Continuous Requirements Engineering for Digital Transformation

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Abstract. In today's world, the constant rapid changes in the technological environment have formed a dynamic ecosystem that is forcing businesses to undergo a digital transformation. This digital transformation causes many challenges and opportunities for those organizations that timely recognize the changes in the environment and decide to take the next step. However, many organizations find the whole digital transformation process very complex. The risk of the entire endeavor can be mitigated by implementing a digital transformation process that serves as a guide with clear and comprehensive tasks for a successful digital transformation. However, this process alone does not guarantee the desired results, as the undertaking needs an orchestrator to facilitate and strengthen collaboration, communication, and knowledge sharing throughout the process. This is where Continuous Requirements Engineering can contribute by providing its functionality. The goal of this work was to develop a continuous requirements engineering supported approach that helps to handle complexity of an entire digital transformation process. The approach consists of two core components: the digital transformation process and the requirements engineering management component that uses the functionality of continuous requirements engineering to support the transformation process. In the end, the continuous requirements engineering approach for digital transformation was validated on a business case described in the related work.

Keywords: Digital Transformation, Continuous Requirements Engineering.

1 Introduction

In today's world, the constant rapid changes in the technological environment have caused businesses to change rapidly. However, due to complex nature of the transformation process companies find it difficult to adapt and successfully meet these rapidly evolving technological standards [1]. This lack of adaptation, and often failure to transform, is causing these companies to be left behind by the competition and, as a result,

they often give up. In this exceptionally uncertain and challenging environment, the context of digital transformation has become a central concept [2].

According to Loonam et al. [1, p. 102], "digitally enabled organizations are supported by new Information and Communication Technologies, referred to as digital technologies, which increasingly promise enormous opportunities for growth." At this point, an organization should analyze its ecosystem and current state and take a step towards digital transformation to take advantage of the opportunities that arise and thus secure its position in the market [3]. However, the successful implementation of digital transformation projects has many complexities that need to be overcome, such as dealing with fast-moving technological innovation and restructuring departments, business processes, and culture [4]. Fast-moving technological innovation leads to digital disruption, which is the biggest risk that can cause significant damage, from compromising core business processes that have a high impact on the company's value chain to excluding the company's activities from the market [5]. At this point, interdepartmental communication and collaboration play a key role in successfully implementing digital transformation and avoiding undesirable situations.

Requirements engineering is the function that brings business, system development, and operations to the same side [6]. However, the traditional notion of requirements engineering provides specific functionality that does not ensure efficiency in dynamic environments and projects such as digital transformation. The digital transformation is a recursive project, and these iterations require additional functionality that ensures continuity of business, collaboration, and communication [7].

Consequently, Continuous Requirements Engineering plays an important role by providing additional functionality that supports today's dynamic organizations. It provides agility and continuous adaptation in organizational policies, strategies, and processes that are consistent with today's extremely challenging and complex information systems environment [7]. In this way, an organization gets the assurance that it is following the right path. As a result, mistakes are eliminated, costs are reduced in terms of budget and time, and possible future needs arising from changes in the technological or business environment are tracked.

Considering the research problem presented and the recommended solution, the following main research question (MRQ) is set out in this paper: *How a continuous requirements engineering can facilitate the digital transformation process*? To answer this question a continuous requirements engineering approach for digital transformation (CRE4DT) is proposed. The approach is presented and discussed in Section 2, including the references to related work which it is based upon. Section 3 tests the applicability of the model. Section 4 provides brief conclusions and points to the directions of further research.

2 Continuous Requirements Engineering Approach in Digital Transformation Process

The purpose of this section is to present the CRE4DT approach that answers the main research question presented above and provides a methodological solution to the

difficulty that many organizations are experiencing to successfully transform and comply with the rapidly evolving ecosystem.

The CRE4DT approach, proposed here, is a hodgepodge of methods and approaches from the literature, the amalgamation of which leverages digital transformation.

