Agile information technology service management with DevOps: an incident management case study

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Abstract: This research aims to investigate how DevOps culture can be applied in the incident management process. The authors believe, based on experience as practitioners, that agile software development methodologies are fair enough to be used on Incident Management process, to quickly restore the business interruption. An application management team which solves incidents and applies DevOps practices was studied. Three data collection methods were used: interviews, document analysis and observation. This research provides novel findings supported by metrics and real experience implementing DevOps practices in incident management process. The novelty of the findings brings advantages for academics, and due to the exploratory nature of this research, it extends the body of knowledge. It also provides contributions for practitioners, by showing how these practices can be applied and the result of the implementation of these practices. Directions of future work are also presented.

Keywords: information technology; case study; interviews; document analysis; observation; DevOps; incident management; application management; agile methodologies; service management.

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1 Introduction

Organisations, since a few decades, have been changing their business management due to the constant competitive behaviour and new technologies, thus, organisations have begun to consider their core business proposition to provide services, changing the world economy to a service-based economy (Badinelli et al., 2012). Services are considered interactive processes between customers and service providers where the customer benefits from the expertise of the service provider (Stokburger-Sauer et al., 2016). Thus, to measure the efficiency of services, the discipline of service management was created so organisations could understand how value can be created (Verma, 2000; Stokburger-Sauer et al., 2016).

To stay competitive, organisations, need to respond to the dynamic changes that markets require, to offer a better experience to their customers and to innovate with new services and products (Soni, 2016). Part of these dynamic changes are grounded on technologic advances. Therefore, organisations have been realising that the information technology (IT) is fundamental to their success (Park et al., 2006). IT changes how organisations work, changing business processes, internal and external communication and most importantly, affects how organisations deliver services to customers (Alsolamy et al., 2014).

Since organisations have started to see the importance of IT, they have begun to implement complex and dynamic IT systems to support their business processes (Jamous et al., 2017). Given the increasing dependence on IT and to support these business processes, organisations began using the term service (Cannon and Wheeldon, 2007). Thus, the concept of IT service started to grow.

Due to both the expansion of IT services and changes in the world economy to a service-based economy, organisations have started to adopt IT Service Management (ITSM) (Pereira and da Silva, 2012). The ITSM is becoming an integral part of organisations (Mora et al., 2015), since it provides a set of activities to align, design, deliver, manage and improve how IT is used within an organisation (Wang et al., 2010).

Despite the existence of some IT frameworks to assist organisations in ITSM implementation, some organisations still struggle to understand the concept behind ITSM, how its processes are implemented (Remfert, 2017) and how to identify which process should be implemented first (Jamous et al., 2017). However, one of the most implemented ITSM processes is the Incident Management (IM) process (Gacenga et al., 2011; Jäntti, 2011; Aguiar et al., 2018).

The Information Technology Infrastructure Library (ITIL) for example, which is one of the most used frameworks to implement ITSM (Pereira and da Silva, 2011; Aguiar et al., 2018) includes the IM process as a core service operations process (Cao and Zhang, 2016). IT operations execute daily tasks to ensure the normal business operation and manage the IT infrastructure (Cannon and Wheeldon, 2007; Cao and Zhang, 2016).

The IM process focuses on restoring a service downtime as quickly as possible (Tan et al., 2010) to avoid any impact to the business users in their daily activities (Ghrab et al., 2016). Due to the competitiveness of the market, organisations want to provide a service of excellence to their customers, and one way to do it is to minimise the negative impact of service interruption on businesses by implementing IM correctly to restore services promptly (Yun et al., 2017). The agile software development methodologies emphasise the rapid software development using frequent and small iterations of development, which is the ideal to restore downtime services to avoid a larger impact for the business (Beddle et al., 2001; Gotel and Leip, 2007; Uikey and Suman, 2016).

To deal with the constant change of requirements, agile methodologies, like SCRUM, Extreme Programming and DevOps were created (Highsmith and Cockburn, 2001; Gotel and Leip, 2007; Laukkarinen et al., 2017). Software developers started to realise that on the traditional software development methodologies it was very difficult to incorporate the clients feedback as the development lifecycle is progressed (Barksdale and McCrickard, 2012).

These agile methodologies, are grounded by the effective communication, collaboration and coordination (Hannola et al., 2013; Suomalainen et al., 2015; Suomalainen and Xu, 2016), not only inside the software development teams but also between the software development teams with the business (Liu et al., 2015; Soni, 2016).

The IM process resolution also has a lot of manual tasks and is time consuming (Gupta et al., 2008) while one of the premises of DevOps is to automate manual processes, like testing, to deliver new functionalities and bug fixes (Sharma and Coyne, 2014).

DevOps is a software development culture that tries to eliminate the lack of collaboration between development and operations teams (Mahanta et al., 2016; Chen, 2019) by teaming them up to promote cooperation, collaboration and communication (Guerriero et al., 2016; Silva et al., 2018).

Building on the previous statements and context there is a gap on the IM process that may be solved by using the DevOps culture. So, this research has the following objective: Explore the relationship between DevOps and the IM process and understand the impacts that DevOps adoption may cause on the IM process.

This research aims to contribute to better a understanding of the impacts that the agile philosophy DevOps may cause on both practitioners and business users, which currently is seen as an unclear area (Kamuto and Langerman, 2017; Prates et al., 2019). More specifically, this research contributes by exploring the impact of DevOps adoption in the IM process.

The remaining article is organised as follows: Section 2 describes the main concepts that frame this research and also examines DevOps case studies (CSs) to confirm that this is an exploratory research; then, Section 3 describes the advisable CS research methodology; subsequently, in Section 4, the authors list all the data that will be needed to conduct the CS; next, Section 5 explains how the authors transform the collected data for analysis; lastly, Section 6 details the main conclusions of the findings discovered during the analysis phase as well as explain the main contributions for academics and professionals.

2 Literature review

To add more scientific rigor to our research, the authors decided to follow the concept-centric approach proposed by Webster and Watson (2002). The literature was collected when analysing several databases such as IEEExplore, ACM, Research Gate and the search engine Google Scholar. Also, this research was made between September 2017 and January 2018, but the author has maintained currency to date.

2.1 Incident management process

Mentioned as one of the key pieces to support any IT system (Pereira and da Silva, 2012) and one of the most implemented ITIL processes (Limanto et al., 2017), the IM process aims to solve incidents and restore services (Wang et al., 2017) while mitigate the impact on business activities and avoiding economic losses (Lou et al., 2013).

Since the organisations' main goal is to generate profit, economic losses must be avoided or mitigated as soon as possible. Moreover, the IM process is not only about solving the issues quickly, but also anticipating and preventing future or repeated incidents from happening (Bezerra et al., 2014; Kikuchi, 2015; Saarelainen and Jäntti, 2016).

An incident can be defined by the interruption of the organisation activity causing negative impacts, like the customers' confidence and financial and productivity loss (Latrache et al., 2015).

In ITIL framework, the Application (AM) is one of the specialist groups, which sometimes also plays the role of application development: "In many cases the same team will be responsible for Application Developments as well as support" (Cannon and Wheeldon, 2007). Such statement indicates that the team that should operate applications and solve incidents can also develop new features for the application, bridging the gap between the IT operations and development that DevOps culture tries to solve.

2.2 DevOps

When developing products and services, there exists a lack of communication between the development and operation teams that are responsible for delivering these products (Rong et al., 2017). The main gap between development and operations teams is the attitude toward changes: the development side embrace the changes as something they need to achieve, but on the other side, operations try to avoid the changes to not compromise the system stability (Hussain, 2015). Besides the fear of change, there exists other problems: risky deployments; the blame-game, where the operations find the production issues and blame the developers for bad developments; and isolation, where developments from programmers, testers and quality assurance occur in silos, while the operations silo includes database administrators, systems administrators and operators (Wahaballa et al., 2015; Katal et al., 2019). To face these problems between the development and operations teams, a new agile culture appeared, DevOps.

The Dev is from Developers and Ops from operations, promoting the collaboration between this two teams sharing tasks and responsibilities while being empowered with full accountability of their service and its underlying technology stack, from development, to deployment and to support (Perera et al., 2017a). This research follows the definition of Dyck et al. (2015) which define DevOps as: "*DevOps is a mindset, encouraging cross-functional collaboration between teams – especially development and IT operations – within a software development organisation, in order to operate resilient systems and accelerate the delivery of changes*". Besides collaboration. DevOps has another main concept, which is the automation to configure and manage deployment environments (Riungu-Kalliosaari et al., 2016; Gupta et al., 2019).

Soni (2016) also says that the philosophy behind the DevOps concept is "the faster you fail, the faster you recover" (Soni, 2016). This means that the faster the deployment of a solution including customers' feedback, the faster developers will be able to make the necessary improvements to enable a better customer experience.

Based on the fast feedback from the application users it would be possible to identify possible incidents sooner. Automation is encouraged by DevOps. Joining the automation with the faster feedback from the application users, the resolution of the incidents can be deployed in production faster, avoiding economic losses for the organisations and contributing to the stability of the application.

2.3 DevOps practices, benefits and challenges

This section lists the main DevOps practices, benefits and challenges found in the literature. More information about the authors that identified challenges and benefits can be seen in Table 1. The authors have given an ID for each benefit (Bx) and challenge (Cx). For a better understanding is not our goal to ring consensus about DevOps practices. A recent study (Jabbari et al., 2016) synthesised DevOps' practices that practitioners have been applying so far. Other studies referring to DevOps practices can be found amongst the literature (Sharma and Coyne, 2014; Soni, 2016; Punjabi and Bajaj, 2017; Stoneham et al., 2017) but not so complete. Therefore, Jabbari' list is used to guide this research about the practices that DevOps includes. These practices can be found in Annex 1.

Table 1 DevOps benefits and challenges

	ID	*Concepts*	*References*	*No. of references*
Benefits	B1	Improved code quality, quality assurance and reliability	Erich et al. (2014), Shahin (2015), Mahanta et al. (2016), Riungu-Kalliosaari et al. (2016), Soni (2016), Laukkarinen et al. (2017), Palihawadana et al., 2017) and Perera et al. (2017b)	8
	B2	Better communication	Erich et al. (2014), Karapantelakis et al. (2016), Riungu-Kalliosaari et al. (2016), Soni (2016), Laukkarinen et al. (2017) and Perera et al. (2017b)	6
	B3	Application stability	Roche (2013), Gottesheim (2015), Guerriero et al. (2016), Mahanta et al. (2016) and Soni (2016)	5
	B4	Visibility to the customer of the implemented features	Roche (2013), Gottesheim (2015), Riungu-Kalliosaari et al. (2016) and Soni (2016)	4
	B5	Continuous experimentation	Erich et al. (2014),Mahanta et al. (2016), Riungu-Kalliosaari et al. (2016) and Soni (2016)	4
	B6	Maximising competences	Shahin (2015) and Riungu-Kalliosaari et al. (2016)	2
	B7	Testing with real customers	Riungu-Kalliosaari et al. (2016)	1
Challenges	C1	Insufficient communication	Riungu-Kalliosaari et al. (2016), Hussain et al. (2017) and Perera et al. (2017b)	3
	C2	Industry constraints	Sharma and Coyne (2014) Riungu-Kalliosaari et al. (2016) and Laukkarinen et al. (2017)	3
	C3	Deep-seated company culture	Shahin (2015) and Riungu-Kalliosaari et al. (2016)	2
	C4	DevOps is unclear but also Evolving	Riungu-Kalliosaari et al. (2016)	1
	C5	Deployment automation for several technologies	Mahanta et al. (2016)	1

2.4 DevOps outcomes vs. benefits

This section aims to elicit which benefits one could expect from DevOps' practices implementation. To do that, the authors searched in the literature for DevOps CSs (Table 2) and synthesised the outcomes and benefits reported by each one. At the end, one can confirm that none of the CSs found was applied to the IM context which proves the novelty of this research.

