



**UTILIZING THE PRINCIPLES OF DEVOPS OUTSIDE SOFTWARE DEVELOPMENT IN
PUBLIC SECTOR**

Lappeenranta-Lahti University of Technology LUT

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ABSTRACT

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Utilizing the principles of DevOps outside software development in public sector

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Keywords: IT management, DevOps, public sector, action research, maturity model

The digitalization of public services causes needs for change in operations of public sector organizations and especially IT management. This thesis studied DevOps approach, the principles of DevOps and their suitability outside software development. DevOps approach had already been selected by the organization studied.

The challenges of the organization were defined based on two previous surveys and interviews with key people in the organization. The challenges were used to form issues to solve, and they were connected with desired results based on the interviews. The issues were connected with the principles of DevOps and the maturity model of DevOps. Proposed solutions were formed for each issue. Based on these a model was built to utilize the principles of DevOps and DevOps maturity model to define capabilities, achievements, and actions.

Issue cards were produced for the organization as final deliverable. Issue cards included all challenges, desired results, the principles of DevOps, focus areas of DevOps maturity model, and proposed solutions connected to each issue. If proposed solutions of an issue included connection to the principles of DevOps, the achievements were derived through the principles and the desired level of capabilities through the maturity model. These led to the actions on how to achieve them.

DevOps approach was found to be at least partially suitable for solving the issues of the organization also outside software development. The performance of the presented model was not evaluated during the work in the studied organization.

TIIVISTELMÄ

Lappeenrannan-Lahden teknillinen yliopisto LUT

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Software Product Management and Business

Sanna Ahtiainen

DevOpsin periaatteiden hyödyntäminen ohjelmistokehityksen ulkopuolella julkisella sektorilla

Ohjelmistotekniikan DI-työ

63 sivua, 14 kuvaa, 7 taulukkoa ja 3 liitettä

Tarkastaja(t): Professori Kari Smolander ja diplomi-insinööri Soili Haapala

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Julkisten palveluiden digitalisaatio aiheuttaa muutostarpeita julkishallinnon organisaatioiden ja erityisesti tietohallintojen toimintaan. Tässä DI-työssä tutkittiin DevOps toimintamallia, DevOpsin periaatteita ja niiden soveltuvuutta ohjelmistokehityksen ulkopuolelle. Tutkittu organisaatio oli valinnut DevOps toimintamallin käytettäväksi jo ennen tätä työtä.

Organisaation haasteet määriteltiin kahden aiemman kyselyn sekä organisaation avainhenkilöiden haastattelujen perusteella. Haasteista muodostettiin ratkaistavia ongelmia sekä niihin haastattelujen perusteella muodostettuja haluttuja lopputuloksia. Ongelmat kytkettiin DevOpsin periaatteisiin sekä DevOpsin kypsyyssmalliin. Jokaiselle ongelmalle tuotettiin ongelmakohtaiset ehdotetut ratkaisut. Näiden pohjalta rakennettiin malli, kuinka DevOpsin periaatteita ja kypsyyssmallia voidaan hyödyntää kyvykkyyksien, tavoitteiden ja toimenpiteiden määrittämiseen.

Lopputuotoksena organisaatiolle tuotettiin ongelmakortit, jotka sisälsivät kaikki yhteen ongelmaan liittyvät haasteet, halutut lopputulokset, DevOpsin periaatteet, DevOpsin kypsyyssmallin osa-alueet ja ehdotetut ratkaisut. Mikäli ehdotettu ratkaisu sisälsi liitoksen DevOpsin periaatteisiin, periaatteiden kautta johdettiin ongelmaan tavoitteet ja kypsyyssmallin kautta kyvykkyydet halutulla tasolla sekä toimenpiteet näiden tavoittamiseen.

DevOps toimintamallin todettiin soveltuvan ainakin osittain organisaation ongelmien ratkaisemiseen myös ohjelmistokehityksen ulkopuolella. Esitellyn mallin toimivuutta ei arvioitu työn aikana tutkitussa organisaatiossa.

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ABBREVIATIONS

AIOps	Artificial Intelligence (AI) for IT operations
BizDevOps	Combination of business (Biz), development (Dev) and operations (Ops)
BT Standard	Business Technology Standard
CALMS	Culture, Automation, Lean, Measurement and Sharing principles of DevOps
CAMS	Culture, Automation, Measurement and Sharing principles of DevOps
CD	Continuous delivery
CDO	Chief Digital Officer
CDp	Continuous deployment
CI	Continuous integration
CIO	Chief Information Officer
CMMI	Capability Maturity Model Integration
CT	Continuous testing
DevOps	Combination of development (Dev) and operations (Ops)
DOMM	DevOps Maturity Model
DevQOps	Combination of development (Dev), quality (Q) and operations (Ops)
DevSecOps	Combination of development (Dev), security (Sec) and operations (Ops)
EA	Enterprise Architecture
IEC	International Electrotechnical Commission
IT	Information Technology
ITIL	IT Infrastructure Library
ISO	The International Organization of Standardization
ITSM	IT Service Management
NoOps	No operations
PESTLE	Political, Economic, Social, Technological, Legal, and Environmental factors

SAFe	Scaled Agile Framework
SPOC	Single Point of Contact
SRE	Site Reliability Engineering

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1 Introduction

Digitalization has been a topic of discussion in the development of public services for many years (Finnish Ministry of Finance, 2022). Digitalization is expected to transform public services to being more flexible and more efficient for citizens to use when needed regardless of place and time (Finnish Ministry of Finance, 2022). The need for new digital services and the need to develop existing digital services causes increasing need for better understanding of information technology in every level of organization (Business Technology Forum Oy, 2021). The development of digital services and the ever-increasing number of services that are at least partially digital also brings the agile methods more familiar from software development into general service development (Business Technology Forum Oy, 2021). The organization studied was a public sector organization that has needs to utilize digitalization in its operations. These needs require changes from both IT management unit and the whole organization. This thesis focused on the DevOps approach and how it could be utilized in public sector IT management and in solving the issues that studied organization has.

This research arose from the need of the organization studied. The organization had identified the need to study how DevOps approach could be introduced to the organization and whether DevOps approach was the right approach to the organization to solve the issues that organization has. Based on discussions with the organization the first idea was to focus on the change of the whole organization, but after further discussions with the organization and the professor the focus was limited to be on the changes needed inside organization's IT management unit.

There was previous consulting about DevOps done in the organization and the final report of the consultation was utilized in some parts of the thesis. That consulting and its final report were in many ways on higher level and did not give the organization enough information about how to implement DevOps in the whole organization, and what are the next steps or actions to take.

The aim of this research was to study DevOps and its utilization outside software development as the organization studied produces both services in IT operations and the services in IT development. Organization's IT development also includes some software

development projects but software development is not the main service that organization provides. This research problem was approached with research questions:

1. What is DevOps and why is it good?
2. Can DevOps be utilized outside software development, and if it can be utilized, how should it be utilized to get the most out of it?
 - What are the issues in the organization that need to be addressed?
 - Can DevOps be used in solving the issues identified during the investigation?
 - How DevOps principles can be used to solve the issues and how to implement principles?

The research was done with action research approach since the researcher was an insider, and thus action research was considered to be the right approach for the case. The research was limited to the IT management unit of the organization. This delimitation was made to ensure that the thesis could be done in six months and to ensure that IT management unit can in future support the whole organization in the possible change from the beginning on.

Key results of this thesis were materials produced for the organization including basic information about DevOps, issue cards, issue specific achievements and actions to be done in the future. These actions were not fully connected with DevOps and its principles since there were other issues to be fixed before DevOps can be introduced to the organization. For the research community the model on how to connect the principles of DevOps, the DevOps maturity model and their actions with issues that have arisen from the organization was presented.

After this introduction chapter there are chapters that introduce DevOps and why to use it, DevOps in IT management, and the research approach selected with the methods used in this study. Chapter five introduces the needs of the organization and how those needs could be approached with DevOps. The last two chapters are discussion and conclusions.

2 What is DevOps and why to use it?

This chapter describes what is and why to use DevOps. For what is DevOps part there are sections about the definition of DevOps and the principles of DevOps. Some of the principles and one of the variations of DevOps are also presented in more detail in this chapter. For why to use DevOps part there is a section about the aims of using DevOps.

2.1 The definition of DevOps

DevOps term is a combination of two words that refer to different functions of IT management. These words are development (Dev) and operations (Ops). The term DevOps originates to DevOpsDays conference in Gent, Belgium in 2009 (Dörnenburg, 2018). DevOps is not considered to be new approach but rather further development of other concepts like Agile and Lean. Nevertheless, DevOps is rather new concept, and it still lacks a common definition. The International Organization of Standardization (ISO) has initiated a new standard “Agile and DevOps principles and practices” (ISO/IEC TR 24586) in July 2019, but it is still in its development phase. (Alt, et al., 2021)

DevOps can be defined to be development methodology, a conceptual framework or a set of capabilities for engineering processes. DevOps has similarities with Agile methodologies, but there are also differences. Both Agile and DevOps aim to achieve shorter software release cycles. The main difference between Agile and DevOps is that DevOps includes automation of software analysis, regular monitoring and some precise procedures. DevOps also has connections to the cloud computing. Cloud computing can be seen as platform to implement DevOps automation and tool sets. (Hart & Burke, 2020)

DevOps has variations that are more focused on solving individual problems. Some of the more popular variations are DevSecOps and DevQOps for security, SRE for reliability, DOMM for maturity, BizDevOps for business development, and AIOps and NoOps for smart automation (Alt, et al., 2021). DOMM is presented later in this thesis in a section about DevOps maturity.

DevOps is based on five, previously four, guiding principles (Alt, et al., 2021). Hemon, et al. (2019) refer to these guiding principles as core values of DevOps. These principles are presented later in this thesis. Before section about principles there is a section about what are the aims of using DevOps that it is understood what can be achieved with DevOps.

For this thesis, the definition of DevOps is that DevOps is a set of principles that aim for better customer satisfaction by enhancing the cooperation between development and operations. This definition includes the ideas of customer focus and cooperation, and the principles that are the base for DevOps approach.

2.2 The aims of using DevOps

Today the world, especially digital world, changes rapidly. This is caused by three transformational forces that are products to services, efficiency to agility and separation to fusion. These forces put IT functions to almost impossible position in trying to change internal IT solutions to support the yet unknown needs of the business for the future. The classic IT development and IT operations practices cannot deliver what is needed so, they need to change as well. (Ravichandran, et al., 2016)

For classic IT operations teams keeping stability, availability and security on high level is the main priority. This priority makes them prefer mature versions of products and services that have proven to provide the desired level of service. Using only mature versions of products and services might in the long run cause the service provided to no longer meet the needs of the customer or lead to security gaps because used technology is outdated. Even when the risks of this “never touch the system that works” law of the administrators are well-known, they are often ignored by operations managers because of the prioritized requirements of stability, availability, and security. (Alt, et al., 2021; Ravichandran, et al., 2016)

In addition, there are too often problems in communication between development and operations teams that leads to lack of understanding the needs and the priorities of the others. These problems arise from the fact that the work and the responsibility of the development team is completed when the product or service is released to production environment, and the work and the responsibility of the operations team only begins then

(Dörnenburg, 2018). Based on study done among IT experts six highest ranked problems were the lack of involvement of IT operations in the requirement specification, poor communication and information flow between development and operations, lack of emphasis on proper test environment, insufficient knowledge transfer from development to operations that leads to insufficient information about the functionalities of the new system, too early deployment of the system with insufficient test phases, and the lack of operational routines for new system prior to deployment. (Alt, et al., 2021)

DevOps aims to reducing problems mentioned in previous paragraph and thus to improve customer experience and satisfaction. These are done by improving communication and collaboration between development and operations teams. The geometrical curve in Figure 1 visualizes the continuous transition from development processes to operations processes and close collaboration of development and operations functions. Similar infinite curve has also been used to describe other relationships in IT management such as relationship between service level and service process management. (Alt, et al., 2021)

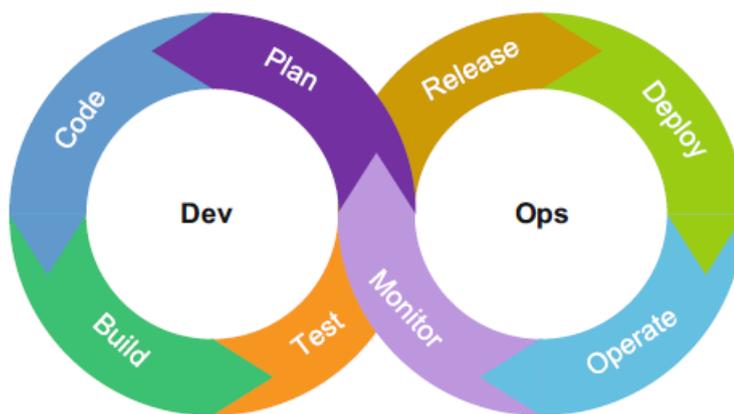


Figure 1. DevOps continuous lifecycle of software delivery and operations (Alt, et al., 2021).

DevOps focuses on removing bottlenecks that prevent fast delivery of solutions (Hemon, et al., 2019). The most important aspect of achieving this is creating the culture of collaboration and increasing automation for example in testing and producing infrastructure (Hemon, et al., 2019). These are part of the guiding principles of DevOps that are presented in next section of the thesis. In addition to culture that supports utilization of DevOps principles there are techniques and technologies that enable deployment of DevOps principles (Dörnenburg, 2018). These techniques or technologies are for example consumer-driven-contract testing, service-oriented architecture, virtualized infrastructure, software-defined

networking, and infrastructure as code (Dörnenburg, 2018). These techniques and technologies enable automation and versioning of different parts of infrastructure and thus ease the changes needed during the development process (Dörnenburg, 2018).

2.3 The principles of DevOps

There are four or five guiding principles of DevOps depending on the source. Sometimes these principles are also referred as core values (Hemon, et al., 2019). The principles are Culture, Automation, Lean, Measurement and Sharing. Lean is the principle that is not mentioned in all sources. Also, the abbreviations CAMS and CALMS are used to describe the principles. The abbreviations are based on the initials of the principles. (Alt, et al., 2021)

The principle of Culture points to the need for cultural change from separate functions to shared responsibility for the quality of delivery (Alt, et al., 2021). In this cultural change the leadership plays a key role when creating and implementing new shared values (Ravichandran, et al., 2016). Cultural change should start with assessment of existing operating models from the perspective of supporting primary business goals (Ravichandran, et al., 2016). The next section of this thesis presents the principle of Culture in more detail.

The principle of Automation reflects the idea of automating deployment phases to achieve faster feedback about the releases to developers (Alt, et al., 2021; Krishna Kaiser, 2018). The base for increasing level of automation is formed by software delivery pipeline that consists of four continuous approaches (Alt, et al., 2021). According to Hemon, et al. (2019) and Krishna Kaiser (2018) viewing infrastructure as code supports the adoption of continuous integration and continuous delivery that are part of delivery pipeline. DevOps delivery pipeline is presented in more detail in later section of this thesis.