The approach is decomposed into two main parts: the core digital transformation process and the supporting requirements engineering management model that supports the organization through the use of continuous requirements engineering functionality. These two main components contain several elements that are described in this section. Fig. 1 illustrates the big picture of the CRE4DT model. Continuous requirements engineering is allocated inside the requirements engineering management component; digital transformation process is divided in three main phases: business planning, system development, and operations. The collaboration of these two components relates to the ecosystem which resembles all organizations and systems the enterprise undergoing the digital transformation is related to.

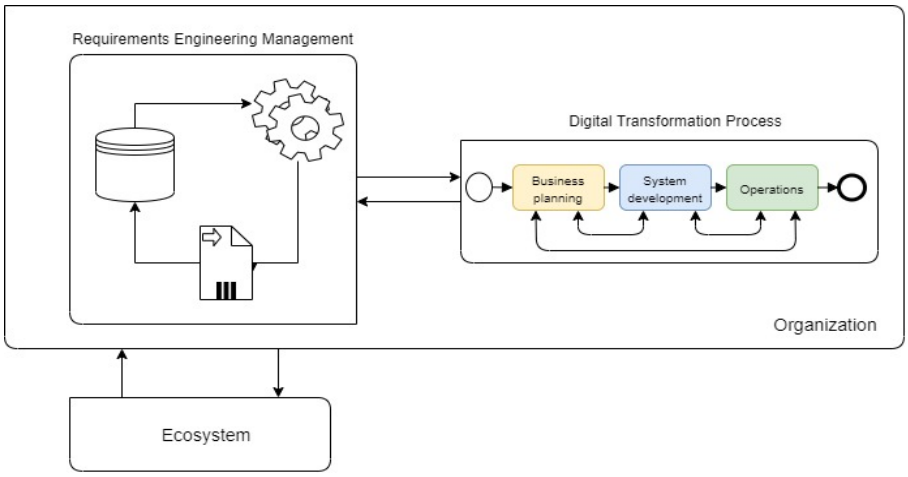

Fig. 1. Big picture of CRE4DT.

2.1 Proposed Digital Transformation Process Model

After thorough research in the digital transformation environment, the step-by-step functionality of the process is explained Table 1 and Fig. 2 that describe possible sequences of tasks in the digital transformation process with the inputs that each of them requires, functions performed, and expected outputs. The proposed digital transformation process provides a holistic, end-to-end process that an organization can follow to accomplish digital transformation. Unlike most papers in the literature that focus on individual parts of the process and analyze them in detail, the proposed digital transformation process presents an end-to-end process. The proposed sequence of steps in the process is seen in the 2nd column of Table 1 and in Fig. 2. Each element of the table is complemented with the reference to the related work which approves its presence in

the table. The functions and their sequence are proposed based on the amalgamated experiences reported in related work about digital transformation in higher education [8], developing strategy for digital transformation [9], handling digitalization in organizational processes [4], and complexity handling in organizational networks [10]. The functions essential in requirements engineering [6] and continuous software development [11] also have been respected so that the digital transformation process would be flexible enough to embrace the complexities of continuous change. Further each identified functionality has been analyzed in the context of related work to identify its inputs and outputs as fully as possible. For instance, for function “Analyze ecosystem”, the work on digital business models [12], conceptual modeling for value added digital transformation [2], digital disruption regarding business and information system engineering [5], and considerations about the success of digital transformation in industry 4.0 [13] have been considered. The related works, on which each item of Table 1 is based, are reflected next to the item.

The entire proposed digital transformation process (see Table 1, middle column, and Fig. 2) is divided into three phases. In Table 1, tasks 1-10 represent the business planning activities, Task 11 represents the system(s) development activities, and Task 12 represents the operations activities. These three phases should work holistically to achieve continuous improvement in digital transformation. To achieve this integration between the different phases, the supporting requirements engineering management model (See Section 2.2) should be introduced to support collaboration and communication using the continuous requirements engineering functionality that enables seamless information flow between the phases.

