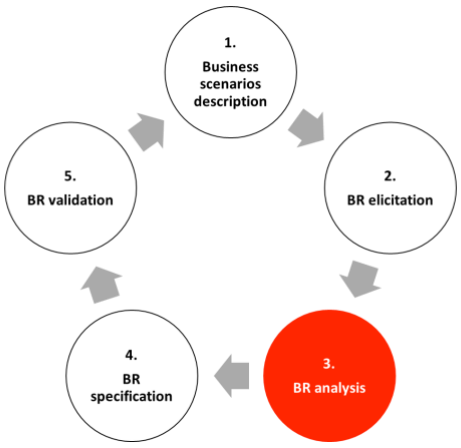
In this environment, one of the main challenges in the requirements elicitation process is the definition of clear, correct and complete requirements.

Living lab approach comes useful at this stage, where key stakeholders are distributed into user panels and then asked about their specific challenges from both non-technical and technical perspectives.

Moreover, the "BE" → "HAVE" paradigm can be of help also here. By adding another element that is the "BEHAVE" aspect, the paradigm then becomes "BE" → "BEHAVE" → "HAVE", where "BEHAVE" recalls a set of activities needed to go from the envisioned expected "new face" of the company or organization ("BE") to the real possession of the features that makes the company or organization be how it is expected to be or achieve defined targets ("HAVE").

According to the example provided above, the "BEHAVE" aspect of the paradigm should be detailed accordingly to the "HAVE" (already linked with the "BE" aspect).

3. Business requirements analysis



The **BUSINESS REQUIREMENTS analysis** establishes if the elicited requirements are necessary, verifiable and reachable by examining their coherence with the defined objectives. The aspirational aim of this phase is limiting/removing requirements ambiguity, inconsistency or incompleteness, which should be avoided. Moreover, hidden or latent interrelations between business requirements or missing assumptions during the process of elicitation should be managed and effort should be put on uncovering them to guarantee the quality of the elicited requirements and to avoid the uprising of obstacles to requirements satisfaction. Effort should be invested in achieving quality in terms of clarity in the description and explanation, and coherence in relation to the achievement of the TO BE scenario. It has to be considered that the spending of resources to be dedicated to this activity should be carefully

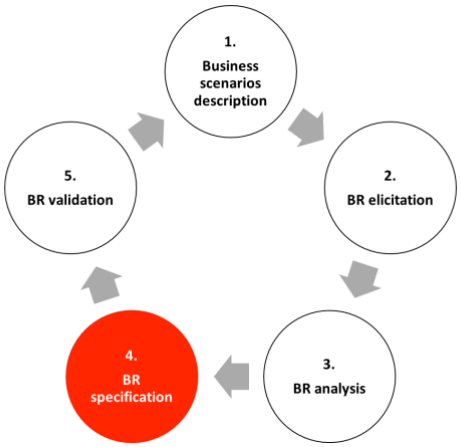
reasoned and evaluated according to the existing trade-off between betterments and cost invested to achieve the improvements[1].

Furthermore, the relevance of the elicited business requirements should be evaluated by establishing a hierarchical structure for requirements' prioritization (i.e. Critical/Preferred/Optional). This allows the identification of the most relevant (must-have) requirements and a critical selection of the relevant requirements to be satisfied in order to reach the desired scenario. In MIDIH RE Framework, this can be supported by different approaches that have to be defined coherently with the approaches implemented during the elicitation process (for further details refer to paragraph **Error! Reference source not found.**) and accordingly to the specific characterization of requirements (Shen et al. 2004).

Furthermore, if the business requirements have an impact on other stakeholders outside the organization it should be discussed if the requirement is SMART enough. Thus, it guarantees that the requirements are "Smart", "Measurable", "Achievable", "Relevant" and "Time-bound". It can be achieved by the early involvement of partners to provide feedback.

Going back to the "BE" → "BEHAVE" → "HAVE" paradigm, the actions specified for the "BEHAVE" allow a smooth and coherent transition from "BE" to "HAVE" in the following structure: "BE" → "BEHAVE" → "HAVE". By doing this exercise following the "BE" → "BEHAVE" → "HAVE" structure, the signs of inconsistency should be immediately visible. Therefore, this paradigm can be used to check the appropriateness of the defined BUSINESS REQUIREMENTS.