The principle of Lean links DevOps to Lean management approach (Alt, et al., 2021). Lean focuses on adding value to the customer, keeping things simple and reducing waste in production process (Krishna Kaiser, 2018). In IT processes the waste is not visible and that makes it hard to be identified and removed. Identifying waste in software lifecycle can be done by using the list of eight elements of waste. These wastes are defects, overproduction, waiting, non-value-added processing, transportation, excess inventory, motion, and unused employee knowledge. (Ravichandran, et al., 2016)

The principle of Measurement is based on the knowledge that an objective assessment of productivity and performance requires measurable metrics and targets (Alt, et al., 2021; Krishna Kaiser, 2018). When developing DevOps metrics, obtainability, reviewability, incorruptibility and actionability of the metrics should be considered (Ravichandran, et al., 2016). DevOps metrics can be divided to four dimensions that are customer and business value, efficiency and effectiveness, quality and velocity, and culture, collaboration and sharing (Ravichandran, et al., 2016). Figure 2 presents four dimensions that Ravichandran, et al. (2016) recommends being used as DevOps metrics and example metrics for all those dimensions.

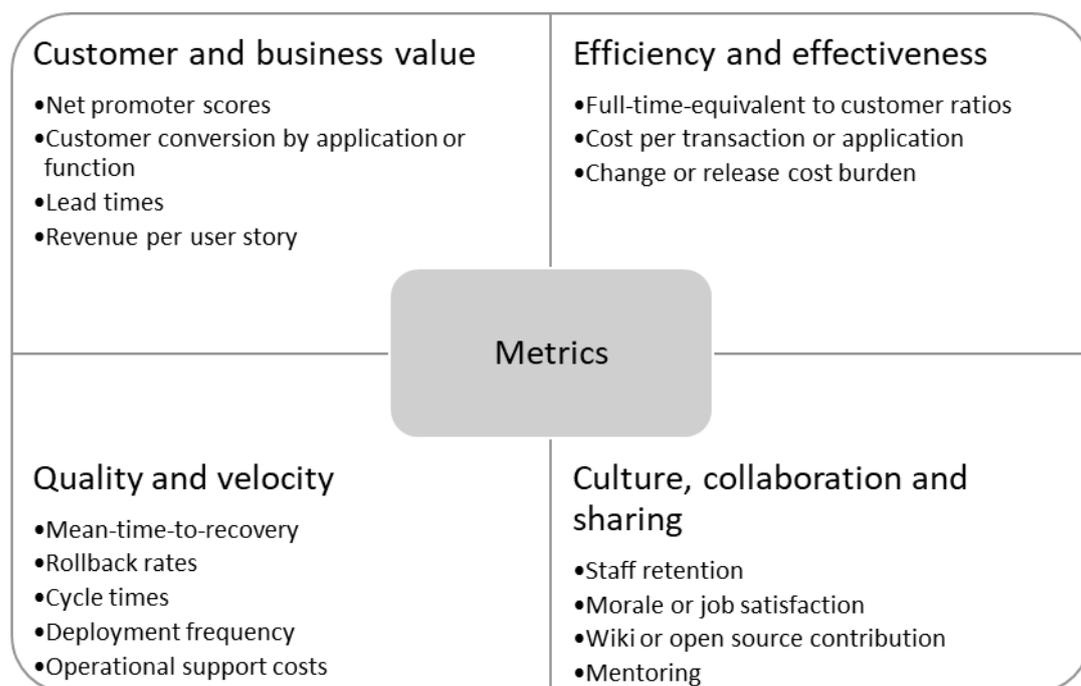


Figure 2. Dimensions and examples of DevOps metrics (based on Ravichandran, et al. (2016)).

The principle of Sharing is the base for collaboration between development and operations which connects it with the principle of Culture. Everyone in the DevOps team needs to have the mindset to share their knowledge, to trust others and their competence, and to respect others (Ravichandran, et al., 2016). Principle of Sharing also includes the ideas of providing necessary training for everyone and providing time for people to explore new tools and technologies and then share their knowledge with others. In addition, this principle encourages people to transfer knowledge from development to operations. (Alt, et al., 2021)

2.4 DevOps culture

"Culture eats strategy for breakfast", said Peter Drucker. This means that the words in strategy do not mean anything if the culture does not support them. DevOps mainly is a cultural change. This kind of change in culture and in people's way of working is a massive process. In DevOps people need to take responsibility of the entire product, not just their own work, innovate and experiment whether the innovations work or not, communicate and collaborate with all teams involved, and remember that they are responsible for what they built. (Krishna Kaiser, 2018)

There are three critical elements of DevOps that enable the cultural change. Figure 3 presents these elements that are people, process, and technology. The overlap of the three circles illustrates the fact that all elements are needed for implementation of DevOps to be successful. People are at the heart of the cultural change. The main objective of cultural change is to achieve shared responsibility of the product between development and operations teams. Processes are the key component of ensuring the success of the development project. For DevOps processes include the continuous approaches of delivery pipeline. Technology delivers the tools for processes to succeed. The right tools for each project depend on the technology that was chosen. (Krishna Kaiser, 2018)

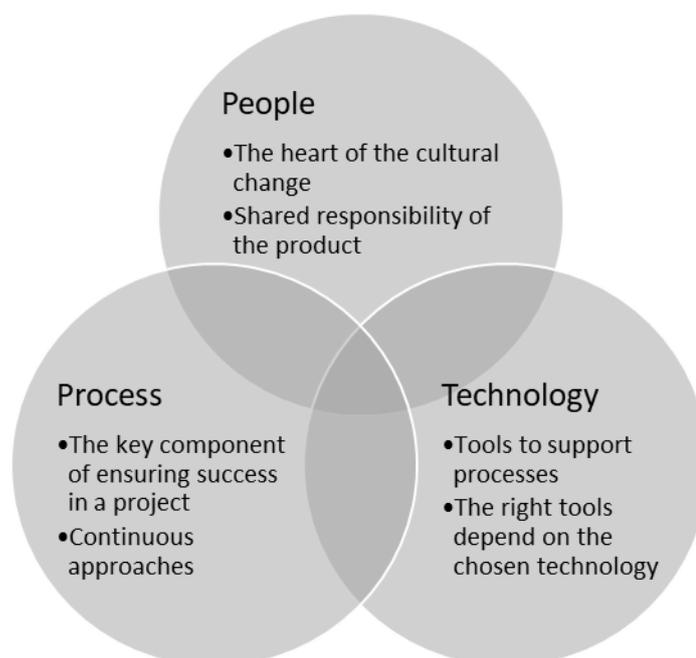


Figure 3. Three critical elements of DevOps (based on Krishna Kaiser (2018)).

DevOps culture connects many things that need to be embraced for implementation to be successful (Verona, et al., 2016; Swartout, 2012). Figure 4 presents these things and how to achieve them. Figure is based on information presented by Verona, et al. (2016).

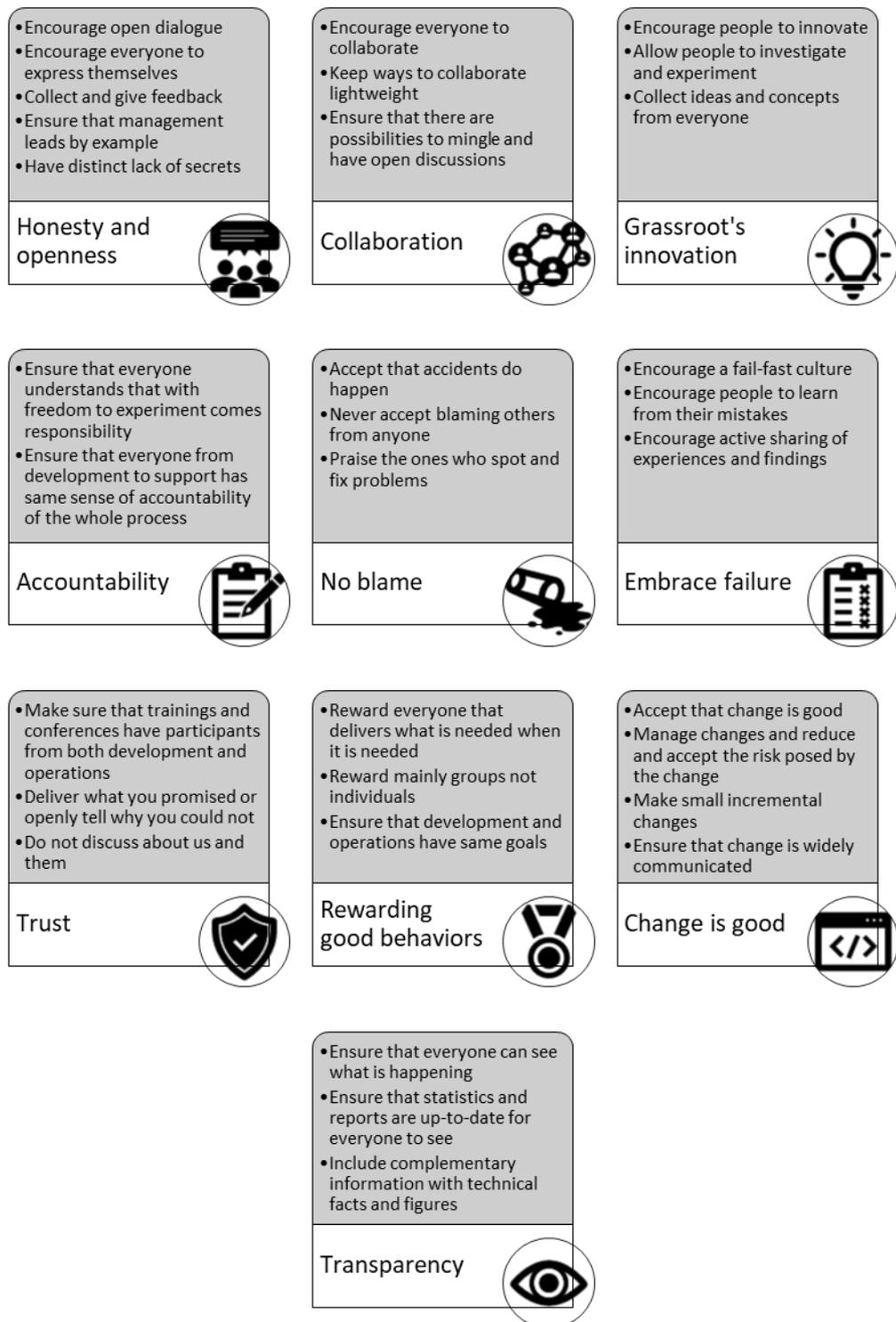


Figure 4. All things connected to DevOps culture and how to achieve them (based on Verona, et al. (2016)).

For organization to allow the needed change in culture it should embrace all things mentioned in Figure 4. These are the things that support transformation from hierarchic, siloed organization to organization utilizing DevOps. The setup of the organization should allow positive behaviour in these things and let this behaviour become the norm of working. Open, honest, and safe environment is the goal pursued by these things. (Verona, et al., 2016)

2.5 Automation with delivery pipeline

DevOps delivery pipeline refers to the origin of DevOps in software development (Alt, et al., 2021). The delivery pipeline is a collection of four continuous approaches (Alt, et al., 2021). These approaches can also be referred as processes (Krishna Kaiser, 2018; Vadapalli, 2017). The approaches are continuous integration (CI), continuous testing (CT), continuous delivery (CD) and continuous deployment (CDp) (Alt, et al., 2021). The goal of delivery pipeline is to keep the delivery flow continuous without bottlenecks (Alt, et al., 2021). Figure 5 presents the phases of deployment process and which phases each continuous approach includes. The differences on how many automated phases approaches include is also visible in the figure.

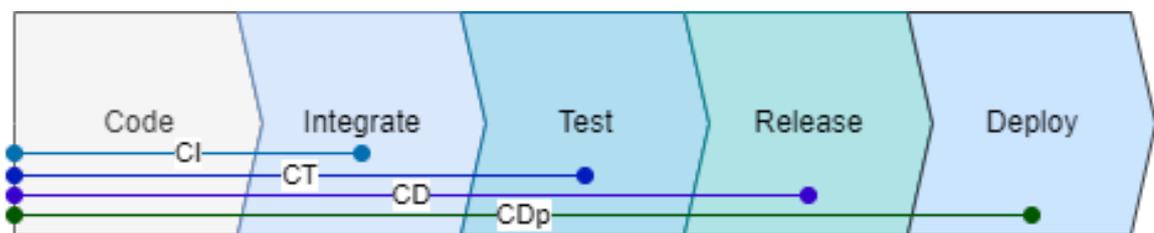


Figure 5. The continuous approaches and phases of deployment process (based on Vadapalli (2017) and Krishna Kaiser (2018)).

CI describes the approach to continuously integrate changes in source code made by individual developers within a common shared source code repository (Vadapalli, 2017; Krishna Kaiser, 2018). The code is continuously tested and deployed, and if errors occur, corrected as early as possible (Alt, et al., 2021; Krishna Kaiser, 2018). To achieve CI there should be a common version repository, scheduled code check, automated test and build, and possibility to deploy to preproduction environment (Vadapalli, 2017).

CT follows CI in delivery pipeline process (Krishna Kaiser, 2018). Keeping it as separate approach emphasizes the importance of the quality of software developed highlighted by DevOps principles (Alt, et al., 2021). The idea behind this approach is to automate testing and thus decrease the need for manual testing (Vadapalli, 2017). CT means that there are no manual phases in testing process, but the execution of tests continues automatically if test passes and the execution is terminated if test fails (Krishna Kaiser, 2018).

CD includes automated process from CI and CT to releasable version in preproduction environment but the last phase of releasing version to production environment is manually triggered. CD makes it possible for organization to have gate between preproduction and production environments and only approved changes pass to production environment. (Krishna Kaiser, 2018)

CDp includes all automated phases of CD and in addition the automated deployment to production environment (Krishna Kaiser, 2018). Deployment in DevOps means the phase where software is commissioned to production environment (Alt, et al., 2021). CDp is not the approach for all organizations because there might be need for structured approvals in changes to production environment (Krishna Kaiser, 2018).

2.6 Roles, skills, and competences required in DevOps

DevOps team is a cross-functional team that consists of roles supporting development and operations of an application (Krishna Kaiser, 2018). If the application is complex, there might be need for several DevOps teams that support development and operations of certain logical parts of the application (Krishna Kaiser, 2018). DevOps team consists of product owner, Scrum master, developers, testers, architect, security engineer and system engineer or system administrator (Alt, et al., 2021). In addition, there can be other roles too such as database administrator, application support and service manager (Krishna Kaiser, 2018).

Product owner represents the business organization and is responsible for the management of the product backlog (Krishna Kaiser, 2018). The role is essential and the person who has the role, needs to understand business needs, and lead the development of the application in the direction that is most beneficial for business (Hemon, et al., 2019). Product owner is

manager role in business and not project management role in such even though there are many similarities with product owner and project manager roles (Hemon, et al., 2019).

