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Using a platform based on the Basic profile of ISO/IEC 29110 to reinforce DevOps environments

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Abstract: The growth of software demand has caused more competition among customers who expect faster changes and better quality in the software products delivered. The need to satisfy the continuous requirements of the market, the need to keep the quality of products and services, as well as the need to improve their processes become a difficult task for organizations. DevOps arises to handle this continuous change because it addresses the reduction of the gap between development and operation. However, the influence of this new paradigm in organizations becomes a big challenge, mainly related to a cultural change. If the change of culture is not properly implemented, it could impact a team with negative consequences. In this context, there is no specific guidance that helps organizations with their implementation. Based on the lack of guidance, this paper presents the Reinforced DevOps Guidance, which aims to help teams to achieve an evolution of their software development, software delivery, and project management processes toward a proper DevOps implementation. The guidance uses a web platform that allows a dynamic implementation. That way helps teams to understand the set of tasks to be followed and the impact of their implementation on their current organizations. This paper shows both an overview of the guidance, highlighting the web platform, and its application in a very small entity (VSE). The results show that the use of the guidance: provides support toward addressing the effort in VSEs; gives the information of the technology, processes, and teams aspects that should be improved; and allows the cultural change in a pace supported by VSEs.

Keywords: DevOps, Guidance, Basic profile, ISO/IEC 29110, Agile, VSE, platform, Assessment
Categories: D.2, D.2.9, D.2.m
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1 Introduction

Nowadays, the fast development of software is fundamental [Mishra, 18] to meet the new IT industry requirements, and this implies the use of automation. This fact forces software development organizations to evolve their software processes to be able to achieve the new requirements. However, the IT industry has grown without precedent in software automation, so that meeting the new requirements of the software market provides a significant challenge to software development organizations.

To provide a solution to address this challenge, it arises DevOps. This implies a set of practices to bridge the operations team and development team, enabling a better collaboration [Humble, 10].

DevOps is an enabler for software development organization to address the faster development of software products while allowing a continuous change focusing on the adoption of new approaches, tools, work products, and roles. But, according to [Wettinger, 16], it is hard to integrate and combine all these elements in one way due to the actual culture of work of most software development organizations.

What makes DevOps interesting for most software development organizations is that it provides a set of tools, such as version control and continuous integration, that helps organizations increase their performance and productivity; while they continue using an agile approach, keeping their deliverables and reinforcing or implementing a continuous delivery of software products [Muñoz, 17].

However, adjusting DevOps practices into the current process of software development in organizations is a big challenge that involves cultural and organizational aspects. Therefore, it implies changes in the way of working and in the technology, such as microservices, containers, cloud computing, and even the serverless implementation, all this, based on project needs [Ivanov, 18] that are complicated to understand for the development team and operation team, causing an overwhelming situation for the team members. Besides, it promotes dynamic and continuous practices that could disturb the daily work that the operation team needs to perform to be able to keep a stable software development environment [Céspedes, 20].

The above-mentioned highlights that having a team with the right technical skills is a big challenge for many organizations. It involves the change of the team members' habits as well as the understanding of infrastructure, setup, and monitoring. According to [Buchan, 18] this is a complicated task due to the change in technology and responsibilities that give rise to the resistance to change.

Besides, the results obtained from the Systematic Literature Review performed in [Muñoz, 19c], the main problems that the implementation of a DevOps environment arises can be summarized in three (3):

(1) *Lack of a defined process for DevOps*: there is a lack of knowledge about how to correctly implement DevOps causing inefficient software development in the organizations [Muñoz, 19]. Besides, the lack of security in the implementation of DevOps practices such as continuous integration, without experienced teams to implement it adequately.

(2) *Lack of guidance that helps organizations to implement DevOps correctly*: the separation between development team and operation team cause that developers commit changes into production to deliver software that achieve their project goals. This can be complicated if the goals between teams are different [Hüttermann, 12].

(3) *Execution of uncoordinated activities due to the lack of knowledge and experience*: teams have to be coordinated to mitigate the possible chaos from the analysis to the testing, including the semi-automatic deployments or even to separate sensitive information to prevent potential security risks [Buchan, 18].

This paper presents a guidance, and a web platform to implement and/or to reinforce a DevOps approach. It enables organizations to check their process dynamically and to know how they can improve or fix the possible gaps that they could have on their DevOps approach, implementation, and adoption [Muñoz, 20].

After the introduction, the rest of the paper is organized as follows: Section 2 provides the research background; Section 3 presents the guidance to reinforce a DevOps approach; Section 4 provides the web platform to use the guidance; Section 5 shows the results of using the guidance by a VSE, and Section 6 presents the conclusions and next steps of this research.

2 Background

Nowadays, customers ask for changes and/or continuous releases, therefore keeping up in business is complicated for organizations. As a solution to these demands, DevOps came up to integrate continuous delivery and automatization testing in a process to assure high quality in software products. However, DevOps is a set of new practices that came with little information, which is continuously changing, that causes problems to be understood and adapted in an organization. Therefore, this section provides a set of key concepts to facilitate the understanding of the research work provided in this paper. Besides, an analysis of a set of related works is provided.

2.1 Key concepts

This section covers three concepts in which this research work is based: agile methods, DevOps, and ISO/IEC 29110.

2.1.1 Agile methods

Agile methods are part of software development methods that promote teamwork, communication, and iterated delivery. These methods encourage the individual teams to make decisions; regarding what, why, and how; related to the development and delivery of the software product to satisfy the customer requirements [ISO/IEC/IEEE, 18].

There are several agile methods such as Crystal Clear, eXtreme Programming (XP), Lean software development, SCRUM, and Feature-driven Development (FDD), being SCRUM and XP the most popular and largely used [Mishra, 18].

2.1.2 DevOps

DevOps is a set of practices intended to reduce the time between making a change in the system and putting this change in the baseline or production and with high quality. Its implementation has an influence on how to organize development and operation teams, to build systems, and to structure the systems [Lwakatare. 16b].

DevOps is a new software development approach based on XP and Lean agile methods, keeping its principles (culture, automation, measurement, sharing), and its third ways (flow, feedback, and continuous learning and implementation) [Kim, 16]. Besides, DevOps has an incremental and iterative process applying the project tasks based on the time slots called sprints.