4. Business requirements specification



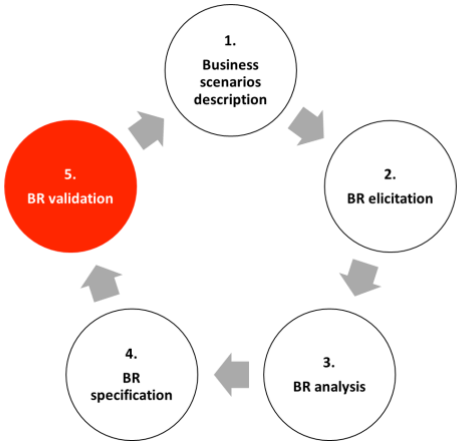
In this part of the MIDIH RE Methodology, the BUSINESS REQUIREMENTS identified in previous sections must be declined in operational requirements (plans and actions). It is to answer the question "What do I have to do in order to satisfy the requirements?".

Thus, the value proposition, the service offer delivery and all the actions needed to fulfil the defined objectives linked to the scenario must be specified. In order to structure and deploy a plan for the fulfilment of the elicited requirements and related objectives, the business processes have to be structured in business workflows, the value proposition, the resources needed and all the other elements characterizing the business planning and modelling must be specified.

The business deployment may require changes or adaptions according to changes in the AS IS scenario that have affected also the expected objectives and requirements.

[1] http://www.hcode.com/seroi/documents/SE-ROI%20Thesis-distrib.pdf

5. Business requirements validation



The validation process allows understanding whether the business objectives defined are still valid and/or have been fulfilled.

According to D2.3, business objectives may be of three types: strategic, tactical, operational (for more details refer to D2.3). At this point in time it is only possible to judge if they are still valid or need to be modified. Strategic objectives in most cases cannot be achieved as they have a longer time horizon, while tactical and operational objectives should be verified by answering the question "Did I achieve the objectives?". If the objective has not been fulfilled yet, since the MIDIH project is half its way, their validity must be confirmed. The process of validation of BUSINESS REQUIREMENTS aims at confirming that the requirements specification is functional to absolve the objectives identified in the previous steps of the MIDIH RE Methodology by means of completeness and correctness of the determined requirements. Thus, it needs to be documented "How" the KPIs have to be validated. Typically, it is a comparison of metrics from the past with the current situation. Furthermore, interesting from the validation point of view is the feedback mechanism within this process. Validation can occur at the end of the project or at any time a new business requirement is deployed in order to guarantee a continuous monitoring and lessons learnt feedback from the implemented actions. The project outcomes are evaluated through a comparison with the requirements specification in order to guarantee the deployed solution to be in line with the desired objectives and expected business impacts. Therefore, the MIDIH RE Methodology involves the different stakeholders in the review of the requirements during validation.

In general, the process of validation that investigates the ability of the reached project outcome to meet the stakeholders' needs and to fulfil its intended functions, goes together with a process of verification that ensures that the project outcome satisfies and respects the requirements and the design specifications.
In order to carefully run the validation of requirements, proper methods/measures need to be selected. The adoption of metrics and tools allows to understand whether a requirement is satisfied or not and to avoid bias by cross verifying the same information. Among different common approaches to data triangulation, in MIDIH project the focus will be on the following:

- **Data source triangulation.** Use of evidence from different types of data sources (i.e. interviews, documents, public records, photographs and observations, etc.);
- **Methodology triangulation.** Combination of multiple methods to gather data (i.e. documents, interviews, observations, questionnaires, surveys, and also different times and in different places for information collection).

The spiral approach allows the continuous check of all the steps undertaken to understand, plan, test and validate the solutions developed by minimizing risks and project resources. Therefore, the five steps of the MIDIH RE Methodology undergo a re-iteration process in order to assure the usefulness and validity of the scenarios, objectives and requirements accordingly.