Scrum master leads the DevOps team (Krishna Kaiser, 2018). Scrum master ensures that the team follows Scrum rules and removes obstacles that slowdown or prevent the work of the team (Alt, et al., 2021). Scrum master needs to understand Scrum process, have good collaboration skills within and outside the DevOps team, and be able to support and coordinate DevOps team (Alt, et al., 2021).

Architect is usually shared role across multiple DevOps teams because it is not a full-time role for a team (Krishna Kaiser, 2018). Architect designs the application, and the role is either a technical, a software or a functional architecture role (Hemon, et al., 2019). There can also be separate cloud architect who defines cloud architecture and helps in implementation of delivery pipeline in the cloud (Alt, et al., 2021).

Developer or developers are responsible for coding and unit testing of the application. Tester or testers are responsible for developing and executing functional and non-functional tests. Security engineer's responsibility is IT security management. System engineer or system administrator configures and manages tools used in development. (Krishna Kaiser, 2018)

Working in IT-related jobs require both technical and non-technical skills for successful outcome. Technical skills are also referred as hard skills and non-technical as soft or behavioural skills. Technical skills include systems, coding and programming languages, software engineering, architecture, testing, quality and security, release management, management, and negotiation. Non-technical skills are communication, courtesy, flexibility, integrity, interpersonal skills, positive attitude, professionalism, responsibility, teamwork, and work ethic. (Hemon, et al., 2019)

Vadapalli (2017) presents DevOps process that includes many of previously mentioned technical skills and Verona, et al. (2016) presents things connected with DevOps culture that include many of previously mentioned non-technical skills. Table 1 present some of the roles in DevOps team, responsibilities and focuses of the roles, and skills needed for each role.

Table 1. Roles, responsibilities, and skills needed (based on Krishna Kaiser (2018), Alt, et al. (2021) and Capgemini (2018)).

Role	Product owner	Scrum master	Developer	Architect	Security engineer	System engineer
Responsibility	Product backlog management	DevOps team management	Coding and unit testing	Designing application	Security management	Configuring and managing tools
Focus	Business and product development	DevOps processes and culture	Application development	Application engineering	Application security	Availability of environments
Non-technical skills	■ ■ ■ ■ □	■ ■ ■ ■ ■	■ ■ ■ ■ □	■ ■ ■ ■ □	■ □ □ □ □	■ ■ ■ ■ □
Technical skills	■ □ □ □ □	■ □ □ □ □	■ ■ ■ ■ ■	■ ■ ■ ■ ■	■ ■ ■ ■ □	■ ■ ■ ■ ■

■ □ □ □ □ acceptable ■ ■ □ □ □ average ■ ■ ■ ■ □ good ■ ■ ■ ■ ■ excellent

It can be seen from Table 1 that needed technical and non-technical skills levels depend on the role of the person. Developer, architect, system engineer and security engineer need more technical skills which is not that important for product owner and Scrum master. Only security engineer of presented roles does not need that much non-technical skills. The skill levels shown in the Table 1 verify Hemon, et al. (2019) suggestion that non-technical skills can in some roles be more important than technical skills.

2.7 DevOps maturity

When an organization needs to know the current state of its operations, to determine the desired future state and to find out how to get from the current state to the desired state, they use maturity model to determine those (Alt, et al., 2021). There are many different DevOps maturity models (DOMM) (de Feijter, et al., 2017). The base for first versions of DOMM is Capability Maturity Model Integration (CMMI) (Alt, et al., 2021).

CMMI includes maturity levels from 0 (Incomplete) or 1 (Initial) to 5 (Optimizing) (Alt, et al., 2021). Similar five (from 1 to 5) or six level (from 0 to 5) model is quite common in different DevOps maturity models (de Feijter, et al., 2017). De Feijter, et al. (2017) prefer the model to have more levels than CMMI model includes because it helps to define smaller steps of growth to reach wanted maturity level. De Feijter, et al. (2017) present DOMM that includes three perspectives, sixteen focus areas and 63 capabilities. Each focus area includes 2-6 capabilities that are divided to eight maturity levels (de Feijter, et al., 2017). Figure 6 presents these perspectives, focus areas and capabilities, and their maturity levels.



Figure 6. Focus areas and resulting capabilities of different perspectives in maturity model of de Feijter, et al. (2017).

The maturity model from de Feijter, et al. (2017) is based on different studies and the idea has been further developed in a study with a software company. Three perspectives in it are Culture and collaboration, Product, process, and quality, and Foundation. Culture and collaboration perspective includes the focus areas of Communication, Knowledge sharing, Trust and respect, Team organization, and Release alignment. Product, process, and quality perspective includes the focus areas of Release heartbeat, Branch and merge, Build automation, Development quality improvement, Test automation, Deployment automation, Release for production, and Incident handling. Foundation perspective includes the focus areas of Configuration management, Architecture alignment, and Infrastructure. (de Feijter, et al., 2017)



Figure 7. DevOps maturity lifecycle phases.

Achieving desired state of maturity is a process that needs to be planned with care. Figure 7 presents the phases of DevOps maturity lifecycle. First two phases include collecting information about current state and DevOps in general, and agreeing target state, tools, and processes to be implemented with timeline and cost of the project. After information collection and agreement of targets there is time for the implementation project itself with development, deployment, and monitoring phases. (Vadapalli, 2017)

3 DevOps in IT management

This chapter focuses itself to IT management. The most used IT service management framework IT Infrastructure Library (ITIL) is shortly presented. Last section of the chapter focuses itself to figuring out how DevOps is connected to different IT management frameworks.

3.1 IT management in public sector

IT management has two meanings which are the IT management as an area of responsibility, and the IT management as a unit that performs IT management tasks. The leader of IT management is usually Chief Information Officer (CIO). In addition, digital transformation has led to the role of Chief Digital Officer (CDO) which either is complementary or superior role in comparison to CIO's role. (Alt, et al., 2021)

IT management can be divided to strategic and operational IT management where strategic part has long-term and operational part short- to medium-term horizon. Strategic part delivers guidelines and initiatives, and operational part implements tasks according to those guidelines. For IT management to be successful there needs to be close relationship and open communication between strategic and operational IT management. (Alt, et al., 2021)

Digital transformation has expanded responsibilities of IT management from technology maintenance function to IT innovation and business development function. This means that the role of IT management in general and especially CIO is more strategic than before. It is suggested that IT management should adapt Agile approaches to be able to utilize capabilities of individual employees in this change of role and function. Also, Enterprise Architecture (EA) has been suggested to be used to manage and simplify increasing complexity of changing environment. (Ylinen, 2021)

In public sector there are laws, regulations and recommendations that guide operations also in IT management. In addition, there is a political dimension to decision-making that may present challenges in situations of change. There might also be challenges in achieving the

organizational flexibility needed for digital transformation in public sector organizations. (Ylinen, 2021)

In addition to the laws, regulations and recommendations, government program of current government has led to the programme for the promotion of digitization that was set by the Finnish Ministry of Finance. The programme aims for high-quality digital public services that are available to citizens and businesses. Another aim is that the use of digital services is primary to non-digital services. (Finnish Ministry of Finance, 2020)

3.2 IT Infrastructure Library (ITIL)

The IT Infrastructure Library (ITIL) is commonly used framework for delivering IT services. ITIL is at its fourth version which was announced in 2017 and was released in 2019. For the newest version ITIL was changed to meet the needs of digital age and agility. The history of ITIL starts in the late 1980s with the first version, second version was introduced in 2000, and the third version in 2007. The third version was embraced by almost every IT organization. (Krishna Kaiser, 2021)

There are many changes in the fourth version of ITIL, ITIL 4, compared to the third version of ITIL, ITIL V3. One of these changes is the change in definition of service. In ITIL 4 the definition includes the idea of co-creation which means that the customer who uses the service gives feedback and directions to receive value from the service. In addition, ITIL 4 introduces principles and next level of automation. (Krishna Kaiser, 2021)

ITIL 4 defines certain concepts of IT service management and IT service management itself. These concepts are for example services, products, organizations, and people roles. In addition, ITIL 4 defines values, service offerings, and service relationships. These concepts, values, and others form the core foundation of ITIL 4. (Krishna Kaiser, 2021; Agutter, 2019)

ITIL 4 defines four dimensions that are the components of service. These dimensions are Organization and people, Information and technology, Suppliers and partners, and Value streams and processes. Although these dimensions are indicated as separate entities, there is grey area between dimensions and things that utilize several dimensions. ITIL 4 also includes six external factors that can influence products and services. These factors are

Political, Economic, Social, Technological, Legal, and Environmental factors that are also preferred with acronym PESTLE. (Krishna Kaiser, 2021; Agutter, 2019)

The guiding principles of ITIL 4 are Focus on Value, Start Where You Are, Progress Iteratively with Feedback, Collaborate and Promote Visibility, Think and Work Holistically, Keep it Simple and Practical, and Optimize and Automate. Guiding principle is defined as recommendation that guides an organization. These principles are in many ways similar to Agile manifesto, and they also connect ITIL 4 with DevOps. (Krishna Kaiser, 2021; Agutter, 2019)

ITIL 4 practices are categorized into three parts that are general management, service management and technical management practices. General management includes fourteen practices, service management seventeen practices, and technical management three practices. These practices also include Service Desk whose purpose is to function as the Single Point of Contact (SPOC) for the users. The full definition of service desk practice in ITIL 4 is in citation below. (Krishna Kaiser, 2021; Agutter, 2019)

“The purpose of the service desk practice is to capture demand for incident resolution and service requests. It should also be the entry point and single point of contact for the service provider with all of its users.” (Krishna Kaiser, 2021; Agutter, 2019)

The role of service desk is integral in ITIL 4 (Krishna Kaiser, 2021). It is different practice compared to the others of ITIL 4 as it is rather people-led than process-led practice (Krishna Kaiser, 2021). Petersen’s (2019) article “It Takes an IT Village to Raise a Service Desk” raises the awareness that the service desk is not just the responsibility of employees in service desk but also others have the responsibility to help and raise the service desk. Only this makes it possible for service desk to be successful (Petersen, 2019).

3.3 DevOps principles in IT management

This section shortly presents three IT management frameworks and their connection to the DevOps. These frameworks are ITIL 4, Business Technology Standard, and IT4IT.

According to Krishna Kaiser (2021) the newest ITIL version's principles are similar to Agile manifesto. If these principles are compared to the principles of DevOps, many similarities can be noticed. Every guiding principle of ITIL 4 can be connected to the principles of DevOps. The connections are for example Focus on value and Keep it simple principles from ITIL 4 can be connected to the principles of Lean from DevOps, and Progress Iteratively with Feedback, Collaborate and Promote Visibility, and Think and Work Holistically principles from ITIL 4 can be connected to the principle of Culture from DevOps.

Agility is also included in Business Technology Standard (BT Standard) that is another framework of IT management. BT Standard is on its fourth version that was introduced in 2019 and it focuses on getting business and technology closer to each other since technology is nowadays everywhere and the role of IT management thus changes. The goal of BT Standard is to provide guidance on how to manage IT in the organization with adequate governance but still utilizing Agile development methodologies such as SAFe and DevOps. ITIL can also be utilized when using BT Standard framework. There are two ISO standards that are connected to IT management. These are ISO/IEC 20000 for IT service management and ISO/IEC 38500 for IT governance. In addition, there is ISO 21500 standard for project management. These three standards are taken into account in BT Standard framework. (Business Technology Forum Oy, 2021)

There is also IT4IT framework for managing digital enterprise. IT4IT is a reference architecture that is presented as value chain that produces efficiency and agility. IT4IT framework can be utilized together with other frameworks, and it is complementary to the best practices of IT industry. One of the proposed key values in IT4IT framework is building a collaborative culture between IT operations and IT development to improve service releases. That is one thing that DevOps is also aiming to. (The Open Group, 2017)

All presented IT management frameworks either have taken agility and different agile methodologies into account or are directly connectable to the Agile manifesto or the principles of DevOps. This makes it possible to utilize both an IT management framework that organization chooses and DevOps with its principles. Collaboration between different IT functions, and between IT and the customer including the end users is emphasized in all these frameworks.

4 Research approach and methods

This chapter introduces selected research approach that is action research. In addition, the phases of the study and how action research is applied in this research are presented.

4.1 Action research

Traditional change models might not provide the respond needed in today's complex change processes. Action research is an alternative approach to engage members of the organization to the change. Action research done by an insider can develop the organization's capabilities to guide and lead the change. This insider action research gives the organization a way to embed mechanisms for continuous learning to the organization. (Coghlan & Shani, 2020)

Action research is rather a class of research approaches, not one monolithic research method. There are many forms of action research, but they all have four common characteristics. Action research is action and change oriented, it has a problem focus, there is systematic and possibly iterative process and collaboration among participants. When action research is done in information system domain four aims can be distinguished. These are the aim of increasing understanding of complex and multivariate social situations, the aim of assisting in practical problem solving and increasing scientific knowledge, the aim of enhancing competencies of researchers and other respective actors, and the aim of understanding the process of change in social systems. (Baskerville, 1999)

Action research process has two stages. The stages are the diagnostic stage and the therapeutic stage. Figure 8 presents these stages and what the stages include. In the first stage the social situation is analysed in collaboration with the researcher and the subjects of the research. In addition, theories of the research domain are formulated. In the second stage changes are experimented and the effects of the changes are studied. (Baskerville, 1999)

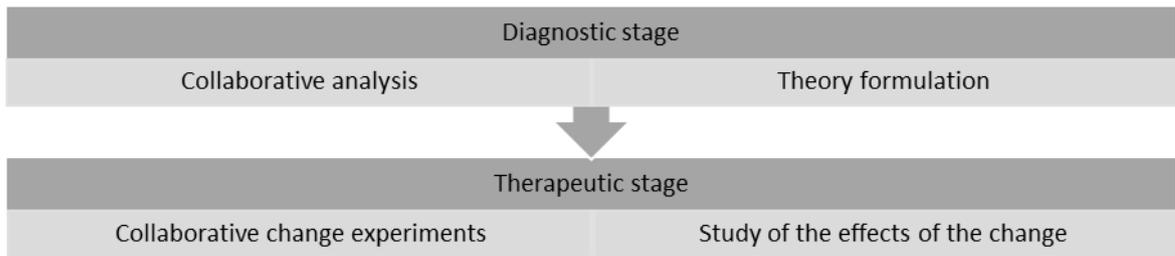


Figure 8. Stages of action research (based on Baskerville (1999)).

For action research an industrial context for the work, object to be changed, what in the object needs to be changed and what kind of effect is expected from the change, and success and failure criteria of the change needs to be defined (Staron, 2020). Action research can be defined as cyclical, five phase process (Baskerville, 1999; Staron, 2020). This process or cycle is introduced in Figure 9. Every research cycle starts from the diagnosing phase (Staron, 2020).