An organization begins its digital transformation journey by first analyzing its ecosystem and its current state. These two tasks require a lot of information about the market state and the organization's current strategy and business model. After analyzing the ecosystem, the organization knows the opportunities and digital technologies it can leverage through digital transformation, but also the challenges and the level of disruption it should face and overcome to remain competitive. The analysis of the current state, on the other hand, provides, as a result, the business layer of the As-Is Enterprise Architecture model

The next step is to assess the operational backbone, examining the organization's information systems and technology architecture. With this assessment, the organization completes the As-Is Enterprise Architecture model, begun in the previous task, by modeling the application and technology layers.

The process continues with the analysis and assessment of the digital maturity of the organization, which requires as inputs the results of the previous tasks, as well as information about the direction of leadership, organizational culture, employee skills, customer centricity, level of automation, etc. The analysis of these factors contributes to the assessment of the digital maturity level based on which the organization decides whether it is capable or whether it is worth pursuing digital transformation.

As Fig. 2 illustrates, when answering the question "Is the organization ready for digital transformation?", in case of a negative answer (No), the exclusive gateway sends the token to the task "Improve digital maturity", otherwise it sends the token to the pathway that continues the digital transformation process. In other words, after

evaluating digital maturity level, the organization decides if it is ready to proceed with the digital transformation or if it needs to take a step back to improve its digital maturity.

Table 1. Digital transformation process.

Input	Function/task	Output
Customer needs [12] Regulations [2] Digital disruption [5]	1. Analyze ecosystem [8]	Challenges [2] Digital technologies [13] Ecosystem's digital disruption level [5]
Current strategy [8] Current business model [8]	2. Analyze current state (strategy and business model) [8]	As-Is Enterprise Architecture model (business layer) [14]
Information systems architecture [15] Technology architecture [15]	3. Evaluate operational backbone [8]	As-Is Enterprise Architecture model (Application and Technology layer) [14]
Ecosystem's digital disruption level [5] Digital technologies [13] Challenges [2] Leadership direction [12] Employees' capabilities [12] Culture [2] Customer experience level (channels) [2] Customer centricity [1] Data-driven enterprise level (data analytics) [12] Level-of-automation [16] Platform-orientation level [12] Current digital strategy (if any) [9]	4. Analyze and evaluate digital maturity [10]	Digital maturity level [10]
As-Is Enterprise Architecture model [14] Digital maturity level [10] Challenges [2] Digital technologies [13] Ecosystem's digital disruption level [5]	5. Build or refine digital strategy [9]	Digital strategy [9] Transformation objectives [17] To-Be Enterprise Architecture model [14] Migration plan [14]
Digital strategy [9]	6. Model digital business model [8]	Digital business model (value streams) [8]

As-Is Enterprise Architecture model [14] To-Be Enterprise Architecture model [14] Digital strategy [9] Digital business model [8] Migration plan [14]	7. Analyze business processes and prioritize IT project backlog [4]	IT project backlog [4]
IT project backlog [4] Digital technologies [13]	8. Select digital technology for the chosen business process [4]	IT project backlog with appropriate digital technologies [4]
IT project backlog with appropriate digital technologies [4] Existing system's information (if any) [6] Stakeholders' needs [6] Organization's standards [6] Regulations [6] Domain's information [6]	9. Plan and define requirements for the system in transformation [6]	Stakeholders' requirements [6] System's requirements [6]
Stakeholders' requirements [6] System's requirements [6]	10. Analyze and negotiate requirements [6]	System's specifications [6]
System's specifications [6]	11. Perform Transformation (System development) [11]	System on production [11]
Systems on production [11]	12. Monitor operations [11]	Systems' performance [11]

The positive decision leads the process to the task that the organization should build or refine its digital strategy (if a digital strategy already exists). This task requires the As-Is enterprise architecture (EA) model created in the previous tasks, as well as the organization's digital maturity level, ecosystem digital disruption level, digital technologies, and market challenges. The goal of this task is to create the organization's digital strategy, transformation objectives, To-Be EA model, and migration plan that navigates the organization from the current state (As-Is model) to the desired future state (To-Be model).