The XP method is based on frequent cycles, which are formalized as a set of 12 primary practices of 4 areas: organizational, technical, planning, and integration. It provides practices related to continuous integration, testing, deployment, etc. [PMI&AA, 17].

Lean thinking emphasizes that software development does account for the entire IT value stream. It highlights the Kaizen word, which is used to mean continuous improvement in a software development context [Lwakatare, 16].

Then, DevOps integrates many techniques to decrease the delivery time as well as to keep the usage of monitoring practices to ensure quality through feedback [Balalaie, 16].

2.1.3 ISO/IEC 29110

ISO/IEC 29110 Systems and Software Engineering Series were developed by the WG 24 as a solution to help VSEs to face challenges such as improving productivity and quality with minimum costs [Muñoz, 19b].

The ISO/IEC 29110 was designed to help VSEs in the development of non-critical systems or software products. It provides a series of software standards and management and engineering guides, which aim to improve VSEs software development process through the implementation of proven practices, easily implemented within VSEs and that are focused on obtaining benefits in product quality, delivery time, and costs of production [Muñoz, 19].

ISO/IEC 29110 is characterized by four features [Muñoz, 19] [Muñoz, 19b]: (1) it has four profiles that should be selected by a VSEs according to their goals (entry, basic, intermediate, and advanced); (2) all profiles have two processes as a base: the project management process and the software implementation process; (3) it works in VSEs using any development approach, methodology or tool, and (4) it provides a set of process elements such as objective, activities, task, roles, and work products.

2.2 Related works

In [Colavita, 16], the author highlights the confusion produced when an organization has a traditional operational environment culture. Therefore, the author proposed four key steps to the successful transformation of an traditional organizational environment to a DevOps environment: (1) to assess DevOps; (2) to identify the maturity of the core development and IT operations processes; (3) to determine the standards and automation to be implemented for continuous workflow; and (4) to establish measures and metrics to monitor DevOps. Besides, the author proposed a DevOps maturity model containing five levels: initial, managed, defined and measured, and optimized.

In [Mann, 18], the authors highlight the hypothesis that every DevOps journey has distinct stages with practices to accelerate successful DevOps adoption, but there are more ways that lead to failure. Then, the author defines five stages to evolve an organization to a DevOps, based on the results of a set of 30,000 surveys around the world: (1) to enable ways for the development and operation teams to work together; (2) to adopt an agile development method; (3) to obtain technology tools, and after applying the tools to establish deployment patterns; (4) to automate; and (5) to keep resources available via self-service.

In [DASA, 19], the authors proposed a model to improve the DevOps adoption. This model is based on capabilities depending on every member of an organization's team. Using a diagnostic test known as DevOps Competence Quick Scan (DASA), they can see the skills that need to be improved. There are four skills areas: Courage, Teambuilding, DevOps Leadership, and Continuous improvement; and eight knowledge areas: Business Value Optimization, Business Analysis, Architecture and Design, Programming, Continuous Delivery, Test Specification, Infrastructure Engineering, Security, Risk, and Compliance to be applied [DASA, 19].

In [Pinheiro, 19], the authors performed a series of studies to know the challenge of adopting DevOps in organizations. After getting information of 15 organizations across four countries that adopted DevOps successfully, they built their model to adapt DevOps, focusing on a collaborative culture. Then, using the Goal Question Metric (GQM) technique and proposing four hypotheses, they created their model. The model has enablers such as automation, transparency and sharing, continuous sharing, continuous measurement, quality assurance, and outcomes such as agility, resilience, continuous measurement, and quality assurance. The model consists of three steps: (1) the organization must propagate the relevance of creating a collaborative culture between developer and operation teams; (2) the organization needs to select and develop the enablers, the best for it according to its context, and (3) the organization should look at the outcomes of the DevOps adoption to verify the relationship with the industrial practices and to explore them according to the company's needs.

In [Rong, 16], the authors reported a case study aiming and evaluating the possibility of implementing CMMI models in DevOps, using a structured method known as Standard CMMI-Appraisal Method for Process Improvement (SCAMPI) C. CMMI has five maturity levels according to the features implemented in the development and maintenance process of software product or services. They suggested that the fusion of the CMMI model with DevOps could help not only the implementation of software but also the project management. They found out that CMMI models are not a perfect fit with DevOps but can work as a guide.

In [De Feijte, 18], the authors proposed a model. To develop the model, they execute seven steps: (1) to collect data; (2) to analyze the data; (3) to construct the DevOps model; (4) to perform the first validation; (5) to build a maturity model; (6) to perform a second validation; and (7) to perform an exploratory case study. As a result of these steps, they proposed a DevOps competence model created with: (1) perspective (such as culture and collaboration; product, process and quality, and foundation); (2) focus areas (such as team organization, communication, trust and respect, knowledge sharing, release alignment, branch and merge, build automation, develop quality improvement, release heartbeat, test automation, deployment of automation, release for production, incident handling, configuration management, architecture alignment, and infrastructure); and (3) stakeholders (could be internal such as product management, architecture, development, test, operations; or external such as customers and third parties).

Next, Table 1 provides a comparison of the features of DevOps addressed by the related works.

Features	[Colavita, 16]	[Mann, 18]	[DASA, 19]	[Pinheiro, 19]	[De Feijte, 18]
Defined Activities				X	
Defined Phases					
Maturity levels	X	X	X		X
Testing Procedures				X	X
Defined Roles with responsibilities			X		X
Verification and Validation practices					
Defined Tasks				X	
Defined Process	X			X	
Work Products					

Table 1: Comparative features of DevOps addressed by the related works

Table 1 shows the most addressed feature is maturity levels. However, features such as the definition of phases, the verification, and validation of practices, and the work products are not addressed by any of the related works. The guideline proposed in this paper aims to address all of the DevOps features.

3 Guidance for reinforcing or implementing a DevOps approach

According to [Bierwolf, 17], organizations do not want to introduce DevOps practices such as continuous deployment, integration, testing, etc. within their current processes because they do not trust that these practices could help them to make things faster than before or to reduce problems. Besides, it is complicated to obtain information about DevOps easily and fast, even though there are many DevOps information sources but too many data without organization, standardization or a path can overwhelm the work between development and operation team causing problems to adapt those practices.

This guidance aims to reinforce a DevOps approach or implement a new one without the three categories of problems listed in the introduction section: processes, guidance, and team. To achieve that, we use the Basic profile of the ISO/IEC 29110. This section provides an overview of the steps followed to build the guidance and the implementation of the guidance.