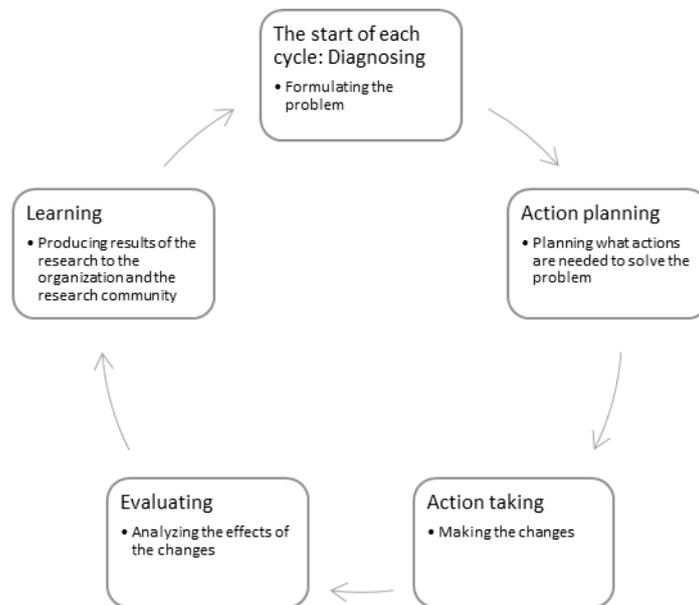


Figure 9. Action research cycle (based on Staron (2020) and Baskerville (1999)).

The goal of the diagnosing phase is to formulate the problem that is going to be solved in this research cycle. The action planning phase is collaborative activity to find the ways to solve the problem and plan the actions needed. In the action taking phase the planned actions are performed and the changes needed are made. After changes are made the effects of the changes are evaluated in the evaluating phase. The last phase of the research cycle is the learning phase in which the results of the research are produced for the

organization and for the research community. These results might be instructions or guidebooks for the organization, and scientific papers to the research community. (Staron, 2020)

Conducting action research can pose challenges to the researcher. This is caused by the dual role of the researcher as they act both as the researcher and as the member of the organization studied. Understanding and addressing the challenges requires researcher to be able to keep a sufficient distance from the subject studied when it is needed. (Coghlan & Shani, 2020)

4.2 Phases and the content of the study

Action research consists of two stages that are diagnostic and therapeutic stage (Baskerville, 1999). The research for this thesis includes only the diagnostic stage of action research, as a maximum period of six months has been reserved for the research. Diagnostic stage includes collaborative analysis and theory formulation parts (Baskerville, 1999). The cycle of action research includes five phases (Baskerville, 1999; Staron, 2020) and the diagnostic stage is in this study divided to include all those phases.

4.2.1 The diagnosing phase

The meaning of the diagnosing phase is to formulate the problem to be solved in the research cycle (Staron, 2020). This phase was implemented in collaboration with the studied organization, and it produced basic ideas for research questions of this thesis.

The use and implementation of DevOps approach was selected by the organization to be studied further. A final report about DevOps consulting was made in December 2018 and it was utilized in some parts of this thesis. The need of the organization was clarified in discussions with two different managers. The first idea was to focus on the change of the whole organization, but after further discussions the focus was limited to be on the changes needed inside organization's IT management unit. This delimitation was made to ensure that the thesis could be made in six months and to ensure that IT management unit can in the future support the whole organization in the possible change from the beginning on.

The unit that is being studied is the IT management unit of a division in a public sector organization. The IT management unit is divided to four subunits that are ICT development, ICT systems, ICT infrastructure and ICT procurement. These units employ a total of 70 - 80 ICT specialists with different areas of expertise and responsibilities. If the units mentioned are divided by the functions in DevOps, ICT development unit is responsible for the development function and ICT systems and ICT infrastructure for the operations function. ICT procurement unit acts as support function for other ICT units.

The goal of this action research cycle is to find answers to three questions that are sub questions for the second research question of this thesis:

1. What are the issues in the organization that need to be addressed?
2. Can DevOps be used in solving the issues identified during the investigation?
3. How DevOps principles can be used to solve the issues and how to implement principles?

How these questions were approached in this study is presented in the following subsection. Answers to the questions are presented in Organization's needs chapter of the thesis.

4.2.2 The action planning phase

The action planning is a collaborative phase that's goal is to find the ways to solve the problem and plan the actions needed (Staron, 2020). This phase focused on planning how to find answers to the questions raised in diagnosing phase. The deliverable from this phase was presented in form of the project plan for the thesis.

The first sub question "What are the issues in the organization that need to be addressed?" was planned to be approached by reviewing materials from two surveys made in organization at the end of year 2021. These surveys are the well-being survey for the employees and the customer survey for internal customers. In addition, the key people of the IT management unit were planned to be interviewed. Based on these materials collected, the issues in organization's operations could be identified.

The second sub question “Can DevOps be used in solving the issues identified during the investigation?” was planned to be approached by achieving sufficient knowledge of DevOps and its principles. After issues had been identified and the knowledge of DevOps was sufficient, the review whether DevOps is the right approach to use to solve these issues or not could be done. This would be the phase when the second question could be answered.

The third sub question “How DevOps principles can be used to solve the issues and how to implement principles?” relates to the second question so that the matter could only be assessed when the answer to the second question was yes. This point would lead to proposals for action on how to introduce DevOps principles to the organization in the future.

4.2.3 The action taking phase

In the action taking phase the actions that were planned in action planning phase are performed (Staron, 2020). For this case changes themselves are not made in the organization but changes needed in the future are identified. Six actions were identified to be done in this phase. These actions are presented shortly in this subsection.

The first action was to achieve sufficient knowledge of DevOps and its principles. For this action, the material about DevOps was searched from LUT Primo with keywords “DevOps” and “DevOps principles”. In addition, for the substantive reasons of the thesis, material about IT management and IT service management was searched with keywords “IT management”, “IT service management”, “ITIL” and “ITSM”, and material about action research was searched with keyword “action research”. Only online materials were considered since the Covid-19 situation still existed when the work for the thesis began.

The second action was to review materials from the well-being survey for the employees and the customer survey for internal customers made in organization at the end of year 2021. The results of the questions in these surveys were transformed to a value out of ten scale since the different questions had different scales and thus the results were not directly compatible. The questions were combined into one table and the values of the normalized results were arranged from smallest to largest, so the question with the weakest result was uppermost. Then only fifteen weakest results were selected for further analysis.

The third action was to interview the key people of the IT management unit. This was done in April 2022. The questions for the interviews were based on knowledge of action research and what needs to be defined to be able to make the changes. The first question was about challenges in the organization, and it was based on idea to precisely define, what is it that is wanted to be changed. The second question about desired results was based on the idea to define what kind of effect is expected from the change. All people interviewed in different phases of the research cycle are listed to Table 2. In addition to interviewee numbers, Table 2 includes time of the interview, role of the interviewee and the phase of the research cycle.

Table 2. List of the interviews

Interviewee	Time of the interview	Role	Research phase
1	April 2022	Manager, ICT development	The action taking
2	April 2022	Manager, ICT procurement	The action taking
3	April 2022	CIO	The action taking
4	April 2022	Manager, ICT infrastructure	The action taking
5	April 2022	Manager, ICT systems	The action taking
6	May 2022	CIO of other public sector organization	The evaluating

The fourth action was to identify the issues in organization's operations based on actions two and three. This was done by combining the fifteen selected questions from the two surveys analysed and the challenges raised from the interviews. Altogether ten issues were identified with connections to desired results that were also raised from the interviews.

The fifth action was to review whether DevOps is the right approach to use to solve these issues or not. This was done by connecting identified issues with the focus areas from the DevOps maturity model and identifying proposed solutions to each issue. If proposed solution included all the principles of DevOps, DevOps could be considered to be the right approach. In other cases, the correctness of the chosen approach had to be considered.

The sixth action was to deliver a model or proposals for measures how DevOps could be utilized in the development of the unit's internal operations. The base for this action was done in other actions. In this action the principles of DevOps connected to the proposed solutions and the focus areas from DevOps maturity model connected to the issues were turned into achievements to be reached and actions to be done in the future, and the model on how this process is done was produced.

4.2.4 The evaluating phase

After action taking phase the effects of the change are evaluated in the evaluating phase (Staron, 2020). In this research cycle the evaluating phase includes the introduction of the proposed solutions, the achievements and the actions identified in the action taking phase. Evaluation was done both with an expert outside the organization, and with the interviewed managers of the organization's IT management unit.

Evaluating was done as couple of separate rounds. First the issue cards with proposed solutions were evaluated with an expert outside the organization, and after little corrections these materials were presented to the interviewed managers to be evaluated. The only improvement proposal from the interviewed managers concerned the prioritization of the issues identified and thus the prioritization of the proposed solutions and actions to be taken to be able to achieve desired results.

Before any actions are taken, the success/failure criteria for these actions must be defined (Staron, 2020). This part has not been done in this thesis since the timeframe for thesis work was limited. The defining success/failure criteria requirement is part of evaluation of the action where the impact of action must be evaluated and learning from the action must be done (Staron, 2020). There is also need for understanding how to diagnose the next action research cycle or how to finish the action research project (Staron, 2020).

4.2.5 The learning phase

The aim of the learning phase is to produce results of the research for the organization and for the research community (Staron, 2020). For this research cycle the results are this thesis and materials produced for the organization including basic information about DevOps, issue cards, issue specific achievements and actions to be done in the future.

For the research community the most visible result was this thesis. Ideas on what to research in the future are presented in addition with lessons learned from this research. Also, the idea for a model on how to connect the principles of DevOps, the DevOps maturity model and their actions with issues that have arisen from the organization was presented.

The actions based on the model are possibly taken in the studied organization after thesis has been completed.

For the organization that was studied this work provided ideas for the next steps and actions to take to develop their operations. These steps and actions were not fully connected with DevOps and its principles since there were other issues to be fixed before DevOps can be introduced to the organization. Also, the knowledge on DevOps and how it could be utilized was increased within the organization.

5 Organization's needs

This chapter introduces the analysis done to figure out the needs of the organization and whether DevOps could be used to develop the operations of the organization. In addition, this chapter introduces the model that could be used to introduce DevOps approach to the organization.

5.1 Analysing the organization

To be able to identify the needs of the organization and issues in the organization material of three previous analysis done in the organization were studied. The material consisted of results of two surveys from 2021, well-being survey for the employees and customer survey for internal customers, and the final report of DevOps consulting from 2018. In addition, interviews of the key people in the IT management unit were conducted in 2022. Next subsections present the material from the earlier analysis and the interviews done for this thesis, and how their results compare to DevOps approach.

5.1.1 Analysing the two surveys

The well-being survey for the employees was conducted in the organization at the end of 2021 (HR unit, 2021). The results of the survey for the IT management unit were studied as a part of this thesis. The survey had several questions, but for this thesis only the questions with weak results were selected. The results were considered to be weak if they were marked with red or light red colour by the analysts of the survey. All these selected questions are presented in Appendix 1. Result of each question was transformed to a value out of ten scale since the different questions had different scales and thus the results were not directly compatible. The values of the normalized result were arranged from smallest to largest, so the question with the weakest result was uppermost. Table in Appendix 1 also includes connection of the questions to the principles of DevOps.

Reviewing connections between questions in the table in Appendix 1 and the principles of DevOps, the principle of Culture is connected to almost every question, the principles of Lean and Sharing to six questions and the principle of Measurement to five questions. The

principle of Automation has no connections to the questions in the survey as was expected based on the nature of the survey.

The customer survey for internal customers was conducted in the organization at the end of 2021 (Business development unit, 2021). The results of the survey for the IT management unit were studied as part of this thesis. The questions and their results are presented in Appendix 2. Weighted average result of each question was transformed to a value out of ten scale since there was need to be able to compare results with the results from the well-being survey for the employees. The values of the normalized result were arranged from smallest to largest, so the question with the weakest result was uppermost. Table in Appendix 2 also includes connection of the questions to the principles of DevOps.

Reviewing connections between questions in the table in Appendix 2 and the principles of DevOps, the principle of Culture is connected to every question, the principles of Lean and Measurement to six questions and the principle of Sharing to five questions. The principle of Automation has no connections to the questions in the survey as was expected based on the nature of the survey.

The results of the two surveys are combined to Table 3. Only fifteen questions with smallest normalized result are left to the table. Questions in need of most development are connected to services that IT management unit produces or acquires (Q1, Q2, Q3, Q5, Q10, and Q13), cooperation (Q4, and Q6), transparency (Q7, Q9, Q11, and Q14), and employee experience (Q8, Q12, and Q15).

Reviewing connections between questions in Table 3 and the principles of DevOps, the principle of Culture is connected to every question, the principle of Lean to eight questions (Q1, Q2, Q3, Q5, Q6, Q10, Q11, and Q14), the principle of Measurement to six questions (Q1, Q2, Q5, Q9, Q10, and Q13) and the principle of Sharing to six questions (Q3, Q4, Q9, Q11, Q13, and Q14). The principle of Automation has no connections to the questions. Every question could be connected to at least one of the principles of DevOps. In average a question could be connected to 2,33 principles. Further analysis of the issues raised from the questions is presented in later section of the thesis.

Table 3. Combined results of the two surveys done.

Question	Normalized result	The principles of DevOps				
		Culture	Automation	Lean	Measurement	Sharing
Q1. ICT procurement is flexible and effortless.	3,34	x		x	x	
Q2. ICT support runs flexibly and effortlessly.	4,55	x		x	x	
Q3. Reachability - I can easily find the right specialist to serve me.	4,71	x		x		x
Q4. Involvement and cooperation - The service is a partner for us who listens to us and develops practices together with us.	4,71	x				x
Q5. The service promise - The service promise "We will respond to our customers' contacts within two business days" has been fulfilled.	4,71	x		x	x	
Q6. Cooperation between the different units is fluent.	5,38	x		x		
Q7. All parties involved are represented in decision-making.	5,56	x				
Q8. The decisions made are consistent (the rules are the same for everyone).	5,82	x				
Q9. The effects of decisions are monitored and communicated.	5,82	x			x	x
Q10. The information systems that are essential to my work, work reliably.	6,06	x		x	x	
Q11. I have received enough information from development of the new information system.	6,19	x		x		x
Q12. When you think about the changes in your work in last year, how would you describe the situation from your point of view?	6,24	x				
Q13. Cyber security issues are well taken care of.	6,42	x			x	x
Q14. In our work community, we promote a culture of addressing, speaking, and acting in the event of deviations from commonly agreed practices.	6,53	x		x		x
Q15. I get enough support from my supervisor to succeed at work.	6,56	x				
Total		15	0	8	6	6

5.1.2 Analysing the interviews

Interviews of the key people of the organization's IT management unit were done in April of 2022 as online interviews that were recorded and transcribed via the meeting solution. The online meeting solution's speech recognition worked quite well even when the support for Finnish language was still on preview phase. The people interviewed were the managers of the IT management unit and its subunits which makes a total of five people (interviewees

1 - 5). Before interviews were conducted, the thesis was shortly presented in a meeting of the managers of the IT management unit.

The interview consisted of informal discussion around two questions or topics. These questions were:

1. What are the challenges in IT management? What are the things you want to improve?
2. What should be changed / improved on these issues? What are the desired results of the changes?

