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Department of Industrial and Systems Engineering

Final Project Report
BPJ 420

The analysis and modelling of Aurecon's RSA Offshoring Admin and Technical Quality Process for process improvement

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Executive Summary

The following project aims to analyse and model Aurecon's RSA Offshoring Admin and Technical Quality Process to evaluate the performance of the process and identify potential areas for improvement. Different methodologies and tools such as the process analysis and design methodology framework, process mapping, business process modelling and notation as well as simulation modelling were used during the execution of this project.

To gain a better understanding of what the objectives, inputs and outputs of the process are, the Process Definition phase of the process analysis and design framework was used. To illustrate the workflow within the admin and technical quality process, process mapping and business process modelling and notation were used. Simulation modelling was then used to determine how the process may perform in certain scenarios.

A specific scenario that had to be tested with the developed simulation model, was how Aurecon's RSA telecommunication department would handle a volume increase in the number of work orders that will occur in the financial year of 2019. The overall aim of this department, specifically the offshoring team of this department, is to achieve their revenue target for 2019. However, this can only be achieved if the team can handle the volume increase that will occur in the financial year of 2019.

Therefore, the specific modelling objective was to determine whether the current number of available human resources within the process would be able to handle the volume increase and if not, the objective was to identify the additional number of human resources required to handle the increase in the work order volume. Different improvements scenarios were developed and tested with the model. Recommendations were then made based on the output that was produced by the model in each of these improvement scenarios.

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LIST OF ABBREVIATIONS

RSA - Republic of South Africa

PADM - Process Analysis and Design Methodology

BPR - Business Process Redesign

IP - Informatics Process

BPM - Business Process Management

BPMN - Business Process Modelling and Notation

TA - Tax Administration

SBRA - Serbian Business Registers Agency's

TIN - Tax Identification Number

DES – Discrete-Event Simulation

ABMS – Agent-Based Modelling and Simulation

Chapter 1: Introduction

The following project aims to analyse and model Aurecon's RSA Offshoring Admin and Technical Quality Process to evaluate the performance of the process in different scenarios and identify potential areas for improvement. This report covers five main chapters. The first chapter explains the background of the company and the relevant process as well as the problem statement and project approach. The second chapter contains a literature study about the methodologies, techniques and tools considered to approach the problem. The third chapter is a detailed description of the methodologies that were followed during the execution of the project. The fourth chapter discusses the results obtained in Chapter 3 in detail. The last chapter deals with the final recommendations and conclusion of the project.

1.1. Problem Background

Aurecon is an international multidisciplinary engineering consulting company that was formed in March 2009 when Connell Wagner, Ninham Shand and Africon merged into the global group. The company provides advisory, design, delivery and asset management services on projects in different markets, such as aviation, construction, data and telecommunication, energy, health and several other markets around the world. Aurecon played a leading role in ground-breaking projects such as the Bethlehem Hydro Project in South Africa, the Australian Square Kilometre Array Pathfinder (ASKAP) Project and many other projects (Group, 2017).

One of Aurecon's business imperatives is offshoring. Aurecon has different Offshoring Centres in Thailand, Vietnam and South Africa. Offshoring is a business strategy used by many companies to save money. This is done by moving work from high-cost environments to lower cost environments (Group, 2018). Most of Aurecon's branches around the world have a telecommunication and data department, namely Telco. The main clients of this department are Ericsson, Vodacom, Huawei and Motorola. It often happens that Telco Australia receives more projects than the department can handle, therefore the department divides these projects into two groups, namely onshoring and offshoring projects. Telco Australia does not offshore an entire project, only the admin and technical quality process of a project.

The offshoring telecommunication projects are then allocated to the different offshoring centres according to each project's specific technical requirements. The department uses these requirements to determine which resources and skills they need to execute a specific project. Aurecon's South African telecommunication department, namely Telco RSA, consists of both an onshoring and offshoring project team. Telco RSA has better resources and a more skilled workforce, when compared to that of Thailand and Vietnam. South Africa's human resources are also 56,53% less expensive than that of Australia (Numbeo, 2018). Due to the less expensive human resources and more skilled workforce, Telco Australia mostly offshores the admin and technical quality process of a project to Telco RSA's offshoring project team.

Even though this process is referred to as an admin and technical quality process, the process can be executed as either a design or drafting process, depending on the type of work order Telco RSA receives from Australia. Figure 1 illustrates an overview of the RSA Offshoring Admin and Technical Quality Process activities after which a brief description of the process follows.

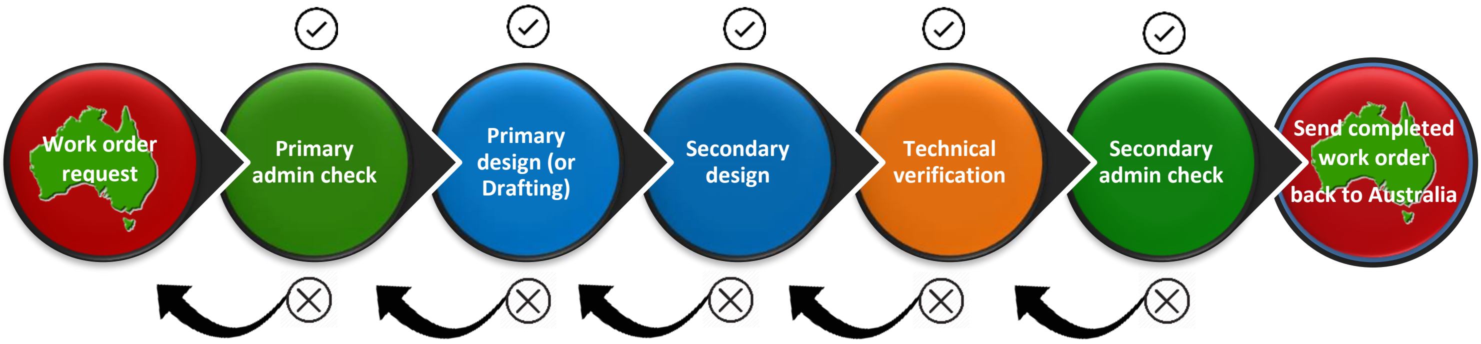


Figure 1: RSA Offshoring Admin and Technical Quality Process.

1. Work order request

Before the RSA Offshoring process can start, employees in Australia must sort all the relevant documentation and information and construct a list of the design (or drafting) requirements for a telecommunication project as requested by one of Telco Australia's clients. These employees then send the list of requirements, in the form of a work order to Telco RSA's offshoring team, which on receipt, initiates the RSA Offshoring Admin and Technical Quality Process.

2. Primary admin check

Employees in the Telco RSA offshoring project team then evaluate the list of project design (or drafting) requirements to determine what the distinctive design (or drafting) tasks are, which level of skills is required and whether all the technical information required to perform these tasks are present. Evaluation of the project deadlines also takes place to determine whether these deadlines are achievable and to know when the due date of the work order is. The design (or drafting) tasks are then allocated to a specific designer (or drafter). If all required documentation and information are not present, the employees send it back to Australia for correction.

3. Primary design (or Drafting)

The designer (or drafter) needs to confirm that all the required documentation is present and determine whether the technical information is correct. If the outcome of the inspection is successful, the designer (or drafter) can start with the first-level designs (or technical drawings). If some information is missing or incorrect, the designer (or drafter) sends the instructions back to Telco Australia for correction. After completing the first-level designs (or technical drawings), the rest of the workflow depends on the type of work order that is being executed. If it is a design work order, the designer then sends the first-level designs as well as the information required to compose the second-level designs to a fellow designer in step 4. In the case of a draft work order, there is no secondary drafting phase. Therefore, the drafter skips step 4 of the process and sends the technical drawings directly to the technical verifier in step 5.

4. Secondary design

If a design work order is being executed, this step is applicable. The fellow designer needs to confirm that all the required documentation is present and determine whether the technical information is correct. If the outcome of the inspection is successful, the fellow designer can start with the second-level designs. If some information is missing or incorrect, the fellow designer sends the first-level designs back to the first-level designer in step 3 of the process for correction. After completing the second-level designs, the fellow designer also needs to complete a verification sheet which serves as a quality check sheet. The fellow designer then sends the first-level and second-level designs as well as the verification sheets to the technical verifier.

5. Technical verification

The technical verifier evaluates each design (or technical drawing) to ensure that it conforms to the technical and quality specifications. All designs (or technical drawings), verification sheets and relevant documentation must be present and signed. If not, the technical verifier sends it back to the designer in either step 3 or 4 (or to the drafter in step 3) of the process for correction. If the inspection is successful, the technical verifier sends these designs (or technical drawings) and verification sheets to the employees in step 6.

6. Secondary admin check

The last step of the process serves as a final quality inspection to ensure that all the verification sheets have a signature and are present, all documents are without any spelling errors, and all the required documentation is present and in the correct folders. These employees also document the actual duration of each part of the process. Thereafter, they compile and sign off the completed work order and send it back to Australia. If any of the documents fail at the final inspection, these administrative employees send it back to the relevant steps for correction. Only when the final inspection was successful and the completed work order was sent back to Australia, the RSA offshoring process ends.

1.2. Problem Statement

In the financial year of 2018, Telco RSA's offshoring team did not only achieve their revenue target but exceeded it with 3.33%. However, the number of telecommunication projects Telco Australia is currently receiving, as well as the future demand thereof, has increased tremendously, causing Telco Australia to face capacity constraints in terms of human resources. Therefore, Telco Australia must increase the number of projects they offshore to Telco RSA from 5240 per year to 7200 per year, which represents approximately 25% of all the telecommunication projects Telco Australia receives from clients. This increase in the volume of work orders has also caused Telco RSA's revenue target for the financial year of 2019 to be 40% more than the amount for 2018.

Since Telco RSA's offshoring team was only able to achieve a revenue slightly above their target for 2018, this new revenue target for 2019 seems like a difficult task. Therefore, there is a need to determine whether Telco RSA's offshoring team has the capacity to handle the increase in the volume of work orders in the light of their current state.

The process must be analysed and modelled to determine if Telco RSA's offshoring team can handle the volume increase, and if not, how the process may be improved to enhance the team's capability with the aim to achieve their revenue target for the financial year of 2019.

1.3. Research Design

With the use of business process modelling and notation and simulation modelling, the expected output of this project is the following:

1. The identified operational capacity constraints within the RSA Offshoring process.
2. The quantified impact of the identified constraints in terms of the lead-time per work order, the average number of work orders that was completed per year, the number of delayed work orders, the average waiting time per work order and the average annual revenue that was incurred.
3. Recommendations on how to manage the constraints to improve the process performance.

1.4. Research method

The project approach was developed using a combination of the methodologies, techniques and tools that are discussed in the literature review of this report. The initial project approach consisted of the following five phases:

1.4.1. Phase 1: Process definition

- Establish the process objectives.
- Define the process boundaries, constraints and interfaces.
- Define the main process inputs and outputs.
- Define departments involved during the execution of the process.
- Define the customers that may benefit from the process.

1.4.2. Phase 2: Capture baseline process

- Construct a high-level draft map of the as-is process.
- Identify the sub-processes and/or steps within the high-level map.
- Collect data and information about the duration of the different tasks, the different costs and staff involved and waiting periods within each sub-process and/or step of the process. Use appropriate data collection techniques such as interviews, observations and/or collecting documents and records to collect the data and information.
- Use collected data and information to draft a detailed map of the current process (capture the as-is state of the current process).
- Use detailed process maps to draft a detailed BPMN model of the current process.

1.4.3. Phase 3: Process Evaluation

- Construct a simulation model in AnyLogic to evaluate the current performance of the process and the effect the increase in the volume of work orders may have on the performance of the process.
- Identify possible capacity constraints within the process using the simulation model.

1.4.4. Phase 4: Process improvement verification and validation

- Use the simulation model to determine what the effect of certain changes within the process may be on the future performance of the process, with the aim to improve the process.
- Determine what the financial implications of these improvements may be.

1.4.5. Phase 5: Recommendations

- Make recommendations based on the findings in the previous phases.

Chapter 2: Literature Review

This chapter of the report contains a discussion of a brief analysis of literature related to the project approach. The focus of this chapter will be to review existing process analysis, improvement and modelling tools and techniques as well as previous articles, papers and case studies that illustrates the application of these tools and techniques. The aim is to determine whether these tools and techniques may be useful to approach the problem.