3.1 Steps to build the guidance

To build the guidance, we followed 10 steps that are briefly explained next:

1. Select and identify key sources of DevOps. This step was performed using a systematic literature review [Muñoz, 19]. As a result, sources such as The science

behind DevOps: building and scaling high performing technology organizations [Forsgren, 18], the DevOps handbook [Kim, 16], DevOps a software architects perspective [Bass, 15], and the Phoenix project [Kim, 13] were taken as a reference to get information about generic phases, activities, tasks, techniques and tools, and roles.

2. Classify the phases, activities, tasks, techniques, and tools of DevOps to define a Generic DevOps process.

3. Map the issues of DevOps related to processes, guidance, and team with the generic DevOps process defined in step 2.

4. Map the Basic profile of the ISO/IEC 29110 with the Generic DevOps process to identify the tasks, work products, and roles needed to improve the Generic DevOps process.

5. Map the work products, which can help to achieve the DevOps objective or fix the generic DevOps process gaps.

6. Map the roles according to the responsibilities, adding the roles needed to achieve the DevOps process.

7. Reinforce the generic DevOps process implementing the selected tasks, work products and roles of the Basic profile of the ISO/IEC 29110.

8. Evaluated and classify the selected task, work products and roles to reinforce the generic DevOps process.

9. Build the guidance to implement the reinforced DevOps process.

10. Update each role's responsibilities using the responsibility assignment matrix also known as RACI matrix according to the tasks to be executed by each role.

The reinforced DevOps process resulted of following the 10 steps has 4 phases and 9 activities. Figure 1 shows each phase purpose, its activities and its involved roles.

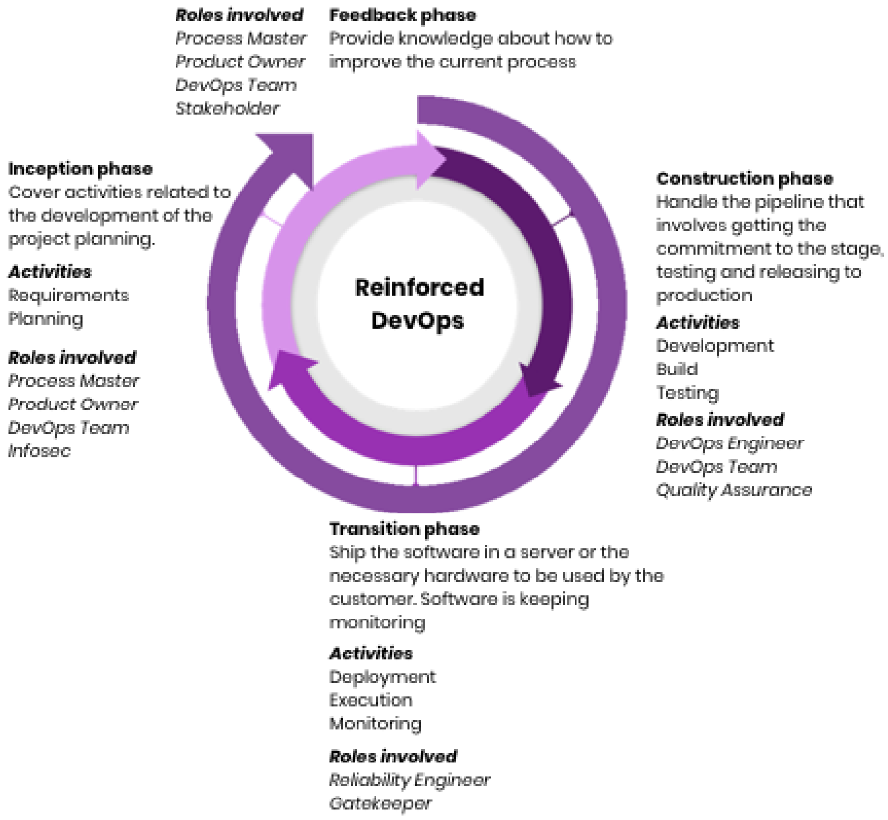


Figure 1: Reinforced DevOps process

3.2 Basics and content of the Reinforced DevOps guidance

To be able to implement the reinforced DevOps process, we build a guidance. To implement the guidance, the idea of the Maslow needs pyramid was taken as base. As Figure 2 shows, we have called it "DevOps pyramid". It was built based on the needs of the organization regarding the implementation of a DevOps approach (culture, sharing, automation, and measurement). Depending on these needs, an organization can adopt tasks that will enable it to achieve a need toward the implementation of DevOps in the right way.

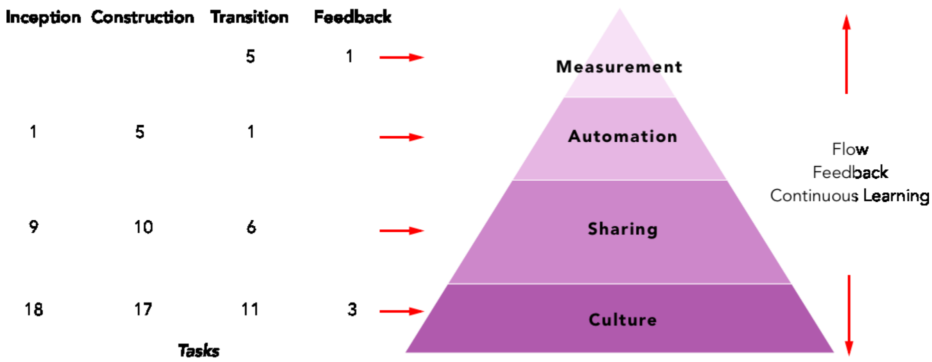


Figure 2: Reinforced DevOps Pyramid

As the figure shows, the *culture* level contains forty-nine tasks that must be added to enable an organization to share the information actively. Achieving this level allows an organization to address the active request of information, shares responsibilities, encourages the cross-functional collaboration among the development and operation team, and treats failures and new ideas as opportunities to improve the system.

The sharing level contains twenty-five tasks that must be added to enable an organization to understand and help each other's goals and priorities. Achieving this level allows an organization to address the understanding of what the organization is doing and the goals and priorities, the share of knowledge across teams, the collaboration of teams, the verification of work products by the teams, and the validation of deliverables with the stakeholders.