The next task is to create the digital business model. The output of this task is the digital business model, which shows in a concrete way to the involved stakeholders the value streams through which the organization creates value while optimizing its assets and capabilities.

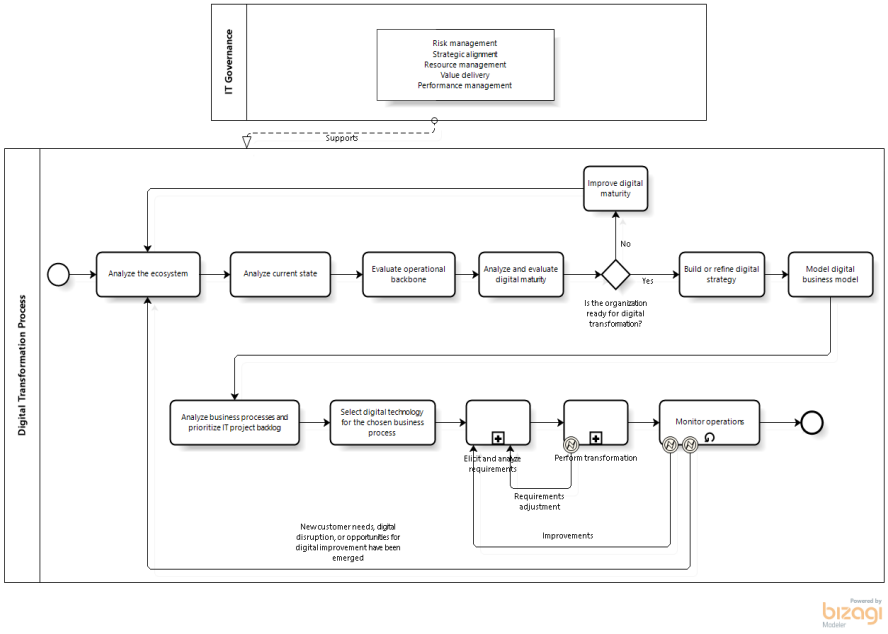

Fig. 2. Proposed generic digital transformation process.

Then, the analysis of the business processes and prioritization of the IT backlog is done, taking into account the As-Is and To-Be EA models, the digital strategy and business model, and the migration plan to generate the IT project backlog required to achieve the desired future state.

This backlog, in conjunction with the digital technologies, serves as an input for the selection of digital technologies for the chosen business process to be transformed. This task outputs the IT project backlog with the appropriate digital technologies.

Then the organization proceeds to plan and define the requirements for the business processes to be transformed. This task requires the IT project backlog from the previous task as well as existing information about these systems, stakeholder needs, organizational standards and regulations, and domain knowledge to create the stakeholder and system requirements.

With these requirements acquired, stakeholders work to analyze and negotiate to create the system specifications needed to transform business processes. These specifications are sent to the IT transformation teams responsible for developing and deploying the system(s) to be transformed. Completion of this "Perform transformation" task results in the deployment of the system(s) to production. Finally, these systems are part of operations and recursive monitoring is performed.

As Fig. 2 shows, the digital transformation process pool is supported by the IT governance which is represented as a black box for the sake of simplicity. The IT governance supports the entire digital transformation process by providing activities such as

risk management, strategic alignment, resource management, value delivery and performance management.

2.2 Proposed Requirements Engineering Management Model

The second component of the CRE4DT is the requirements engineering management model. In this section, this component is illustrated and briefly explained to show what functions it provides and how the information is managed.

The main goal of this model is the reusability of requirements. Requirements should be structured, documented, and stored in one place to make a future review and use for reforming and updating the organization's systems easier, faster, and more effectively, and to reduce costs in terms of time and budget. It also stores more general information that is the results of the analysis to be used as requirements in business planning and decision making. The model (Fig. 3) shows that requirements engineering management is done using continuous requirements engineering functionality. This functionality continuously supports communication and collaboration among people and various activities in the organization. It is supposed to be based on a requirements management tool that stores all the necessary information and requirements to continuously support these activities. More specifically, there is a seamless flow of information that is acquired, analyzed, documented, and stored in the requirements management tool. This information and requirements respectively can be prioritized, tracked, and become again the subject of negotiation and analysis. This documentation and storage of requirements are extremely important in today's dynamic environments as they enable reusability for timely reconfigurations and changes to systems.