These questions were selected based on the selected research approach and its diagnosing phase. The goal of the first question was to define what is wanted to be changed and the goal of the second question was to define what kind of effect is expected from the change. During the interview, further specific questions were asked according to the need and the situation. An hour was reserved for each interview, and the interviews lasted from 37 minutes to 1 hour 8 minutes where average duration was 51 minutes. In addition to the two questions presented in the interviews, before starting to make the change, there is the need to define success/failure criteria for the change. Defining these criteria was not done in the interviews since the interviews had a different purpose at this point.

Table 4 introduces the challenges identified from the interviews and their connection to the principles of DevOps. Reviewing connections between challenges and the principles of DevOps, the principle of Culture is connected to twelve challenges (C1, C2, C3, C6, C8, C11, C12, C13, C14, C17, C18, and C19), the principle of Automation to one challenge (C13), the principle of Lean to thirteen challenges (C2, C4, C5, C8, C9, C11, C13, C15, C16, C17, C18, C19, and C20), the principle of Measurement to one challenge (C18) and the principle of Sharing to six challenges (C1, C2, C3, C5, C7, and C12). All but one challenge could be connected to at least one of the principles of DevOps. In average a challenge could be connected to 1,65 principles.

Table 4. Challenges and their connection to principles of DevOps.

Challenge	Number of mentions	The principles of DevOps				
		Culture	Automation	Lean	Measurement	Sharing
C1. Not enough cooperation between different units	5 / 5	x				x
C2. Shortcomings in the flow of information inside and outside unit	5 / 5	x		x		x
C3. A manager-centric culture	4 / 5	x				x
C4. The lack of resources, for example no time to develop subunit's internal operations	4 / 5			x		
C5. The lack of documentation and common ways to do things, for example the lack of project model	4 / 5			x		x
C6. The lack of responsibility for the provided service or change of service	4 / 5	x				
C7. Shortcomings in the ability to see the whole picture	2 / 5					x
C8. The lack of coordination between different functions	2 / 5	x		x		
C9. Defects in the conceptualization of ICT support	2 / 5			x		
C10. Staff turnover, problems in recruiting	2 / 5					
C11. Too much division into different areas of responsibility	2 / 5	x		x		
C12. "Knowledge is power" culture	2 / 5	x				x
C13. The lack of agility	1 / 5	x	x	x		
C14. Feeling of inequality between units	1 / 5	x				
C15. Technical debt, slow progress in repairing technical debt	1 / 5			x		
C16. The absence of single point of contact	1 / 5			x		
C17. The lack of leadership in some parts of organization or projects	1 / 5	x		x		
C18. Shortcomings in task management (monitoring, coordination, and prioritization)	1 / 5	x		x	x	
C19. Shortcomings in the employee's ability to prioritize tasks	1 / 5	x		x		
C20. The skills of employees are not fully utilized	1 / 5			x		
Total		12	1	13	1	6

Here are some selected extracts from the interviews that present challenges in the organization:

"Pretty traditional challenges to some extents are still, in my opinion, siloes. The kind of observation is that you might be helping your own projects or things. Then between those siloes, working together sometimes works well, sometimes it has challenges." (Interviewee 1)

“A very traditional organizational challenge is the flow of the information. ... Communication depends on your own activity and then it slides to such a mode of operation that people only answer questions and get in touch when there is a problem that you need to sort out.” (Interviewee 5)

“A lot of things go through the managers. Although there would be no need to go like this.” (Interviewee 2)

“One challenge is that we are running on low human resources. We have a small group running this activity.” (Interviewee 4)

“Although the environment is reasonably large, little has been done to ensure that the environment works. ... There is no common way, but it is done according to how each expert sees it.” (Interviewee 4)

“Then I must mention projects separately. What I have understood that there is no common project portfolio, project management model, or unified practice. Our unit's projects are nowhere to be found, and what is a project? If we look at where the project account has been opened, then there are only one such project going on now. But smaller development projects, they are also meant to be monitored and should be monitored systematically. There are no such means.” (Interviewee 5)

“There is such a culture here that I do if I can. If I do not know then I will not do. Then that work can be left unattended. And then one wonders why things do not work out.” (Interviewee 2)

“If you think about leading an organization, then at least for some leaders or managers when the people in their services participate or manage networks, the challenge is that they are giving up their own power. It has been seen as a challenge in practice. It has many aspects when you need to trust and then people also must take responsibility if they are given the power to make their own decisions.” (Interviewee 3)

Table 5 presents the desired results of the change and their connection to principles of DevOps. Reviewing connections between desired results and the principles of DevOps, the principle of Culture is connected to ten results (DR1, DR2, DR3, DR4, DR5, DR9, DR10, DR11, DR12, and DR14), the principle of Automation to one result (DR12), the principle of Lean to nine results (DR2, DR5, DR8, DR9, DR10, DR12, DR13, DR15, and DR16), the principle of Measurement to seven results (DR3, DR4, DR13, DR14, DR15, DR16, and DR17) and the principle of Sharing to seven results (DR1, DR2, DR3, DR5, DR6, DR7, and DR8). Further analysis of the results is presented in later section of the thesis.

Table 5. Desired results and their connection to principles of DevOps.

Desired result	Number of mentions	The principles of DevOps				
		Culture	Automation	Lean	Measurement	Sharing
DR1. Working is done together in networks inside and outside the organization, the networks are managed	5 / 5	x				x
DR2. The operating culture is proactive (specialists own their expertise, act self-directed and take responsibility of the provided service)	4 / 5	x		x		x
DR3. The operating culture is open, knowledge is shared, and things are processed together extensively enough	4 / 5	x			x	x
DR4. Goals are common and unit-independent	3 / 5	x			x	
DR5. Development is done in all units and by co-development	3 / 5	x		x		x
DR6. Employees are multitalented	3 / 5					x
DR7. There is wider ability to see the big picture	3 / 5					x
DR8. Key competencies are improved for example by utilizing more broadly the role of senior or leading specialist	3 / 5			x		x
DR9. The operating culture is customer-oriented	2 / 5	x		x		
DR10. Coaching leadership is used, for example tasks are given as desired results and specialists decide how to achieve that	2 / 5	x		x		
DR11. People dare to try and fail	2 / 5	x				
DR12. Working is done in agile ways	1 / 5	x	x	x		
DR13. Systematic task management is done	1 / 5			x	x	
DR14. Employee satisfaction is at a good level, no overload at work	1 / 5	x			x	
DR15. Production is operating at a good level	1 / 5			x	x	
DR16. Projects are progressing on schedule	1 / 5			x	x	
DR17. Economies of scale are exploited	1 / 5				x	
Total		10	1	9	7	7

Here are some selected extracts from the interviews that present desired results in the organization:

“It is this dynamic, networking, silo-breaking operating model that we should probably aim for.” (Interviewee 1)

“By no means does all new development need to be the ICT development unit. ICT development unit could rather focus on something specific, but

development is done extensively in all the other units too. So, we need to make it even more visible what all the development we are doing.” (Interviewee 3)

“One main thing is to make cooperation work with our ICT service provider.” (Interviewee 4)

“Employees are self-directed so that they know what to do and there is less need for meetings about everything and less need to ask things from the manager.” (Interviewee 2)

“But in general, a better solution, if the team has good ability to work together and everyone gets along with each other, then the team can be given a task and so it should usually be done that this is the kind of task to do. This result should be achieved. How are you going to do it and when will you have time to do it? And then those questions will be answered and then task is done.” (Interviewee 5)

“The changes are specifically intended to increase transparency. Because through it, we get the best experts to work together in line with our strategy for these tasks. And supporting the strategy is, of course, the task of all of us.” (Interviewee 3)

“We want things to go smoothly, projects to progress and staff satisfaction with the work to be on a good level. And there is no overload for anyone. The work is evenly distributed. Yes, and probably that there is communication. Could I say an open environment where communication is open?” (Interviewee 4)

“If someone has done 99 percent of the job and can no longer do the last percent, then at that point it is very frustrating and a huge loss of working time when someone else starts learning the job of getting the last percent done. Such a method is not good, but everyone should complete the work if they can. It should be allowed to get done, get a little step on another territory and if someone steps on your territory then you must not get angry about it because it is just a good thing.” (Interviewee 5)

5.1.3 Analysing maturity

As a part of organization’s earlier DevOps consulting the DevOps maturity of the organization has been assessed. The assessment included both assessment of current state and determination of target state. In the earlier assessment the maturity was assessed from three areas: Organization and culture, Processes, and Automation and agility. Each area was assessed on a five-level rating scale: Level 1 Basic, Level 2 Evolving, Level 3

Coordinated, Level 4 Enhanced, and Level 5 Leading. Organization was on level 1 or 2 in every perspective and the goal is to be on level 4 or 5 in every perspective. (Capgemini, 2018)

Based on the earlier maturity assessment from Capgemini (2018) the target state for the organization is to have:

1. Joined/combined teams for the whole lifecycle of the solution with principal architect that owns the solution, or one teams in one location with continuous collaboration and information sharing.
2. One common process from strategy planning to development and to maintenance of the solution.
3. Automated management, monitoring and scaling of the environments, applications and services with automated quality assurance that is built within development of the service.

When comparing earlier maturity assessment to the maturity model of de Feijter, et al. (2017), some similarities can be found. Area of Organization and culture includes capabilities from some focus areas in perspective of Culture and collaboration, areas of Processes and Automation and agility include capabilities from some focus areas in perspective of Product, process, and quality and in perspective of Foundation. De Feijter, et al. (2017) approach maturity from three perspectives with different focus areas and capabilities, and with eight maturity levels. The earlier assessment is clearly more on higher level than the model of de Feijter, et al. (2017). With more detailed maturity assessment there is possibility to direct development at a more detailed level to achieve preferred targets.

Compared to the maturity model of de Feijter, et al. (2017) to be able to reach the target state of “Joined/combined teams for the whole lifecycle of the solution with principal architect that owns the solution, or one teams in one location with continuous collaboration and information sharing.” the organization should at least have the capability D of focus area F11, the capability C of focus area F12, the capability C of focus area F13, the capability C of focus area F14, and the capability B of focus area F15 from perspective P1. With these capabilities the maturity levels of focus areas are F11 level 7, F12 level 5, F13

level 6, F14 level 6, and F15 level 6. In average the level of maturity in P1 should thus be 6/8 to achieve target state. Additional information about P1's capabilities and maturity levels, and explanations of abbreviations used can be seen in Figure 10.

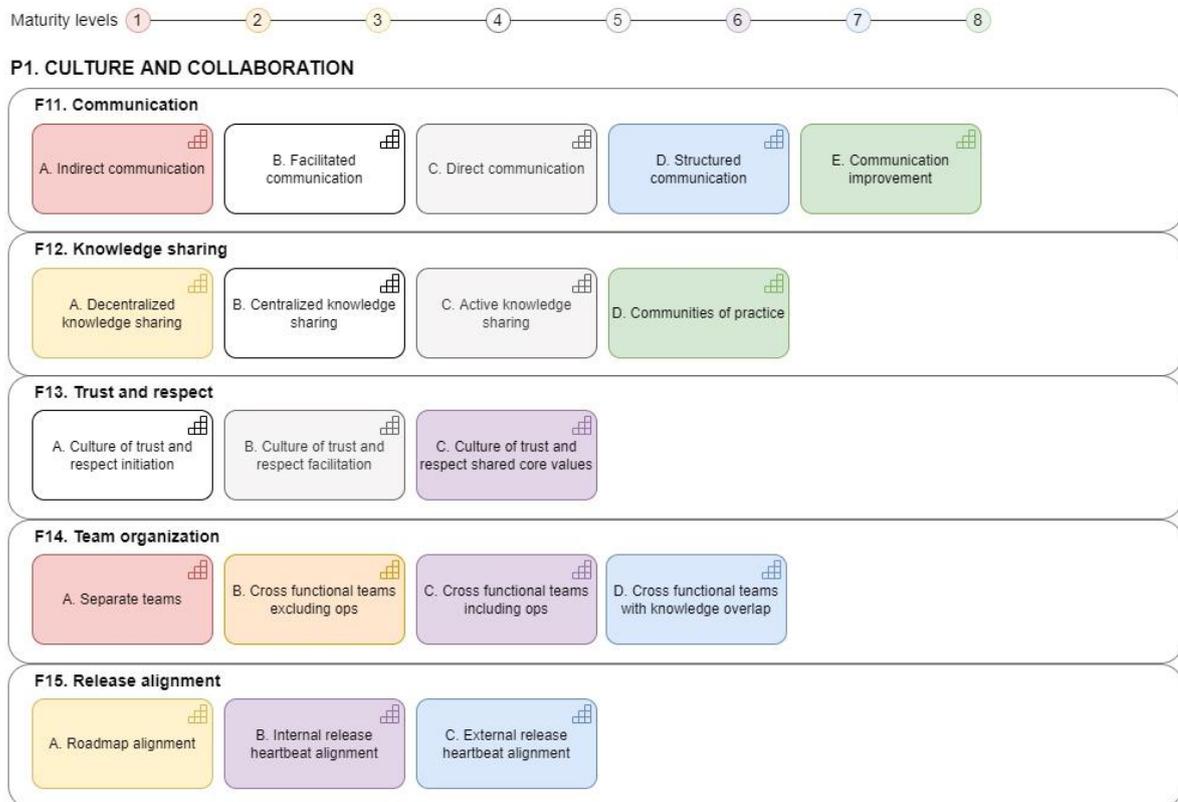


Figure 10. Culture and collaboration perspective with its focus areas and capabilities (de Feijter, et al., 2017).

Compared to the maturity model of de Feijter, et al. (2017) to be able to reach the target state of “One common process from strategy planning to development and to maintenance of the solution.” the organization should at least have the capability D of focus area F21, and the capability C of focus area F27 from perspective P2, and the capability B of focus area F32 from perspective P3. With these capabilities the maturity levels of focus areas are F21 level 6, F27 level 6, and F32 level 6. This target has also some connection with focus area F15 from perspective P1 that was presented earlier in this section. Additional information about P2's capabilities and maturity levels, and explanations of abbreviations used can be seen in Figure 11 and about P3's capabilities and maturity levels, and explanations of abbreviations used can be seen in Figure 12.