Table 2 Extant DevOps case studies in the literature in application development

ID	*DevOps practices implemented*	*Reference (author, year)*	*Industry*
CS.1	Automated tests; automated monitor; feedback loops; process standardisation	Roche (2013)	N/A
CS.2	Continuous integration; automated monitor; deployment and test automation	Soni (2016)	Financial industry – insurance
CS.3	Continuous integration	Laukkarinen et al. (2017)	Health
CS.4	Continuous improvement; test automation; shift-left; infrastructure as code	Sharma and Coyne (2014)	Software development
CS.5	Test automation; deployment automation; continuous integration;	Punjabi and Bajaj (2017)	Software development
CS.6	Continuous monitor; deployment automation	Karapantelakis et al. (2016)	Software development
CS.7	Continuous integration; test automation; deployment automation	Stoneham et al. (2017)	Retail
CS.8	Continuous integration; feedback loops	Stoneham et al. (2017)	Government agencies
CS.9	Continuous integration; infrastructure as code	Stoneham et al. (2017)	N/A (Regulated)
CS.10	Stakeholder participation; continuous integration; automated monitors; continuous planning	Stoneham et al. (2017)	Large consume
CS.11	Continuous integration; test automation; feedback loops; stakeholder participation	Stoneham et al. (2017)	N/A
CS.12	Continuous integration; automated tests	Croker and Hering (2016)	N/A
CS.13	Continuous integration; deployment automation; test automation; automated monitor	Shivakumar (2017)	N/A

For better comprehension, the authors grouped the outcomes with a generic description of the outcome. An outcome can be written in a different way depending on its context but mean the same, so the authors have grouped these outcomes by what they have understood from the meaning of the outcome.

Information is synthesised in Tables 3 and 4 to identify which outcomes lead to which benefit and how many times each benefit and outcome is identified by the CSs. It is interesting to note that all CSs reported benefits but only two reported challenges and that the benefits "Breaking Down the Silos" and "Short Release Cycles" are reported by most of the CSs.

Analysing Table 3, the following conclusions can be drawn. The improvements in code quality and reliability are present in DevOps in nine CSs (69%), respectively. The objective of DevOps is to deliver fast of high quality, and our literature review confirms it in practice. Better communication was only matched with "Breaking down the Silos"; however, this was found in seven of 13 CSs, which also represents more than 50% of the sample of CSs. Application stability was also found nine times in the CSs. This shows that DevOps culture works. The final objective of each software project is to deliver with quality, but it is also important to deliver stable software. Having developers and operators working together monitoring the application stability brings great results, building confidence between the IT and business teams.

Table 3 DevOps outcomes and benefits

CS ID	*Outcome*	*Benefit/Challenge ID (Section 2.3)*
CS.1	Breaking down the silos	B2; B6
	Short release cycles	B3; B4
CS.2	Short release cycles	B1; B3; B4
	Application availability	B3
CS.3	CI brings quality	B1
	Industry constraints	C2
CS.4	Short release cycles	B1; B3; B5
	Industry constraints	C2
	Breaking down the silos	B2
CS.5	Short release cycles	B4; B5
CS.6	Short release cycles	B3
	Application availability	B3
CS.7	Breaking down the silos	B2
	Short release cycles	B1; B3
CS.8	Short release cycles	B1
	Breaking down the silos	B2; B6
	High scalability	B3
CS.9	Application availability	B1; B3
CS.10	Breaking down the silos	B2
	Short release cycles	B1
CS.11	Breaking down the silos	B2
	Short release cycles	B5
CS.12	Short release cycles	B5
	Improved security with resiliency	B1
CS.13	Short release cycles	B1; B5

Table 4 Outcome vs. benefit

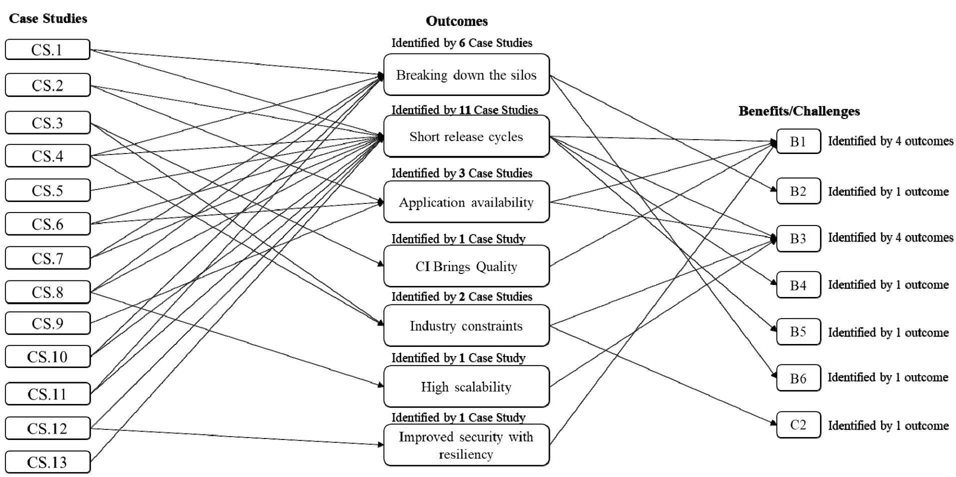
	B1	*B2*	*B3*	*B4*	*B5*	*B6*	*C2*	*Total*
Breaking down the silos		6				2		9
Short release cycles	6		5	2	5			**18**
Application availability	1		2					3
CI brings quality	1							1
Industry constraints			1				2	3
Improved security with resiliency	1							1
High scalability			1					1
Total	**9**	6	**9**	2	5	2	2	

Analysing Table 3, "Short Release Cycles" appears to be the most beneficial practice. Having short release cycles bring a lot of benefits since developers and operators deal with smaller chunks of code, it is easier to maintain, test and deploy. This also allows the business to see their application grow step by step and be able to provide feedback to include in a possible next release, creating a user engagement between the application and the business users.

As far as the authors could find, the application of DevOps culture on the IM process remains an unstudied field. Therefore, grounded on the motivation presented in the Introduction, this research intends to provide more insights about the possible application of DevOps culture on the IM process. At the end of this research, the authors propose to answer the research questions (RQ) presented in Table 5. Since no researches exist about the application of DevOps on the IM process, it is possible to conclude that this research is exploratory.

As shown in Table 2, some scientific studies exist about DevOps application but none of these researches aimed to study or elicit any conclusions/implications regarding the IM process. In Figure 1 there is possible to analyse the relationship between Tables 1–4.

Figure 1 Relationship between case studies, outcomes and benefits and challenges



3 Research methodology

Since the research in the domain of DevOps application in the IM process is in its very early stages, as stated in the previous section, the nature of this research is exploratory rather than hypothesis testing. Exploratory research is meant to start a study on a determined phenomenon observed, where there are no prior (or few) works (Zaidah, 2007). Zaidah (2007, p.1), argues that "a case study enables the researcher to examine the data within a specific context".

Yin (2009) argues that questions like 'what' are exploratory since the purpose is to develop propositions for further inquiry, which fits the questions that were previously stated. A CS also has ‘how’ and ‘why’ questions, where the researcher does not have control over the variables, which suits this research (Perry et al., 2004).

Moreover, a CS is built around a question (Thomas, 2016), which in this case is, “How do DevOps affect professionals working on the Incident Management Process”? For a better synthesis of this research, the authors detailed the main question in several research questions that can be found in Table 5. Following Thomas (2016) theory, this CS is classified as a local knowledge case since the study focus on a team that applies DevOps practices and use the IM process. More information regarding this team can be found in Section 3.2.

Perry et al. (2004) also argues that CS is a powerful method for exploratory researches because they try to understand and explain the phenomenon or construct theory.

Since this research focuses on the analysis of a single team, which will be a single unit of analysis as described by Yin (2009), the authors argue that this research follows a single CS approach.

Table 5 Research questions

Research question ID	*Description*	*Article section*
RQ1	What DevOps practices can be used in each phase of IM?	5.1.1; 5.2; 5.3;
RQ1.1	How can these practices be applied?	5.1.1; 5.2; 5.3;
RQ1.2	Why should these practices be applied?	5.1.1; 5.2; 5.3;
RQ2	What are the benefits of using DevOps practices in IM?	5.1.2
RQ3	What are the challenges of using DevOps practices in IM?	5.1.3
RQ4	How do DevOps improve the resolution of incidents?	5.1.4

For a better understanding on how this research maps with Thomas’ framework, to build a CS, Figure 2 describes the different classifications of our research according to Thomas’ framework and guidelines.

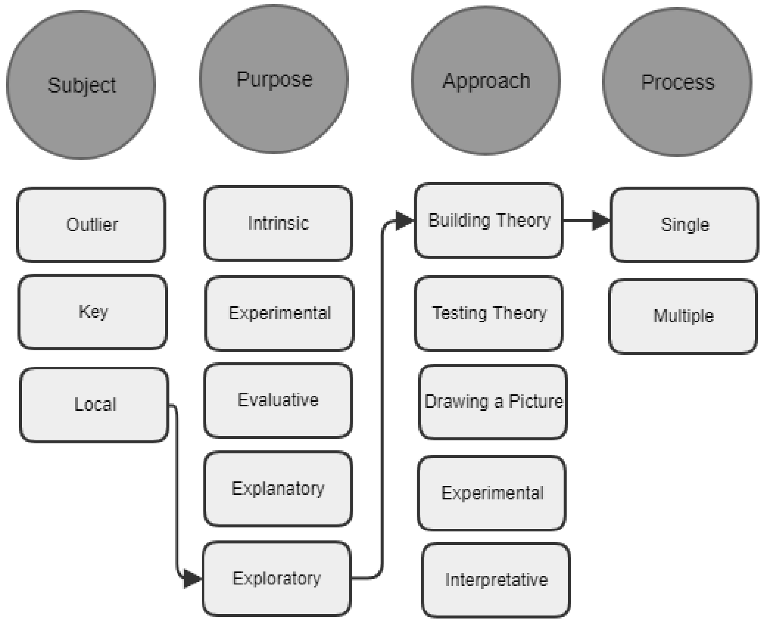
Thomas (2016) also says that time is important and defines three timeframes: Retrospective (where the studied phenomenon happened in the past); Snapshot (where the study happens on a timeframe); and Diachronic (where the study shows a change over time). Since this CS is based on the experience (past) of a single team, this CS is considered as retrospective.

According to Thomas (2016), CSs are about seeing different behaviours from different angles, so many authors advise the triangulation of several data collection methods (Tellis, 1997; Modell, 2005). Therefore, the authors will use triangulation between the following research methods: semi-structured interviews, document analysis and observation recommended by Thomas (2016).

To sum up, performed CS will follow a single, retrospective approach, and the triangulation of methods (semi-structured interviews, data analysis and observation) will be used to enrich the research findings.

In the following sub-sections, the authors explain how this research maps the CS stages proposed by Telis (1997) and Yin (2009): Design the CS Protocol; Conduct the CS; Analyse CS Evidences; and Develop Conclusions. Subsequently, to demonstrate the validity of our CS, the authors use the CS validity test proposed by Yin (2009) to demonstrate our research rigor and relevance.