In the model, three different entities can be noticed: the requirements engineering management, the business environment, and the ecosystem. Requirements engineering acts as a communication interface that provides its functionality to the business and retrieves information flows that are internally analyzed, documented, prioritized, tracked, and stored in the requirements management tool. The business environment is conceptually divided into three blocks: Business Planning, System Development, and Operations as for digital transformation process in Fig. 1 and Table 1. Requirements management communicates seamlessly with these blocks acquiring domain knowledge, key performance indicators, business strategies, business models, and system development requirements. It stores and analyzes this knowledge to support decision making and, as it will be explained in the following section, to support the digital transformation process. The system development requirements elicited at this stage are further analyzed, negotiated between the right stakeholders, and are included in requirement specifications which are then inserted into the system development block. There is open and continuous communication between the requirements engineering and the system development block for possible changes in the requirements in the design phase, but also in further steps of the system development. The last block of the business environment is the operation that ensures the systems are continuously monitored to elicit requirements about emerging needs, improve current performance, and fix possible bugs.

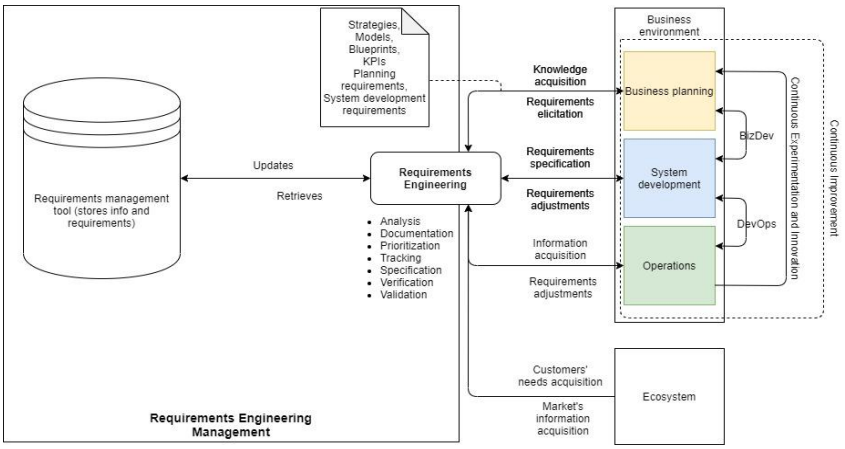

Fig. 3. Role of requirements engineering management model.

These three blocks articulate the BizDevOps approach introduced by Fitgerald and Stol [11] and leverage the opportunities for continuous improvement through the open communication and collaboration that continuous requirements engineering brings to support all continuous activities. Continuous requirements engineering also supports the capture of customer needs and market information that serves as input to business planning and decision making.

2.3 Continuous Requirements Engineering Approach for Digital Transformation

The amalgamation of the digital transformation process and requirements engineering management model explained in the previous sections, prepared the ground for the constitution of the Continuous Requirements Engineering approach for digital transformation - CRE4DT. The CRE4DT approach (Fig. 4) explains how the requirements engineering management model is implemented in the digital transformation process to use the continuous requirements engineering functionality to streamline collaboration and communication between the three different phases of digital transformation process, with the main goal being the successful and efficient implementation and continuous improvement of digital transformation.