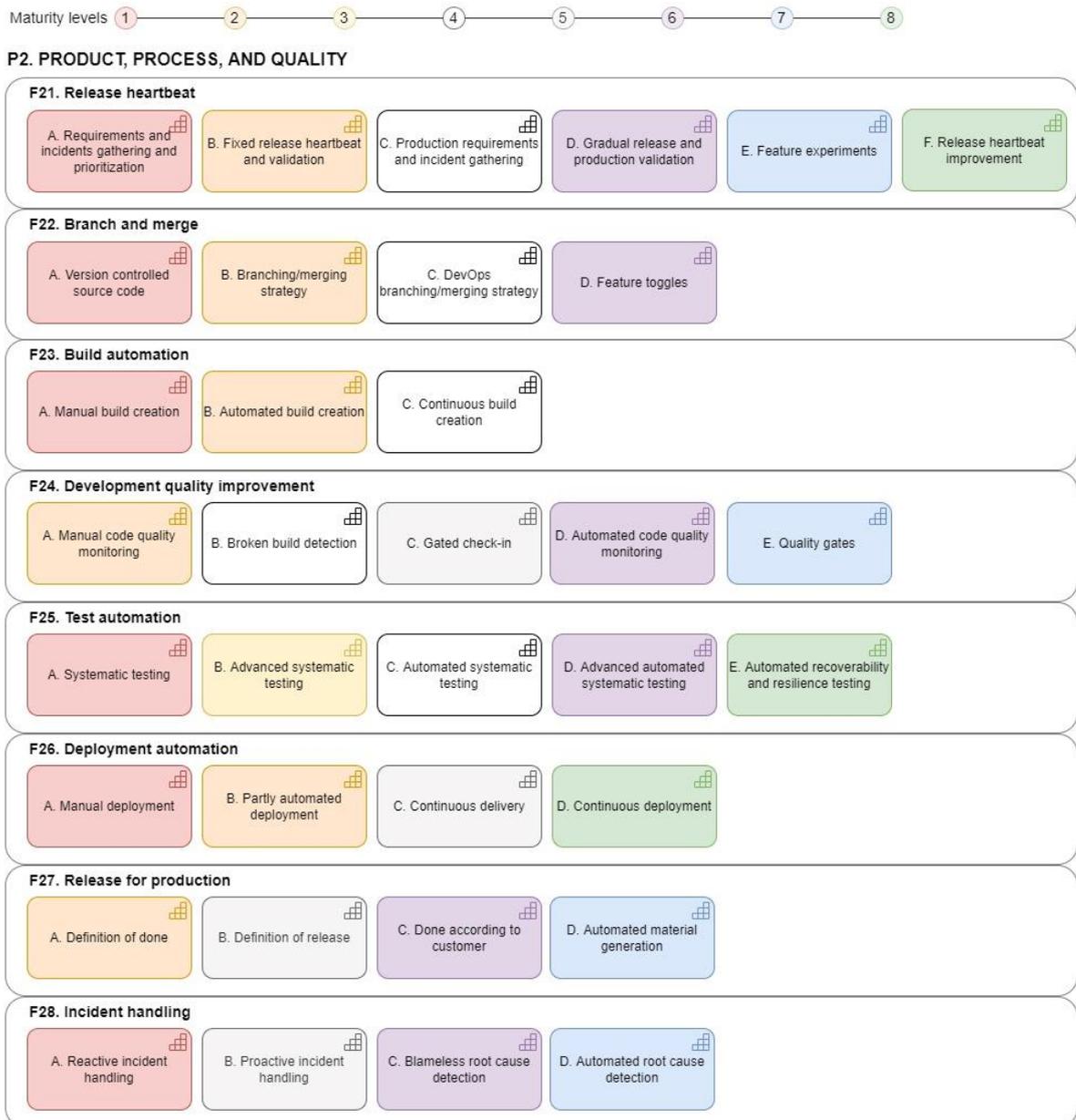


Figure 11. Product, process, and quality perspective with its focus areas and capabilities (de Feijter, et al., 2017).

Compared to the maturity model of de Feijter, et al. (2017) to be able to reach the target state of “Automated management, monitoring and scaling of the environments, applications and services with automated quality assurance that is built within development of the service.” the organization should at least have the capability C of focus area F22, the capability C of focus area F23, the capability D of focus area F24, the capability D of focus area F25, the capability C of focus area F26, and the capability D of focus area F28 from perspective P2, and the capability C of focus area F31, and the capability C of focus area F33 from perspective P3. With these capabilities the maturity levels of focus areas would

be F22 level 4, F23 level 4, F24 level 6, F25 level 6, F26 level 5, F31 level 5, and F33 level 6. In average the level of maturity should thus be 5,3/8 in P2 and 5,7/8 in P3 to achieve target state. Explanations of abbreviations used and additional information about P2's capabilities and maturity levels, can be seen in Figure 11 and same things about P3 can be seen in Figure 12.

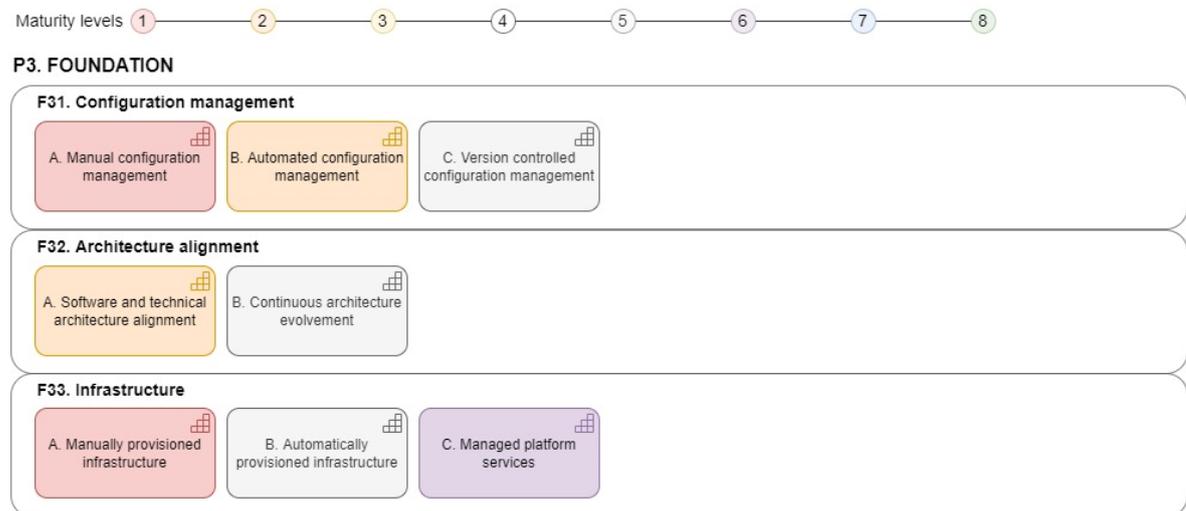


Figure 12. Foundation perspective with its focus areas and capabilities (de Feijter, et al., 2017).

5.2 The model for utilizing DevOps

This section includes answers to the three sub questions defined for the second research question of this research. Section includes information about issues identified and ideas on how to solve those issues with the principles of DevOps. In addition there is suggestion on how to utilize DevOps approach and the principles of DevOps in different kind of IT related projects in the organization.

5.2.1 The issues identified and the proposed solutions

This subsection begins with the answers to the first sub question “What are the issues in the organization that need to be addressed?”. These issues are produced from the challenges presented in previous section. These challenges are collected from many different sources. There was fifteen questions selected from the two previously done surveys and twenty challenges identified from the interviews held as part of this thesis. The

identified issues are presented in Table 6. The number of issues was limited to ten by mainly combining multiple questions and/or challenges to one issue. Issues are not in any specified order. In addition to the issues Table 6 includes desired results from interviews and their connection to the issues. For easier readability questions, challenges, desired results, and focus areas of the maturity model in Table 6 are opened as issue cards to Appendix 3. Appendix 3 also includes the proposed solutions for each issue.

Table 6. Issues identified and their connection to questions, challenges, desired results, and focus areas of the maturity model.

Issue	Questions connected to issue	Challenges connected to issue	Desired results connected to issue	Connection to focus areas of the maturity model
I1. The services produced do not work as desired from the customer's point of view	Q1, Q2, Q13	C9, C13, C16	DR4, DR6, DR9, DR12, DR13, DR15	F28, F31
I2. The lack of documentation and common ways to do things	-	C5	DR3, DR7, DR13, DR15	F12, F28, F31, F32, F33
I3. Specialists are not reachable and service promise is not fulfilled	Q3, Q5	C4	DR1, DR2, DR4, DR5, DR8, DR9	F11, F14
I4. There is not enough cooperation between different units inside and outside IT management unit	Q4, Q6	C1, C8	DR1, DR3, DR4, DR5, DR9	F11, F12, F13, F14, F15, F27
I5. The culture is manager-centric and does not support shared responsibility of the services provided	-	C3, C6, C11	DR1, DR2, DR6, DR8, DR9, DR10	F11, F12, F13, F14
I6. Shortcomings in the flow of information, transparency, and openness	Q7, Q9, Q11, Q14	C2, C7, C12	DR3, DR7, DR8	F11, F12, F13, F15, F27, F32
I7. Shortcomings in task management and leadership in task/project management	-	C17, C18, C19	DR2, DR8, DR10, DR13, DR16	F15, F28
I8. Technical dept that causes problems in reliability	Q10	C15	DR15, DR17	F31, F32, F33
I9. The feeling of inequality between units or employees	Q8	C14	DR1, DR3, DR4, DR14	F13
I10. The employee experience is not good in all respects	Q12, Q15	C10, C20	DR3, DR4, DR10, DR11, DR14	F13
Abbreviations of different things in the table				
Questions Q1. ICT procurement is flexible and effortless. Q2. ICT support runs flexibly and effortlessly. Q3. Reachability - I can easily find the right specialist to serve me. Q4. Involvement and cooperation - The service is a partner for us who listens to us and develops practices together with us. Q5. The service promise - The service promise "We will respond to our customers' contacts within two business days" has been fulfilled. Q6. Cooperation between the different units is fluent. Q7. All parties involved are represented in decision-making. Q8. The decisions made are consistent (the rules are the same for everyone). Q9. The effects of decisions are monitored and communicated. Q10. The information systems that are essential to my work, work reliably. Q11. I have received enough information from development of the new information system.		Desired results DR1. Working is done together in networks inside and outside the organization, the networks are managed DR2. The operating culture is proactive (specialists own their expertise, act self-directed and take responsibility of the provided service) DR3. The operating culture is open, knowledge is shared, and things are processed together extensively enough DR4. Goals are common and unit-independent DR5. Development is done in all units and by co-development DR6. Employees are multitasking DR7. There is wider ability to see the big picture		

<p>Q12. When you think about the changes in your work in last year, how would you describe the situation from your point of view?</p> <p>Q13. Cyber security issues are well taken care of.</p> <p>Q14. In our work community, we promote a culture of addressing, speaking, and acting in the event of deviations from commonly agreed practices.</p> <p>Q15. I get enough support from my supervisor to succeed at work.</p> <p>Challenges</p> <p>C1. Not enough cooperation between different units</p> <p>C2. Shortcomings in the flow of information inside and outside unit</p> <p>C3. A manager-centric culture</p> <p>C4. The lack of resources, for example no time to develop subunit's internal operations</p> <p>C5. The lack of documentation and common ways to do things, for example the lack of project model</p> <p>C6. The lack of responsibility for the provided service or change of service</p> <p>C7. Shortcomings in the ability to see the whole picture</p> <p>C8. The lack of coordination between different functions</p> <p>C9. Defects in the conceptualization of ICT support</p> <p>C10. Staff turnover, problems in recruiting</p> <p>C11. Too much division into different areas of responsibility</p> <p>C12. "Knowledge is power" culture</p> <p>C13. The lack of agility</p> <p>C14. Feeling of inequality between units</p> <p>C15. Technical debt, slow progress in repairing technical debt</p> <p>C16. The absence of single point of contact</p> <p>C17. The lack of leadership in some parts of organization or projects</p> <p>C18. Shortcomings in task management (monitoring, coordination, and prioritization)</p> <p>C19. Shortcomings in the employee's ability to prioritize tasks</p> <p>C20. The skills of employees are not fully utilized</p>	<p>DR8. Key competencies are improved for example by utilizing more broadly the role of senior or leading specialist</p> <p>DR9. The operating culture is customer-oriented</p> <p>DR10. Coaching leadership is used, for example tasks are given as desired results and specialists decide how to achieve that</p> <p>DR11. People dare to try and fail</p> <p>DR12. Working is done in agile ways</p> <p>DR13. Systematic task management is done</p> <p>DR14. Employee satisfaction is at a good level, no overload at work</p> <p>DR15. Production is operating at a good level</p> <p>DR16. Projects are progressing on schedule</p> <p>DR17. Economies of scale are exploited</p> <p>Focus areas</p> <p>F11. Communication</p> <p>F12. Knowledge sharing</p> <p>F13. Trust and respect</p> <p>F14. Team organization</p> <p>F15. Release alignment</p> <p>F21. Release heartbeat</p> <p>F22. Branch and merge</p> <p>F23. Build automation</p> <p>F24. Development quality improvement</p> <p>F25. Test automation</p> <p>F26. Deployment automation</p> <p>F27. Release for production</p> <p>F28. Incident handling</p> <p>F31. Configuration management</p> <p>F32. Architecture alignment</p> <p>F33. Infrastructure</p>
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As presented before and as can be seen from Table 6 ten issues to be solved have been identified in this process. To be able to form a model or proposals for measures how DevOps could be utilized in the development of the IT management unit's internal operations, the answer to the second sub question "Can DevOps be used in solving the issues identified during the investigation?" must be clarified first. The answer was sought by considering the proposed solutions to the issues. These proposed solutions were then evaluated with a discussion with a person outside the studied organization (interviewee 6) with a long history in IT services and IT management. This discussion was not recorded as an exception to the previous interviews.

The evaluation of the proposed solutions was done by presenting an issue with its connections to questions, challenges, desired results, maturity model, and proposed solutions by the author of the thesis, and then discussing whether the issue and its proposed solutions were in line with the experiential knowledge. Issues 3, 5 and 6 were the ones whose proposed solutions needed fine-tuning. Below is a comment from the discussion regarding issue 3.

"This issue is probably related to the lack of knowledge on who is the right specialist. This can be addressed with efficient and accurate productization."
(Interviewee 6)

After this discussion there were eight proposed solutions that cover all the issues. These proposed solutions were: PS1. Operations compliant with or adapted from ITIL practices (proposed solution for three issues), PS2. Utilizing the principles of DevOps (proposed solution for seven issues), PS3. Definition and implementation of a development model including the project model (proposed solution for three issues), PS4. Productization of the services (proposed solution for two issues), PS5. A well-functioning Single Point of Contact (SPOC) (proposed solution for one issues), PS6. Wider use of the ticket management system in task management, definition of other task management practices (proposed solution for one issue), PS7. Systematic repair of technical debt / projectization of the repairs and project management (proposed solution for one issue), and PS8. Coaching for supervisors and team leaders (proposed solution for two issues). PS5 is separated from PS1 to raise the proposed solution more even though SPOC is part of ITIL practices. Previously presented solutions show that all issues identified cannot be addressed with the principles of DevOps. Further analysis of the issues that could be addressed with the principles of DevOps connected issues with only some (1-3) of the principles of DevOps. These principles are Culture (7/7 issues), Lean (5/7 issues), Measurement (1/7 issues), and Sharing (5/7 issues).