2.1. Process Analysis and Design (PADM)

Process Analysis and Design Methodology (PADM) is a Business Process Redesign (BPR) methodology that focuses on enhancing an organisations' understanding of a certain business process aiming to improve and redesign the process (The Regents of the University of California, 2017). Although PADM is an eclectic methodology influenced by several other BPR methodologies, an Informatics Process (IP) group at the University of Manchester was able to develop a detailed PADM framework in 1994. The framework consisted of four phases and different activities assigned to each phase. Figure 2 illustrates the detailed PADM framework.

Process Definition	Baseline Process Capture	Process Evaluation	Target Process Design
• *Establish process objectives*	• *Model process in detail*	• *Identify weaknesses and problems within the process*	• *Design a new process*
• *Define boundaries and interfaces*	• *Communicate with the process users*	• *Define and measure key process performance indicators*	• *Develop a new Role Activity Diagram*
• *Define main process inputs and outputs*	• *Examine preconceptions*		• *Streamline and rationalise the process*
• *Define departments involved during execution of process*	• *Develop a Role Activity Diagram*		• *Expliot IT support*
• *Define customers that will benefit*	• *Group activities into the different roles*		• *Change job and social structure*
• *Define the suppliers*			

Figure 2: The PADM framework (Source: (Wastell et al., 1994)).

In an article by Wastell et al. (1994), the above-mentioned IP group, the PADM framework was used by this group in multiple projects across a wide range of industries. The objective of the article was to analyse the flexibility and adaptability of PADM as BPR methodology. In the article the team only discussed three of the projects they executed in detail.

During the first project, the team examined a telecommunication service provider's bill production process. Although the process was relatively well-defined and understood, the service provider wanted to make the process more flexible and effective by developing new ways to manage and support the process. During the last two phases of the framework, the IP group discovered that the current billing process was inflexible and difficult to change. The main reason for the inflexibility of the process was the rigid IT system. The system could only be modified to eliminate some identified weaknesses and some of these small changes took several months. According to the article, this was a typical problem countless companies around the world struggle with.

The aim of the second project was to analyse a Cardiology department's operational processes and make recommendations for IT based improvements. The focus of the project was on the department's outpatients process. This process involved cooperative work of a diverse range of people, such as doctors, nurses, patients and several more, making it overly complex. The process was also the source of several problems such as misplacing clinical notes, causing patients to wait longer and miscommunication between the hospital and the family doctor. The use of the PADM framework enable the IP group to make a variety of recommendations of which many of these were accepted and implemented. The development of a proposed local management information system that assisted the department with critical administrative and clinical information activities and more, was only one of these recommendations. Other departments in the hospital also used the recommended system as a template.

The third project was commissioned by a large manufacturer of computer systems to analyse and redesign the company's systems integration division's key processes. The systems integration division consisted of three main units. During the first two phases of the PADM framework the IP group struggled to define one of these units' key processes. This was due to the unit's informal way of working. In the case of a poorly defined process, PADM recommends the use of soft systems methodologies. Soft system methods are techniques used to solve or to help structure complex, unstructured problems effectively. Several soft system workshops were held towards the end of the project just to define the key process of this unit. However, the IP group was able to proceed with the PADM and make recommendations for the other two units (Wastell et al., 1994).

In each project, the PADM framework has proven to be an effective, flexible, and contingent approach used to better understand and define a business process. Although this article was written many years ago, PADM seemed to remain a relevant process improving methodology until today. The University of California currently has a Process Analysis and Design department called, Organizational Excellence, that uses the PADM framework to support campus clients and improve the administrative processes of the Davis campus of the University of California (The Regents of the University of California, 2017).

2.2. Process Mapping

Process mapping is a process improvement technique used to represent a business process with the use of flowcharts (Bailey, 2018). It increases process transparency so that the various parts and status of a process are always clear to all people. A typical process map shows the different tasks that need to be performed, who needs to perform it, at what stage and where it needs to be performed (Klotz et al., 2008). Figure 3 illustrates a template of a basic process map as well as the meaning of the relevant flowchart symbols.

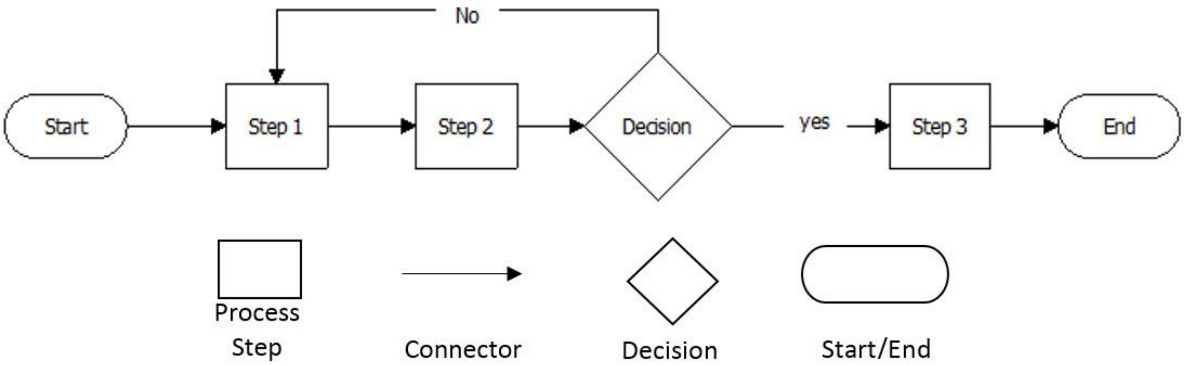


Figure 3: A template of a basic process map (Source: (Simpson, 2015)).

According to an article by Kelley III and Gravina (2018), process mapping was used as a process improvement technique in a project that aimed to improve the door-to-discharge time in an emergency department. The emergency department forms part of a 150-bed hospital located in the south-eastern United States. Since the time a patient spent in the emergency department had an impact on the cost incurred by the hospital ($1.27/minute a patient spent in the emergency department), the goal of this project was to improve the average door-to-discharge time in this specific department.

The team that executed this project used process mapping to assess the current door-to-discharge process by creating an as-is process map. After constructing and analysing the as-is process map, it became clear that the longest part of the process was the door-to-order part (the time between entering the door, seeing the patient, and leaving the room with the patients' orders). Therefore, the team changed the scope of this study to focus mostly on the door-to-order sub-process. The process mapping exercise also showed that nurses were more likely to attend to patients and much quicker than physicians. However, a nurse needed the approval of a physician for all orders such as laboratory tests and X-rays. Therefore, the team created a pre-approved order set of ten of the most common cases found in patients entering the emergency department. This enabled nurses to attend to patients and to enter the patients' orders without waiting for the approval of a physician.

After the implementation of the pre-approved order system, the average door-to-order time decreased with 14.4 minutes over a period of a few months. This also led to a decrease of 23 minutes in the average door-to-discharge time over the same period. After the team had done a cost-benefit analysis, they found that the change in the process saved the department an estimate of $137 511.41 throughout the life of the study. It also increased patient satisfaction from 34.3% to between 52,5% and 62.7% (Kelley III and Gravina, 2018).

This project is one of many that proved that process maps can be useful to identify parts of a process that are wasteful, missing, or could be streamlined. The main benefits of process mapping are that it increases the understanding of a process, analyses how a process may be improved and helps improve communication between the different individuals involved in a process (LucidSoftware, 2018). It also enables employees to construct an "as-is" map of the process that can be used as a baseline during process improvement and shows responsibility and accountability within the process (Cooper, 2017).

However, process mapping is often confused with process modelling. The main difference between these two tools is that a process map is usually an abstract and holistic representation of all the processes of a company and their relations where process modelling is used to model the details of a business process. Therefore, a process map is often used as the foundation on which a process model is constructed (Monika Malinova, 2015).

2.3. Business Process Modelling and Notation (BPMN)

2.3.1. Background

Business Process Management (BPM) is a business process analysis and improvement discipline. During BPM, a business process is analysed and then modelled to determine its performance in different scenarios. BPM also helps execute improvements, monitor the improved process and continually optimising it (Rouse, 2017). An important consideration when modelling a process is which modelling language to use.

Business process modelling languages can be divided into two main categories. The first category of languages, such as Event-driven Process Chain, focusses on capturing and understanding processes and defining business requirements and initiatives for process improvement. The second category of languages, such as Petri nets, is based on mathematical, rigorous paradigms and is used to analyse or execute a process. It also facilitates process simulation or experimentation. Due to the wide range of process modelling languages that have been developed over time, a need for standardisation within the modelling field arose. The development of different BPMN tools originated as a solution for this need (Recker, 2010).

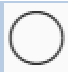
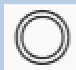
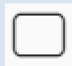
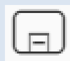
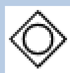
2.3.2. About BPMN

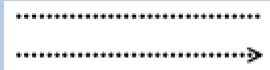
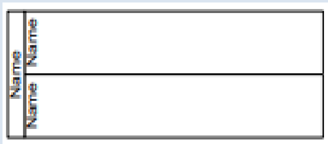
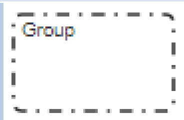
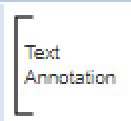
Business Process Modelling and Notation (BPMN) is a BPM tool used to represent a variety of business processes in an expressive graphical way. A BPMN model often includes more process details like operating information such as time and cost (Chinosi and Trombetta, 2012). BPMN therefore enables companies to communicate these business processes to employees in a standard and understandable way. BPMN elements can be grouped into five main categories, namely (Bizagi, 2014):

1) **Flow objects:** The main category of BPMN elements that outline the behaviour of the process.
2) **Connection objects:** Elements used to connect different objects in a business process.
3) **Swim lanes:** Elements used to organise flow activities in different visual categories which can represent functional areas, roles or responsibilities.
4) **Data objects:** Elements used to provide information about which business activities need to be executed and/or what the output of these activities are.
5) **Artifacts:** These elements are used to provide additional information about a business process.

Table 1 shows each category with its main elements as well as a description and the BPMN notation of each element.

Table 1: Main BPMN elements (Source: (ObjectManagementGroup, 2011))

Category	Element	Description	Notation
Flow objects	Event	An event consists of something that happens during a business process and usually has a cause and result. Events can be grouped into three main categories, namely start events, intermediate events and end events.	• Start  • Intermediate  • End 
	Activity	An activity represents any work performed during a business process. Activities can be grouped into two main categories, namely task and sub-processes.	• Task  • Sub-process 
	Gateway	A gateway is used to control the divergence and conjunction of sequence flow in a business process. These elements determine branching, merging, forking and joining of paths. Five types of gateways exist, namely exclusive, event-based, parallel, inclusive and complex gateways.	• Excusive  • Event-based  • Parallel  • Inclusive  • Complex 

Connection objects	Sequence flow	Sequence flows are solid lines used to connect flow objects and show the order in which activities are performed.	
	Association	Associations are dotted lines used to link information and artifacts with BPMN graphical elements.	
	Message flow	A message flow shows the flow of messages between two participants in a business process.	
Swim lanes	Pool	A pool represents a participant in a collaboration process. A collaboration exists when there is an interaction between two or more business entities. These entities are graphically represented as separate pools.	
	Lane	A lane is a sub-partition within a pool and are used to organise and categorise activities. Each lane usually represents a specific actor within a business process.	
Data objects	Data object	Data objects are used to provide information about which business activities need to be executed and/or what the output of these activities are.	
	Data store	Data stores provide a mechanism for activities to retrieve of update stored information that will persist beyond the scope of a business process.	
Artifacts	Groups	A group is used to group graphical elements that fall within the same category.	
	Text annotations	The process modeller can use text annotations to provide additional text information for the reader of the BPMN model.	

In a conference paper by Pantelić et al. (2011), the execution of a project in the public sector is discussed. In this conference paper BPMN was used as a main tool. The objective of the paper was to highlight some application of BPMN and to share the difficulties encountered and lessons learned.

During the project, the Tax Administration (TA) processes within a One-Stop-Shop system for the registration of business entities were analysed and modelled. The term One-Stop-Shop in e-Government refers to the electronic networking of many public bodies and integrates the provision of services. BPMN was selected as a modelling tool based on the standardised notation it offers as well as due to several benefits it has. Some of these benefits are that it facilitates the understanding of models, it offers a wide set of symbols, and it is an expressive modelling tool. These benefits enable the modelling of many real-world processes, as well as the collaboration of different business entities in an understandable way that corresponds to the concrete requirements of each process.