The digital transformation process is divided into three main phases, indicated by yellow, blue, and green dashed lines (Fig. 4) similarly as by block colors in Fig. 1. The yellow color indicates the business planning, which includes all the activities related to the analysis of the ecosystem and the current state of the organization, the modeling of As-is and To-Be EA models, the definition of the migration plan to achieve the future desired position (To-Be), the definition of the digital strategy and business plan, as well as the analysis of business processes, prioritization of projects, selection of digital technologies and requirements acquisition, analysis and negotiation. The blue color shows the development and/or refinement of the predefined system(s); and the green color shows operations monitoring. The red dashed line, in Fig. 4, overlays the entire process

explaining the continuous improvements accomplished using the requirements engineering management model. The purple dotted line, which covers the tasks from the creation of the digital strategy to the development of the system(s), indicates the migration phase, the phase where the transformation activities start and go up to the point where we reach the results of the predefined To-Be model. The whole process is also supported by IT governance, which provides risk management, strategic alignment, resource management, value delivery and performance management activities.

On the other side, as shown in Fig. 4, there is the requirements engineering management model, which seamlessly provides information flows and supports the three main phases (business planning, system(s) development, and operations) in obtaining and delivering information and requirements needed throughout the digital transformation process. It also elicits information from the ecosystem about new customer needs and market information needed for the business planning phases of the digital transformation process.

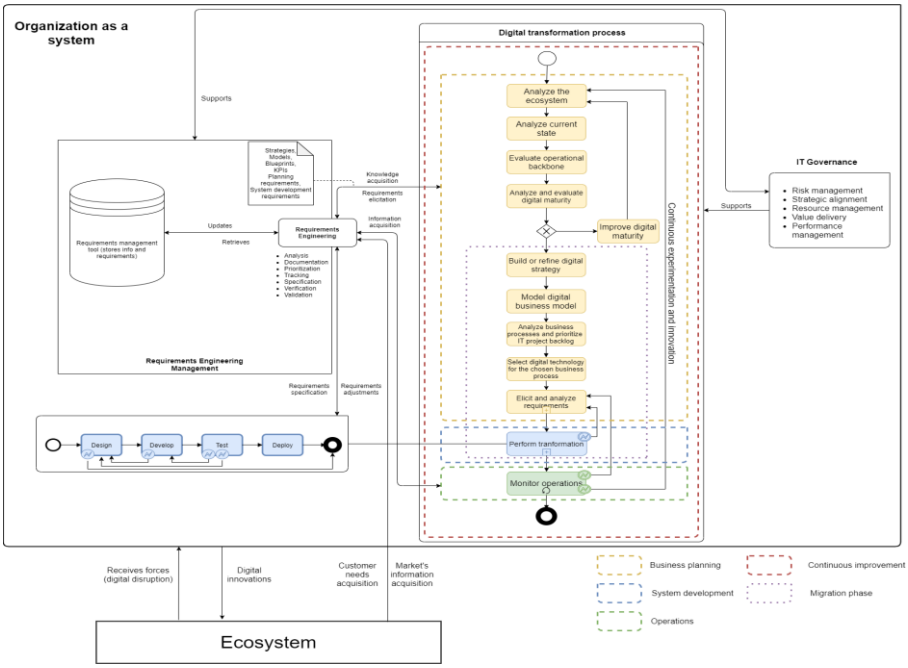

Fig. 4. Continuous Requirements Engineering approach for Digital Transformation (CRE4DT).

More specifically, requirements engineering acquires knowledge and requirements from the business planning phases, such as strategies, models, planning requirements, and system development requirements. This knowledge and requirements are stored and shared whenever they are needed by the respective stakeholders to streamline the tasks of the digital transformation process. In this way, each time the digital transformation process goes through an iteration and can start again from the beginning to ensure continuous improvement, the information required to analyze the ecosystem, the

current state of the organization, etc., is retrieved and reused, making the transformation process faster, more cost-effective, and more accurate. This reusability of knowledge is much more valuable when the time comes for system refinement. Stakeholder requirements, system requirements, and requirements specifications are available for reuse and analysis to understand and define the new stakeholder needs and functionality of the system, and to be able to trace the root of the problem of the system in the configuration phase more quickly and accurately.

Then, the system development phase communicates with the requirements engineering management model, which receives the requirements specification and sends any requirements adjustments that were found out during the design phase and are necessary for the successful development of the system.

Finally, the requirements engineering acquires information and requirements from operations about the performance of the systems and the overall performance of the digital transformation project through the monitoring activity.