Based to the previous, the answer to the second sub question “Can DevOps be used in solving the issues identified during the investigation?” is that it depends on the issue. The solution to the three of the issues was clearly outside the principles of DevOps. The rest of the issues could be connected to DevOps, but each of them to only some of the principles. This means that the DevOps approach is not the best solution to solve these issues but the principle of Culture from the principles of DevOps in particular could be utilized in solving the issues.

5.2.2 The principles of DevOps and the issues identified

The third sub question to be answered in this research was “How DevOps principles can be used to solve the issues and how to implement principles?”. As the answer to the previous sub question “Can DevOps be used in solving the issues identified during the investigation?” was that some issues could be connected to only some of the principles, this subsection focuses on how to utilize DevOps principles only partially.

The simplified process on how possible achievements and needed actions to reach the achievements have been formulated can be seen in Figure 13. The process includes Current state and target state, Issue cards, and Proposed solutions, achievements, and actions phases. Current state and target state phase includes the formulation of challenges and desired results for which various sources are utilized. Issue cards phase includes connecting similar challenges, their desired results, and focus areas of the DevOps maturity model as one formulated issue. For this thesis, these connections are visualized with issue cards that are presented in Appendix 3. The last phase in the process is Proposed solutions, achievements, and actions which includes formulating the proposed solutions with connections to DevOps principles if possible. Proposed solutions are then included in issue cards. The DevOps maturity model from de Feijter, et al. (2017) is utilized in formulation of the achievements and needed actions in addition to the other knowledge from DevOps presented in the thesis.

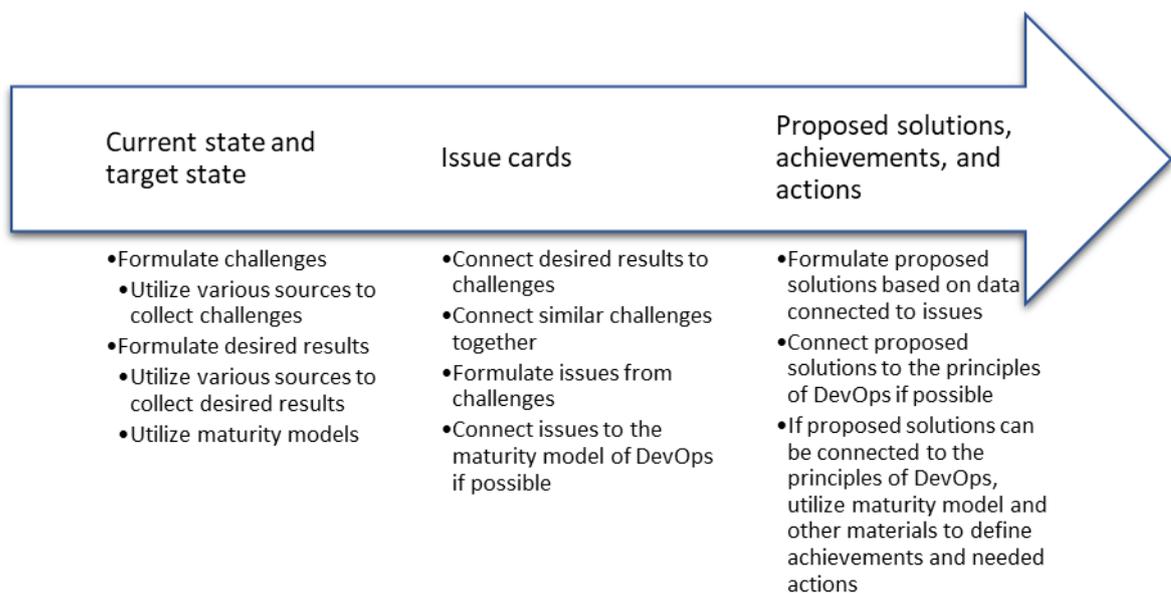


Figure 13. Process of providing solutions based on DevOps principles and the maturity model.

When this process is utilized with issues that are identified to have connections to the principles of DevOps, things that could be achieved by implementation of DevOps approach can be identified. Those things lead to the needed actions on how to implement the principles in these situations. As an example, the proposed solution of the issue 2 has been mapped with its connections. This mapping can be seen in Figure 14.

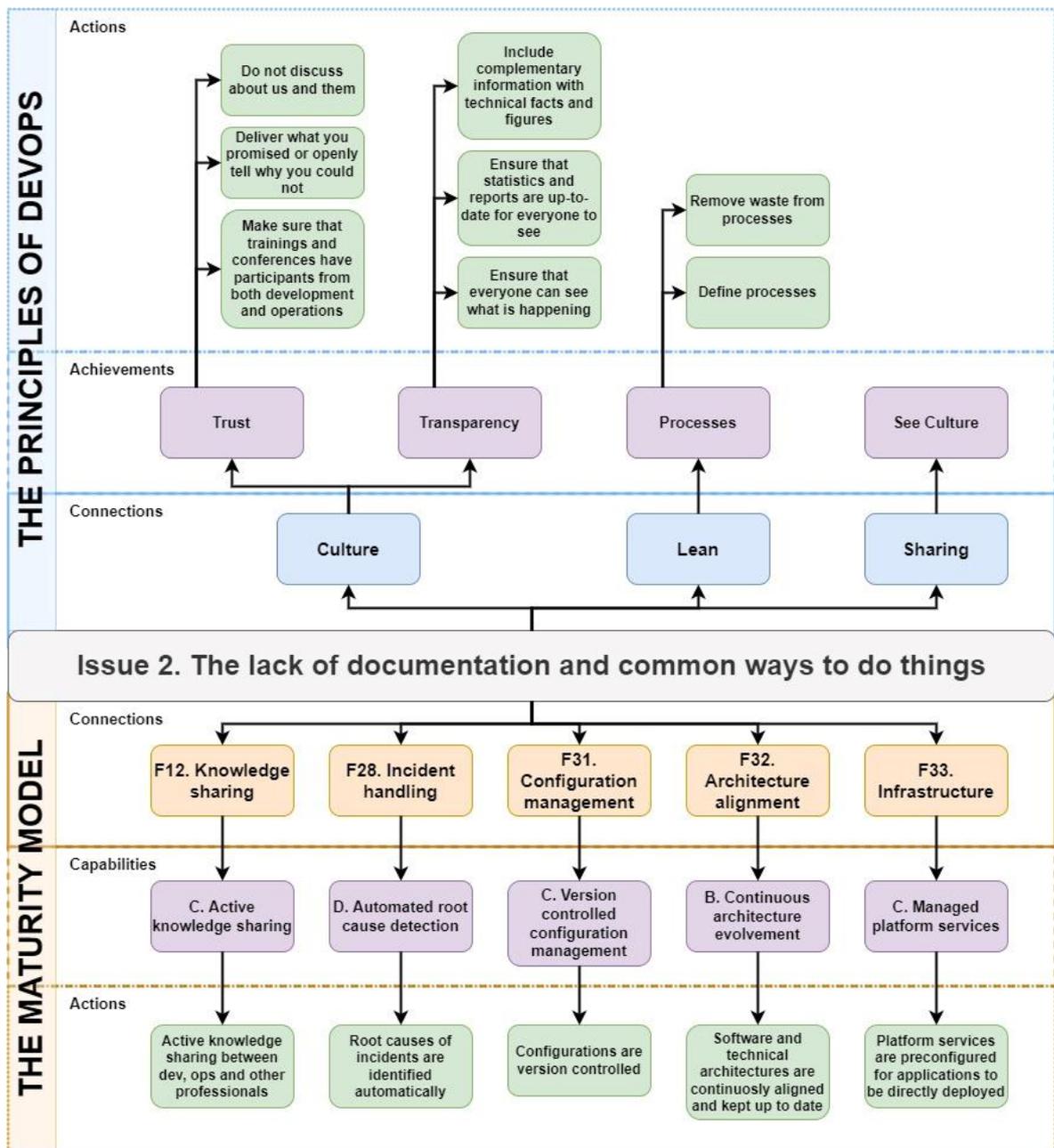


Figure 14. Issue 2 - what can be achieved and on which actions (actions are based on the maturity model of de Feijter, et al. (2017) and things connected to DevOps culture by Verona, et al. (2016)).

As can be seen from Figure 14 the proposed solution to the issue 2 has connections to three DevOps principles that are Culture, Lean, and Sharing. In earlier section of this thesis there is Figure 4 which presented things connected to DevOps culture. Those things include things from the principle of Sharing too. At this moment, the things are referred as achievements. For issue 2 those achievements are Trust, and Transparency. Trust can be achieved with three actions that are “Make sure that trainings and conferences have

participants from both development and operations”, “Deliver what you promised or openly tell why you could not”, and “Do not discuss about us and them”. For Transparency, the actions are “Ensure that everyone can see what is happening”, “Ensure that statistics and reports are up-to-date for everyone to see”, and “Include complementary information with technical facts and figures”. The principle of Lean aims to producing value to the customer. For issue 2 it has been identified that the processes must be defined to be able to achieve common ways to do thing. In addition, waste can be reduced from processes after there is knowledge on how things are done.

Another part of the mapping in Figure 14 is the connection to the focus areas in the maturity model. Capabilities presented in the figure are the capabilities on the target state of DevOps maturity defined by the organization in earlier maturity assessment. The actions have been derived from the actions presented in the maturity model of de Feijter, et al. (2017). Actions to achieve target state of capability are “Active knowledge sharing between dev, ops and other professionals”, “Root causes of incidents are identified automatically”, “Configurations are version controlled”, “Software and technical architecture are continuously aligned and kept up to date”, and “Platform services are preconfigured for applications to be directly deployed”.

The answer to the third sub question “How DevOps principles can be used to solve the issues and how to implement principles?” is alike the answer to the second sub question which is that it depends on the issue. The proposed solutions to the issues must be able to be connected to the principles of DevOps and to the DevOps maturity model to be able to produce achievements and actions to each issue separately.

5.2.3 IT related projects and DevOps

Even though the issues in the organization were only partly connected to the principles of DevOps, the need to define a project model arose as a challenge from the interviews. Utilization of DevOps approach and its principles should be considered when defining the project model. This subsection presents an idea on how this could be achieved with help of the maturity model and its actions to achieve target capabilities.

The IT management unit of the studied organization has both IT related projects with no software development and software development projects. Both types of projects need

contribution from different areas of expertise inside and outside of the IT management unit. The focus areas and their capabilities from the maturity model of de Feijter, et al. (2017) can be divided into those that apply to both types of projects as well as into those that only apply to software development projects.

All projects should meet the target capabilities of focus areas F11 - F14, F21, F27, F28 and F31 - F33. In addition to the focus areas mentioned to be met in all projects, software development projects should meet the target capabilities of focus areas F15 and F22 - F26. Table 7 presents these focus areas, their target capabilities in the organization studied and the action needed to achieve each target capability. If these capabilities would be considered as requirements for new projects, DevOps approach could be gradually introduced to the organization and the target state of DevOps maturity would be met at some point in the future.

Table 7. Focus areas, target capabilities and action to achieve target capability (partly based on de Feijter, et al. (2017)).

Focus area	Project type	The target capability	Action to achieve target capability
F11. Communication	All projects	D. Structured communication	Structured communication between dev, ops and other professionals is in place
F12. Knowledge sharing	All projects	C. Active knowledge sharing	Active knowledge sharing between dev, ops, and other professionals
F13. Trust and respect	All projects	C. Culture of trust and respect shared core values	Shared core values are followed between dev, ops, and other professionals
F14. Team organization	All projects	C. Cross functional teams including ops	There are cross functional teams that include ops
F15. Release alignment	Software development projects	B. Internal release heartbeat alignment	Release cycles are aligned with internal stakeholders that have dependencies on the release
F21. Release heartbeat	All projects	D. Gradual release and production validation	Release of functionality is done gradually (small groups > bigger group > all) and validated in production
F22. Branch and merge	Software development projects	C. DevOps branching/merging strategy	Branching/merging strategy is DevOps compatible
F23. Build automation	Software development projects	C. Continuous build creation	Verification of working software build is done by creating a CI build after each check-in
F24. Development quality improvement	Software development projects	D. Automated code quality monitoring	Monitoring of code quality is done automatically
F25. Test automation	Software development projects	D. Advanced automated systematic testing	Regression, integration, and acceptance tests are automated and done systematically

F26. Deployment automation	Software development projects	C. Continuous delivery	Automated deployment to all environments
F27. Release for production	All projects	C. Done according to customer	Customer satisfaction defines whether functionality is declared done or not
F28. Incident handling	All projects	D. Automated root cause detection	Root causes of incidents are identified automatically
F31. Configuration management	All projects	C. Version controlled configuration management	Configurations are version controlled
F32. Architecture alignment	All projects	B. Continuous architecture evolvment	Software and technical architecture are continuously aligned and kept up to date
F33. Infrastructure	All projects	C. Managed platform services	Platform services are preconfigured for applications to be directly deployed

6 Discussion

The aim of this research was to study DevOps and how it could be utilized outside software development. The organization studied was the IT management unit of a public sector organization. IT management unit produces IT operations and IT development services. IT development includes some software development projects but software development is not the main service that IT management unit produces.

There were two research questions from which the second included three sub questions. The first question was “What is DevOps and why is it good?”, and the second question was “Can DevOps be utilized outside software development, and if it can be utilized, how should it be utilized to get the most out of it?”. The sub questions for the second question were “What are the issues in the organization that need to be addressed?”, “Can DevOps be used in solving the issues identified during the investigation?”, and “How DevOps principles can be used to solve the issues and how to implement principles?”.

The first question “What is DevOps and why is it good?” is answered in the second chapter of this thesis. Since DevOps is rather new approach it still lacks a common definition. For this thesis DevOps is defined to be a set of principles that aim for better customer satisfaction by enhancing the cooperation between development and operations. That includes the goal of DevOps which is to improve customer experience and satisfaction, and the actions to achieve that goal which are by improving communication and collaboration between development and operations teams (Alt, et al., 2021). DevOps also includes the focus of removing bottlenecks and increasing automation (Hemon, et al., 2019). The connection to Lean management approach (Alt, et al., 2021) and the idea of people centric cultural change still remembering processes and technology that support the change (Krishna Kaiser, 2018) makes DevOps interesting approach also outside software development. Simplicity and collaboration are profitable principles in service production regardless of the industry.

The answer to the second question “Can DevOps be utilized outside software development, and if it can be utilized, how should it be utilized to get the most out of it?” is that DevOps could be at least partly utilized outside software development since the principles of DevOps are quite common from different management frameworks too. One interviewee said it well

when Figure 4 including all things connected to DevOps culture was presented as part of the interview.

“Could it be said that those things put together are what a good work environment is like.” (Interviewee 4)

This question is explored more widely in chapter five. The model on how to connect challenges of the organization, desired results, the focus areas of DevOps maturity model, and proposed solutions to issue cards and how to derive that to achievements, capabilities at desired level and actions to achieve them was presented. The model and its performance were not evaluated during this thesis process. The idea of the model is that if proposed solutions of an issue include connection to the principles of DevOps, the achievements are derived through the principles and the desired level of capabilities through the maturity model. These then lead to the actions on how to achieve desired capabilities and achievements.