During the project, an iterative approach was followed to model the TA processes. After internal meetings with the TA team and gathering information from key users, drafts of the processes were created. To facilitate collaboration between the TA's and the Serbian Business Registers Agency's (SBRA) processes, the focus was placed on designing the TA's complex process models. A basic TA process consists of the following activities: the registration of a taxpayer through SBRA, editing the data of a taxpayer, the temporary withdrawal of a Tax Identification Number (TIN), the cancellation of the decision of temporary withdrawal of a TIN and the permanent withdrawal of a TIN.

A combination of a core set of BPMN elements and an extended set of BPMN elements were used to model the registration process. A particularly important aspect of using BPMN as a modelling tool was to highlight the collaboration of the TA's and SBRA's processes. The use of message exchanges between the involved business entities helped to define the interaction between the entities. To give an understandable illustration of the interaction between the TA's and SBRA's processes for the conference paper, the registration process was simplified. This was done by presenting the SBRA's process as a black box (an empty pool) and modelling the activities within the TA's private process with a certain level of abstraction. The focus was placed on message exchange between the TA's and the SBRA's processes to highlight critical points within the collaboration process.

Figure 4 illustrates the simplified BPMN model of the registration process of a taxpayer through the SBRA. Table 2 gives the description and notation of some elements used in the simplified BPMN model that were not earlier discussed in the literature review.

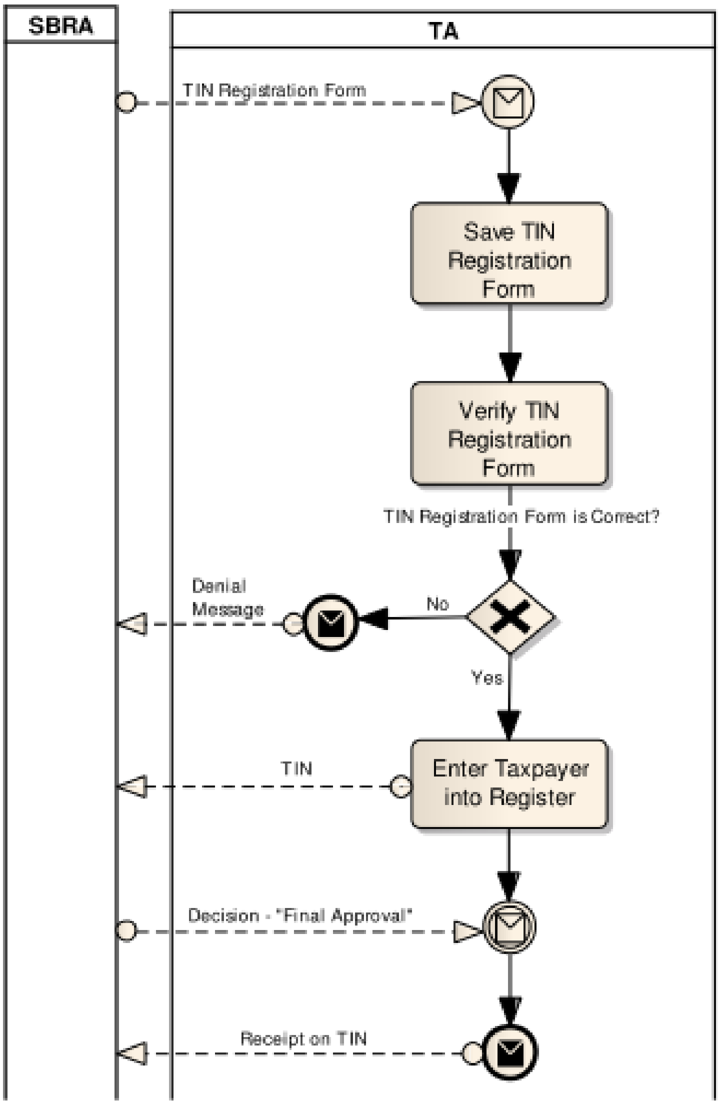
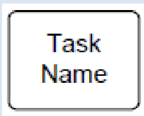
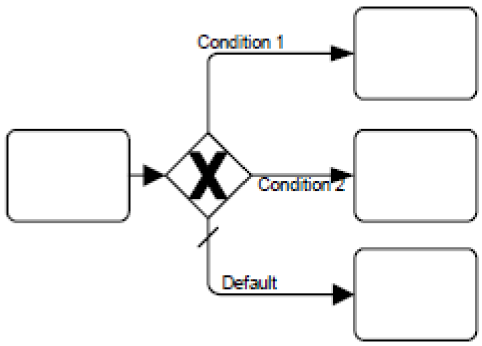


Figure 4: A simplified BPMN model of the registration process (Source: (Pantelić et al., 2011)).

Table 2: Elements used in the simplified BPMN model (Source: (ObjectManagementGroup, 2011))

Element	Description	Notation
Task	A task represents an activity within a business process and is used when the work in a process cannot be decomposed to a finer level of detail.	

Exclusive gateway	An exclusive gateway represents a decision that needs to be made within a process and is used to create alternative paths within the business process. An exclusive gateway evaluates all outgoing sequence flows, but only selects one of them.	
Message start event	A message start event is an event that triggers the start of a process at the arrival of a certain message from another participant in a collaboration process.	
Message end event	A message end event is an event that indicates the end of a process at the time the message is sent from one participant to another in a collaboration process.	
Message intermediate catching event	A message intermediate event can be used to either send (throw) or receive (catch) a message. Therefore, a message intermediate catching event is used within the process of the participant that needs to receive a message that is sent by another participant. These elements are also used in a collaboration process.	

To define collaboration processes within the boundaries and conditions of legal ambiguities and non-conformities of by-laws was one of the main challenges during the modelling phase of the project. During this phase, the team made use of seven important process modelling guidelines to ensure the correctness of the process models.

The seven guidelines are:

1) use a limited number of elements in the model,
2) keep the routing paths per element as short as possible,
3) make use of only one start and one end event,
4) model as structured as possible,
5) avoid the use of ‘OR’ routing elements such as gateways,
6) use verb-object labels to name the process activities and
7) if the model has more than 50 elements, decompose it.

In this specific project, guideline number 3 was not possible to apply due to the complexity of the TA processes. To avoid loading the graphical representation of the process with detail, the team also documented the models so that every diagram was accompanied by a detailed description of the process model. This approach helped to keep the diagrams simple and understandable to all members and users. Some lessons learned during the study were that it is crucial to design models that are easy to read and that models should not be too basic, nor too complex to avoid these models from losing their capability (Pantelić et al., 2011).

2.4. Simulation modelling

2.4.1. About simulation modelling

According to Robinson (2004), a simulation in general can be defined as "*an imitation of a system*". Robinson (2004) further defines a system as "*a collection of parts organised for some purpose*". Robinson (2004) also states that simulation models are used to comprehend, change, manage and control reality. It can be seen as a "what-if" analysis tool. Different scenarios can be entered into these types of models and the outcome of the scenarios are then predicted by the models, which in turn, assists with decision-making. To justify the use of simulation, specifically computer-based simulation, one should always consider the following: the nature of the system of interest, the advantages of simulation over other approaches and the disadvantages of simulation.

When considering the nature of the system of interest, simulation modelling may be an appropriate tool to use if the system is subject to variability, the components within the system are interconnected and the system is complex. Simulation models enable the modeller to explicitly represent the system's variability, interconnectedness and complexity. Therefore, the simulation model can be used to determine the future performance of the system as well as the effects of change within the system on the system's performance.

Alternatives for simulation may either be experimenting with the real system or to use another modelling approach. However, the advantages of simulation modelling over experimenting with the real system are that the use of simulation is:

- more cost-effective,
- less time consuming,
- it enables the modeller to control the experimental conditions and
- it enables the modeller to develop and test a model of a system that may not yet exist.

The advantages of simulation over other modelling approaches are that simulation:

- enables the modeller to model variability,
- it makes use of restrictive assumptions and
- it is a more transparent approach enabling non-experts to have a better understanding of the model.

On the other hand, the disadvantages of simulation are that:

- simulation software and the development of the model may still be expensive and time consuming,
- it requires a significant amount of data and
- it may require expertise.

One should also be careful not to take everything produced by the computer-based simulation as correct, without proper validation and considering the correct assumptions (Robinson, 2004).

Furthermore, when considering the use of computer-based simulation, one should determine which of the different approaches that exist, may be appropriate to use. Given the nature of this project, two approaches were considered, namely Discrete-Event Simulation (DES) and Agent-Based Modelling and Simulation (ABMS) approach. The DES modelling approach is based on the concept of entities, resources and process blocks with the focus on the flow of entities and resource sharing (Borshchev and Filippov, 2004). On the other hand, the ABMS approach is a relatively new approach used to model systems that consist of interacting, autonomous 'agents' (Macal and North, 2010). An agent can be defined in general as an autonomous, active unit that can be diverse in character or content (Crooks and Heppenstall, 2012).

Therefore, the main difference between these two approaches is that DES enables the modeller to answer questions like how many of a certain type of resource are needed to improve the performance of a process, where ABMS modelling enables the modelling of a system where agents need learn from their experiences and adapt their behaviour to better fit into their environment (Macal and North, 2010). Even though the human resource within the Telco RSA department can be trained to become multiskilled, this does not form part of the scope of this project.

Since the aim of this project is to identify the operational capacity constraints within the RSA Offshoring project, quantify the impact of the identified constraints in terms of certain factors and then make recommendations on how to manage the constraints to improve the process performance, DES modelling was identified as an appropriate modelling approach to achieve the aim of this project.

2.4.2. Discrete-Event Simulation

A mentioned above, the Discrete-Event Simulation (DES) modelling approach is based on the concept of entities, resources and process blocks with the focus on the flow of entities and resource sharing. Entities can represent different objects such as documents, people, tasks, parts, messages and several more. The process blocks in a DES model represents the different parts of the process logic. These process blocks are used to model queues, delays, entities being processes, seized and released by resources and many other situations the entities may encounter (Borshchev and Filippov, 2004).

According to an article by Sumari et al. (2013), the main advantages of DES are the following:

- The use of built-in animation and graphics make it easy for the user to understand the model.
- It has unlimited flexibility that enables the determination of the behaviour of entities.
- Developing a model with the use of this approach is straight forward if the problem has been clearly defined.

However, the disadvantages of DES are that it is not very effective in showing the impact of true variability and it is not an appropriate approach to use when attempting to model human behaviour (Sumari et al., 2013).

To evaluate the application of DES, two articles were considered. The first article contains a discussion of the application of DES in the healthcare sector to improve the overall service delivery and system throughput of the emergency department of a hospital located in Moncton, Canada. The second article contains a discussion of the application of DES in a small and medium industry in Malaysia to improve the production process of the burgers production process within the production company. Even though these two articles are about the application of DES in two industries that are different from the one this project is concerned with, the nature of the projects in these two articles and the application of DES modelling, are similar to the those of this project.

1) The application of DES in the healthcare sector

DES modelling has been an immensely popular tool to use in the healthcare sector over the past few years. In an article by Duguay and Chetouane (2007), DES was used as the main problem investigation and process improvement tool in a study in the emergency department at Dr. Georges L. Dumont Hospital in Moncton, Canada. The aim of the study was not only to reduce the time patients had to wait before being assisted, but also to improve the overall service delivery and system throughput of the department.

Simulation was chosen as process improvement tool since the healthcare system of interest was complex and subject to variability because of the amount of human involvement. DES was identified as modelling approach because it has proved to be an effective approach for process improvement. For this study, the team had to consider the following aspects of the emergency department:

- the physical layout of the department,
- the healthcare staff and shifts within the department,
- the flow of patients through the department,
- the process stages as illustrated in Figure 5 below and
- the triage code system. The triage code system is a system used in Canada, where triage codes are associated with standardised waiting times and then assigned to each patient that enters the system according to how critical the patient's condition may be. For example, patients who are in a critical condition and should not wait to be treated, are assigned code 1 and patients that should not wait more than 15, 30, 60 and 120 minutes are assigned code 2, 3, 4 and 5 respectively.