The automation level contains seven tasks that must be added to enable an organization to get continuous actions, not only in software implementation but also in project management. Achieving this level allows an organization to address the sharing of technical knowledge, automated deployment, and support, reduces testing time, keeps up the monitoring of data, and reduces the time to set up functions.

The measurement level contains six tasks that must be added to enable an organization to check, in a quantitative way, the performance of the whole team getting better metrics in quality. Achieving this level allows an organization to address the reduction of rework and monitoring and increases the quality of the software product.

It is important to highlight that the DevOps pyramid was built to support an organization to obtain the maturity and, in this way, to change its traditional environment to a DevOps one. Therefore, the organization cannot change to a higher level if the current level is not achieved. To help organizations to know their current level, the guidance provides a diagnostic assessment questionnaire included as part of the web platform.

4 Web Platform to use the guidance

To provide support in the use of the proposed guidance, a web platform has been developed. Then, the web platform contains both the diagnostic assessment questionnaire and the guidance, which includes the supporting material to help organizations to know how to implement the reinforced DevOps processes, such as the description of each phase, the tasks, the roles, the work products, the templates, and the metrics for the assessment.

The web platform was built following the Model-View-Controller (MVC) architecture pattern, and the interoperability between the two frameworks is using the HTTPS protocol. To build it, the next tools were used:

- Tools for software development:
  - Visual Studio Code: a code editor to build every software component.
  - Sketch: a design toolkit to create templates, design, and mockups.
  - Apache: as HTTP server.
  - MongoDB: NoSQL documents' database.
  - Angular: a framework to build a responsive design web application.
  - Laravel: open-source framework.
- Tool for project management:
  - Azure DevOps: planning tool with Kanban board.

4.1 Architecture

Figure 3 is a static representation of the web platform architecture using a C4 model [Brown, 18]. This C4 model helps to create a map of the code with various levels of detail. This representation is about the third level, which shows a zoom in the components section.

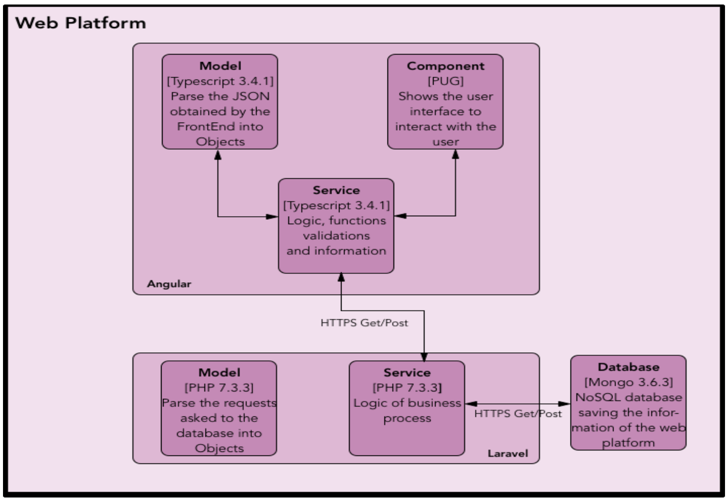


Figure 3: C4 components view of Web Platform

The web platform is stored in a Google Cloud server, which has containers with all the configuration of Angular, Laravel, and Mongo in the same server.

4.2 Web platform sections

The web platform contains two sections: the diagnostic assessment questionnaire section and the guidance.

a) The diagnostic assessment questionnaire part provides a set of questions that allows an organization to know its current state regarding the level of DevOps, so that it is possible to provide a start point to the implementation of DevOps in the appropriate way based on the organization's needs. As Table 2 shows, the diagnostic assessment questionnaire covers 10 information blocks related to a level of need (culture, sharing, automation and measurement). Besides, the third column provides a justification of each block.

Blocks	Related level	Justification
Block 1 is focused on establishing how the planning is performed in the organization projects.	Culture	Knowing how the organization planning was established is needed to get a precise background.
Block 2 is focused on establishing how is performed the tracking of the projects in the organization and the use of corrective actions in possible deviations.	Sharing	After planning the project, how the development and operation teams is making the tracking and implementing corrective actions to possible deviations through the project.
Block 3 is focused on analyzing if the organization recognizes the project's risks and defines ways to prevent or handle them.	Sharing	Risks that could affect the verification and validation activities have to be considered to be prevented or mitigated to ensure the quality of the project.
Block 4 is focused on analyzing the way to get the project requirements and their understanding by the whole team.	Culture	It is ensured that the whole team knows the requirements and understands them.
Block 5 is focused on analyzing the perception of customer satisfaction by the organization.	Measurement	Customer satisfaction is related to the quality of the service or product. The whole team has to qualitatively and quantitatively assess aspects of quality.
Block 6 is focused on checking the providers' management.	Sharing	It is ensured a way to handle the providers according to the project's needs.
Block 7 is focused on analyzing if the training is contemplated to develop the project effectively.	Automation	To implement the automation tools, it is needed to have a development and operation teams with enough skills.
Block 8 is focused on analyzing the quality of the products.	Sharing	It is ensured the management of the quality of the project work products.

Block 9 is focused on analyzing and keeping the configuration of the project plan and the development.	Culture	It is ensured that the whole team knows the configuration management and uses it.
Block 10 is focused on analyzing the infrastructure implemented in the project.	Automation	The automation tools, practices, and tactics are evaluated.

Table 2: Blocks, their related levels and its justification

Figure 4 shows an example related to how the diagnostic assessment questionnaire are displayed on the platform. These questions are in the following structures, yes/no questions and/or multiple-choice questions.