The following points are the main advantages that the CRE4DT approach offers by incorporating continuous requirements engineering in a digital transformation.

- Open collaboration and communication between different stakeholders at different stages of the digital transformation process through seamless knowledge sharing.
- Knowledge and requirements needed for digital transformation are documented and stored in one place for future reusability.
- Information acquisition from the ecosystem to understand and define the challenges and opportunities in the environment.
- Seamless knowledge and requirements acquisition from the system development and monitoring operations phases for rapid response to changes in the environment and potential failures of the systems.
- Continuous improvement through rapid and cost-effective iterations of the digital transformation process that ensures competitiveness and continuous improvement through continuous experimentation and innovation.

3 Validation of the Continuous Requirements Engineering Approach for Digital Transformation

The goal of this section is to validate the Continuous Requirements Engineering approach for Digital Transformation (CRE4DT) by virtually implementing it in a real case scenario. The case study [18] under review refers to T-Systems MMS, which is an IT service provider for digital transformation projects based in Germany. It is part of the Deutsche Telekom Group and offers a wide range of IT solutions to its customers. The company is very active in software development and, also, gets involved in consulting. This case is an example of successful digital transformation. Table 2 outlines the digital transformation process that has happened in the company and its seven tasks reported in [18].

Table 2. T-Systems MMS transformation process, based on [18].

Transformation task	Description
1. Collaboration model	Define vision, responsibilities, roles, processes, and terminology. Understand the impact of DevOps on IT.
2. Integrated task management	Develop an integrated management system to manage the transformation process. Unify processes and tools of development, testing and operations.
3. Continuous delivery	Design and align process to enable continuous software delivery.
4. People empowerment	Identify and implement necessary training. Invest in people, new tools, collaboration models and innovation.
5. Infrastructure provisioning	Select, implement, and develop tools. Define the infrastructure and integrated platforms that are needed.
6. Pipeline automation	Select, implement, and develop tools. Standardize automated setup, technical testing, and delivery. Compile, build and deploy software at any time.
7. Organizational implementation	Define organizational structures, rules, and roles. Transfer knowledge between development and operations.

The case study reported in [18] aims to describe how T-Systems MMS decided to embrace digital transformation and took a step towards implementing a DevOps program that would explicitly position the company to gain a foothold in the market for innovative digital services and consulting.

For each performed task reflected in Table 2, the T-Systems MMS project team conducted six sequential phases: Initiation, Planning, Prototyping, Piloting, Roll-out, and Review to ensure the correctness of each transformation task. In the end, a committee decided if the process is ready to move on to the next task. This development, implementation, and evaluation of each task were done in agile sprints (six consecutive phases) [18].

The validation of the CRE4DT approach was done as follows. First, the CRE4DT approach was (successfully) applied in the reported business scenario [18]. Second, the correspondence between the business case transformation process shown in Table 2 [18] and the proposed CRE4DT approach was analyzed. It was identified that all tasks of the business case transformation process reported in [18] can be aligned with the tasks and components of the CRE4DT approach. In addition, it was revealed that the CRE4DT approach describes in more detail the steps that a company interested in digital transformation should follow to perform a successful digital transformation. This is illustrated in Fig. 5. Pink circles with numbers indicate here which transformation tasks from Table 2 correspond to which CRE4DT elements. The number "0|" depicts the tasks which were not reported to be performed in [18].