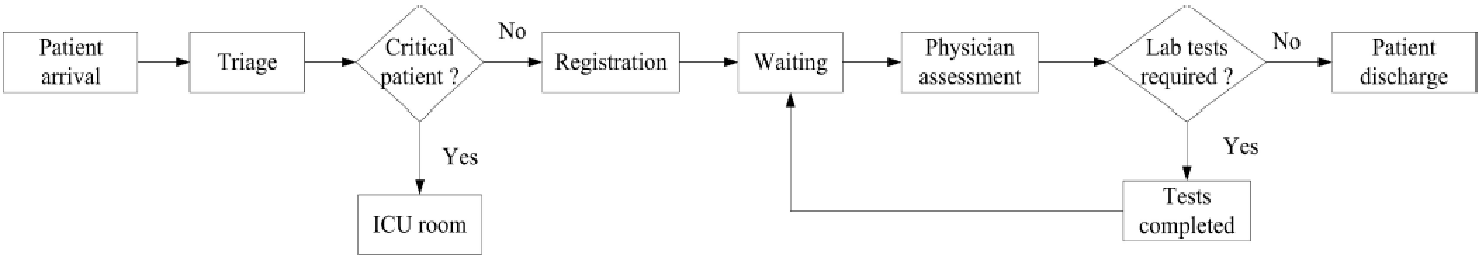


Figure 5: The care process in the emergency department (Source: (Duguay and Chetouane, 2007)).

The methodology of this study was based on considering key resources such as physicians, nurses and examination rooms as control variables. Since the time patients had to wait, was directly depended on the availability of these key resources, DES was used to evaluate key performance improvements. Arena was used as simulation software for DES during this study. Figure 6 illustrates the main steps of the methodology that was followed during this study.

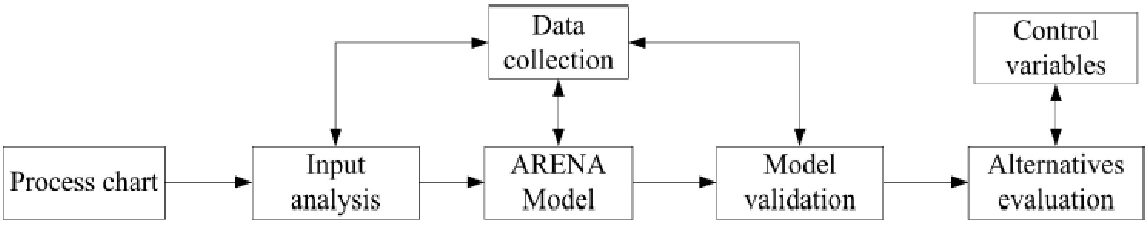


Figure 6: Methodology main steps (Source: (Duguay and Chetouane, 2007)).

During the data collection stage, data of two types of time durations namely waiting durations and activity durations were collected. Waiting durations are the time a patient had to wait between the end of an activity to the start of the next activity. Activity durations are the time it takes to execute an activity in the process. During the design stage of the simulation model, several assumptions had to be made to define the limits of the model based on the availability of data. Some of these assumptions included the following:

- Only days of the week such as Monday to Friday were considered.
- Time delays within the process only depended on key resources such as nurses, physicians and examination rooms.
- The time a patient had to wait from entering the examination room until the physician arrives in the room, were not considered since it was difficult to collect data on these waiting times.
- Nurses and physicians worked in conjunction.
- Even though there were eight examination rooms in total, only five were considered since the other three rooms were reserved for specific situations.

The model was also limited by the following:

- The model output could not be generalised to all seasons, because data were only collected during the summer time.
- The patients that were assigned triage code 1 and 2, which represented 7% of the patient flow, were not considered.
- The travel times in the emergency department were not considered.

During the model validation phase of the study, the output of the simulation model was compared to the collected data using a 95% confidence level. The output of the simulation model showed that the longest period patient had to wait within the process was between the point of registration and until an examination room was available. Therefore, focus was placed on finding alternative designs for the model that might reduce the time a patient had to wait at this stage in the process. All five the alternatives that were considered, involved increasing the staff and/or room capacity. However, these alternatives had to be tested within the budgetary constraints of the department.

After testing the effect of the different alternatives on the output of the model, the model showed that the alternative to add one physician and nurse from 08h00 to 16h00 decreased the time patients had to wait between the point of registration and until an examination room was available, the most. It also showed that by increasing the number of examination rooms without adding matching staff as well, had no effect on the above-mentioned waiting time (Duguay and Chetouane, 2007). From this article, it is clear that DES may be an effective problem investigation and process improvement tool to use.

2) The application of DES in a small and medium industry

In an article by Ramli and Zahelm (2016), DES was used to develop a simulation model of the current burger production line within a food company in Napoh, Northern Kedah, Malaysia. The objective of the model was to evaluate the current performance of the process and suggest methods for improvement. The company had to improve the burger production process in terms of resources, facilities and limitations within their sector to meet the demand of competitive markets.

Figure 7 illustrates these 11 steps within the burger production process.

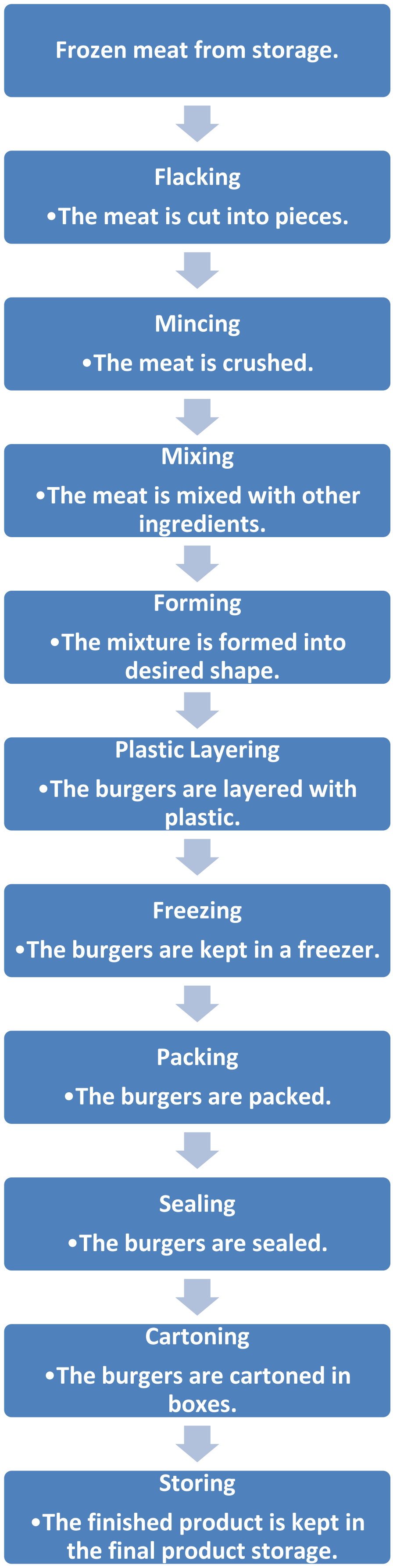


Figure 7: The stages in the burger production process (Source:(Ramli and Zahelem, 2016)).

The methodology that was used for this study was based on the framework shown in Table 3. In the pre-assessment phase, the problem was identified. After the pre-assessment phase, research was done at the burger production company. During this phase, data was collected and the process was observed to gain a better understanding of the process flow of the production of burgers within the factory. During the third phase of the study, the simulation model was developed using ProModel software after which the model was run and the output of the model was validated. Some improvements were then made at the different points within the process where bottlenecks occurred. The output of the improved models was analysed during phase five after which recommendations were made based on the findings in phase five.

Table 3: The Research framework based on the simulation studies (Source: (Ramli and Zahelem, 2016))

Phase	Steps
Pre-assessment	Problem formulation and plan study.
Research	Data collection and model development.
Development of actual simulation model	Build the actual simulation model. Do the pilot run and model validation.
Development of improvement model	Make some modifications for improvements of the system. Running the improvement model and verification of the model.
Discussion and analysis	Analyse the output data.
Recommendations and conclusions	Suggestion, documentation and implementation of the model.

The model was verified and validated with the used of the following formula:

$$\boldsymbol{Percentage\ of\ error} = \frac{|\boldsymbol{output\ (simulation)} - \boldsymbol{output\ (data)}|}{\boldsymbol{output\ (data)}} \times \mathbf{100}$$

where the out (simulation) refers to the entities processed by the simulation model and the output (data) refers to the number of entities observed in the actual system. For this project, the results from the simulation output should not have deviated more than 10% from the real output data.

According to Ramli and Zahelm (2016) the company aimed to increase their production output from 3 tonnes of meat (30 000 pieces) to 5 tonnes of meat (50 000 pieces). Therefore, the average number of boxes of burgers produced had to increase from 150 boxes to 250 boxes. To develop the improvement model, the following factors were calculated:

- The current capacity of the factory.
- The current utilisation of the workstations.
- The current utilisation of the operators within the process.

From the results of the above-mentioned three factors, the as-is model showed that the production capacity could be increased to achieve the company's desired targets. The as-is model was also used to determine how the process would perform if the production capacity of the process was increased from 3 tonnes up to 5 tonnes of meat. The results also showed that the forming and packaging steps were the bottlenecks within the process. Therefore, the improvement model was developed based on these findings.

The improvement model showed the following results as well:

- To increase the production capacity, the company might need to invest in an extra forming machine, since this was where the highest bottleneck occurred.
- The modified model only achieved 92% of the production capacity target of 5 tonnes. This observation could be assigned to the fact that the operating hours are not enough to fulfil the entire task. However, this can be improved by increasing the operating hours, but this would then result in higher production costs in terms of salary and operating cost.

Ramli and Zahelm (2016) concluded that investing in a new forming machine would be beneficial for the company in the long run. According to Ramli and Zahelm (2016), simulation modelling is very useful to analyse and determine the outcome of various scenarios that cannot be directly applied in the real work. The use of simulation modelling enables one to test the performance of a process in different scenarios without disturbing the current structures and setup in a facility (Ramli and Zahelem, 2016).

2.5. Conclusion

The tools and techniques discussed in the literature review were considered during the structuring of the project approach. Since process definition is an important first step towards process improvement, the first phase of the PADM framework, namely the Process Definition phase, was identified as a potential tool to define the admin and technical quality process as accurately as possible. This decision was made based on the flexibility and contingency of the PADM framework.

To capture the as-is state of the RSA Offshoring process, process mapping was identified as a potential technique to use for this purpose. However, since process modelling helps to model more process detail than process mapping, BPMN can be used as a modelling technique to model the workflow of the as-is processes in more detail. The process maps can be used as the foundation on which the as-is BPMN models can be constructed.

The decision to use BPMN as a modelling tool was made based on some features that stood out in the conference paper. It provided important guidelines that should be considered when modelling in BPMN. It also emphasised the importance of keeping models as simple as possible, without allowing the model to lose its capabilities.

Simulation modelling will be used during the process evaluation and improvement phases of this project. It will be used to simulate the RSA Offshoring process with the aim to evaluate the current performance of the process and identify possible process constraints. It will also be used to develop and tests alternatives with the aim to improve the performance and capability of the system. Since the RSA Offshoring process is a complex process and subject to variability, simulation modelling was chosen as main modelling tool.

Given the nature of the RSA Offshoring process, DES modelling was identified as an appropriate simulation approach. Similar to the process within the emergency department as well as the burger production process, the availability of key resources within the RSA Offshoring process will also be control variables. Also, the methodology that the teams followed in both articles may be of great value. Since the objectives of the simulation models that were developed in both the articles are similar to what the objective of the simulation model for this project will be, the successful application of DES modelling and the benefits the use of this approach held for both teams, can be seen as confirmation to use DES modelling to achieve the aim of this project.

Chapter 3: Methodology

This chapter of the report contains a detailed description of the methodologies that were followed during the execution of the project.

3.1. Phase 1: Process definition

Without clearly defining a process, any effort at improving it will be built on a weak foundation. Therefore, the Process Definition phase of the PADM framework was used, as illustrated in Figure 8, to define the RSA Offshoring process. The results of this phase are discussed in section 4.1 of Chapter 4 of this report.