Figure 2 Path for the CS, adapted from (Thomas, 2016)



3.1 Designing the case study protocol

On this stage, it is required to determine the necessary skills to conduct the CS and develop a protocol where a reading about the topic should be done, to create some draft questions. Tellis (1997) uses Yin as an example arguing that researchers should be good listeners and have a good interpretation of the responses.

In this research, the most required skill is to have a good knowledge of software engineering (SE) and IM process; thus, the authors can interpret the results and know what to ask the target audience.

For the CS protocol, the authors performed a literature review about IM process and DevOps to reach a deep understanding about these domains and how they have been applied so far. To support the interviews, a questionnaire was built to guide the authors.

3.2 Conducting the case study

In this stage, the authors performed interviews to collect practitioners' opinions and experience about the implementation of DevOps practices and their impact for the project and for themselves as IT professionals.

Since our RQs aim to explore what or how DevOps practices influence the work of professionals in the IM process, the authors used semi-structured interviews. This type of interview is used when one needs to gather more detailed information by giving the interviewees the liberty to express their opinions (Miles and Gilbert, 2005). To accomplish the triangulation goal, other techniques for data collection were also used, such as data extraction from performance reports and direct observation.

The interviews were performed with members and ex-members of a maintenance team of a big corporation, which currently employs around of 3000 employees and has offices in six different locations, five locations in Portugal and one in Angola. This team works on an AM workstream, analysing and developing the solutions for production incidents. All the team members work for the same corporation, and they work on the same project as consultants. The client is a Danish organisation that operates in the financial sector. This team also uses several software's in their daily tasks: HP Service Management (HPSM) to manage incidents and changes; Microsoft Team Foundation Server (TFS) as a code repository and to perform CI; Jenkins for building changes and packages of the code checked in TFS; SonarQube to validate the code quality; Artifactory to save the packages that are built on Jenkins; and CA LISA to perform the installation of packages. Additionally, this team works at three different sites at the same time (two offices in Portugal and one office in Denmark), so communication is very important for their success. This team supports the business users in their daily work by helping them when they face some errors with the application, sometimes proving workarounds and making some extractions for business reports. The team also supports the development teams. The dev teams usually present the solutions of the new features to members of the AM team, so weaknesses can be identified before going to production, to improve the quality of the delivery. Also, the AM team is required to help to define the requirements and performance metrics. Generically, observation is used to analyse the 'before and after' of the behaviour of a certain phenomenon after some change (Yin, 2009). However, since the practices were already implemented by the team, it is not possible to verify this change of behaviour in the first place. Thus, the authors will use the observation to validate the findings that were gathered during the interviews.

Observation can be seen as structured or unstructured (Thomas, 2016). Structured observation occurs when the researcher systematically looks for particular kinds of behaviours, while unstructured observation happens when the researcher informally observes important details of what is happening (Thomas, 2016). Unstructured observation may also be called participant observation, where the researcher is also a participant. The kind of observation that should be used in this research is unstructured observation, since the observation will only be used to validate some of the results of the interviews, such as taking notes. We also analysed some performance reports on team performance discrepancies that this team produced weekly to present to business users.

3.3 Analysing the case study evidence

The authors analysed the data that was collected from the semi-structured interviews and from the reports. Furthermore, all the data from performance documentation provided from the team under study was also analysed as well as from direct observation.

3.4 Developing conclusions

This stage must describe all the main findings regarding the data previously collected and analysed. The authors intend to condense all the data collected from practitioners, documentation and observation.

3.5 Case study validity

Yin (2009) proposes four tests to validate CS reliability. These tests are: Construct Validity; Internal Validity; External Validity; and Reliability. All these tests were applied to this case study except for Internal Validity, since Yin (2009) says this test should not be applied to exploratory research. For Construct Validity test, multiple data sources were used on this case study, such as, semi structured interviews and document analysis. Regarding External Validity test the existing literature was reviewed in section two, where was not found any reference about the DevOps application on the IM process, showing the novelty of this research. For the last test, Reliability, there was created a path on how the researchers have built this case study to show to future research how they can proceed with the investigation.

4 Case study protocol and conduct

Since our RQs aim to explore what or how DevOps practices influence the work of professionals in the IM process, the authors used semi-structured interviews. This type of interview is used when one needs to gather more detailed information by giving the interviewees the liberty to express their opinions (Miles and Gilbert, 2005). To accomplish the triangulation goal, other techniques for data collection were also used, such as data extraction from performance reports and direct observation.

Table 6 Interviewees details

Interviewee	*Position*	*Experience*			*Projects in IM*
		Years	*IT*	*IM*	
A	Developer	3.5	3.5	3.5	2
B	Developer	3.5	3.5	3.5	2
C	Senior Developer	4	4	4	3
D	Developer	2.5	2.5	2.5	1
E	Team Leader	7	7	7	3
F	Team Leader	10	10	10	3
G	Developer	3	3	1	1
H	Manager	13	13	10	3
I	Developer	1.5	1.5	1.5	1.5
J	Team Leader	6	6	5	4
Average		*5.4*	*5.4*	*5.4*	*2.35*

At the end of the CS, the authors were able to interview 10 members of the studied team. The details about each interviewee are listed in Table 6. These team members were chosen to be interviewed since they are the ones that put the DevOps practices in place inside the team. There is possible to find the questions used in the questionnaire in Appendix E. All the interviews were performed by one of the authors. The interviews were recorded, where the authors have collected an agreement to authorise the usage of the data collected during the interview. The average time of the interviews was about of 63 minutes and they were performed between March 2018 and August 2018. The interviews were all performed by the same interviewer. There was no software involved on the interview data analysis. All the data analysis was performed by the authors.

The average experience of the team members is about five years. Moreover, most of the interviewees have been involved in more than one IM project, allowing us to retrieve a range of ideas on best practices.

5 Case study analysis

5.1 Semi-structured interviews data analysis

In the questionnaire, the authors asked some basic questions about DevOps, like what practices the respondents are familiar with and what they apply or had applied on previous/current projects. When enquiring about the practices already applied, the authors made a scale from 1 to 3, where 1 meant did not apply, 2 meant partially applied and 3 meant fully applied. One should assume partial implementation as a practice that is incomplete or could not be implemented in the entire context it was expected to work. For example, for deployment automation, a developer cannot use the deployment automation tool for production deployments while a team leader has permission to do it.

Table 7 shows the results for these two questions. From Table 7 one can see that the interviewees have considerable knowledge about the existence of DevOps practices. From the 12 practices addressed in Section 2.3 (Jabbari et al., 2016), Shift-left and Infrastructure as Code were the only practices that the interviewees had no prior knowledge of. Furthermore, from Table 7 one can conclude that the most known practices are being fully or partially applied. The authors also noted that there appears to exist a relation between the experience of the interviewee and the practices implemented. For example, the deployment automation practice is fully applied by interviewees E, B and F, while the others only applied it partially. The CI is being fully applied by the entire team, likely because it is an intuitive and easy practice to employ due to the existence of tools that allow this practice, like Jenkins.

5.1.1 Incident management phases vs. DevOps practices (RQ1)

Given the practical experience and knowledge of the interviewees, the authors introduced a matrix (like Table 8) to gain better understating of the questionnaire where each DevOps practice can be applied in each IM process phase as shown in Table 8. The authors highlighted and coded interviewee’s answers (grey cells in Table 8), why (Wx in Table 8) and how (Hx on Table 8) the practices can help on each IM phase. The grey cells are coded by three tones which go from a lighter to a darker grey, where one or two matches are identified with the lighter grey tone, three matches are the medium grey tone, and greater than three matches are the darker grey tone.

From Table 8 one can see that the only practice where the interviewees did not point any possible correlation is the Shift-left. The interviewees’ lack of knowledge on the corresponding practice is a possible reason for such finding. Regarding all the other practices, the interviewees engaged them in one or more IM phases. The IM phases considered in this research are the IM phases described by Cannon and Wheeldon (2007).

Table 7 Practices known vs. fully and partially applied

	Continuous planning	*Feedback loops between Dev & Ops*	*Continuous integration*	*Deployment automation*	*Test automation*	*Change management*	*Automated monitoring*	*Prototyping application*	*Stakeholder participation*	*Process standardisation*	*Shift left*	*Infrastructure as code*	*Total*	*Percentage*
						Practices known								
A			●	●	●	●	●						*5/12*	*42%*
B		●	●	●	●	●	●	●	●	●			*9/12*	*75%*
C	●	●	●	●	●	●							*6/12*	*50%*
D	●		●	●	●	●		●	●	●			*8/12*	*67%*
E	●	●	●	●	●	●	●	●	●	●			*10/12*	*83%*
F	●	●	●	●	●	●	●	●	●	●			*10/12*	*83%*
G	●		●				●						*3/12*	*25%*
H	●		●	●	●	●	●		●	●			*8/12*	*67%*
I	●	●	●		●	●	●	●		●			8/12	67%
J		●	●	●	●	●	●	●	●				8/12	67%
Total	*7*	*6*	*10*	*8*	*9*	*9*	*8*	*6*	*6*	*6*	*0*	*0*		
						Practices fully vs. partially applied								
A			●	◖	◖	●	◖						*5/12*	*42%*
B		●	●	●	◖	●	◖	◖		●			*8/12*	*67%*
C	◖	◖	●	◖	◖								*5/12*	*42%*
D	●		●	◖		◖			●				*5/12*	*42%*
E	●	●	●	●	◖	●	◖		●				*8/12*	*67%*
F	◖	◖	●	●	◖	●	◖		◖	◖			*6/12*	*50%*
G	◖		◖				◖						*1.5/12*	*12%*
H	●		◖	◖		●			◖	●			*4.5/12*	*37.5%*
I	●		●			●				●			*4/12*	*33.3%*
J		◖		●		●	◖	●	◖				*4.5/12*	*37.5*
Total	*5.5*	*3.5*	*8*	*6*	*2.5*	*7.5*	*3*	*1.5*	*3.4*	*3.5*	*0*	*0*		

To extend Table 8, Table 9 lists interviewees' opinions on why organisations would benefit by applying DevOps culture on IM process and how one could achieve such benefits. The collected information answers the RQ1 by describing the relation between

DevOps practices and IM process phases in more detail, grounded on the experience of the AM team under study. Such mapping is a step forward in this subject. The qualitative data present in Table 9 give us interesting and novel qualitative information to answer RQ 1.1 and RQ 1.2. This table shows arguments from the interviewees to justify why and how DevOps practices may be applied in each IM process phase.

Table 8 IM phases where DevOps practices can be applied

	Detection and recording	*Classification and initial support*	*Investigation and diagnosis*	*Resolution and recovery*	*Closure*	*Monitor and tracking*
Shift-left						
Continuous planning	2 W1, H1	3 W2, H1, H2	1 W3, H1			
Feedback loops between Dev and Ops			3 W4, H3			
Continuous integration			3 W5, H4	4 W6, H4		1 W7, H5
Automated monitoring	1 W8, H6					5 W9, H6
Prototyping application				3 W10, H7		
Deployment automation				2 W11, H8	3 W12, H8	
Test automation	1 W13, H9		1 W14, H10	2 W15, H10		1 W16, H10
Infrastructure as code			3 W17, H11			
Stakeholder participation	4 W18, H12	3 W19, H13	4 W20, H12			
Process standardisation	2 W21, H13, H14	2 W22, H15	2 W23, H16	1 W24, H16		
Change management				1 W25, H17	5 W26, H18, H19	1 W27, H20

Each practice matches an average of approximately three IM phases, which indicates that the practices are, in fact, compatible with the IM process. Moreover, there are 2.3 matches for each grey cell 2.3 which shows that on average, two different interviewees have identified a match between the practice and the IM phase.