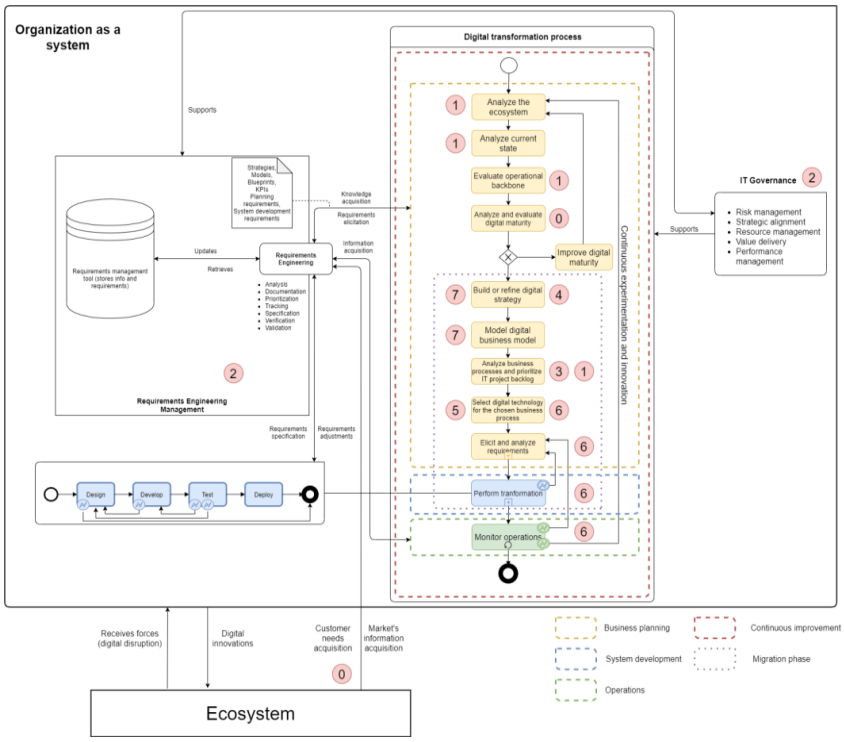

Fig. 5. T-Systems MMS Transformation process compared to CRE4DT approach.

4 Conclusion

The CRE4DT approach answers the research question by showing how continuous requirements engineering can facilitates digital transformation. More specifically, the approach suggests:

- A clear and comprehensive digital transformation process model that works as a guideline in digital transformation.
- Open collaboration and communication between different stakeholders at different phases of the digital transformation process through seamless knowledge sharing.
- Knowledge and requirements documentation for future reusability.
- Continuous interaction with the ecosystem for acquisition of challenges and opportunities of the environment regarding new customer needs.
- Continuous tracking of development and operations phases for rapid responses to changes in the environment and potential incompliant performance of the systems.
- Continuous improvement through iterations of the digital transformation process that ensures the company's continuous improvement.

As already mentioned in the functionality of the proposed CRE4DT approach, it can be used as a guide for end-to-end digital transformation, providing a comprehensive

step-by-step process. In this way, the organization knows the structure of the digital transformation process from the beginning and has the overall picture of the steps that need to be taken. In addition, the approach embraces an attitude of continuity and openness to change. However, it is clearly up to the organization how it develops this attitude. IT Governance is a supporting component of the model that provides additional activities to the process by supporting it on an ongoing basis. One of these activities is resource management, which is responsible for allocating all types of resources to the project as well as defining the various employees' roles required for the project. In addition, resource management, in cooperation with risk management, can prevent undesirable situations, such as problems with the profitability of the organization during the project.

Challenges regarding technology are addressed through open communication and collaboration between different departments and stakeholders in the organization, as well as communication with the ecosystem to obtain information, such as digital technologies involved in the specific market. In addition, a thorough analysis of the operational backbone and a careful definition of the digital strategy are part of the CRE4DT approach. Through these tasks, the organization understands its technical debt and creates the migration plan it must follow to achieve the desired state.

CRE4DT approach uses the requirements engineering management component to communicate with and receive information from the ecosystem. In this way, early detection of ecosystem digital disruptions and changes in customer needs is achieved, providing the organization with timely information about its environment. This continuous communication also provides knowledge about new regulations in the field. Finally, cyber-attacks can be prevented through continuous monitoring and testing of operations and continuous improvement of the operational backbone.

The presented research is associated with some limitations regarding the practical implementation of the model. The model has been validated in the context of a business case that has already occurred and not in a real-time implementation. Therefore, further research directions could be suggested as follows:

- Implementation of the model in real-time scenario.
- Defining requirements for supporting continuous requirements engineering tool.

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