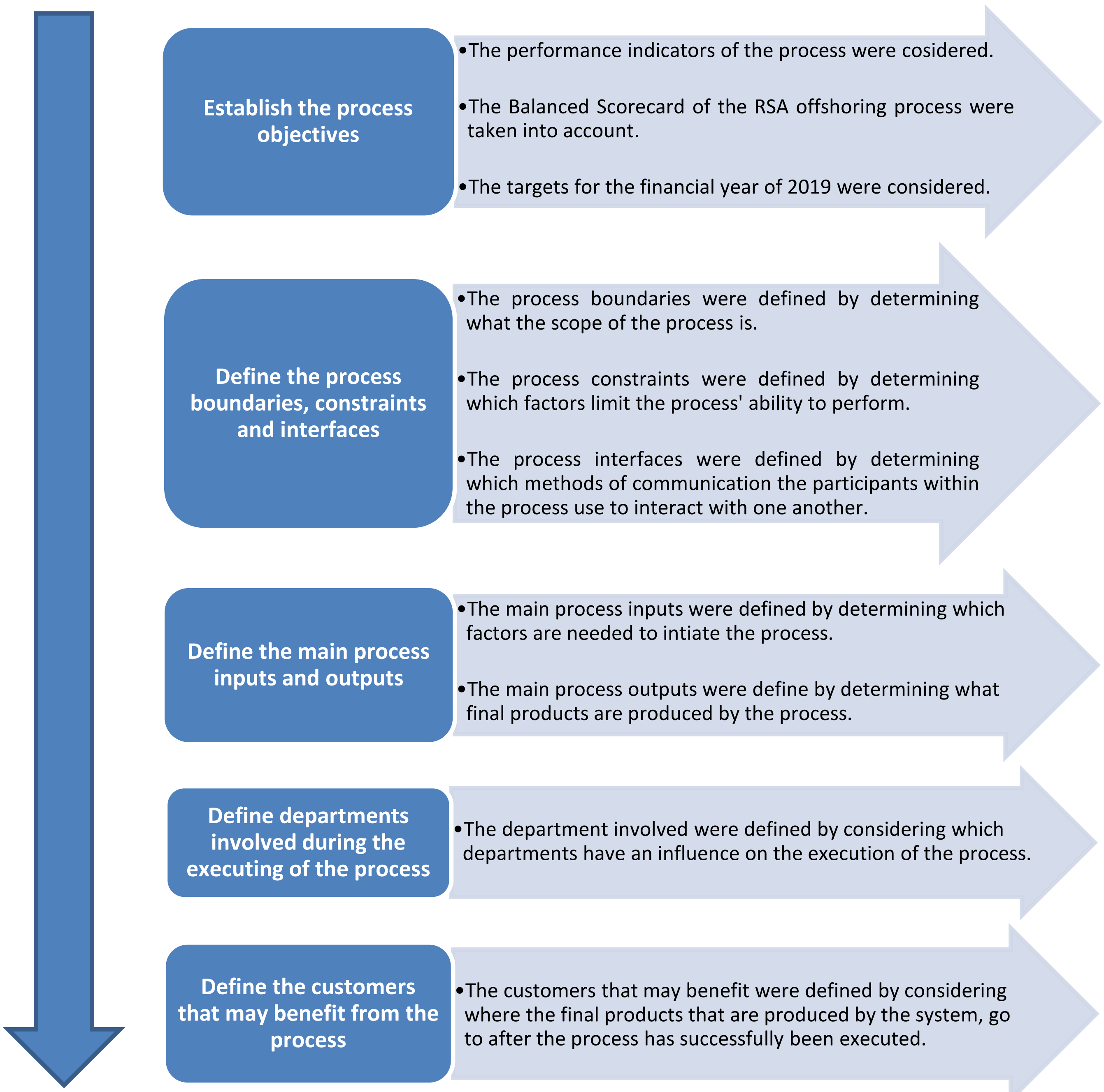


Figure 8: Steps followed to define the RSA Offshoring process

The results of phase 1 was obtained by conducting interviews with the employees of Telco RSA's offshoring team.

3.2. Phase 2: Capture baseline process

To gain an overview of the RSA Offshoring process, high-level as-is process maps of the RSA Offshoring process were constructed. The as-is process maps were then used to construct detailed BPMN models of the as-is process. For the scope of the BPMN models, only the parts of the RSA Offshoring Admin and Technical Quality Process that are executed within Telco RSA were taken into consideration. Camunda Modeller was used as BPMN modelling tool.

For this project the aim of the BPMN models are only to illustrate the workflow of the process and to gain a better understanding of how the process is executed. Since the flow of the process is determined by the type of work order that needs to be executed, two BPMN models were used to illustrate the workflow of the admin and technical quality process. The results of these two BPMN models can be found in section 4.2 of Chapter 4.

The first BPMN model illustrates the workflow of the process in the case of a design work order, which include all the different types of design work orders mentioned in section 4.1 of Chapter 4. The second BPMN model illustrates the workflow of the process in the case of a draft work order, which also includes all the different types of draft work orders mentioned in section 4.1 of Chapter 4. These two BPMN models were constructed based on the basic process scenario discussed in Chapter 1 of this report.

The following modelling approach was used to construct the two BPMN models:

1) Even though Telco RSA and Telco Australia are both part of Aurecon, they were modelled as two different participants with the use of pools, since the focus will only be on the process flow within Telco RSA. Therefore, the offshoring process was modelled as a collaboration process.
2) The different actors within the process are represented by the different lanes within the Telco RSA pool. These actors are the document controllers, designers, drafters and the technical verifiers.
3) Since the entire process is executed by humans, user tasks were used to represent the different tasks the employees must perform.
4) To depict the interaction between Telco RSA and Telco Australia, message flows, send tasks as well as receive tasks were used.
5) Each quality inspection within the process is represented by an exclusive gateway.
6) Call activities were used to represent the different sub-process within the process.
7) Inclusive gateways were used to represent decisions where more than one outgoing sequence flow can be true.

3.3. Phase 3: Process Evaluation

This section of the report contains the conceptual and numerical model of the RSA Offshoring Admin and Technical Quality Process. The results of this chapter are discussed in section 4.3 of Chapter 4 of this report.

3.3.1. Conceptual model

A conceptual model serves as a description of a computer-based simulation model that needs to be developed. Therefore, the aim of the conceptual model in this section is to give a description of the logic behind the simulation model of the RSA Offshoring process that will be developed. This section also contains the data that was collected and used in the development of the computer-based simulation model.

1) The problem situation

As stated in section 1.2 of Chapter 1, there is a need to determine whether Telco RSA has the capacity to handle the increase in the volume of work orders. Firstly, the process had to modelled to evaluate the current performance and capabilities of the process. Secondly, the model will be used to determine how the process may be improved to enhance Telco RSA's ability to handle the increase in work order volume with the aim to achieve their revenue target for the financial year of 2019.

2) Modelling objectives

The overall aim of Telco RSA's offshoring team is to achieve their revenue target for 2019. However, this can only be achieved if the team can handle the increase in the work order volume. The number of work orders is said to increase with 1960 work orders per year in 2019. Therefore, the specific modelling objective is to:

- Determine whether the execution of an extra 1960 work orders per year can be achieved with the current number of available human resources within the process.

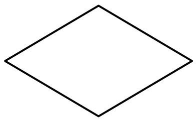
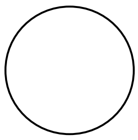
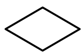
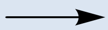
If the above-mentioned cannot be achieved, then the objective is to:

- Identify the additional number of human resources required to handle the increase in the work order volume.

Figures 12 and 13 in section 4.2 of Chapter 4 give an overview of the admin and technical quality process in the case of a design work order and a draft work order, respectively. However, for the purpose of the simulation model, the execution of these two types of work orders need to be integrated. Therefore, all the different work order codes, different human resources as well as different teams mentioned in section 4.1 of Chapter 4 must also form part of the simulation model.

Figure 9 illustrates a process map of the integrated version of the admin and technical quality process to illustrate the logic behind the simulation model. Table 4 gives a description of the different symbols used in the process map. Since a process map can give a broad overview of the logic of a process and a BPMN model gives a more detailed description of a process, process mapping was rather used to illustrate the integrated version of the process.

Table 4: Description of the symbols used in Figure 9

Symbol	Description
	An oval denotes either the start or the end of the process.
	A big diamond denotes a decision point within the process.
	A rectangle denotes an activity within the process.
	A circle denotes an inspection point within the process.
	A striped-rectangle denotes a sub-process within the process.
	A small diamond denotes a gateway where more than one activity can flow in or out.
	An arrow denotes the flow of the process.

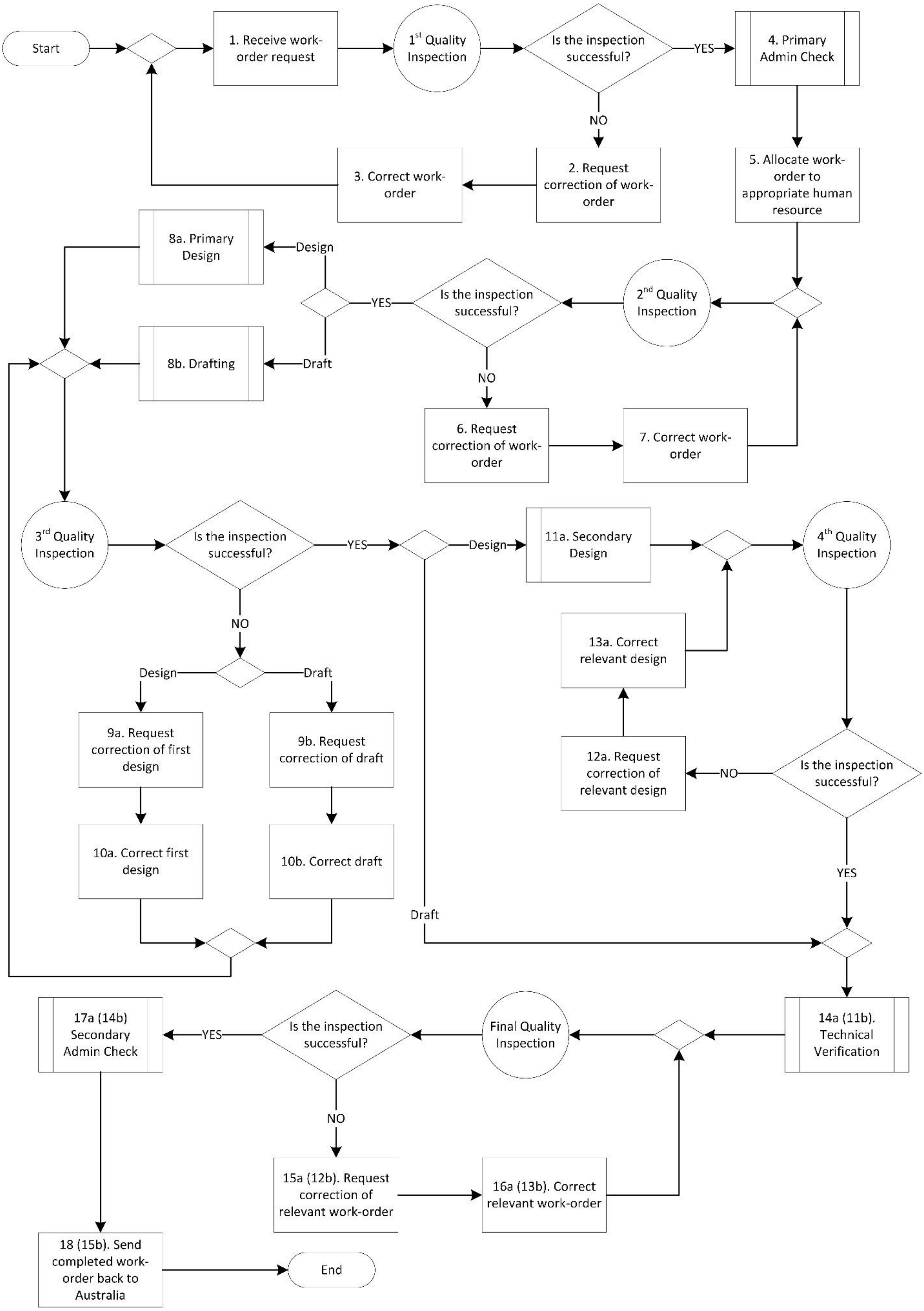


Figure 9: Description of the logic behind the simulation model of the RSA Offshoring Admin and Technical Quality Process

Note that the logical flow in the case of a design work order is shown by the following steps in the integrated process: 1, 2, 3, 4, 5, 6, 7, 8a, 9a, 10a, 11a, 12a, 13a, 14a, 15a, 16a, 17a and 18. Also, the logical flow in the case of a draft work order is shown by the following steps in the integrated process: 1, 2, 3, 4, 5, 6, 7, 8b, 9b, 10b, 11b, 12b, 13b, 14b and 15b.

3) Model inputs and outputs

Before defining what the different inputs and outputs of the model will be, the calculation of the revenue will first be explained. The revenue is calculated (in South African Rand) with the following equation:

$$\boldsymbol{Revenue = Budget - Effort}$$

Where:

- The budget refers to a certain budget that is allocated to each specific work order at the beginning of the process.
- The effort is calculated by multiplying the labour cost rate of a human resource (in R/hr) with the number of hours the human resource spent executing a specific work order.