The practices with more matches in different IM phases were 'Process Standardisation' and 'Test Automation' matching four different IM phases. Since IM is a process it makes sense that teams who apply this process will try to make a standard for each phase, so it can be easier for everyone on the team to follow it. The Test Automation framework is used to ensure that the testing of new functionalities and incident fixes have the desired quality, ensuring that everything works appropriately.

Table 9 Interviewees' feedback

Why	
W1	"Continuous planning helps the business to know what needs to be fixed and the negative impact that it is causing"
	"It's important to register and centralise incidents to identify the ones that affect multiple users' ability to execute daily work"
W3	"Feedback provided while planning and selecting the next priorities will help in the investigation"
W5	"All the code will be easily merged, facilitating its diagnosis"
	"With CI it is possible to keep track of the changed code, which will be easier to find the person who changed it (given that person is still working for the company) to know why the code was changed that way, since that person could have different thinking on how the functionality should work"
	"Having all the code integrated on the last version and ready to be deployed in any environment may help with replicating incidents, avoiding misalignments between lower environments and production environment"
W8	"Automated monitors are useful to check the health of the system detecting incidents"
W9	"Constant monitoring of the system to find if the incident was solved"
	"Helps to find issues and to guarantee that the fixes are working"
	"The automated monitor will check if the system is ok; this way will also monitor if the fix for the incident was successful"
How	
H2	"By perform quick analysis of the issue reported and affected portfolio"
H3	"Promote Knowledge Transfer sessions"
	"Consider inviting operations for discussions when analysing incidents"
	"Having more sessions between Dev and Operations"
H19	"By requesting action requests/changes to responsible teams"
H20	"By planning in advance future releases in the system"

But these tests can be applied in different contexts according to the interviewees (Table 9). This explains why these tests are not only related to the 'Resolution and Recovery' phase where the solutions are being taken and tested.

The practices that matched fewer IM phases were as follows: 'Automated Monitor', matching two different IM phases; 'Prototyping Application', matching one phase; and 'Deployment Automation', matching two different phases. Regarding the 'Automated Monitor' practice, half of the interviewees placed a match on the Monitor phase, as they have found that this practice is helpful to determining how the incident was really solved. However, there was one interviewee who matched the Detection phase, justifying that the automated monitor might find issues that were never identified. Prototyping Application was only matched with 'Resolution and Recovery' but it was matched by three different interviewees, which is almost half of the interviewees. For Deployment Automation, it was found in ‘Resolution and Recovery’ and ‘Closure’. The purpose of this practice is to speed up the delivery of the code in several environments. Therefore, it will speed up the closure of the incident and its resolution.

To analyse the qualitative data provided in Table 9, the authors opted to concentrate on the most quoted matches (equal or greater than three) from Table 8. Table 9 is just a sample of the interviewees’ answers, and the full table can be seen in Appendix C. Also, the authors analysed some matches that seems contradictory between the interviewees, which makes a relevant discussion (presented in Table 10) on how the DevOps practices might help the IM process phases.

From Table 10, it is possible to conclude that all the IM phases were approached regarding the matching with DevOps practices. This reinforces the idea that DevOps practices can help in several phases of the IM process.

Table 10 Discussion on interviewees’ feedback

Wx, Hx	*Practice*	*IM phase*	*Comments*
W2, H1, H2	Continuous planning	Classification and initial support	The quotes for this practice show that the interviewees are greatly concerned with the prioritisation of their tasks. Their objective is to help the firm’s client’s, but they need to know what the most critical tasks are, so there can be better alignment between the AM team and the business. Two of the quotes shown talk about this prioritisation, while one of the quotes cites their concern on collecting feedback from the customer to provide the initial support This may be achieved by having meetings with the business and regularly reviewing the incidents backlog
W4, H3	Feedback loops between Dev and Ops	Investigation and diagnosis	Here the interviewees have focussed on feedback and knowledge sharing between Dev and Ops teams, bringing better cohesion between both teams and quality to the final solution to deliver to the business
W5, W6, H5	CI	Investigation and diagnosis; resolution and recovery	For both matches, the interviewees have mentioned the importance of the integration and alignment of the code. Having the last code version installed on lower environments will help with diagnosing the root cause of incidents, thus, accelerating resolutions. It was interesting to see that the same ‘why’ can benefit two different IM phases using the same ‘how’ (H4)
W8, W9, H6	Automated monitor	Detection and recording; monitor and tracking	Even though W7 only had one match, the authors found quite curious how all the interviewees had focussed their answers on the Monitor and Tracking phase, creating the match W8. On W8 the interviewees showed that their concern was to use the Automated Monitor to check the system health and if their fixes had indeed solved the incident. While in W7 the only interviewee had justified his choice by using the Automated Monitor to find new incidents. To achieve this, the interviewees suggest implementing some automatic dashboards or scripts to produce reports related with system health

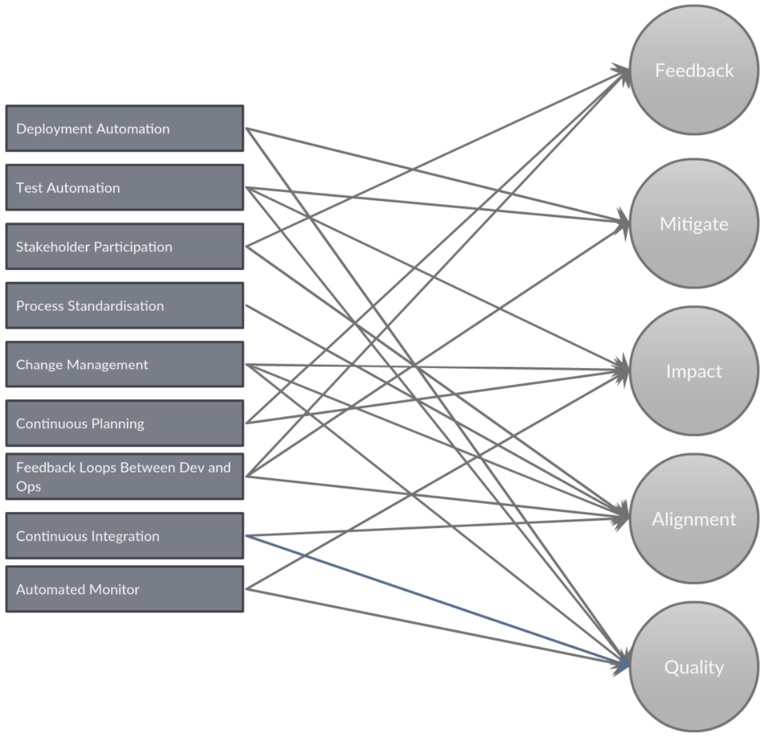
Table 10 Discussion on interviewees' feedback (continued)

Wx, Hx	*Practice*	*IM phase*	*Comments*
W10, H7	Prototyping application	Resolution and recovery	The interviewees have commented this match by showing the result to the business. It looks like this team thinks this practice will lead to a better alignment between them and the business
W11, W12, H8	Deployment automation	Resolution and recovery; closure	Automation deployment is another example where it is possible to see that a practice can be applied for different contexts. The interviewees who found that Deployment Automation is useful for Resolution and Recovery have said that it can be used to deploy fixes for different environments quickly, so the users can approve of the fixes. While the interviewees who have matched the Deployment automation with the Closure phase have justified this by saying that the move accelerates incident closure due to the time saving that this practice brings to the team
W17, H11	Infrastructure as code	Investigation and diagnosis	In their answers, the interviewees have shown some concern regarding the readiness of their environments. None of them have ever applied this practice, but they seem to be intrigued while discussing this practice with the authors, showing interest in applying it later. The interviewees suggested using cloud environments, which provide better tools for implementation
W18, W19, W20, H12, H13	Stakeholder participation	Detection and recording; classification and initial support; investigation and diagnosis	Analysing the quotes from the interviewees, it is possible to conclude that they depend a lot on the business to succeed in their work. The major need that they require from the business is feedback. Without feedback to obtain answers on how to replicate the issues or to get the correct prioritisation for the incidents, they will not be able to solve the incidents as quickly. To achieve this, the interviewees recommend planning meetings with the business users to discuss the incidents impacts
W26, H18	Change management	Closure	The interviewees believe that this practice will facilitate the closure of the incident by guaranteeing the quality requirements that are needed to do the deployments in production. By guaranteeing the quality of the delivery, they can confirm that the incident was correctly solved, contributing to the closure of the incident. There is a need to implement this process very carefully, so it can guarantee the quality required for the deliveries

5.1.2 DevOps benefits (RQ2)

To find the benefits that the DevOps practices brought to this team, the authors have asked the interviewees, "Why have you started to apply this practice?" to determine its benefits as viewed by the participants. The answers are visible in the table provided in Appendix D and serve as the answer to RQ2. In this table we show the number of matches and some quotes from the interviewees citing their justifications.

Figure 3 Practices vs. keywords



Analysing Appendix D, the authors tried to identify keywords that could translate into generic benefits of each practice. The keywords identified by the authors were the following: feedback, mitigate, impact, alignment and quality. By looking at Appendix D, these words are largely used by the interviewees in several practices. For better understanding, the authors highlighted these keywords on the quotes column of Appendix D.

In analysing the table provided in Appendix D, it is possible to find that there is a relationship between these keywords and the practices, which enabled the authors to investigate the benefit behind that practice. One can find these relationships in Figure 3.

Based on Figure 3 and Appendix D, the authors were able to elicit and synthesise the benefits described by the interviewees for each practice, as shown in Table 11.

After analysing Table 11, the authors summed up the benefits of DevOps adoption in the IM process, raising five major concepts, which where possible to map with the benefits identified in the literature review (Section 2.3). This can be seen in Table 12.

5.1.3 DevOps challenges (RQ3)

To determine the DevOps challenges, the authors asked, “What was the adoption of these practices like?” This question was rated from 1 to 5, meaning ‘Very Hard’, ‘Hard’, ‘Neutral’, ‘Easy’ and ‘Very Easy’. The interviewees were given the opportunity to justify their answers. By doing so, it was possible to collect their opinion about the challenges of adopting each DevOps practice. In Table 13, one can find the interviewees’ answers to this question in a condensed format; the full set of answers can be seen in Appendix A.

The columns in the table list the different ratings that the interviewees could choose (with respective comments) and the practices in the rows, creating a matrix. One of the columns presents the sum of the interviewees' ratings so the reader can have an idea of which practices are easier or harder to adopt. Not all the interviewees had experience in the practice in question. So, the sums of the ratings can be different from practice to practice.

Regarding the challenges, the authors have reviewed the answers from the interviewees and take the main idea from their comments to identify the challenge. The authors only considered the practices where the average was less than three, since three in the questionnaire means neutral.