The second iteration of the MIDIH RE Methodology starts with the validation of the business requirements elicited during the first iteration of the MIDIH RE Methodology and specified in D2.3. Therefore, during the second iteration of the MIDIH RE methodology, new scenarios, objectives and requirements could be evoked and specified based on the experience gained in the first half of the MIDIH project and to renew awareness of the expected results.

4 Recommendations for Scenarios and Requirements 2

As shown by the feedbacks collected and presented in Chapter 2 and in connection with the conclusions that could have been drawn as consequence in Chapter 3.1, the method for the MIDIH RE Methodology 1 is in principle appropriate. To empower this evidence, it can be added that in D2.3 the RE Methodology could have been applied well, although with exceptions in the execution.

Therefore, in the following chapters recommendations and suggestions are given to drive the validation of the business scenarios and requirements collected in D2.3 and the elicitation of new ones.

4.1 Recommendations for the Validation of the scenarios, business requirements and impacts from D2.3

The process of validation of the business requirements collected in D2.3 is intended to propose changes (if any) to be implemented in the second iteration of the MIDIH project.

This process aimed at uncovering the reasons behind any misalignment between the expected and actual results obtained after the deployment of the operational planning of business activities in the first half of the MIDIH project and aimed at achieving the goals and KPIs declared in D2.3. The reasons for misalignment to occur may be different.

The correctness of the objectives and related identification of the impact generated have to be verified, as well as the correctness of estimation of the magnitude of the generated impact (check for under/over estimations).

Furthermore, once the eligibility of the requirements elicitation process (objectives and impacts estimation) is verified, the reasons for failures in the deployment of the TO BE scenario have to be sought in the operational and business planning developed in the requirements specification phase of the RE.

Finally, external events may affect the results of the implemented strategy such as changes in the stakeholders' community setting or the modification of stakeholders' needs. These evidences will constitute the starting point for the RE Methodology 2 iteration by modification of a new AS IS scenario.

Therefore, the process to be adopted when validating the business scenarios, requirements, objectives and impacts declared in the first half of the MIDIH project, the following approach should be considered.

In D2.3, business requirements, business objectives and related KPIs from the MIDIH partners were collected in a dataset. The following Figure 5 shows the template that has been used in the deliverable D2.3 for the collection and storage of the objectives and KPI information.

Operational Objectives and KPI for CCs/DIHs (for Chapter 7.1)								
Obj. N°	Obj. Description	Actions	Task	As Is	To be	Indicators (KPI)	CCs/ DIHs	Validation
1	Objective Description in a short period (see D1.5 definition)	Real Actions performed to reach the defined objective	add a task to which a link refers here …	describe the starting point before MIDIH	Describe the TO BE beeing a MIDIH partner and tahnks to MIDIH	Defne a quantitative KPI as difference between AS-IS and TO BE		

Figure 5 Tool for the collection of Operational Objectives and KPIs for CCs/DIHs retrieved from D2.3

This is the starting point for the process of validation of the objectives and KPIs.