Therefore, the outputs to achieve the initial modelling objective will be the following:

- The average number of work orders Telco RSA can complete per year with their current capacity of human resources. This is required to determine if the Telco RSA has the capacity to handle the increase in work order volumes.
- The budget allocated to each specific work order that was completed.
- The total number of hours each human resource spent executing each specific work order (including the time it took to correct mistakes that were made).

Experimental factors

As stated under the modelling objectives, if the execution of an extra 1960 work orders per year cannot be achieved with the current number of available human resources within the process, the additional number of human resources required to handle the increase must be determined. Therefore, the number of each type of human resource within the process will be the main experimental factor during the development of the process improvement scenarios.

The aim will be to determine where certain human resources should be added to the process by identifying where the bottlenecks are located within the process and how these added resources can influence the performance of the process in terms of the following:

- The average number of work orders that was be completed per year.
- The average annual revenue that was be incurred.
- The percentage of completed work orders that had a lead-time that fell between the given estimated minimum lead-time per work order of 6 hours and the given estimated maximum lead-time per work order of 6 days.
- The average number of delayed work orders at each human resource per year.
- The average waiting time per work order at each resource per year.

Bottlenecks in this process will refer to the human resources where the highest number of the work orders had to wait and/or where the waiting time per work order was the longest. The number of work orders that had to wait, will be referred to as the number of delayed work orders.

General input data

The general data inputs were collected using data collection techniques such as interviews and the use of historical records of the process. However, due to a lack of historical data about the duration of the different sub-process, the time it takes to correct a work order that failed a quality inspection and the probabilities of quality failures, Telco RSA gave estimates for each of these data inputs. Data about the following inputs were collected:

- The given number of different human resources per team within the Telco RSA offshoring team shown in Table 5. A brief description of each teams follows directly after Table 5.
- The given labour cost rates of the different human resources shown in Table 5.
- The given estimated distribution of the two main work order categories shown in Table 6.
- The given estimated distribution of the five work order sub-categories shown in Table 7. A brief description of work order codes follows directly after Table 7.
- The budget range that can be assigned to each of the work order sub-category shown in Table 8.
- The given estimated process times of each sub-process within the process shown in Table 9.
- The given estimated probabilities to fail the different quality inspections within the process shown in Table 10.
- The given estimated correction times of each correction sub-process as a result of a failed quality inspection shown in Table 11.

Table 5: Data related to the human resources within the RSA Offshoring process

Team	Human resource	Number of human resources	Rate (R/hr)
Project Management Team	Document Controller	2	41,98
	Technical Verifier	3	38,80
NBN Team	Senior Designer	2	54,61
	Junior Designer	1	33,44
	Senior Drafter	2	55,14
	Junior Drafter	1	18,37
Telstra Team	Senior Designer	2	54,61
	Junior Designer	1	33,44
	Senior Drafter	2	55,14
	Junior Drafter	1	18,37
EME Team	Senior Designer	2	54,61
	Junior Designer	1	33,44
	Senior Drafter	3	55,14
	Junior Drafter	1	18,37

The Project Management Team is mainly responsible for completing administrative activities. The NBN team is mainly responsible for completing work orders related to NBN work order types, namely N-code and H-code designs and drafts. The Telstra team is mainly responsible for executing work orders related to Telstra work order types, namely T-code and O-code designs and drafts. The main responsibility of the EME team is to execute work orders related to electrical designs and drafts, namely E-code work order.

Table 6: The given distribution of the two main work order categories

Work order category	Distribution
Design	0,50
Draft	0,50

Table 7: The given distribution of the five work order sub-categories

Work order sub-category	Distribution
T-code (ranges from T1 to T31)	0,1669
H-code (ranges from H1 to H22	0,0344
N-code (ranges from N1 to N19)	0,1760
O-code (ranges from O1 to O26)	0,0304
E-code (range from E1 to E10)	0,5923

The letter the code starts with represents a different client and each number represents the specific design or draft that needs to be executed, for example H4 refers to either a design or draft for a Standard Greenfield Rooftop for Huawei.

Table 8: The budget range of each of the work order sub-categories

Work order category	Work order sub-category	Minimum budget (in South African Rand)	Average budget (in South African Rand)	Maximum budget (in South African Rand)
Design	T-code	365,05	5045,51	9647,75
	H-code	365,05	3486,02	6883,80
	N-code	365,05	3316,74	8239,70
	O-code	5527,90	5979,83	6883,80
	E-code	469,35	1022,14	2763,95
	P-code	677,95	1368,94	2763,95
	A-code	677,95	4754,31	8239,70
Draft	T-code	625,80	5684,35	9178,40
	H-code	625,80	4854,64	8291,85
	N-code	625,80	4241,57	8239,70
	O-code	625,80	5288,01	8239,70
	E-code	469,35	1022,14	2763,95
	P-code	677,95	1368,94	2763,95
	A-code	625,80	4241,57	8239,70

Table 9: The estimated production time of a work order at each sub-process within the process

Team	Work order category	Sub-process	Production time (in minutes)
NBN and Telstra Team	Design	Primary Admin Check	uniform(15, 140)
		Primary Design for Senior Designer	uniform(45, 1440)
		Primary Design for Junior Designer	uniform(90, 2880)
		Secondary Design (only Senior Designer)	uniform(22.5, 720)
		Technical Verification	uniform(90, 300)
		Secondary Admin Check	uniform(10, 120)
	Draft	Primary Admin Check	uniform(15, 140)
		Drafting for Senior Drafter, Senior Designer and Junior Designer	uniform(240, 3000)
		Drafting for Junior Drafter	uniform(480, 6000)
		Technical Verification	uniform(15, 120)
		Secondary Admin Check	uniform(10, 60)
EME Team	Design	Primary Admin Check	uniform(10, 120)
		Primary Design for Senior Designer	uniform(10, 360)
		Primary Design for Junior Designer	uniform(15, 720)
		Secondary Design (only Senior Designer)	uniform(10, 180)
		Technical Verification	uniform(15, 75)
		Secondary Admin Check	uniform(10, 30)
	Draft	Primary Admin Check	uniform(10, 120)
		Drafting for Senior Drafter, Senior Designer and Junior Designer	uniform(60, 750)
		Drafting for Junior Drafter	uniform(120, 1500)
		Technical Verification	uniform(10, 30)
		Secondary Admin Check	uniform(10, 30)

Table 10: The given estimations related to quality inspections in the case of a design work order

Quality inspection	Description	Probability to fail	Correction time (in hours)
1st Quality Inspection	When the Document Controller inspects the documents and information prior to the Primary Admin Check sub-process	5%	uniform(8, 16)
2nd Quality inspection	When the first-level Designer checks if all the technical information is correct prior to the Primary Design sub-process.	10%	uniform(8, 16)
3rd Quality inspection	When the fellow Designer checks the first designer's work prior to the Secondary Design sub-process.	Due to mistake made by a Senior Designer: 5% Due to mistake made by a Junior Designer: 10%	Senior Designer's mistake: uniform(0.5, 4) Junior Designer's mistake: uniform(0.5, 1)
4th Quality inspection	When the Technical Verifier checks if all the designs, documents and information are correct after the Technical Verification sub-process.	Due to mistake made by a Senior Designer: 3.5% Due to mistake made by a Junior Designer: 5%	Senior Designer's mistake: uniform(0.5, 4) Junior Designer's mistake: uniform(0.5, 1)
Final Quality inspection	When the Document Controller executes the final inspection prior to the Secondary Admin Check sub-process.	Due to mistake made by a Senior Designer: 1% Due to mistake made by a Junior Designer: 1%	Senior Designer's mistake: uniform(0.5, 4) Junior Designer's mistake: uniform(0.5, 1)

Table 11: The given estimations related to quality inspections in the case of a draft work order

Quality inspection	Description	Probability to fail	Correction time (in hours)
1st Quality Inspection	When the Document Controller inspects the documents and information prior to the Primary Admin Check sub-process	5%	uniform(8, 16)
2nd Quality inspection	When the Drafter checks if all the technical information is correct prior to the Drafting sub-process.	5%	uniform(8, 16)
3rd Quality inspection	When the Technical Verifier checks if all the technical drawings, documents and information are correct after the Technical Verification sub-process.	Due to mistake made by a Senior Drafter, Senior Designer and Junior Designer: 4% Due to mistake made by a Junior Drafter: 8%	Senior Designer's mistake: uniform(0.5, 4) Junior Designer's mistake: uniform(0.5, 1)
Final Quality inspection	When the Document Controller executes the final inspection prior to the Secondary Admin sub-process.	Due to mistake made by a Senior Drafter, Senior Designer and Junior Designer: 1% Due to mistake made by a Junior Drafter: 2%	Senior Designer's mistake: uniform(0.5, 4) Junior Designer's mistake: uniform(0.5, 1)

4) Model content

Table 12: Model scope

Component	Included/Excluded	Justification
Human resources	Included	The number of hours a human resource spends executing a work order influences the revenue.
Work orders	Included	The number of work orders, budget per work order and time to complete the work order influence the revenue.
Quality inspections	Included	The time a human resource spends to correct a work order due to quality issues influence both the number of hours a human resource executes a work order and the overall process time of a work order.
All sub-processes	Included	The process time of a work order at each sub-process influences the revenue.

Assumptions

The following assumptions were made during the development of the simulation model:

- If a senior designer executes a first-level design, the relevant second-level design must also be executed by a senior designer. Therefore, there will be assumed that only senior designers can execute the secondary design sub-process.
- Since designers are also competent to execute all types of draft work orders, both the senior and junior designers will also be modelled as drafters.
- In exceedingly rare cases, the two verifiers take the role of either a designer or a drafter. Therefore, these cases will not be modelled.
- Since the EME design and draft work orders are electrical type of work orders, the assumption will be made that only the EME team is competent to execute these types of work orders. However, the EME team can also execute the designs and drafts of the NBN and Telstra teams, but due to the large number of EME work orders Telco RSA receive, this scenario will be excluded from the model.
- Since the human resources do not work on weekends or holidays the assumption was made that the human resources work on average 241 days a year, which exclude all weekends and possible holidays within a year.

Simplifications

The following simplifications were made during the development of the simulation model:

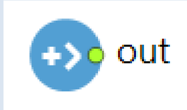
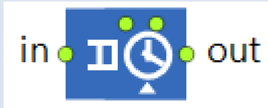
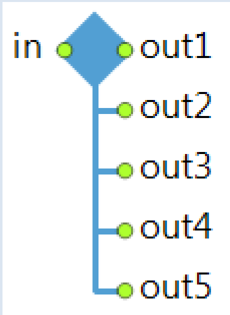
- The activities within the sub-processes will not be changed or improved, for this does not form part of the scope of this project. Therefore, the model will not include the detail within the sub-processes.
- The designers and drafters in the NBN team are also competent to execute the Telstra team's design and draft work orders and vice versa. Therefore, these two teams will be modelled as a combined team. This combined team will be referred to as the NBN and Telstra team.
- The uniform distributions of the process time of each sub-process as given by Telco RSA also account for the time the human resources are not at work, meaning these distributions account for a 24-hour day. Therefore, the model can be developed to run for 241 days, 24 hours a day without any interruptions.

3.3.2. Numerical model

This section of the report contains a detailed description of the developed simulation model as well as the calculations within the model. The equations that was used for the results in Chapter 4, are also given in this section. The conceptual model was used as a framework for the development of the computer-based simulation model. All the data mentioned above was used in the development of the model. The simulation software, namely AnyLogic 8.1.0 University Edition, was used to develop the model.

AnyLogic offers a variety of flowchart blocks that can be used during model development. The DES approach was used to model the RSA Offshoring process. Table 13 gives the different flowchart blocks that were used in the development of the simulation model with a description of each block's functionality. These blocks will be referred to in the discussion of the developed model.

Table 13: Flowchart blocks used in simulation model (Source: (AnyLogic, 2018))

Name	Description	Symbol
Source	Generates agents and usually represents the start of a process model.	
Delay	Delays agents for a given amount of time within the process.	
Service	Seizes a given number of resource units, delays the agent and releases the seized units.	
Select Output	Routes the incoming agents to one of the two output ports depending on a probabilistic or deterministic condition that were given.	
Select Output5	Also routes the incoming agents to one of the five output ports depending on the probabilistic or deterministic conditions that were given.	
Resource Pool	Defines a set of resource units that can be seized and released by agents using different other flowchart blocks for example the service flowchart block mentioned above.	
Sink	Disposes the agents and usually represents the end point of a process model.	