Table 11 Keyword conclusions about the benefits

Practice	*Keywords*	*Conclusion*
Continuous planning	Feedback Impact	With this practice development teams, together with business, can plan the next steps based on the feedback and the impact of the incidents on the business, contributing to business satisfaction and business engagement with the development teams
Feedback loops between Dev and Ops	Feedback Impact Alignment	All the teams can bring their feedback to the table regarding the new developments, reducing the impacts to the business. This practice also guarantees an alignment between the developers and operators, where they can learn from each other, contributing to the quality of software delivery and engagement between developers and operators and maximising competences
Continuous integration	Alignment Quality	This practice will bring alignment between the developments, contributing to the quality of software deliveries and engagement between teams
Automated monitoring	Impact Quality	The Automated Monitor is essential to guaranteeing a fast response to the recent issues, minimising their impact and guaranteeing the quality of the fixes from the AM team, which contributes to software quality
Deployment automation	Mitigate Quality	Deployment Automation is a key practice to mitigate human error, ensuring better quality software delivery
Test automation	Mitigate Impact Quality	Regression tests can be performed automatically, mitigating human error, which will result in less impact on existing functionalities. This will bring more quality to the software solution that was developed
Stakeholder participation	Feedback Alignment	Feedback from all the stakeholders is the key to the success of any application, leading to engagement between stakeholders
Process standardisation	Alignment	The standardisation of processes will lead to alignment between all individuals and later between teams, which will guarantee that everyone will work the same way, leading to quality developments
Change management	Impact Alignment Quality	The change management process measures the impacts of the software change, where all the involved teams will need to be aligned to ensure the quality required for the software

Table 12 Conclusions about the benefits

Benefits	*LR (Section 2.3)*	*CS*
Quality	B1 B3	The participants identified quality of the software delivery in several topics. The quality of software delivery is key for every development team. The quality of the software delivery should not be measured when the software is delivered but during all stages until delivery: meaning, requirement gathering, designing, building, testing. If the quality is improved in all phases, the software delivery quality will be higher
Engagement	B2 B4	The engagement of all the stakeholders on the application is a key success factor for the application. Everyone, this means business users, developers, operators, managers, etc., need to be on the same page; otherwise, the success of the application will not be maximised
Value	Not found in the LR	The objective of every project is to bring value to the business. From the quotes of the interviewees, they are very focussed on getting the feedback from the business and to provide their feedback to businesses to improve them. They know that the business is depending on the applications and since they are responsible for maintaining these applications, they not only try to fix them but also to improve them and avoid possible issues. They implement practices that help them to find the issues quickly to minimise impacts and even find them before the issues happen
Integrity	Not found in the LR	The interviewees are currently maintaining an application that currently is not finished. The development teams are currently working and adding more functionalities to the application. This requires substantial integration between these two workstreams
Personnel development	B6	The concept behind DevOps is to join Operators and Developers. Joining these two workstreams will make them share knowledge between them, which will create more capable professionals who are able to work for these two workstreams

From Table 14, it is possible to identify that the interviewees had challenges in implementing five of the 10 practices that they currently apply. The main challenges found were as follows: time spent on documentation, culture, communication and the technical challenge of implementing the respective practice. Like the previous section, the authors mapped the findings of Section 2.3 and the challenges the interviewees identified.

In Table 15, the authors identify four concepts and some challenges. Comparing the results from the LR in Section 2.3 with the results of the interviewees, it is possible to see that for Technical Challenges the interviewees have stated the difficulty of maintaining the monitors updated to observe the current solution. The Automated Monitors are both important for the developers of the AM team and for the Ops team. This results in a new challenge for the DevOps: since this culture promotes a quick delivery life cycle, it will be possible to deliver with more frequency, not giving enough time to maintain the monitors. Unless, maintaining the monitors should be a task for the developers when they make new developments that could affect these monitors. Regarding the time consumption, all the other authors never found that time was an issue. However, based on the interviewees they lost ample time producing the necessary documentation to support the agile meetings, resulting also in a new challenge.

Table 13 DevOps challenges in each practice

Practices	*Rates*						*Comments*
	1	*2*	*3*	*4*	*5*	*Average*	
Continuous planning		3	1	2		2.8	"It was hard to define which ceremonies should be part of this practice"
Feedback loops between Dev and Ops	1		2	1		2.75	"Challenges due to busy agendas and different time zones between Dev and Ops"
Continuous integration			2	4	2	4	"Easy to implement with the correct tools. Also, easy to understand its benefit"
							"Easy process to use"
Automated monitoring	1		2			2.3	"Requires some time to build these monitors and know what should be monitored"
Deployment automation		2	3	1	1	3.1	"The automated deployment was complex to use due to the team's lack of knowledge of the tools"
Test automation	1	1	2			2.25	"Hard to configure and to maintain due to the continuous delivery"
Stakeholder participation	2		3			1.6	"Lack of engagement from the stakeholders to participate in some decision processes"
Process standardisation		1	1	1		3	"The project management encourages this since it will reduce the mistakes during the process execution"
Change management		1	2	4		3.4	"On the change management process, there are a lot of people involved. The communication between all these people is not easy"

Table 14 Conclusions about the challenges

Practice	*Average*	*Challenge*
Continuous planning	2.8	The challenge for this practice was the time spent to build the support documentation for the required meetings
Feedback loops between Dev and Ops	2.75	The interviewees felt some lack of will from the Ops side to break down the silos; also, the combination between agendas of different time zones was a challenge
Automated monitoring	2.3	It requires time to build these monitors, and the management does not see much value on implementing them since it will take some time to maintain these monitors due new releases
Test automation	2.25	The interviewees have stated this practice is hard to incorporate in their system and to maintain due to new releases
Stakeholder participation	1.16	The interviewees stated there are challenges due to the technical/functional language that can lead to a lack of interest from stakeholders. Also, some stakeholders do not want to be included in the decision-making process since they do not want to have to be accountable if something goes wrong

Table 15 Challenges crosscheck between LR and CS

Concepts	*LR (Section 2.3)*	*CS*
Technical challenges	C5	The interviewees have stated they have found some challenges while implementing the Automated Monitor and Test Automation. The automated monitor needs to be aligned with the current solution that is in production; since the DevOps culture promotes a fast delivery life cycle, it is hard for the Automated Monitor to keep up with these changes. Regarding Test Automation, these tools are hard to configure, which makes this AM team spend a lot of time just to configure/reconfigure the tool
Culture	C2 C3	The interviewees stated the fear of the stakeholders to take accountability for their decisions, which may be related with deep-seated company culture. It is common to have a deep-seated company culture in the financial sector, like the company where these interviewees provide their services
Communication	C1	The interviewees also stated the reluctance of the Ops to provide feedback on the sections of "Feedback between Dev and Ops". This may be related with the insufficient communication challenge since the Ops side does not want to communicate with the developer
Time spending	Not found on the LR	The interviewees have stated they need to spend a lot of time on preparing meetings and all the documentation that is required for these meetings

5.1.4 Team performance (RQ4)

To evaluate if the team performance was improved due to the implementation of the DevOps practices, the authors added a question on the questionnaire where the interviewees could rate from 1 to 3, 1 meaning did not improve while 3 means improved; a box was also provided for comments to justify why a practice had or had not improved. Again, an abridged version appears in Table 16, while the full table can be found in Appendix B.

Analysing Table 16, it is possible to conclude that most of the practices that the interviewees have in place, have improved their work. All the practices have an average greater than two, except for Test Automation, where the final average was 2. From the interviewees' point of view, the test automation practice can be a good practice to improve their work, since they can apply this practice to execute regression tests, which usually takes a lot of time. However, when a test is marked as failed on this tool, it takes a lot of time to check why the test was marked as failed; moreover, some of the failed tests are false positives, which may lead to wasted time.

The authors want to highlight the practices 'CI', 'Automated Monitoring' and 'Continuous Planning'. These three practices got an average of three, which was the maximum rate for this question. For the CI the interviewees focussed their answers on saving time since they have reduced their merge activities and the human error of these activities. When working with other teams, the code merging activities can be very time consuming, as no one wants to make an error on others' code.

Table 16 Team performance

Practices	*Rate*			*Average*	*Comments*
	1	*2*	*3*		
Shift-left					
Continuous planning			6	3	"It helps the team to define objectives and keep their focus on the tasks"
Feedback loops between Dev and Ops		2	2	2.5	"It helps to prevent issues, but it takes a lot of time in meetings"
					"Due to a better relationship between Dev and Ops, errors may be found earlier and even avoided"
Continuous integration			8	3	"It will ensure the code merge, avoiding placing effort on merging activities"
					"It prevents errors in merging and facilitates the alignment between teams"
Automated monitoring			3	3	"Reduces time on monitoring activities"
Deployment automation		2	5	2.71	"Reduces time on deployment activities so there are no worries on creating manual packages"
Test automation		4		2	"Even when automated tests are made, we always need to perform unit and integrated tests
Stakeholder participation		1	3	2.75	"It can improve the performance if all the stakeholders that are involved on the discussion are interested on the topic"
Process standardisation	1		2	2.33	"It requires a lot of time and efforts to define the processes"
Change management	1	2	3	2.33	"It wastes some time to ensure that the right participants are doing their tasks"

Regarding continuous planning, the interviewees have focussed on having a defined scope for their tasks. As previously said in other sections, this team seems to have problems on working within priorities. This practice will allow a continuous scope of activities, so the interviewees do not need to be changing all their tasks from day by day. The interviewees for the Automated Monitor, focussed on how it saves time. The Automated Monitors will create reports or a dashboard, so this team can check the health status of the system and react on time if something goes wrong.

For the remaining practices, the interviewees talked about other topics, like maximising competences (feedback between dev and ops), saving time (deployment automation), the importance of the business of taking decisions (stakeholder participation), making an easier process for everyone to follow (process standardisation) and achieving quality (Change Management).

One can conclude that these interviewees are concerned about the improvement of their work. It is possible to identify that they consider that these practices improve their work, since most of the practices that they implement got an average of greater than two (neutral). They have focussed their improvement of performance on the time saving and on the quality of the delivery. They seem to be satisfied with the time that has been reduced in support and routine tasks, so they can focus on the problems that their business users face every day. Also, they appear to be concerned with the quality of their deliveries and this was also a focus on their answers when asked about performance increase.

Based on the previous statements, it is possible to conclude that DevOps practices may improve the IM process by reducing the time to reach the resolution.

5.2 Document analysis

The documents analysed by the authors were provided by one of the interviewed Team Leaders. Due to the risk of broken confidentiality between this consulting team and their client, all the documents were anonymised, hiding the identity of their client. Plus, the authors could only see the documents using the laptop of the interviewed Team Leader. The authors had the opportunity to analyse two kinds of reports from this team: the one produced at the end of each sprint to evaluate what needs to be changed. The other were weekly performance reports to highlight key issues that were the focus of the AM team for that week. By analysing these reports, the authors intended to cross-check information from the interviewees' feedback. The authors analysed all the reports produced between March 2016 and June 2018, Overall, 18 sprint reports (major releases) and 115 weekly reports were analysed.