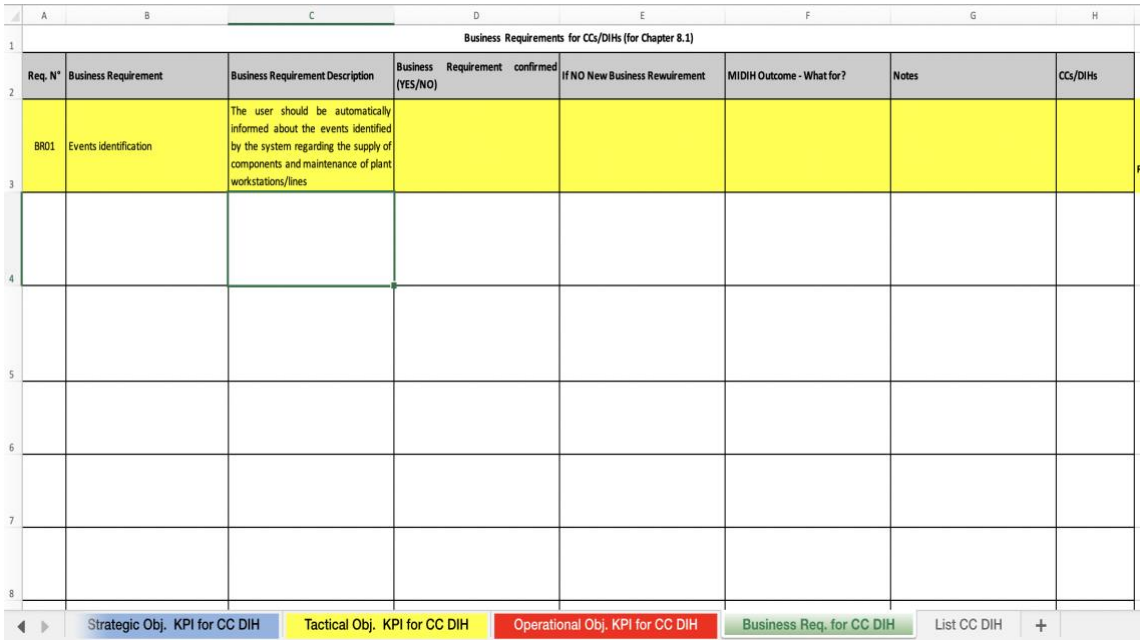
In order to support the validation, this file could be enriched with some more columns intended to track the changes occurred at this point of the project compared to what declared by each partner previously in D2.3 as shown in the following Figure 6.

Strategic Objectives and KPI for CCs/DIHs (for Chapter 7.1)									
Obj. N°	Obj. Description	Actions	Indicators (KPI)	Validation Check Objectives (yes/no)	Validation of the KPI (yes/no)	How the KPI was measured?	New KPI	Note	CCs/DIHs
1	Plant productivity increase	Apply MIDIH solution	2% production increase						

Strategic Obj. KPI for CC DIH | Tactical Obj. KPI for CC DIH | Operational Obj. KPI for CC DIH | Business Req. for CC DIH | List CC DIH

Figure 6 Tool for collection of Strategic Objectives and KPIs for CCs/DIHs for D2.4

In case the validation column has value “NO” because the objective has changed or the KPI for the objective could not be reached any more, considering the activities done in the last 18 months, the partners have to indicate the reason, the new objective and/or KPI.
The same occurs for the business requirements worksheet (see Figure 7) where you still have to validate or not the previous business requirements.



Business Requirements for CCs/DIHs (for Chapter 8.1)

Req. N°	Business Requirement	Business Requirement Description	Business Requirement confirmed (YES/NO)	If NO New Business Rewuirement	MIDIH Outcome - What for?	Notes	CCs/DIHs
BR01	Events identification	The user should be automatically informed about the events identified by the system regarding the supply of components and maintenance of plant workstations/lines					

Strategic Obj. KPI for CC DIH | Tactical Obj. KPI for CC DIH | Operational Obj. KPI for CC DIH | Business Req. for CC DIH | List CC DIH | +

Figure 7 Example of tool for the validation of Business Requirements for CCs/DIHs in D2.4

4.2 Recommendations for D2.4 on the adoption of the MIDIH RE Methodology

This chapter concludes with key recommendations and principles in addition to the RE Framework from Chapter 3. In line with the recommendations for the validation of KPIs, objectives and requirements in Chapter 4.1, Chapter 4.2 provides recommendations for the elicitation and specification of new requirements. Basis for this chapter are also the results from D2.5, especially findings related to the adoption of the MIDIH RE Methodology 1.

First of all, it should be clear that the MIDIH RE Methodology must be applied as carefully as possible in this second iteration. There are specific indications given on how to apply it in the different work packages.

D2.5 has identified two issues that should be methodologically supported:

a) A close collaboration between the work packages is needed to ensure quick and continuous information flow, especially during the definition and refinement of the requirements (WP2).

In order to ensure close cooperation and collaboration in the requirement engineering should be methodically based on clear roles and setting expectations. This can be done, for example, through cross functional groups of interests. It is recommended to form teams out of people who representing the customer side and those who develop one particularly addressed core outcome of MIDIH. The teams should work together in workshops, but often it is not possible to work in Workshop in this project. The structure of the consortium is too heterogeneous, many consortium partners work at even more different locations in Europe. The use or introduction

of IT collaboration systems such as confluence can help here. Important are structures that make information flow.

b) For the next iteration, it is recommended to continue working on the specification of requirements and adapt them to the specific work packages.