A detailed description of the developed simulation model will first be given after which the model calculations will follow.

1) Description of developed simulation model

Figure 10 gives a schematic representation of the logic of the developed simulation model. Due to the complexity of the model, the description thereof is divided into five parts. These five parts are represented by different colours as illustrated in Figure 10 and will be referred to as Part A to E in the description that follows this figure.

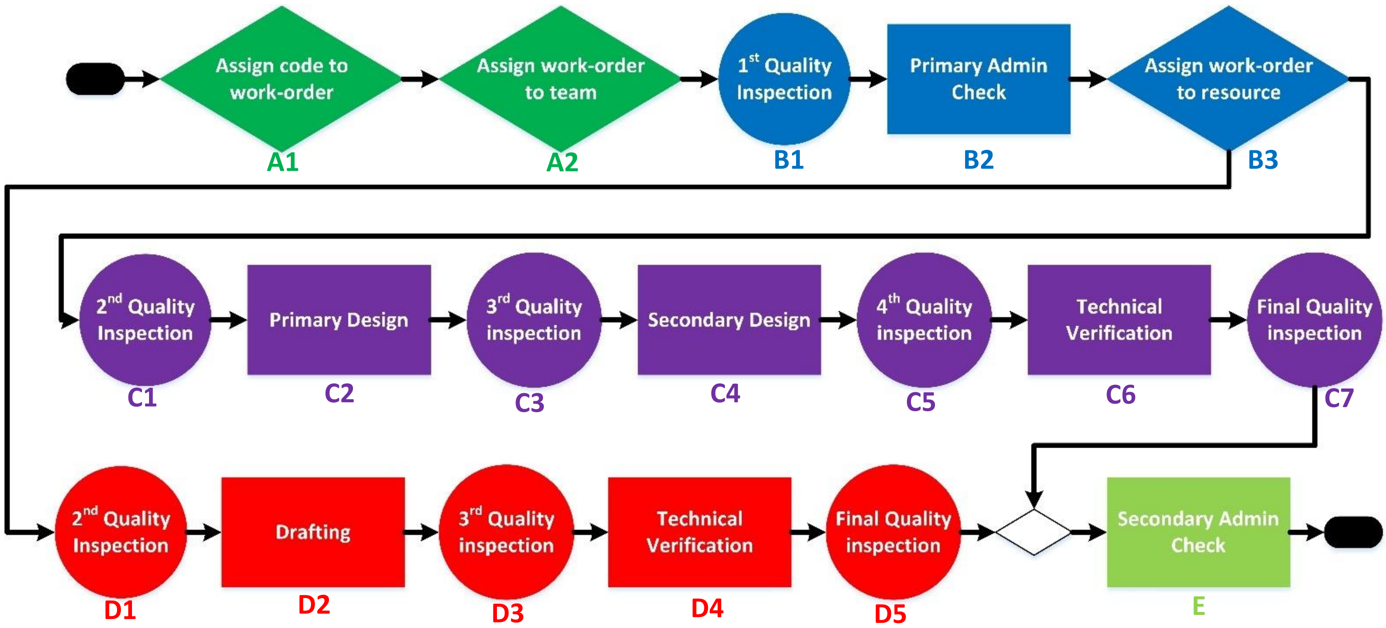


Figure 10: A schematic representation of the developed simulation model.

<u>**Part A**</u>

As seen in Figure 10, Part A represents the first part of the model. A source block is used to generate rectangular-shaped agents, which represent the work orders that are received by Telco RSA from Australia. Work orders are generated according to a uniform distribution, since the number of work order Telco RSA receives per day can vary.

Several variables were created for the work order agent to enable the assignment of certain attributes and values to the agent throughout the model. Table 14 only shows the variables that are used within the description of the developed model. The rest of the variables will be given and discussed with the calculations.

Table 14: The variables of the work order agent used in the description of the developed simulation model

Variable	Assigned attribute or value
Code	This is a combination of a letter and a number. The letter can either be “T”, “H”, “N”, “O” or “E” and the number is assigned using a uniform distribution of which the parameters of this distribution represent each work order code’s relevant minimum and maximum value.
Colour	Either the colour blue or green should be assigned to the work order agent. The colour blue represents a design and green represents a draft.
Budget	This represents the unique budget of each specific work order code.

After a work order agent has been generated, a work order code must be assigned to it as stated by Part A1 in Figure 10. This is achieved with the use of a select output5 block. When the work order agent enters the select output5 block, the block determines which code should be assigned to the work order agent based on the distributions given in Tables 6 and 7 in section 3.3.1 above. The relevant colour and budget are also assigned to the agent. The agent then exits the select output5 block in the following manner:

- If the code type “T” was assigned to it, it will exit the first output port of the block.
- If the code type “H” was assigned to it, it will exit the second output port of the block.
- If the code type “N” was assigned to it, it will exit the third output port of the block.
- If the code type “O” was assigned to it, it will exit the fourth output port of the block.
- If the code type “E” was assigned to it, it will exit the last output port of the block.

After the work order agent exits the select output5 block, the work order is allocated to one of two teams, as represented by Part A2 in Figure 10. The two teams are the NBN and Telstra team and the EME team. This allocation is based on the work order code that was assigned to the agent. Work orders of code type “T”, “H”, “N” and “O” are allocated to the NBN and Telstra team and only work orders of code type “E” are allocated to the EME team. At this allocation, the model logic splits into two separate paths each representing a team, since these two teams operate independently.

<u>Part B</u>

After the work order was allocated to a team, the work order agent moves on to Part B1. At Part B1, the agent enters a select output block, which represent the first quality inspection each work order encounter in the process. This quality inspection refers to the one that is executed before the Primary Admin Check sub-process as mentioned in Tables 10 and 11 in section 3.3.1 above. The select output block determines if the work order agent failed the quality inspection based on the probability given in Tables 10 and 11. If the work order fails the inspection, it is sent back to Australia for correction. This action is modelled as a time-out with a uniform distribution as stated in Tables 10 and 11. A delay block is used to represent this time-out.

However, if the work order agent passes the quality inspection, it moves on to Part B2. At this part the agent enters the first service block within the simulation model, which represents the Primary Admin Check sub-process. This sub-process is executed by a Document Controller resource according to a uniform distribution as stated in Table 9.

After the execution of the Primary Admin Check sub-process, the agent moves to Part B3, where it must be assigned to either a designer or drafter based on the type of work order it is. This part of the process happens in two steps. Firstly, the colour attribute of the work order agent comes into play. After the agent exits the Primary Admin Check service block, it enters another select output block. When the work order agent enters the select output block, the model evaluates the colour that was assigned to the work order in Part A1. If the colour of the work order is blue (representing a design), the work order exits the first output port of the select output. However, if the colour of the work order is green (representing a draft), the work order exits the second output port of the select output block.

Secondly, the availability of the different human resources should be checked before assigning any work order to a particular human resource. The different types of human resources as well as each team's resource capacity are given in Table 5 in section 3.3.1 above. In the case of a design, the availability of each team's Senior and Junior Designers should be checked. However, since Senior and Junior Designers can also execute draft work orders, the availability of the Senior and Junior Drafters, as well as the availability of Senior and Junior Designers, should be checked in the case of a draft. Therefore, since there are two types of designers and four types of drafters in effect, the model logic had to account for this. This model code was achieved with the use of several different select output blocks.

In the case of a design, when the agent enters the relevant select output block the model updates the percentage utilisation of both the Senior and Junior Designer with the use of an in-built function of AnyLogic. The percentage utilisation of each resources at the time of entry is then assigned to two separate variables. The minimum between the two variables are then determined also on entry. If the percentage utilisation of the Senior Designers is lower than that of the Junior Designers, the design work order is allocated to a Senior Designer. If not, the design work order is allocated to a Junior Designer.

The same principle is used for the selection of a drafter. However, since designers are also able to draft, even though this is not preferred, the logic of the drafter selection looks a bit different. Three consecutive select output block are used of which the first two are select output5 blocks and the last one is only a select output block. As the draft work order agent enters the first block, the model checks whether there are any drafters or designers, either senior or junior, who are idling (doing nothing). For this first select output5 block the agent exits the block in the following manner:

- If one of the Senior Drafters is idling, the draft work order exits the first output port of the select output5 block.

- If the there are no Senior Drafters idling, the model then check the second condition which is whether there are any Junior Drafters who are idling. If there are, the work order exits the second output port of the block.
- If not, the model checks whether there are any Junior Designers who are idling. If there are, the work order exits the third output port.
- If not, the model checks whether there are any Senior Designers who are idle. If there are, the work order exits the fourth output port.
- If there are no resources who are idling, the work order exits the last output port of the block.

If the agent exits the last output port of the first select output5 block, the model updates the percentage utilisation of each resource also with the use of the in-built function. The utilisation of each of the resources are also assigned to four separate variables. The minimum between these four variables is also then determined on entry. The exit conditions for the second select output5 block are as follow:

- If the percentage utilisation of the Senior Drafters is the minimum of all the resources, the work order exits the first output port.
- If the percentage utilisation of the Junior Drafters is the minimum of all the resources, the work order exits the second output port.
- If the percentage utilisation of the Junior Designers is the minimum of all the resources, the work order exits the third output port.
- If the percentage utilisation of the Senior Designers is the minimum of all the resources, the work order exits the fourth output port.
- If the percentage utilisation of different resources is the same, the work order exits the last output port.

If the work order agent exits the last port of the above-mentioned select output5 block, it enters a third select output block. Since all the resources are equally busy, the work order is allocated to either the Senior Drafters or the Junior Drafters based on a 0.5 probability. After a work order agent has been allocated to a specific resource, the path of the agent looks different depending on whether the work order is a design or a draft. Part C1 to C7 represent the logic a design work order will follow and Part D1 to D5 represent the logic a draft work order will follow. These two paths will now be discussed separately.

<u>Part C</u>

After the design work order agent has been allocated to either a Senior or Junior Designer, the agent moves on to Part C1 in both cases. At Part C1, the agent enters another select output block, which represent the second quality inspection the design work orders encounter within the process. This quality inspection refers to the one that is executed before the Primary Design sub-process as mentioned in Table 10 in section 3.3.1 above. The select output block determines if the work order agent failed the quality inspection based on the probability stated in Table 10.

If the work order fails the inspection, it is sent back to Australia for correction. This action is also modelled as a time-out according to the uniform distribution stated in Table 10. This time-out is also modelled with the use of a delay block.

If the agent passes the second quality inspection, it moves on to Part C2. At this part the agent enters another service block, which represents the Primary Design sub-process. This sub-process is executed according to a uniform distribution as stated in Table 9 and by the resource to whom the agent was initially allocated. After the Primary Design sub-process has been executed, the agent moves on to Part C3. At Part C3, the agent enters another select output block, which represent the third quality inspection the design work orders encounter in the process. This quality inspection refers to the one that is executed before the Secondary Design sub-process as mentioned in Table 10. The select output block determines if the work order agent failed the quality inspection based on the probability mentioned in Table 10. If the work order fails the inspection, it is sent back to either the Senior or Junior Designer for correction. The correction of a design is also modelled as a service block since it needs to be executed by a specific resource. The correction of the primary design is also executed according to the uniform distribution stated in Table 10.

If the agent passes the third quality inspection, it moves on to Part C4. At this part the agent enters another service block, which represents the Secondary Design sub-process. This part is modelled similar to Part C2. Part C5 is also modelled similar to Part C3. Part C5 represents the fourth quality inspection a design work order encounters as described in Table 10. Part C6 of the model is also modelled similar to Part C4 and represents the Technical Verification sub-process which is executed by the Technical Verifiers. Part C7 is also modelled similar to Part C5 and C3. Part C7 just represents the final quality inspection a design work order encounters as stated in Table 10. After a design work order exits Part C7, it moves on to Part E.

Part D

After the draft work order agent has been allocated to either a Senior or Junior Drafter or a Senior or Junior Designer, the agent moves on to Part D1 in all four these cases. At Part D1, the agent enters another select output block, which represent the second quality inspection the draft work orders encounter in the process. This quality inspection refers to the one that is executed before the Drafting sub-process as mentioned in Table 11 in section 3.3.1 above. The select output block determines if the agent failed the quality inspection based on the probability stated in Table 11. If the agent fails the inspection, it is sent back to Australia for correction. This action is also modelled as a time-out according to the uniform distribution stated in Table 11. This time-out is also modelled with the use of a delay block.