Table 17 Report analysis

Type of report	*Report findings*	*Interviewees cross-check*	*Metrics*			
			Detail	*Baseline*	*Evolution*	*Δ% to baseline*
Sprints	In a former report, AM team evidences the lack of engagement of the business on providing feedback and help on the analysis of the incidents. While on the last one, business engagement is already pointed as something positive	W15 H9	N/A	N/A	N/A	N/A
	On the most recent reports, the AM team evidences how important could be implement automated deployments during the test phase of the sprint, optimising the tests of the users	W8	Time to deploy a bugfix	48 h	2 h	–95%
	Changes to scope were also mentioned on these reports. Due to the continuous planning, business users could change the incidents' scope to be delivered on that sprint. The users can prioritise these incidents by their impact, having them solved more quickly.	W1 W2	N/A	N/A	N/A	N/A

Table 17 Report analysis (continued)

Type of report	*Report findings*	*Interviewees cross-check*	*Metrics*			
			Detail	*Baseline*	*Evolution*	*Δ% to baseline*
Sprints	There is no record of the AM team not delivering any incident where was compromised to deliver	N/A	N/A	N/A	N/A	N/A
	Before of the implementation of the Continuous Planning and other agile practices, the AM team did not have any evidence of over deliver incidents that were not planned on the plan of the release. After the implementation of those practices the team was able to show 'Out of Sprint' scope that was being delivered on the release (an average of 10,1 incidents per release)	N/A	Over delivered incidents	0 incidents	10.1 incidents	+100%
	The AM describe that the Business was not interest on showing up on the sprint planning ceremonies, which result on a lot of changes on the sprint scope. After they started to show, the sprint scope started to have less changes, and the changes that were made was a well-defined agreement between the AM team and the business	Appendix B, Continuous Planning quotes	Number of attendees from the business side	1 attendee	5 attendees	+400%
	Before the implementation of the CI and automated deployments, all the environments were misaligned, which impacts a lot the acceptance tests environment. After the implementation of these practices the environments come more stable and aligned	W5	N/A	N/A	N/A	N/A
	On the first, the AM team realises on how the agile ceremonies for the continuous planning consumes time. However, they do not see this as an issue anymore since they have made standard documents	N/A	Time to prepare documentation for ceremonies	4 days	1.5 days	–62.5%
	Stakeholder Participation – The AM team misses the expertise of some areas on the continuous planning meetings. After some time, they do not see this as a problem anymore	Appendix B, Stakeholder Participation description	From the five attendees before mentioned, there are at least one representative of each application module	0 attendees	1 attendee	+100%

Table 17 Report analysis (continued)

Type of report	*Report findings*	*Interviewees cross-check*	*Metrics*			
			Detail	*Baseline*	*Evolution*	*Δ% to baseline*
Performance reports	The AM team could implement biweekly releases with only hotfixes for the most critical incidents (identified after the sprint planning and due to the complexness were not able to include on the sprint). Such biweekly releases exist due to the deployment automation and CI performed by the team. Having a good integration of the software allow to have several tracks of development without having merge errors. Also, the deployment automation saves developers' time, so they can focus on solving the incidents	W4 W5 W9 H6 H9	Number of releases per month	1 release per month	3 releases per month	+200%
	These reports also evidence the existence of some problems on the production infrastructure. The AM team have implemented these monitors to have a reactive posture in case that something was not right. On these reports is stated that the issues were found in time, minimising the impact for the business users	W6	Average of infrastructure problems per month	3 problems per month	0.5 problems per month	–83.33%

The analysis of the documentation was useful to bring consensus on the information collected from the interviewees. These findings can be seen in Table 17. The main findings were the time to deliver a fix, in which the time was reduced in 48 h, over deliver of fixed and more releases per month. These findings demonstrate that some of the premises of DevOps were fulfilled, such as lead time between releases and less time to deploy a delivery.

5.3 *Direct observation analysis*

As previously stated before, the authors have chosen to perform a unstructured observation, which may also be named as participant observation (Thomas, 2016). The team manager allowed to the authors to perform the observation, however only during periods which causes less impact for the business. The observer was a different author than the author that performed the interviews, this way the team members would not recognise the observer and they would be more transparent while performing their job. Unfortunately, it was not possible to observe how the implementation of the practices affected the interviewees behaviour, therefore, the observation will just be used to validate the responses and findings from the other data collection methods. According to Thomas (2016), this, reinforces the definition of this CS (retrospective) stated in Section 3. In Table 18 one can analyse the findings within its sources and if it can be confirmed by observations. Overall, only 10 of the 19 findings were not able to be confirmed by the observation, due to not having a baseline to compare the before and after. It is also possible to note that some of the findings are supported by both semi-structured interviews and report analysis.

Validation of the triangulation between data collection methods will be discussed in the next section.

Table 18 Research findings

ID	*Main findings*	*Source*	*Confirmed by observation?*	*Comments*
F.1	Shift-left was not considered by the Interviewees	Semi structured interviews	Yes	This team usually does not evolve the Ops since the beginning of the software development cycle. Only when it is just really needed
F.2	Each DevOps practice matches at least in an average of 3 IM phases (50% of the IM phases)	Semi structured interviews	No	By observing the interviewees behaviour, it is not possible to see in which phases they apply each practice. Only by looking at documentation
F.3	All the IM phases have at least a match	Semi structured interviews	No	By observing the interviewees behaviour, it is not possible to see in which phase of the IM process the practice is being applied
F.4	Automated Monitor, Prototyping application and Deployment automation matched fewer phases since they can only be applied to reduced contexts	Semi structured interviews	Yes	These practices are applied in reduced scenarios by the AM team
F.5	CI helps on the incident analysis and resolution	Semi structured interviews/ Performance reports	Yes	Sometimes, there were some situations where the team could not replicate the issue reported by the business user. After performing the integration of the most recent code to a lower environment, it was possible to replicate the issue like in production. The environment alignment is also discussed in the report analysis
F.6	Prototyping Application helps to understand the business needs	Semi structured interviews	Yes	It was possible to see that the business was satisfied with seeing some demos before deployment, so they can check the behaviour after the new code

Table 18 Research findings (continued)

ID	*Main findings*	*Source*	*Confirmed by observation?*	*Comments*
F.7	Infrastructure as Code may help ensure the readiness of the environments	Semi structured interviews	No	Since this team does not apply infrastructure as code, it was not possible to observe
F.8	Stakeholder Participation may help on Detection and Recording, Classification and Initial Support, Investigation and Diagnosis	Semi structured interviews	Yes	It was possible to see that the AM team often looks for the business when they find issues, expresses the need to prioritise them and needs help with the investigation. However, it is not possible to confirm in which phase the AM team is
F.9	Change Management is related with Closure IM phase	Semi structured interviews	Yes	It was possible to confirm that the Change Management is related with the closure of the incident. An incident that requires code fix needs to be related with a Change, and the incident will only be closed once the change is approved by the several quality controls
F.10	Several benefits were uncovered after applying the DevOps Practices: Quality; Engagement; Value; Integrity; Personal Development	Semi structure interviews	No	Since the authors could not follow the implementation of the practices, it is not possible to analyse if there are benefits after implementation. However, the increase of engagement is also referred to in the analysis
F.11	It was possible find the following challenges when implementing the DevOps practices: Technical Challenges; Culture; Communication; Time Spending	Semi structured interviews	No	Since the authors could not follow the implementation of the practices, it is not possible to analyse if there are benefits after implementation. Time resources are also discussed in the report, saying that over time, this problem subsides
F.12	All the practices improved the performance except test automation	Semi structured interviews	No	Since the authors could not follow the implementation of the practices, it is not possible to analyse if there are benefits after implementation
F.13	CI and Deployment Automation saves time	Semi structure Interviews/ Performance reports	Yes	There is possible to see that this team saves a lot of time when performing continuous merges using CI where the human error is reduced. This also applies for Deployment Automation

Table 18 Research findings (continued)

ID	*Main findings*	*Source*	*Confirmed by observation?*	*Comments*
F.14	With continuous planning it is possible to have a well-defined scope, and in case of making changes to the scope, it could be aligned between business and team management	Semi structure interviews/ Sprint reports	Yes	In some meetings it was possible to see that the business users wanted to change the scope of the releases a few times, since the plan is made on a continuous way, it was possible to align and change the scope. This is also mentioned that the scope was changed several times during the sprints, on the reports
F.15	While discussing the performance improvement of the team it was referred to as Time saving; Maximising competences	Semi structured Interviews	No	Even that the authors do not have a baseline to compare times for time saving, the authors recognise that applying some of the practice reduces time due to all the manual work that was performed before. Regarding the maximising of competences, it was possible to see that some of the developers do not have any knowledge of the database/environment maintenance, as they are now able to make analysis on the database/environment issues by themselves
F.16	Regarding the performance it was also mentioned an increase of quality	Semi structured interviews	No	There is no baseline to consider before and after the quality that is delivered by this team
F.17	More releases	Performance reports	Yes	It was possible to see this team have several releases per month
F.18	More performance (overdeliver)	Sprint reports	Yes	By looking at the scope delivered incidents by this team, was possible to check that they can deliver a lot of out of sprint incidents
F.19	Infrastructure problems	Performance reports	No	Even not having a baseline to compare the before and after, it is possible to analyse that this team does not handle so much infrastructure issues

5.4 *Synthesis of results*

In this section authors compare the findings that were described on Sections 5.1–5.4, to validate the data collection methods triangulation, as can be seen in Table 19. This table relates all the findings that will be able to answer to each RQ. It also shows in which data collection method it was collected. It is possible to see that most of the findings were found on the Interviews and more than 50% of the findings can be found at least in 2 of the data collection methods, showing that the triangulation of data collection methods was useful in this case study.

Table 19 Data analysis synthesis

Research question	*Finding*	*I*[1]	*R*[2]	*O*[3]	*S*[4]
RQ.1	F.1	X		X	5.1.1
RQ.1	F.2	X			5.1.1
RQ.1	F.3	X			5.1.1
RQ.1	F.4	X		X	5.1.1
RQ.1	F.5	X	X	X	5.1.1/5.2
RQ.1	F.6	X		X	5.1.1
RQ.1	F.7	X			5.1.1
RQ.1	F.8	X		X	5.1.1
RQ.1	F.9	X		X	5.1.1
RQ.2	F.10	X			5.1.2/5.2
RQ.3	F.11	X			5.1.3
RQ.2; RQ.4	F.12	X			5.1.2/5.1.4
RQ.2; RQ.4	F.13	X	X	X	5.1.2/5.1.4
RQ.2	F.14	X	X	X	5.1.2
RQ.2	F.15	X			5.1.2/5.1.4
RQ.4	F.16	X			5.1.4
RQ.2	F.17		X	X	5.2
RQ.2	F.18		X	X	5.2
RQ.4	F.19		X		5.2

[1]Semi structured interview.

[2]Report analysis.

[3]Observation.

[4]Section where this finding is described.

6 Conclusion

Thanks to the interviews made to IT professionals that apply DevOps practices while working with the IM process, and due to their documentation regarding their performance, it was possible to collect a dataset, presented in Section 5, with a lot of findings to answer to the RQ proposed for this study

With these interviews and documentation, it is possible to conclude that these practices can help to increase AM team performance as well as the engagement with business users by making them involved with the solutions that are provided by the AM team, when diagnosing and solving the incidents.

Due to the automation practices like testing and deployment, the interviewees also pointed that they could perform more emergency changes, contributing to the health of the application and to solve the incidents that cause more impact faster. They have also shared, that they would like to fully apply some of the practices like test automation, automated monitoring and infrastructure as code because they understand that by applying this, they have more benefits. Most of the practices were implemented by request of the AM team's client, however some of them, like feedback loops between Dev and Ops and Process Standardisation, were practices that are encouraged to be practiced by the team management, due to the performance improvement that these practices can bring. Also, using Feedback Loops, the AM team could expose some issues regarding new developments, increasing the quality and preventing future problems on the application.

In general, the interviewees are happy to apply these practices due to the agility of DevOps and the involvement of all the stakeholders, they feel their work has impact and it is recognised by the entire organisation.