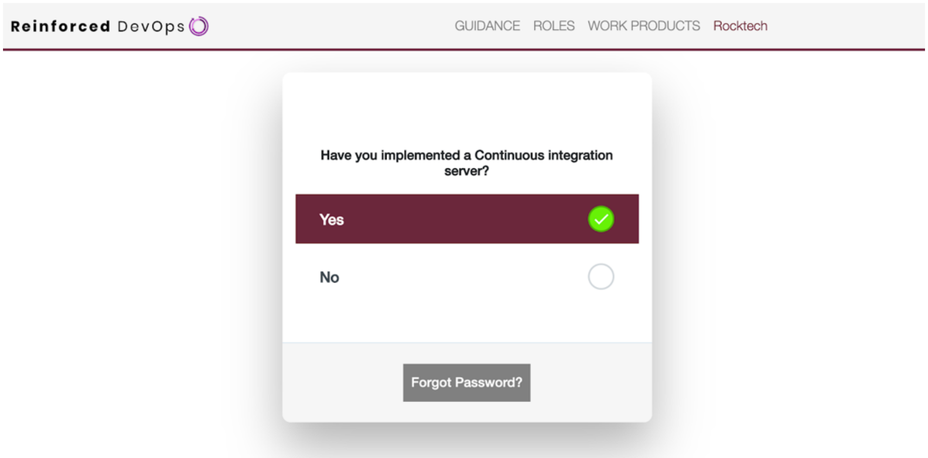
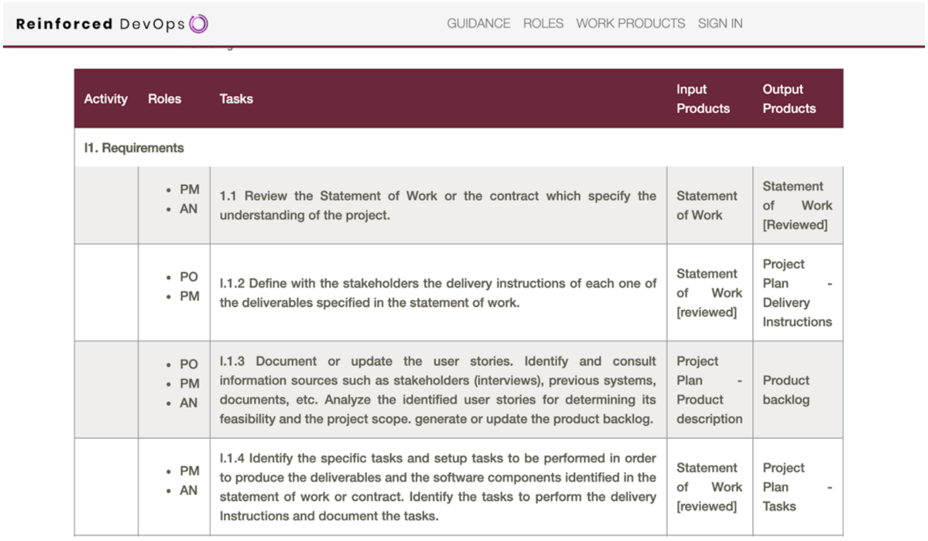


Figure 4: Example of the assessment questions

b) The guidance part is based on the guide to implement a reinforced DevOps process to help an organization to implement it adequately; here, the screenshots of the workflow included in the web tool to demonstrate the parts that integrate and how a VSE or small group of a big organization can adopt a reinforced DevOps approach are provided.

It is important to highlight that web platform consists of the next sections: the guidance, its roles, its work products, and the signing in as briefly described:

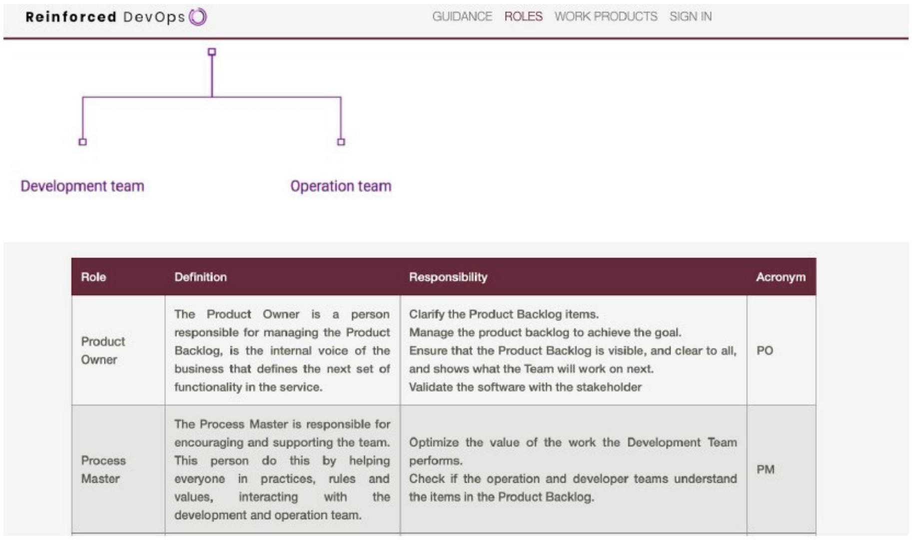
- The guidance section provides all the information contained in the reinforced DevOps process, covering the four levels of the DevOps pyramid (culture, sharing, automation, and measurement). For each level, the activities, roles, tasks, input products, and output products are described. Figure 5 is an example of the requirements activity.



Activity	Roles	Tasks	Input Products	Output Products
I1. Requirements				
	• PM • AN	1.1 Review the Statement of Work or the contract which specify the understanding of the project.	Statement of Work	Statement of Work [Reviewed]
	• PO • PM	I.1.2 Define with the stakeholders the delivery instructions of each one of the deliverables specified in the statement of work.	Statement of Work [reviewed]	Project Plan - Delivery Instructions
	• PO • PM • AN	I.1.3 Document or update the user stories. Identify and consult information sources such as stakeholders (interviews), previous systems, documents, etc. Analyze the identified user stories for determining its feasibility and the project scope. generate or update the product backlog.	Project Plan - Product description	Product backlog
	• PM • AN	I.1.4 Identify the specific tasks and setup tasks to be performed in order to produce the deliverables and the software components identified in the statement of work or contract. Identify the tasks to perform the delivery Instructions and document the tasks.	Statement of Work [reviewed]	Project Plan - Tasks