The answers to the sub questions of the second question were introduced in section 5.2. The issues to be addressed were produced from challenges from the two previous surveys and the interviews. Based on these issues and their proposed solutions the answer to the sub question “Can DevOps be used in solving the issues identified during the investigation?” was interpreted as that it depends on the issue. The solution to most of the issues could be connected to DevOps, but each of them to only some of the principles. The DevOps approach is thus not the best solution to solve these issues, but the principle of Culture could be utilized in solving the issues. The answer to the sub question “How DevOps principles can be used to solve the issues and how to implement principles?” is presented previously in this chapter in the form of presented model.

Even though the work related to this thesis is finished, there are work that needs to be done within the organization studied. This work to be done includes deciding on the model on how to prioritize the issues identified, and thus the proposed solutions and actions they lead to. This thesis presents the connections between issue and the principles of DevOps, and issue and DevOps maturity model for issue 2, but for other issues the connections have not been done. In addition, there were issues for which the proposed solutions are not connected to the principles of DevOps, and for those the actions need to be identified otherwise. When the actions are identified, also the success/failure criteria for these actions must be defined.

For future research there is the need to evaluate how the presented model works in the organization studied in this thesis and correct the model if needed. After that, the study should be performed in other organizations to generalize the model and to get wider feedback on its performance and usability. Only then can conclusions be drawn about the performance, usability, and correctness of the model.

7 Conclusions

This research process was an agile process where the requirements changed during the process, but the basic idea of studying DevOps approach in a public sector organization remained. The first ideas were changed by the time of the thesis project plan, and the ideas evolved during the process. Finally, this thesis was about studying DevOps approach and especially DevOps principles, and how they could be utilized in IT management also outside software development.

The change in requirements was partly because the author's knowledge of the DevOps approach was rather superficial before the research. As knowledge evolved, the requirements could be defined more accurately. This evolution led to the model for utilizing DevOps that is based on one maturity model and things connected to DevOps culture. That was not a deliverable in the original plan, but at this point it is presented as the main deliverable of the research.

Although the deliverables for the actual thesis and the organization studied changed in the process, the result of the research should be considered to be success. A model was formed, and the organization studied was pleased with the practical presentation form of issue cards and the basic information of DevOps. Bilingual approach to research, which was Finnish for the organization studied and English for the actual thesis work, had effects on timeframe of the process. It was surprisingly time consuming to produce materials both in Finnish and in English, and there were some issues on how to translate different things so that the idea remains the same in both versions.

DevOps approach in IT management or IT service management has been studied before. For example, Krishna Kaiser's books (2018 and 2021) connect ITIL framework and DevOps together to form approach that focuses on the demands of digital age. The final deliverable of this thesis aims to be on more practical level and so that the principles of DevOps could be introduced in the organization little by little, focusing more on the cultural change. The maturity model of de Feijter, et al. (2017) was found to be easily approachable and thus it was easy to be used as the base for the model presented in this thesis. In addition the materials from Verona, et al. (2016) had huge effect on the presented model when thinking about the actions to perform to achieve desired goals.

In a wider perspective this thesis presents the idea of widening the DevOps approach to industries outside software development. It might not make sense to consider development and production as clearly separate functions in other industries either. An application of the DevOps approach could also work in these to bring development and production closer together. The spread beyond the original industry has taken place with the Lean approach which shows that this could happen with other generally applicable approaches too.

This research was limited to the IT management unit, but it might be interesting to form similar connections from other units or industries and their challenges and desired results too. It might be a good idea to conduct research from this focus in the future. In addition, the presented model should be evaluated since there was no time to do that in this research at the level it should have been done.

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Appendix 1 Questions with the weakest results from the well-being survey and their connection to the principles of DevOps (partly based on HR unit (2021))

Question	Original result	Normalized result	The principles of DevOps				
			Culture	Automation	Lean	Measurement	Sharing
Cooperation between the different units is fluent.	2,15 / 4	5,38	x		x		
All parties involved are represented in decision-making.	2,78 / 5	5,56	x				
The decisions made are consistent (the rules are the same for everyone).	2,91 / 5	5,82	x				
The effects of decisions are monitored and communicated.	2,91 / 5	5,82	x			x	x
When you think about the changes in your work in last year, how would you describe the situation from your point of view?	4,37 / 7	6,24	x				
In our work community, we promote a culture of addressing, speaking, and acting in the event of deviations from commonly agreed practices.	2,61 / 4	6,53	x		x		x
I get enough support from my supervisor to succeed at work.	3,28 / 5	6,56	x				
Our operating culture is open, inspiring and trust-building.	2,63 / 4	6,58	x			x	
In the work community, our attitude is "We work together".	3,30 / 5	6,60	x				x
I think decision-making in my work community is fair.	3,31 / 5	6,62	x				
Will you recover from the strain of the workday before the next workday?		6,72			x		
My supervisor gives feedback on progress on work goals.	3,44 / 5	6,88	x			x	
We purposefully develop our competence in various ways.	2,76 / 4	6,90	x				x
When there are changes in my work or work community, my supervisor clearly explains why the changes are being made.	3,47 / 5	6,94	x		x		x
I am enthusiastic and motivated in my work.	3,50 / 5	7,00	x			x	
In our work community, we have discussed the future of our work.	3,51 / 5	7,02	x				x
I can make a lot of independent decisions in my work.	3,52 / 5	7,04	x		x		
My supervisor enables the efficiency of our work.	3,54 / 5	7,08	x		x	x	
Total			17	0	6	5	6

Appendix 2 Results from the customer survey for internal customers and their connection to the principles of DevOps (partly based on Business development unit (2021))

Question	Weighted average of the original result	Normalized result	The principles of DevOps				
			Culture	Automation	Lean	Measurement	Sharing
ICT procurement is flexible and effortless.	2,34 / 7	3,34	x		x	x	
ICT support runs flexibly and effortlessly.	3,19 / 7	4,55	x		x	x	
Reachability - I can easily find the right specialist to serve me.	3,3 / 7	4,71	x		x		x
Involvement and cooperation - The service is a partner for us who listens to us and develops practices together with us.	3,3 / 7	4,71	x				x
The service promise - The service promise "We will respond to our customers' contacts within two business days" has been fulfilled.	3,3 / 7	4,71	x		x	x	
The information systems that are essential to my work, work reliably.	4,24 / 7	6,06	x		x	x	
I have received enough information from development of the new information system.	4,33 / 7	6,19	x		x		x
Cyber security issues are well taken care of.	4,49 / 7	6,42	x			x	x
I have the essential software I need for my job.	5,01 / 7	7,15	x			x	x
Total			9	0	6	6	5

Appendix 3 Issue cards with issues identified

Issue I1. The services produced do not work as desired from the customer's point of view	
Questions connected to issue	Q1. ICT procurement is flexible and effortless. Q2. ICT support runs flexibly and effortlessly. Q13. Cyber security issues are well taken care of.
Challenges connected to issue	C9. Defects in the conceptualization of ICT support C13. The lack of agility C16. The absence of single point of contact
Desired results connected to issue	DR4. Goals are common and unit-independent DR6. Employees are multitalented DR9. The operating culture is customer-oriented DR12. Working is done in agile ways DR13. Systematic task management is done DR15. Production is operating at a good level
Connection to focus areas of the maturity model	F28. Incident handling F31. Configuration management
Proposed solutions	PS1. Operations compliant with or adapted from ITIL practices

Issue I2. The lack of documentation and common ways to do things	
Questions connected to issue	-
Challenges connected to issue	C5. The lack of documentation and common ways to do things, for example the lack of project model
Desired results connected to issue	DR3. The operating culture is open, knowledge is shared, and things are processed together extensively enough DR7. There is wider ability to see the big picture DR13. Systematic task management is done DR15. Production is operating at a good level
Connection to focus areas of the maturity model	F12. Knowledge sharing F28. Incident handling F31. Configuration management F32. Architecture alignment F33. Infrastructure
Proposed solutions	PS1. Operations compliant with or adapted from ITIL practices PS2. Utilizing the principles of DevOps <ul style="list-style-type: none"> • Culture, Lean and Sharing PS3. Definition and implementation of a development model including the project model

Issue I3. Specialists are not reachable and service promise is not fulfilled	
Questions connected to issue	Q3. Reachability - I can easily find the right specialist to serve me. Q5. The service promise - The service promise “We will respond to our customers’ contacts within two business days” has been fulfilled.
Challenges connected to issue	C4. The lack of resources, for example no time to develop subunit’s internal operations
Desired results connected to issue	DR1. Working is done together in networks inside and outside the organization, the networks are managed DR2. The operating culture is proactive (specialists own their expertise, act self-directed and take responsibility of the provided service) DR4. Goals are common and unit-independent DR5. Development is done in all units and by co-development DR8. Key competencies are improved for example by utilizing more broadly the role of senior or leading specialist DR9. The operating culture is customer-oriented
Connection to focus areas of the maturity model	F11. Communication F14. Team organization
Proposed solutions	PS2. Utilizing the principles of DevOps <ul style="list-style-type: none"> • Culture and Lean PS4. Productization of the services PS5. A well-functioning Single Point of Contact (SPOC)

Issue I4. There is not enough cooperation between different units inside and outside IT management unit	
Questions connected to issue	Q4. Involvement and cooperation - The service is a partner for us who listens to us and develops practices together with us. Q6. Cooperation between the different units is fluent.
Challenges connected to issue	C1. Not enough cooperation between different units C8. The lack of coordination between different functions
Desired results connected to issue	DR1. Working is done together in networks inside and outside the organization, the networks are managed DR3. The operating culture is open, knowledge is shared, and things are processed together extensively enough DR4. Goals are common and unit-independent DR5. Development is done in all units and by co-development DR9. The operating culture is customer-oriented
Connection to focus areas of the maturity model	F11. Communication F12. Knowledge sharing F13. Trust and respect F14. Team organization F15. Release alignment F27. Release for production
Proposed solutions	PS2. Utilizing the principles of DevOps <ul style="list-style-type: none"> • Culture and Lean

Issue I5. The culture is manager-centric and does not support shared responsibility of the services provided	
Questions connected to issue	-
Challenges connected to issue	C3. A manager-centric culture C6. The lack of responsibility for the provided service or change of service C11. Too much division into different areas of responsibility
Desired results connected to issue	DR1. Working is done together in networks inside and outside the organization, the networks are managed DR2. The operating culture is proactive (specialists own their expertise, act self-directed and take responsibility of the provided service) DR6. Employees are multitalented DR8. Key competencies are improved for example by utilizing more broadly the role of senior or leading specialist DR9. The operating culture is customer-oriented DR10. Coaching leadership is used, for example tasks are given as desired results and specialists decide how to achieve that
Connection to focus areas of the maturity model	F11. Communication F12. Knowledge sharing F13. Trust and respect F14. Team organization
Proposed solutions	PS2. Utilizing the principles of DevOps <ul style="list-style-type: none"> • Culture, Lean and Sharing PS5. Productization of the services

Issue I6. Shortcomings in the flow of information, transparency, and openness	
Questions connected to issue	Q7. All parties involved are represented in decision-making. Q9. The effects of decisions are monitored and communicated. Q11. I have received enough information from development of the new information system. Q14. In our work community, we promote a culture of addressing, speaking, and acting in the event of deviations from commonly agreed practices.
Challenges connected to issue	C2. Shortcomings in the flow of information inside and outside unit C7. Shortcomings in the ability to see the whole picture C12. "Knowledge is power" culture
Desired results connected to issue	DR3. The operating culture is open, knowledge is shared, and things are processed together extensively enough DR7. There is wider ability to see the big picture DR8. Key competencies are improved for example by utilizing more broadly the role of senior or leading specialist
Connection to focus areas of the maturity model	F11. Communication F12. Knowledge sharing F13. Trust and respect F15. Release alignment F27. Release for production F32. Architecture alignment
Proposed solutions	PS2. Utilizing the principles of DevOps <ul style="list-style-type: none"> • Culture, Measurement and Sharing PS3. Definition and implementation of a development model including the project model

Issue 17. Shortcomings in task management and leadership in task/project management	
Questions connected to issue	-
Challenges connected to issue	C17. The lack of leadership in some parts of organization or projects C18. Shortcomings in task management (monitoring, coordination, and prioritization) C19. Shortcomings in the employee's ability to prioritize tasks
Desired results connected to issue	DR2. The operating culture is proactive (specialists own their expertise, act self-directed and take responsibility of the provided service) DR8. Key competencies are improved for example by utilizing more broadly the role of senior or leading specialist DR10. Coaching leadership is used, for example tasks are given as desired results and specialists decide how to achieve that DR13. Systematic task management is done DR16. Projects are progressing on schedule
Connection to focus areas of the maturity model	F15. Release alignment F28. Incident handling
Proposed solutions	PS3. Definition and implementation of a development model including the project model PS6. Wider use of the ticket management system in task management, definition of other task management practices

Issue 18. Technical dept that causes problems in reliability	
Questions connected to issue	Q10. The information systems that are essential to my work, work reliably.
Challenges connected to issue	C15. Technical debt, slow progress in repairing technical debt
Desired results connected to issue	DR15. Production is operating at a good level DR17. Economies of scale are exploited
Connection to focus areas of the maturity model	F31. Configuration management F32. Architecture alignment F33. Infrastructure
Proposed solutions	PS1. Operations compliant with or adapted from ITIL practices PS7. Systematic repair of technical debt / projectization of the repairs and project management

Issue 19. The feeling of inequality between units or employees	
Questions connected to issue	Q8. The decisions made are consistent (the rules are the same for everyone).
Challenges connected to issue	C14. Feeling of inequality between units
Desired results connected to issue	DR1. Working is done together in networks inside and outside the organization, the networks are managed DR3. The operating culture is open, knowledge is shared, and things are processed together extensively enough DR4. Goals are common and unit-independent DR14. Employee satisfaction is at a good level, no overload at work
Connection to focus areas of the maturity model	F13. Trust and respect
Proposed solutions	PS2. Utilizing the principles of DevOps <ul style="list-style-type: none"> • Culture and Sharing PS8. Coaching for supervisors and team leaders

Issue I10. The employee experience is not good in all respects	
Questions connected to issue	Q12. When you think about the changes in your work in last year, how would you describe the situation from your point of view? Q15. I get enough support from my supervisor to succeed at work.
Challenges connected to issue	C10. Staff turnover, problems in recruiting C20. The skills of employees are not fully utilized
Desired results connected to issue	DR3. The operating culture is open, knowledge is shared, and things are processed together extensively enough DR4. Goals are common and unit-independent DR10. Coaching leadership is used, for example tasks are given as desired results and specialists decide how to achieve that DR11. People dare to try and fail DR14. Employee satisfaction is at a good level, no overload at work
Connection to focus areas of the maturity model	F13. Trust and respect
Proposed solutions	PS2. Utilizing the principles of DevOps <ul style="list-style-type: none"> • Culture, Lean and Sharing PS8. Coaching for supervisors and team leaders