The adaptation of the requirements and takeover by the work packages requires that a requirement is clearly assigned. A requirement should be assigned to a project objective or even better to a field operation in MIDIH. This succeeds through the clear definition of the purpose of a requirement. It is about the addressee or the "What for" within MIDIH. The "What for" is explained by the core activities resp. the core outcomes and must be transparent to all partners. Requirements always refer to one of these core activities.

To address these two aspects proposed by D2.5, in addition to Chapter 3 the following is proposed:

- Set up a structure based on the core objectives/outcomes in MIDIH so that the requirements find their addressees despite different users or customers;
- In order to ensure the support of field operations through specific requirements, work in stakeholder or interest groups is proposed;
- The caller of the requirements and the partner who is implementing them have to discuss among each other and run the specification and validation agile in short cycles. Unilateral requirement elicitation has to be avoided;
- Not all partners can or must elicit requirements for every activity pertaining the MIDIH project. Each partner should focus its requirements engineering, which not necessarily derives requirements for all field operations;
- Each MIDIH partner will be asked to position him/herself according to specific interest and relation with each MIDIH outcome in order to envision new potential scenarios and decline them into a new business perspective and opportunities. This helps customizing the MIDIH outcomes in the way to permit to achieve the individual objectives in terms of increased awareness and competencies towards the related stakeholders on CPS/IoT technologies and manufacturing topics at large;
- To elicit requirements, a simplifying approach should be given. Originated in agile project management, the approach follows the description of requirements expressed in user stories. A business requirement provides information to the following question: Who wants what and why or for what purpose, which contributes to which project goal (see Table 1). It should be clear that a requirement described in a user story can help considering several important aspects. This should be especially considered in D2.4 but can also be used later on within the work packages. D2.4 should further detail out this simple idea by filling in project related content such possible stakeholders, specific MIDIH outcomes etc. so that all project partners know the stakeholders and roles that exist in MIDIH. It must be clear how the RE Methodology and the scenario analysis are used to define requirements, why satisfied requirements create added value and finally to which core outcome in MIDIH this is assigned.

Table 1: Express a requirement as a user story

Who	wants **what**	and **why**	,which contributes to **which project objective**
Stakeholder, or clustered in groups of interests	Business requirement	To achieve future business scenario and business objective	Core operations to be addressed within MIDIH, on work package level

Below some examples are provided in order to guide the MIDIH partners in positioning themselves in line with the MIDIH goals and define new business objectives accordingly.
Taking as outcome of reference the DIHIWARE Innovation and Collaboration Platform, we list possible new objectives and KPIs a MIDIH partner may provide.

Example 1) Business objectives and KPIs from a MIDIH Competence Center

Objective: I want to increase the number of SMEs managed at regional level providing new services on CPS/IoT through a one-stop-shop marketplace in a collaborative way.

KPI: the number of SMEs contacting the CC for technical and consultancy support will increase by 10%.

Example 2) Business objectives and KPIs from a DIH

Objective: We want to better support our SMEs/Startups stakeholders through their Digitalization process in manufacturing thanks to new consultancy methodologies developed in MIDIH.

Objective: We want to increase the skills related to CPS/IoT competencies through the adoption of new training methodologies and tools identified and experimented in the MIDIH project.

KPI: The number of SMEs that complete their digitalization migration path in one year (duration depending on your already available services) will increase by 5%.

In the same way, the MIDIH partners will be asked to provide new Business Requirements (BR) related to the define business objectives connected to the MIDIH outcomes. The BR should be thought according to their ability to support the fulfilment of the expected objective and KPIs.

Example 1) Business requirements for a MIDIH Competence Center

BR1: The DIHIWARE should allow me to get information and feedbacks on the most recent digital solutions supporting business process monitoring and analytics to boost manufacturing efficiency.

BR2: The DIHIWARE should allow me to get a list of upcoming events in order to fix an appointment to discuss B2B relationship with other organizations of the platform

Example 2) *Business requirements for a MIDIH DIH*

BR1: The DIHIWARE should allow me to access a community of DIHs that may support the growth of me as a DIH.