Figure 5: View of information about guidance for the requirements activity

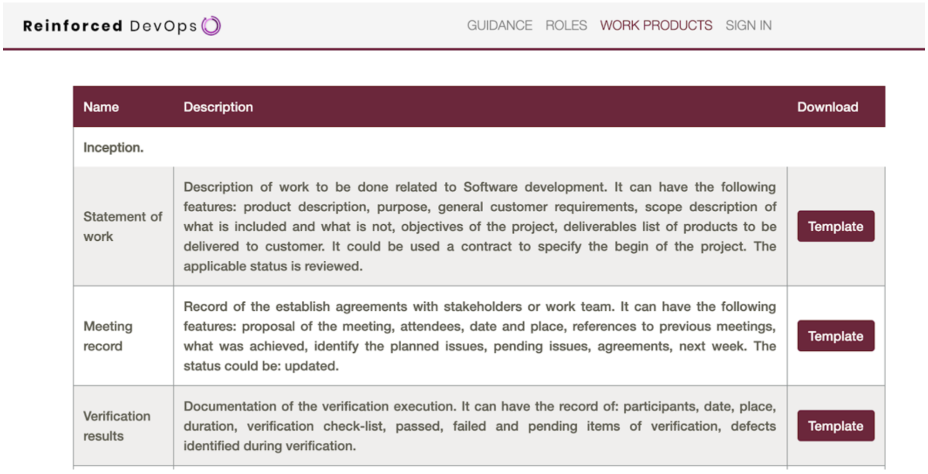
- The roles section provides information about the hierarchy, responsibilities, and definition of every role. Figure 6 shows an example of roles for the product owner and the process master.



Role	Definition	Responsibility	Acronym
Product Owner	The Product Owner is a person responsible for managing the Product Backlog, is the internal voice of the business that defines the next set of functionality in the service.	Clarify the Product Backlog items. Manage the product backlog to achieve the goal. Ensure that the Product Backlog is visible, and clear to all, and shows what the Team will work on next. Validate the software with the stakeholder	PO
Process Master	The Process Master is responsible for encouraging and supporting the team. This person do this by helping everyone in practices, rules and values, interacting with the development and operation team.	Optimize the value of the work the Development Team performs. Check if the operation and developer teams understand the items in the Product Backlog.	PM

Figure 6: View of information about roles.

- The work products section provides information on the name of the work products, their description, and the templates to download (if necessary). Figure 7 shows an example of work product information of the inception phase: statement of work, meeting record, and verification results.



Name	Description	Download
Inception.		
Statement of work	Description of work to be done related to Software development. It can have the following features: product description, purpose, general customer requirements, scope description of what is included and what is not, objectives of the project, deliverables list of products to be delivered to customer. It could be used a contract to specify the begin of the project. The applicable status is reviewed.	Template
Meeting record	Record of the establish agreements with stakeholders or work team. It can have the following features: proposal of the meeting, attendees, date and place, references to previous meetings, what was achieved, identify the planned issues, pending issues, agreements, next week. The status could be: updated.	Template
Verification results	Documentation of the verification execution. It can have the record of: participants, date, place, duration, verification check-list, passed, failed and pending items of verification, defects identified during verification.	Template

Figure 7: View of information about work products

- The Login has different functions, login the platform to see the profile and create a form, forgot password, and create an account are these functions. Figure 8 shows an example of the Login.

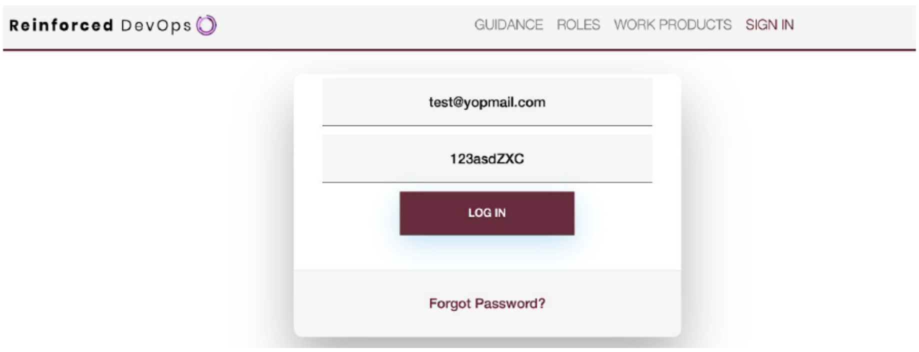


Figure 8: View of information about Login

4.3 How does the web platform work?

This section provides an overview of how the guidance works after a user signs up in the web platform, and a new diagnostic assessment questionnaire to obtain a start point to implement DevOps is created:

- A decision tree structure following the structure if, else is enabled.

- Depending on the user answer to a diagnostic assessment question, the next question can be about a work product, a role, the process, or the process implementation.
- The final result of the diagnostic assessment questionnaire is shown for the organization in a web platform screen. This screen provides the results of the organization's needs, in that specific time, toward the implementation of the reinforced DevOps process (see Figure 9).
- The percentage obtained after answering the questions can have three possible values: Not Approved, when the result is less than 70%; Approved, when the result is more than 70% but less than 100%; and Satisfied, when the result is 100%.
- Based on the percentage obtained, the web platform recommends the organizations to check the instructions provided to get or do the tasks missing to achieve their goals.
- After that, the organization has access to the guidance to complete the tasks or downloads a work product template that will help them to achieve their goals.

5 Case study

To assess and validate the benefits of this web platform, a case study was designed and executed in an organization to know the viability of the web platform finding out its possible points of improvement regarding the implementation of a reinforced DevOps process.

The case study design is next shown:

- The Objective: the objective is to assess and validate the web platform user experience, diagnostic assessment questionnaire, and the guidance information.
- The case: check if all parts of the web platform are understandable to the whole team, who will use it to adapt the tasks, concepts, or anything that they need to improve their process towards the establishment of a DevOps environment.
- Theory: it seems that DevOps is everywhere, or at least, it is part of many agile processes. Its adoption has been surrounded by many proposals, all of them aiming at being agile with the automation process [Mansfield-devine, 18]. However, this information is widely dispersed and not easily accessible, making it difficult for interested organizations to understand what its proper implementation implies.
- Research question: How efficient and effective is the web platform in providing support to the organization of where to start for implementing a DevOps?
- Selection Strategy: (1) to give to the Scrum Master access to the platform to sign in and then use it; (2) to keep up with him to know any question he has and the time he/she uses to finish answering the diagnostic assessment questionnaire; (3) to ask if the results are understandable for him and explain all the questions about the results view; (4) to set up a meeting to know about the situation and what they can do to solve or improve the current process.

To perform the case study, an organization that wanted to reinforce its DevOps environment was located and invited to participate. This organization uses Scrum to complete its projects, and it is applying automation tools. A person responsible for the team was assigned to participate in the case study following the selection strategy; finally, the information about the current scenario was saved in the platform. Figure 9 shows a screenshot of the results view.