It is possible to see that the agile principles are well grounded on the DevOps culture. This culture encourages the communication and collaboration not only between the IT teams, but also between the IT teams and the business units, to gather and include as much feedback as possible. Also, more but smaller releases help both developers and IT operations to stabilise the system.

To conclude, all the RQs that this research proposed to answer, were addressed. Regarding RQ1, according to the interviewees all the DevOps practices may be used in the several phases of the IM process, except for Shift-left, which is considered a limitation in this research. Regarding RQ2, several benefits were found for each practice and they were common for all practices, such as, quality of the deliverables, engagement from all the stakeholders and personnel development. Also, interviewees reported some benefits that were not found on the LR, like Value and Integrity. Regarding RQ3, some challenges were also identified as similar as the in the LR, but in this research it was also possible to identify some more challenges that were not previously identified like Time Spending. Regarding RQ4, it was possible to see that the practices reduce time in several manual tasks, IM performance.

Theoretical contribution of the study could be identified in terms of establishing new baselines for further research. In addition, this research provides new insights for the practitioners. In the absence of studies exploring the relation between DevOps and ITSM (IM and AM team), this research brings new insights on why and how an AM team should adopt DevOps practices. Benefits of the practices are also mentioned on this research, as well as the adoption challenges such as time spending on documentation and communication, so the practitioners be aware of their possible outcomes.

6.1 Research limitations

This research also has some limitations. First, DevOps is a very recent culture and few strong studies exist in respectful journals and conference proceedings that can be related to this topic. Second, this research is based on data obtained from a single team. An example of this limitation is that no member of this team knows about the Shift-Left practice. So, this research lacks any conclusions regarding its impact on the IM process.

6.2 Future work

Future researches may investigate how DevOps practices may be applied in other ITSM processes. This is a goal that the authors intend to pursue. Also, the authors suggest the exploration of additional challenges regarding the DevOps implementation, since most researchers appear to be focused on exploring the benefits.

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Annex 1

Practice name	*Description*
Shift left	This practice refers to include operations as early as possible on the SDCL
Continuous planning	Business owners will see the growth of the application, so they can give feedback on whether the application is corresponding to their needs
Continuous integration (CI)	The developers will check in their code on the source control repository and integrate it with the code from other teams, allowing CI
Feedback loops between Dev and Ops	The goal of this practice is to get as much feedback as possible to perform the necessary corrections
Automated monitoring	Allows a better perception of the health of the system. This will allow continuous monitoring of the application
Prototyping application	This will give a better idea of what requirements are needed for the application, reducing time on redesigned requirements
Deployment automation	These tools facilitate by managing the software components that need to be deployed and what middleware components and configurations need to be updated. This will allow continuous deployment
Test automation	Test automation will save some time by performing regression tests to be sure that older functionalities will not be impacted by new developments. This will also allow a continuous testing approach
Infrastructure as code	Allows the organisations to manage which environments need to be provisioned and configured to enable continuous delivery
Stakeholder participation	The participation of stakeholders will provide more feedback to the DevOps teams
Process standardisation	By standardising the processes, they will be perfected over time by identifying errors and correcting them
Change management	Process for the efficient handling of IT changes

Appendix A

	Rates						
Practices	*1*	*2*	*3*	*4*	*5*	*Average*	*Comments*
Continuous planning		3	1	2		2.8	"It was hard to define which ceremonies should be part of this practice"
							"The major challenge of this practice was the definition of dates to book the meetings"
							"The attendees from the business could not realise of the benefits of these meetings, so, they came reluctant to the implementation of this practice"
							"There was a lot of effort to create the template documentation for support for these ceremonies"

Appendix A (continued)

Practices	*Rates*						*Comments*
	1	*2*	*3*	*4*	*5*	*Average*	
Feedback loops between Dev and Ops	1		2	1		2.75	"We felt a lot of lack of engagement from the Ops teams to participate in on our meetings. Maybe due to the different consultant teams between the Development teams and Ops team. After showing this to the client responsible, the Ops, started to accept to attend the meetings and we were able to seem more engagement from their side"
							"Challenges due to busy agendas and different time zones between Dev and Ops"
							"The knowledge transfer sessions that exists between Dev and Ops take a lot of time from the attendees that could be used to perform their tasks"
Continuous integration			2	4	2	4	"Easy to implement with the correct tools. Also, easy to understand its benefit"
							"Easy process to be used"
Automated monitoring	1		2			2.3	"Hard to maintain due the continuous delivery"
							"Lack of interest from the project management. The project management is focussed in fixing incidents and doesn't want to waste the time of their resources in maintain these automated monitors"
							"Requires some time to build these monitors and know what should be monitored"
Deployment automation		2	3	1	1	3.1	"The automated deployment was complex to use due to the lack of knowledge of the team about the tools"
							"It was hard to use due to the lack of the debugging tools to find why the deployment fails"
							"The use is hard due to the lack of knowledge on how to configure this kind of tools, but easy to use"
Test automation	1	1	2			2.25	"It is hard to configure the tools to the system"
							"Hard to configure and to maintain due to the continuous delivery"
Stakeholder participation	2		3			1.6	"Lack of engagement from the stakeholders to participate in some decision processes"
							"There are some challenges to break the barrier between the technical and functional language. In these meetings it is needed some stakeholders that can make this bridge"

Appendix A (continued)

Practices	*Rates*						*Comments*
	1	*2*	*3*	*4*	*5*	*Average*	
Process standardisation		1	1	1		3	"The project management encourages to do this, since it will reduce the mistakes on the process execution" "It takes a lot of time to achieve the perfection on the process. Every time that someone makes a mistake on the process, it needs to be redesigned"
Change management		1	2	4		3.4	"On the change management process there are a lot of people involved. The communication between all these people is not easy"

Appendix B

Practices	*Rate*			*Average*	*Comments*
	1	*2*	*3*		
Shift-left					
Continuous planning			6	3	"Creates more interaction between the development teams and the business, creating better relationships" "With continuous planning we are able to take care of the incidents already discussed with the business, saving time on the analysis" "With continuous planning it will be possible to always have scope to deliver on next releases, which will leave to the decrease of incidents" "It will guarantee that the delivery will be what the business has requested, avoiding wastes of time to code the functionality over again" "It helps the team to define objectives and keep their focus on the tasks" "With this practice, we can have a well-defined scope from the business, so we were able to keep our focus on the scope that was defined"
Feedback loops between Dev and Ops		2	2	2.5	"It helps to prevent issues, but it takes a lot of time on meetings" "Due to a better relationship between Dev and Ops, errors may be found earlier and even avoided" "The team will have a broader knowledge, where the team members will be more autonomous"

Appendix B (continued)

Practices	*Rate*			*Average*	*Comments*
	1	*2*	*3*		
Continuous integration			8	3	"It will ensure the code merge, avoiding having effort on merging activities"
					"Prevent errors on merging and facilitates the alignment between teams"
					"Guarantee the code integration saving time from merging activities"
					"Saves time on merging activities with other teams, avoiding errors of overwritten code"
					"Avoids errors and wasting time on merging activities"
					"It facilitates the code versioning, avoiding mistakes on merging"
					"It allows to have updated environments and ready to work"
					"Our productivity was increased due to the reducing of the merging tasks that we did before"
Automated monitoring			3	3	"Reduces time on monitoring activities"
					"Saves time"
					"Saves time on performing manual monitors that were being done, and allows to find errors and react on time"
Deployment automation		2	5	2.71	"Reduces time on deployment activities and there are no worries on creating manual packages"
					"Reduces the human error and ensure the correct deployment"
					"When it goes fine it can save a lot of time, but when it goes wrong it may result on a big amount of time to understand why"
					"It improves the deployment process, mitigating the human error"
					"Saves time but it can be painful to analyse in case of errors"
					"Allows better release management in terms of time consumed by the deployments"
					"We spent a lot of time on supporting the deployments, but with this practice, we almost don't spend any of our time on supporting these tasks"
Test automation		4		2	"Even when automated tests are made, we are always needed to perform unit and integrated tests"
					"It may have false positives and when this happens, the developers waste a lot of time to find the false error"
					"Tests will be executed faster, but in case of false positives it may result on a big waste of time"
					"Even this practice was in place, our process also includes unit testing, so the developer also needs to take time to perform these tests"

Appendix B (continued)

Practices	Rate 1	Rate 2	Rate 3	Average	Comments
Stakeholder participation		1	3	2.75	"Helps to understand the business needs" "It can improve the performance if all the stakeholders that are involved on the discussion are interested on the topic" "Having business present while fixing a functionality it will give us the right path to follow, instead of trying to fix something which can lead to another error" "The participation of all the stakeholders is important because the accountability of the decisions can be distributed. So, every time that we need to have a decision from the business, we don't need to be reduced a small amount of points of contact"
Process standardisation	1		2	2.33	"It makes the development process easier since the process will be the same for everyone" "It requires a lot of time and efforts to define the processes " "The standard processes make the team to work on the same way for all the processes, there the space for errors will be reduced over the time"
Change management	1	2	3	2.33	"It's essential, but we lose a lot of time on requesting to the other participants on the change process to do their tasks" "It wastes some time to ensure that the right participants are doing their tasks" "All the participants need to be careful on their tasks and do them with the maximum of attention" "Guarantees that all the changes follow the a restrict quality control, contributing to the quality of our delivery" "It guarantees that all the quality procedures have been done, to avoid errors" "The change management process will guarantee that our deliver will follow all the quality standards that are imposed by our client. However, the change management process that we follow today, takes some time since that are required a lot of participants to act, which also impact our timings"

Appendix C

	Why
W1	"Continuous planning helps the business to know what needs to be fixed and the negative impact that is causing" "It's important to register and centralise incidents to identify the ones that affect multiple users to execute daily work"

Appendix C (continued)

Why	
W2	"During the planning, business will show their needs and will expose the next priorities"
	"Feedback from the client will help on establishing a correct classification providing an initial support"
	"The correct incident classification in terms of severity and priority allow to better select mandatory incidents"
W3	"Feedback provided while planning and selecting the next priorities will elk on the investigation"
W4	"By providing feedback from both teams with different perspectives, the issues can be found and analysed easily"
	"Both teams will have different approaches on how to solve the issues generating brainstorms and a better cohesion"
	"Sharing knowledge will maximise the capabilities for both teams, contributing for a faster analysis"
W5	"All the code will be easily merged, facilitating its diagnosis"
	"With CI it is possible to keep a track of the changed code, which will be easier to find the person who change it (in case that person is still working at the company) to know why the code was changed on that way, since that person could have different thinking on how the functionality should work"
	"Having all the code integrated on the last version and ready to be deployed in any environment may help on replicating incidents, avoiding misalignments between lower environments and production environment"
W6	"By always working on the last version of the code will help to find the resolutions"
	"Resolution of the code will be easier, and the code may not be smashed"
	"By using the latest code version, we will be working on the last software version, finding the resolution faster"
	"Since all the integrated code is easier to evaluate the impacts of the resolution, thereby accelerating the resolution"
W7	"It allows to detect any problems originated by teams" parallel developments"
W8	"Automated monitors are useful to check the health of the system detecting incidents"
W9	"Constant monitoring of the system to find if the incident was solved"
	"Helps to find issues and to guarantee that the fixes are working"
	"Automated monitoring will save time for everyone and find issues in production"
	"Can help on checking the system health and if the incidents were indeed fixed"
	"The automated monitor will check if the system is ok; this way it will also monitor if the fix for the incident was successful"
W10	"It will show a proposal of the solution and final behaviour, so the business can accept it faster"
	"It will guarantee that the solution is what the business is expecting"
	"By having a prototype of the fix of the functionality, we can show the result to the users, so they can approve the resolution or tell us what is supposed to be the final result"