BR2: The DIHIWARE should allow me to get access to contacts for exchange of experiences and knowledge.

BR3: The MIDIH DIH role models should set the path for cross-DIH collaboration, so then my DIH can improve the offer of services that other DIHs already offer in the education and training of the employees.

5 Conclusions

The major outcome of this deliverable is the confirmation that the MIDIH RE Methodology 1 was confirmed to be suitable and accurate, and therefore it will support the validation of old business scenarios and requirements and definition of new ones in the second iteration of the MIDIH project.

Despite that, come challenges have been encountered during the first iteration of the MIDIH project, as some difficulties occurred in the definition of business scenarios and elicitation, analysis and specification of business requirements for DIHs and CCs (WP3), industrial experimenters (WP5), and technology providers and systems integrators (WP4).

Barriers mainly pertain the adoption of the methodology in a way that the elicited scenarios and requirements can be translated into concrete actions and find a solution in the outcomes of the MIDIH project.

The main issues encountered are related to aspects of clarity, due to the need to take into account and rely on the inclusion of several stakeholders. The complexity of the different organizations involved in the identification of a business need requires the interrelation between other entities inside the consortium, but also outside the consortium.

Time is a constraint as well as defining business objectives linked to expected results that will come later in time requires an envisioning effort at the time of the elicitation of the business requirements and objectives. Therefore, the need for clear enough, but high-level requirements need to find a balance.

In order to support a smooth execution of the next tasks in this direction, some guidelines are suggested to guide the next coming activities, starting from D2.4 “Scenarios, Use Cases and Requirements for MIDIH 2”. During the validation of the business requirements and scenarios collected during the first iteration of the MIDIH project and recorded in D2.3 “Scenarios, Use Cases and Requirements for MIDIH 1”, a new approach should be applied.

Attention should be paid to who are the stakeholders of a specific business scenario in order to protect the realistic nature of the elicited need. The business requirements must be then uncovered by creating a clear link with the business scenario. In other word, it must be evident the reason why a certain business requirement should be achieved in order to satisfy the stated business need. How the need is satisfied states the link between the business requirement and the outcomes of the MIDIH project. This means that requirements that are not strictly connected with the aim of the project are out of scope, and thus not realistic in the panorama of options offered by MIDIH.

6 List of Acronyms and Abbreviations

Acronym	Meaning
BO	Business Objective
BR	Business Requirement
BS	Business Scenario
CC	Competence Center
DIH	Digital Innovation Hub
IT	Information Technology
KPI	Key Performance Indicator

Annex I: Questionnaire for the collection of feedback on the adoption of the MIDIH RE Methodology 1

1) **BUSINESS SCENARIO DESCRIPTION**
   - What is in your opinion a BS?
   - Which are the main features of a BS?
   - Which are the main difficulties in describing a BS being a CC/DIH – tech provider - Experimenter?
   - How did you manage them?

2) **BR ELICITATION**
   - What is in your opinion a BR?
   - What do you think specifying a BR is useful to at project level?
   - How did you define your BR?
   - What constitutes a BR?
   - Which are the main difficulties in defining a BR being a CC/DIH – tech provider - Experimenter?
   - How did you manage them?

3) **BR ANALYSIS**
   - What is the BR analysis in your opinion?
   - How would you evaluate a BR?
   - Which are the risks of non-performing the BR analysis?
   - Which are the main difficulties in analysing a BR being a CC/DIH – tech provider - Experimenter?
   - How did you manage them?

4) **BR SPECIFICATION**
   - What is the BR specification in your opinion?
   - What is it needed to?
   - Which info do you think are relevant to be included as “specifications” of a BR in the MIDIH project?
   - Which are the main difficulties in specifying a BR being a CC/DIH – tech provider - Experimenter?
   - How did you manage them?

5) **BR VALIDATION**
   - What is BR validation in your opinion?
   - How would you proceed with the BR validation?
   - Which are the main difficulties in validating a BR being a CC/DIH – tech provider - Experimenter?
   - How would you manage them?