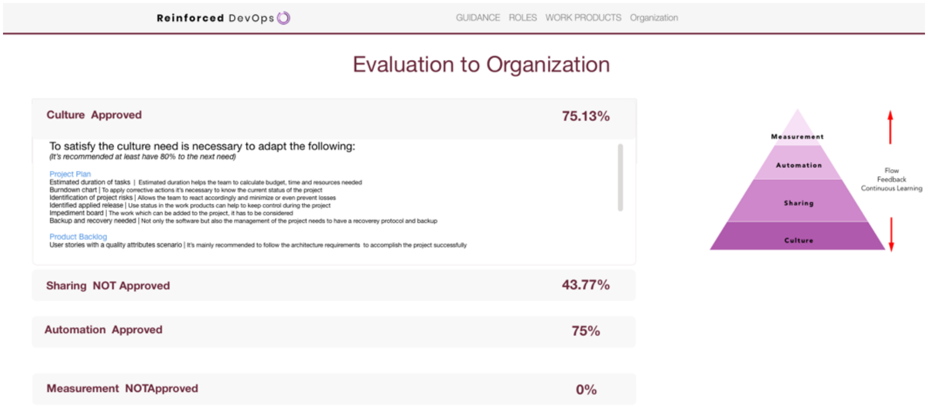


Figure 9: Case study web platform results

As the figure shows, the evaluation provides the percentage of coverage related to the four levels of DevOps based on the answers to the assessment questions. In this case, according to the results of the diagnostic assessment questionnaire, the organization obtained 75.13% in the culture level, 43.71% in the sharing level, 75% in the automation level, and 0% in the measurement level.

Even when they have passed two levels (culture and automation), they did not get the 100% coverage; then, the web platform suggests that they must achieve 100% of the culture level to get all the benefits of this level. It is important to mention that the web platform provides a list of tasks that will help them to satisfy each level.

In this case, the organization is working with the adaption of their methodology, but now they are considering to take some tasks of DevOps proposed by the web platform to adapt it. An important data is that the Scrum Master was assessed in about 45 minutes.

The time to perform this evaluation and the obtained results were compared with the implementation of the guidance made in another case study published in [Muñoz, 20], in this case study, the organization aimed to improve the management and software implementation with DevOps practices because they had problems in their releases. The execution of this case study has the particularity that the diagnostic assessment questionnaire was applied face to face to the team responsible to implement the DevOps environment.

As mentioned in [Muñoz, 20] because for this case study we do not have the web platform, it was needed to give some workshops and training to help the whole team to adopt the Reinforced DevOps guidance.

The first difference between the case study presented in [Muñoz, 20] and the case study presented in this paper was on time. The first one was needed about one week to explain to the whole team the guidance and get the information using interviews and here. However, using the web platform (second case study), the time required to know the current process was reduced to 45 minutes.

The second difference was on the experts' dependence. In the first case study [Muñoz, 20] was needed to have an expert that helps team members to understand the organizational needs to adapt the tasks of the Reinforced DevOps process within the organizational processes. However, using the web platform (second case study), after answering the diagnostic assessment questionnaire using the web platform, the team members could check the information needed in the web platform to help themselves to adapt the reinforced DevOps process into the organizational processes.

After comparing the results of both case studies, the web platform proved to be efficiently and effectively, providing support to the organization of its current state compared to the levels of DevOps, and it provides detailed information on where the organization should start for competently implementing a DevOps.

6 Conclusions and next steps

DevOps application is much more than a set of tools; it is a culture, a way to collaborate among the development and operation team members to complete the project successfully. It provides a cultural change in organizations in many ways. For example, setting a visible workflow for the whole team, automating processes, not only in the software part but also in managing and learning through experimentations to improve themselves.

There is a lot of DevOps information, but for an organization that is working in a traditional approach, changing to something new like DevOps approach including automation in the process is arduous. The benefits could be less than the cost involved. Several opinions aim to the same: there is a lack of guidance to implement DevOps step by step. Besides, if an organization wants to change the cultural workflow, the time will increase, depending on the team skills and how they currently manage their projects.

The team members have to improve their knowledge with some concepts, which are related to infrastructure such as serverless, containers, cloud configuration, continuous integration, deployment servers, etc. Therefore, DevOps includes a learning curve, management changes, and a different way to work, which could be catastrophic if not implemented adequately.

Organizations do not need to change their whole process; they should adopt DevOps into their current process and implement it step by step successively.

This guidance aims to provide a way to start the implementation of a reinforced DevOps process or to adapt it to the current process to get the benefits depending on which need is a priority for the organization.

The guidance for implementing a reinforced DevOps process brings the information to enhance the DevOps approach with the elements of the ISO/IEC 29110. Besides, to use the guidance, a web platform is provided, which allows applying the guidance in the organizations in a dynamic way, facilitating the understanding of DevOps and the task that can be adopted to achieve its adequate implementation.

The web platform can show the user how to adapt the DevOps practices in his organization's process. It is important to highlight that using the web platform does not force to change the methodology or set it up again; it depends on the team's needs and what they should change to reduce the issues.

The result of the case study shows that the time to evaluate the organization decreased using the web platform. The Scrum Master, who did the evaluation, just needed about 45 minutes to know the diagnostic results of his organization regarding the starting point to reinforce the organization's DevOps approach. The information provided by the web platform helped the Scrum Master to identify the improvement opportunities to ensure the achievement of the needs level toward the adequate implementation of DevOps within the organization.

Besides, the web platform gives information about the roles, the work products, and the tasks of each level. Depending on the level desired, it provides information to clarify an organization what the implementation of DevOps involves.

The next steps in this research work are to apply the web platform in more organizations, to compare the results, and get feedback from those organizations regarding the web platform.

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References

[Balalaie, 16] Balalaie A., Heydarnoori A and Jamshidi P. Microservices architecture enables DevOps: migration to a cloud-native architecture. IEEE Software. 33, 42–52. 2016.

[Bass, 15] Bass L., Weber I. and Zhu L., Devops A Software Architects Perspective. 2015 Addison Wesley - SEI.

[Bierwolf, 17] R. Bierwolf, P. Frijns and P. van Kemenade, "Project management in a dynamic environment: Balancing stakeholders," *2017 IEEE European Technology and Engineering Management Summit (E-TEMS)*, Munich, Germany, 2017, pp. 1-6, doi: 10.1109/E-TEMS.2017.8244226.