Appendix C (continued)

Why	
W11	"Automated deployments will allow more deployments for several test environments, accelerating the user tests to approve the resolutions"
	"The deployment automation may help on the resolution, accelerating the fixes deployment for other environments, finding issues that those fixes may cause in production"
W12	"Incidents may be closed faster since more deployment windows are available"
	"Due to the time saving there will be more deployments, which will give the possibility to install hotfixes more often"
	"To allow deploying release and related incidents/change requests without manual process it will help on the closure of the incident"
W13	"Reduce the manual tests performed to the build solution and application stability"
W14	"If we receive an incident that we guess could fail on an automatic test, we can run that test and check where it fails, giving an idea of where the issue can be found"
W15	"By knowing the final result, it's possible to design the automatic test, saving time, instead of doing the manual test; therefore, the resolution will be found earlier"
	"Automated tests to perform integrated tests to check if the resolution doesn't impact other functionalities"
W16	"By executing automated tests, we can find if the incidents are fixed or not"
W17	"Environments can be easily provisioned to have all the needed components"
	"It will help to have environments ready for the analysis of incidents"
	"This practice will help with having the environments work for the necessities of the developers, helping to analyse the incidents"
W18	"Communicating with the stakeholders will aid in understanding the real impacts and issues that one incident is causing"
	"Will help the business to understand how the functionalities are working and create incidents if needed"
	"By discussing with the business, we can understand if the functionalities are correctly implemented and if there is a misalignment, an incident should be created"
	"Helps understand what the real requirement was and what was implemented"
W19	"By providing feedback to the business, they can categorise the incidents correctly"
	"We can help the business to evaluate the impact of an issue, so it can have a better prioritisation"
	"Due to the stakeholder participation, it is possible to have an initial support in order to help the business in order to understand if there is an issue or not"
W20	"By evolving all the stakeholders, including technical stakeholders, not only the business, it may help on the investigation phase by contributing with other knowledge areas"
	"Business users may help replicate the issues facilitating the analysis"
	"The functional knowledge of the business may be a great plus on investigating the root cause of the incidents"
	"Having businesses participate in the investigation and diagnosis will help to find the root cause for the incidents and finding if the software is working as it was designed. From this we might get two different conclusions: there is no issue and there was an error from the user when interpreting the result of the functionality, or a Change Request may be raised to change the functionality design"

Appendix C (continued)

Why	
W21	"Having standardised processes on how to report incidents will help the users to report incidents properly"
	"In order to report incidents with necessary detail to allow identify the root cause"
W22	"Implement processes to evaluate impacts in order to have a better prioritisation"
	"Having processes to define priorities"
W23	"Having procedures to report incidents properly will help on the diagnosing the incidents"
	"Implementing processes on how to replicate certain behaviours may help on diagnosing the incidents"
W24	"Standard processes may help on the incident resolution facilitating what should be done to progress with the solution that was made while diagnosing the incident"
W25	"Important to detect any undesired effect in the system due to implemented changes"
W26	"Helps with guaranteeing process to deliver a change into production"
	"Manages all the process of the change reducing the impacts that may cause"
	"By being a rigid process, it certifies that the change is in condition to go to production"
	"This process will evaluate the required change to fix the incident, minimising the impact that may cause on the application health"
	"Production/lower environments application changes and incident closure should follow defined process/rules"
W27	"It allows to collect better environment interventions and allocate resources for implementing them"
How	
H1	"Promote planning meetings with the business"
	"Use the Agile ceremonies: Spring Planning, Sprint Retrospective and Sprint Review. Even if the goal of retrospective and review is not planning, it will help to understand the status of the application and the remaining incidents that need to be fixed; therefore, it needs to be prioritised"
	"Regular meetings with the business"
	"Promoting business meetings and discussing the priority incidents to be addressed in following releases"
H2	"By perform quick analysis of the issue reported and affected portfolio"
H3	"Promote knowledge transfer sessions"
	"Consider inviting operations for discussions when analysing incidents"
	"Having more sessions between Dev and Operations"
H4	"Having tools to enable this"
	"TFS and Jenkins are good tools to do this"
	"Having tools that facilitate this integration"
	"The Version Control Software should be able to integrate with a build software"
	"Tools should be used to enable this, like TFS and Jenkins"
H5	"By updating main source code repository and refreshing lower environments"

Appendix C (continued)

How	
H6	"Scripts that can be executed and produce reports"
	"Having tools that trigger alerts when something is wrong with the system"
	"Having dashboards that are automatically refreshed in time to time to detect something wrong with the system"
	"Having reports that are generated automatically are very useful to evaluate the system health"
	"Scripts that are executed everyday generating reports checking the system health"
H7	"Having environments that are not used to analyse incidents but just to install the solutions, so the users can see the final results"
	"Having environments with similar data as production so the users can test the solutions"
	"Lower environments with production data"
H8	"Having tools that can deploy the changes without user action"
	"Tools to enable the automatic deployment for several environments"
	"Tools that deploy changes that are needed"
	"By implementing automation process and reducing human error"
H9	"Executing regression tests and programming specific tests scenarios"
H10	"Having a tool that allow us to provide the final result so that the tool can follow several flows in order to reach that result"
	"Having testing tools that can test several modules of the application at the same time"
	"Having tools where we can insert break points in order to check the flow of the test"
	"Test tools that can make the tests based on final outputs provided by the business to check if the functionality is working as it is supposed to, confirming that the incident was solved"
H11	"Using cloud environments"
	"Cloud environments are an enabler for this"
	"Having scripts and tools that can configure the environments quickly"
H12	"Have regular meetings with technical and functional stakeholder to discuss the health of the system so it can help on diagnosing issues and finding new issues"
	"Involving business on the incident analysis and asking them questions when we find something that looks wrong"
	"By booking meetings to discuss the incident status and ask for help to replicate"
	"Book regular meetings to provide statuses of the most urgent incidents. This way business will participate in case of any doubt that we may have"
H13	"By trying to get involved with the business to help"
	"Having prioritisation meetings with the business"
	"Due to the stakeholder participation, it is possible to have an initial support in order to help the business to understand if there is an issue or not"
	"Prioritisation meetings are needed where the root cause of the incidents is explained and how is impacting the application, in order to have better prioritisation"
H14	"Having a report document template that the business should use when reporting incidents"
	"By defining templates to report mandatory information and this way facilitate root cause identification"

Appendix C (continued)

How	
H15	"Create an incident prioritisation matrix comparing impacts vs. affected people"
	"Having templates with the parameters that should be considered when prioritising incidents"
H16	"Include steps to reproduce when reporting incidents"
	"Setting the steps to reproduce the incidents"
	"Document all the process since the investigation until having the change in production, so everybody can follow the same process"
H17	"Validating the outputs and implementing rollback tasks if needed"
H18	"Have a checklist to check if the change is following the right path"
	"Follow the process step-by-step in order to reduce the impacts"
	"Define the correct path that this process should follow or consider having a software that already has this kind of process"
	"Have the process well defined. However, due to the changes of other processes or teams, this process may need to be redefined. It is needed to adapt this process to all other changes around on the company"
H19	"By requesting action requests/changes to responsible teams"
H20	"By planning in advance future releases in the system"

Appendix D

Practice	*No. of matches*	*Quotes*
Continuous planning	6	"To receive *feedback* from the client as soon as possible in order to enhance incident management/resolution if required"
		"Showing the progress of developments to the business to check if a re-plan is needed"
		"Plan in medium-long time to guarantee a continuous delivery"
		"There were implemented some meetings to re-prioritise the incidents in case of need"
		"Due to the changes of requirements due to the developments"
		"Meetings are made to consider the most critical incidents on the pipeline to be solved"
Feedback loops between Dev and Ops	4	"To *mitigate* errors on deployment activities and enhance recovery activities"
		"To guarantee a better *alignment* between teams"
		"Getting *feedback* from other teams"
		"There are knowledge transfer sessions between the Dev's and the Ops where the dev's share their new developments; so, the ops could share their concerns on how these developments may *impact* the software"

Appendix D (continued)

Practice	*No. of matches*	*Quotes*
Continuous integration	8	"To facilitate the process of having teams working simultaneous on the same application"
		"It helps the development since the developers will always work on the latest software version"
		"Developing the most recent code version allows us to find the errors easily"
		"To keep the integrity to decrease the amount of errors to ensure the *quality* of the software"
		"Due to the increase of deliveries by all the teams it's needed to have all the code integrated to avoid that the code gets overwritten and guarantees the *alignment* between teams"
		"To guarantee all the integration of the software between teams, to avoid merge issues"
		"Allows the team to work on the latest code version, avoiding merge issues"
		"Allows the integration of the most recent code in lower environments, guaranteeing that the team is working on an environment with the most recent code"
Automated monitoring	5	"To monitor system health"
		"It verifies the system health before, during and after the deployments"
		"Saves time and finds new issues"
		"Saves time and find issues introduced by new software deliveries or middleware issues, ensuring *quality*"
		"Finds issues in preliminary stages causing less *impact* to businesses"
Deployment automation	6	"*Mitigates* human error and the process becomes standard"
		"Saves time for the developers by deploying their changes to test environments"
		"Saves time and makes a standard process that everyone will follow"
		"Helps on the deployment reducing human error"
		"*Mitigates* the human error"
		"Saves time and *mitigates* human error"
Test automation	5	"*Mitigates* the risk of breaking existing functionalities"
		"So, the regression tests can be done in a more severe way"
		"More *quality* on testing"
		"Guarantees a rigid regression test plan verifying that the new developments will not result in new errors on the software"
		"Regression tests are made to guarantee the *quality* of the solution"

Appendix D (continued)

Practice	*No. of matches*	*Quotes*
Stakeholder participation	3	"Provides continuous *feedback* of the existing processes"
		"Helps on understanding the needs of the business"
		"Helps to guarantee that everything is delivered as intended"
		"Guarantees that the stakeholders are aware of the status of the application, to know what the most critical issues that need to be solved"
Process standardisation	3	"Defining rules to be followed by everyone"
		"Guarantees that everyone will follow the same process"
		"Implementing standard processes will make sure that everyone will follow the same process, reducing errors"
Change management	6	"To guarantee *quality* on the Software Delivery"
		"To be sure that *quality* control process is made to register the software changes"
		"To guarantee that the code change follows all the defined steps of the *quality* control process"
		"This process helps minimise the *impact* of the change"
		"Process that follows all the code change to ensure that will not cause other issues and guarantees that the problem will be solved"
		"All the deployments are address by following the same rules"

Appendix E

1. Do you know the DevOps methodology? If yes, please give a brief description?
2. Which DevOps practices do you know?
3. Which DevOps practices do you apply/applied?
4. Why have you applied these practices?
5. When have you started to apply these practices?
6. On the beginning of the implementation of these practices, they were applied by all members or just a few? Why?
7. How was the adoption of these practices?
8. Have these practices improved your team performance?
9. How did you do before applying the practices?
10. In which phases of IM do you apply the following practices? How do you apply? Is there any practice that doesn't apply to IM?

Appendix E (continued)

11 Would you like to apply any of the following practices that you don't use today? If so in which IM phases?

12 Would you like to suggest any practice that wasn't identified here?

13 In which other ITIL processes, DevOps would make sense to be applied? In your opinion, how?