[Brown, 18] Brown, S. Software Architecture for Developers, vol. 2. Visualise, document and explore your software architecture. Leanpub. 2018.

[Buchan, 18] Buchan J. DevOps Capabilities, Practices, and Challenges: Insights from a Case Study. 2018.

[Céspedes, 20] Céspedes, D., Angeleri P. and Melendez K. Software Product Quality in DevOps Context: A Systematic Literature Review. In: Mejia J., Muñoz M., Rocha Á., A. Calvo-Manzano J. (eds) Trends and Applications in Software Engineering. CIMPS 2019. Advances in Intelligent Systems and Computing, vol 1071. Springer, Cham. 2020.

[Colavita, 16] Colavita, F. DevOps Movement of Enterprise Agile Breakdown Silos, Create Collaboration, Increase Quality and Application speed. 2016.

[DASA, 19] DASA. DevOps Agile Skills Association. Retrieved November 12, 2019 from https://www.devopsagileskills.org/,theHALOpenArchive. 2019.

[De Feijte, 18] De Feijte, R., Vliet V. and Jagroep E. DevOps Competences and Maturity for Software Producing Organizations, vol. 1. Springer International Publishing. 2018.

[Forsgren, 18] Forsgren, N., Humble, J., & Kim, G. (2018). Accelerate: The science behind DevOps : building and scaling high performing technology organizations.

[Humble, 10] Humble J. and Farley D. Continuous Delivery: Reliable Software Releases Through Build, Test, and Deployment Automation, Addison-Wesley Professional. 2010.

[Hüttermann, 12] Hüttermann, M. DevOps for Developers, Berkeley, CA: Apress. DOI 10.1007/978-1-4302-4570-4. 2012.

[ISO/IEC/IEEE, 18] ISO/IEC/IEEE. International Standard ISO/IEC/IEEE 26515. Systems and software engineering — Developing information for users in an agile environment. Second Edition. 2018-12. 2018.

[Ivanov, 18] Ivanov V. and Smolander, K. Implementation of a DevOps Pipeline for Serverless Applications, vol. 2. Springer International Publishing. 2018.

[Kim, 13] Kim, G., Behr, K., Spafford, G. 2013. The Phoenix Project: A Novel About IT, DevOps, and Helping Your Business Win. IT Revolution Press; https://www.goodreads.com/book/show/17255186-the-phoenix-project

[Kim, 16] Kim, G., Debois P, Humble J. and Willes J. The DevOps Handbook. How to Create World-Class Agility, Reliability & Security in Technology Organizations, IT Revolution. 2016.

[Lwakatare, 16] Lwakatare L, Kuvaja P. and Oivo M. Relationship of DevOps to Agile, Lean and Continuous Deployment. A Multivocal Literature Review Study. 2016.

[Lwakatare, 16b] Lwakatare L. E., Kuvaja P. and Oivo M. Product-Focused Software Process Improvement, vol. 10027, pp. 399–415. 2016.

[Mansfield-devine, 18] Steve Mansfield-Devine, DevOps: finding room for security, Network Security, Volume 2018, Issue 7, Pages 15-20, 2018.

[Mishra A, 18] Mishra A. Quality and Reliability Engineering. Trends and Future Directions JUCS Special Issue, vol. 24, no. 12, pp. 1677–1679. 2018.

[Mishra D, 18] Mishra, D. Software Quality Issues in SCRUM: A Systematic Mapping," vol. 24, no. 12, pp. 1690–1716. 2018.

[Muñoz, 17] Muñoz, M. and Díaz O. DevOps: Foundations and Its Utilization in Data Center. Springer International Publishing AG 2017 J. Marx Gómez et al. (eds.), Engineering and Management of Data Centers, Service Science: Research and Innovations in the Service Economy, DOI 10.1007/978-3-319-65082-1_10. 2017.

[Muñoz, 19] Muñoz M., Mejia J. and Laporte C.Y. Reinforcing Very Small Entities Using Agile Methodologies with the ISO/IEC 29110. In: Mejia J., Muñoz M., Rocha Á., Peña A., Pérez-Cisneros M. (eds) Trends and Applications in Software Engineering. CIMPS 2018. Advances in Intelligent Systems and Computing, vol 865. Springer, Cham. 2019.

[Muñoz, 19b] Muñoz M., Mejía J. and Laporte C.Y. Implementing ISO/IEC 29110 to reinforce four very small entities of Mexico under agile approach, IET Software. Special Issue: Software Engineering Applications to Solve Organizations Issues. DOI: 10.1049/iet-sen.2019.0040. 2019.

[Muñoz, 19c] Muñoz M., Negrete M. and Mejía J. Proposal to Avoid Issues in the DevOps Implementation: A Systematic Literature Review. In: Rocha Á., Adeli H., Reis L., Costanzo S. (eds) New Knowledge in Information Systems and Technologies. WorldCIST'19 2019. Advances in Intelligent Systems and Computing, vol 930. Springer, Cham. 2019.

[Muñoz, 20] Muñoz M. and Negrete M. Reinforcing DevOps Generic Process with a Guidance Based on the Basic Profile of ISO/IEC 29110. In: Mejia J., Muñoz M., Rocha Á., A. Calvo-Manzano J. (eds) Trends and Applications in Software Engineering. CIMPS 2019. Advances in Intelligent Systems and Computing, vol 1071. Springer, Cham. 2020.

[Pinheiro, 19] Pinheiro W., Pinto G., and Bonifácio R. The Journal of Systems and Software Adopting DevOps in the real world: A theory, a model, and a case study, vol. 157, pp. 1–16. 2019.

[PMI&AA, 17] Project Management Institute and Agile Alliance. Agile Practice Guide. 2017.

[Mann, 18] Mann A., Stahnke M., Brown, A. and Kersten N. State of DevOps. Puppet. Report Retrieved July 20, 2019 from https://puppet.com/resources/report/2018-state-devops-report/. 2018.

[Rong, 16] Rong G., Zhang H. and Shao D. CMMI Guided Process Improvement for DevOps Projects: An Exploratory Case Study. 2016.

[Wettinger, 16] Wettinger, J., Breitenbücher, O. and Leymann, F. Streamlining DevOps automation for Cloud applications using TOSCA as standardized metamodel, vol. 56, pp. 317–332. 2016.