If the agent passes the second quality inspection, it moves on to Part D2. At this part the agent enters another service block, which represents the Drafting sub-process. This sub-process is executed according to a uniform distribution as stated in Table 9 and by the resource to whom the agent was initially allocated. After the Drafting sub-process has been executed, the agent moves on to Part D3.

At Part D3, the agent enters another select output block, which represent the third quality inspection the draft work orders encounter in the process. This quality inspection refers to the one that is executed before the Technical Verification sub-process as mentioned in Table 11 in section 3.3.1 above. The select output block determines if the work order agent failed the quality inspection based on the probability stated in Table 11. If the work order fails the inspection, it is sent back either the Senior or Junior Drafter or the Senior or Junior Designer for correction. The correction of a draft is also modelled as a service block since it needs to be executed by a specific resource. The correction of the draft is also executed according to the uniform distribution stated in Table 9.

If the agent passes the third quality inspection, it moves on to Part D4. Part D4 of the model is modelled similar to Part D2 and represents the Technical Verification sub-process which is executed by the Technical Verifiers. Part D5 is modelled similar to D3. Part D5 just represents the final quality inspection a draft work order encounters as stated in Table 11. After a draft work order exits Part D5, it moves on to Part E.

<u>Part E</u>

After all the relevant design and draft work order agents have been corrected by the relevant human resources, the agents move on to Part E. At this last part of the model, the agents enter the last services block in the model, which represents the Secondary Admin Check sub-process. The Document Controllers also execute this sub-process according to the uniform distribution as stated in Table 9. After an agent has exited this last service block, the agent disappears from the model with the use of a sink block, which represents the completion of a work order.

2) Calculations

The following section explains the calculation done by the model as well as the equations used for the calculations of the results in Chapter 4 of this report. To better understand the calculations, the difference between the process time, the correction time, the waiting time and the lead-time of a work order needs to be understood.

The process time of a work order refers the sum of the time the human resources spent executing the work order at the relevant sub-processes. The correction time of a work order refers to the sum of the time the human resources spent correcting the work order in the case of a quality inspection failure. The waiting time of a work order refers to the sum of the time the work order had to wait at any point within the process before the relevant human resources were able to execute the work order. The lead-time of a work order refers to the sum of the process time, correction time and waiting time of the work order.

a. Model calculations

The main calculations done by the model are the following:

1. The calculation of the revenue per work order.
2. The calculation of the total waiting time at each human resource.
3. The calculation of the number of delayed work orders at each specific human resource.

To explain the calculations done by the model, the variables defined in Table 15 and the parameters defined in Table 16 will be used.

Table 15: The defined variables for the explanation of the calculations done by the model

Symbol	Assigned attribute or value
$\boldsymbol{R_w}$	The revenue that was generated for completing work order w, where $w = \{1, \dots, n\}$ and n represents the total number of work orders that was completed during a model run.
$\boldsymbol{B_w}$	The budget that was assigned to work order w, where $w = \{1, \dots, n\}$ and n represents the number of work orders that was completed during a model run.
$\boldsymbol{E_w}$	The effort it took to execute work order w, where $w = \{1, \dots, n\}$ and n represents the number of work orders that was completed during a model run.
$\boldsymbol{P_{sh}^{w}}$	The time resource of type h spent executing work order w at sub-process s, where $h = \{1, \dots, 6\}$ and 1 = Document Controller, 2 = Technical Verifier, 3 = Senior Designer, 4 = Junior Designer, 5 = Senior Drafter and 6 = Junior Drafter and where $s = \{1, .., 6\}$ and 1 = Primary Admin Check, 2 = Primary Design, 3 = Secondary Design, 4 = Drafting, 5 = Technical Verification and 6 = Secondary Admin Check.
$\boldsymbol{Q_{ch}^{w}}$	The time resource of type h spent correcting work order w at correction sub-process c, where $h = \{1, \dots, 6\}$ and 1 = Document Controller, 2 = Technical Verifier, 3 = Senior Designer, 4 = Junior Designer, 5 = Senior Drafter and 6 = Junior Drafter and where c $= \{1, .., 3\}$ and 1 = Correction sub-process for 3rd quality inspection fails, 2 = Correction sub-process for 4th quality inspection fails and 3 = Correction sub-process for final quality inspection fails.

Table 16: The defined parameter for the explanation of the calculations done by the model

Symbol	Assigned attribute or value
$\boldsymbol{C_h}$	The labour cost rate of human resource of type h, where $h = \{1, \dots, 6\}$ and 1 = Document Controller, 2 = Technical Verifier, 3 = Senior Designer, 4 = Junior Designer, 5 = Senior Drafter and 6 = Junior Drafter.

Calculation of the revenue per work order

As stated in section 3.3.1 of Chapter 3, to calculate the revenue per completed work order the following two factors are needed:

- The budget that was allocated to the work order at the beginning of the process.
- The effort it took to complete the work order.

Several variables were created for the work order agent that enables the model to assign the relevant information that is needed to calculate the revenue for that work order, to that work order. This information mainly consists of which human resource worked on the work order at part of the process and for how long. The labour cost rates of the different human resources were modelled as parameters. Therefore, for each work order that exits the model, the model uses the following equation to calculate the revenue for each work order:

$$\boldsymbol{R_w = B_w - E_w}$$

where:

$$\boldsymbol{E_w} = \sum_{s=1}^{6}\sum_{h=1}^{6}(\boldsymbol{P_{sh}^{w}} \times \boldsymbol{C_h}) + \sum_{c=1}^{3}\sum_{h=1}^{6}(\boldsymbol{Q_{ch}^{w}} \times \boldsymbol{C_h})$$

Note that $\boldsymbol{P_{sh}^{w}}$ refers to the process time of a work order and $\boldsymbol{Q_{ch}^{w}}$ the correction time of a work order.

Calculation of the waiting time per work order per human resource

The variables that were created for the work order agent that enables the model to assign the relevant information to that work order, were also used in the calculation of the waiting time of a work order per human resource. To calculate the total waiting time of a work order per human resource, the following three action consoles of each service block within the model are used:

- **On enter:** The code in this action console is executed when the work order agent enters the service block.
- **On enter delay:** The code in this action console is executed when the work order agent's waiting time is over, and the resource is ready to execute the work order.
- **On exit:** This is the code executed when the work order agent exits the service block.

Therefore, for each work order that enters a service block, which represents one of the sub-processes (including the correction sub-processes), the following steps are executed to calculate the total time work orders had to wait for a specific human resource at a certain sub-process:

- **Step 1:** When the work order enters the service block, the model records the model time at that moment and assigns it to the relevant variable of the work order that represents the start of the work order's waiting time at that specific sub-process for the relevant human resource.

- **Step 2:** When the work order enters the "On enter delay" action console the model again records the model time at that moment to the relevant variable of the work order that represents the end of the work order's waiting time at that specific sub-process process for the relevant human resource.
- **Step 3:** A second line of code within the "On enter delay" then subtracts the start waiting time value from the end waiting time value. For each work order the difference between the work order's start and end waiting time values is then added to a new variable that was created for each human resource at each sub-process. This new variable represents the sum of all the work orders' waiting time at that specific sub-process process for the relevant human resource.

At the end of a model run, the model executes certain lines of code that sum the waiting time at the different sub-processes for each human resource.

Calculation of the number of delayed work orders per human resource

To calculate the number of delayed work orders per specific human resource, an If-statement was used within the "On enter delay" action console of each service block. The If-statement enables the model to increment another variable that was created for each specific human resource at a specific sub-process. The value of this variable represents the number of work orders that had to wait for the specific human resource to be executed at a specific sub-process. At the end of a model run, the model executes certain lines of code that sum the number of work orders that had to wait at the different sub-processes for each specific human resource.

b. Calculations for results in section 4.3

The calculations that will be done for the results in section 4.3 of Chapter 4, consist of the following:

1. The calculation of the minimum and maximum parameters of the uniform distribution that represents the arrival rate of the work orders as generated by the source block at the beginning of the process.
2. The calculation of the average number of work orders that was completed per year.
3. The calculation of the annual revenue that was generated.
4. The calculation of the average annual revenue that was generated.
5. The calculation of the average number of delayed work orders at each specific human resource.
6. The calculation of the average waiting time per work order at each specific human resource.
7. The calculation of the percentage difference between the output of the model and the target.

To explain the calculations that will be done for the results in section 4.3 of Chapter 4, the variables defined in Table 17 and the parameters defined in Table 18 will be used.

Table 17: The defined variables for the explanation of the calculations that will be done for the results

Symbol	Assigned attribute or value
$\boldsymbol{w_i}$	The number of work orders that was (or can be) completed during financial year i, where $i = \{1, 2\}$ and 1 = 2018 and 2 = 2019.
$\boldsymbol{w_j}$	The average number of work orders that was completed during scenario j, where $j = \{1, \dots, x)$ and x represents the total number of scenarios.
$\boldsymbol{O_r}$	The number of work orders that was completed during run r, where $r = \{1, \dots, 100\}$.
$\boldsymbol{R_{wr}}$	The revenue that was generated for completing work order w during run r, where $w = \{1, \dots, n\}$ and n represents the total number of work orders that was completed during a model run and $r = \{1, \dots, 100\}$.
$\boldsymbol{R_j}$	The average annual revenue that was generated during scenario j, where $j = \{1, \dots, x)$ and x represents the total number of scenarios.
$\boldsymbol{D_{rg}}$	The number of delayed work orders at human resource of type g for run r, where $g = \{1, \dots, 11\}$ and 1 = Document Controllers, 2 = Senior Designers NBN/Telstra, 3 = Junior Designers NBN/Telstra, 4 = Senior Drafters NBN/Telstra, 5 = Juniors Drafter NBN/Telstra, 6 = Technical Verifiers NBN/Telstra, 7 = Senior Designers EME, 8 = Junior Designers EME, 9 = Senior Drafters EME, 10 = Junior Drafters EME and 11 = Technical Verifiers EME and $r = \{1, \dots, 100\}$.
$\boldsymbol{W_{rg}}$	The total time a work order had to wait at human resource of type g for run r, where $g = \{1, \dots, 11\}$ and 1 = Document Controllers, 2 = Senior Designers NBN/Telstra, 3 = Junior Designers NBN/Telstra, 4 = Senior Drafters NBN/Telstra, 5 = Juniors Drafter NBN/Telstra, 6 = Technical Verifiers NBN/Telstra, 7 = Senior Designers EME, 8 = Junior Designers EME, 9 = Senior Drafters EME, 10 = Junior Drafters EME and 11 = Technical Verifiers EME and $r = \{1, \dots, 100\}$.
$\boldsymbol{D_g}$	The average number of delayed work orders at human resource of type g, where $g = \{1, \dots, 11\}$ and 1 = Document Controllers, 2 = Senior Designers NBN/Telstra, 3 = Junior Designers NBN/Telstra, 4 = Senior Drafters NBN/Telstra, 5 = Juniors Drafter NBN/Telstra, 6 = Technical Verifiers NBN/Telstra, 7 = Senior Designers EME, 8 = Junior Designers EME, 9 = Senior Drafters EME, 10 = Junior Drafters EME and 11 = Technical Verifiers EME.
$\boldsymbol{W_g}$	The average time a work order had to wait at each human resource g, where $g = \{1, \dots, 11\}$ and 1 = Document Controllers, 2 = Senior Designers NBN/Telstra, 3 = Junior Designers NBN/Telstra, 4 = Senior Drafters NBN/Telstra, 5 = Juniors Drafter NBN/Telstra, 6 = Technical Verifiers NBN/Telstra, 7 = Senior Designers EME, 8 = Junior Designers EME, 9 = Senior Drafters EME, 10 = Junior Drafters EME and 11 = Technical Verifiers EME.

Table 18: The defined parameter for the explanation of the calculations that will be done for the results

Symbol	Assigned attribute or value
m_i^-	The minimum parameter for the uniform distribution of the arrival rate for the financial year i, where $i = \{1, 2\}$ and 1 = 2018 and 2 = 2019.
m_i^+	The maximum parameter of the uniform distribution of the arrival rate distribution for the financial year i, where $i = \{1, 2\}$ and 1 = 2018 and 2 = 2019.
t	The model runtime.

Calculation of the arrival rate parameters

The minimum parameter of the uniform distribution of the arrival rate was calculated using the following equation:

$$m_i^- = \frac{w_i}{t}$$

where:

$$t = 241\ days \times 24 \frac{hours}{day} = 5784\ hours$$

A sensitivity analysis was done on the as-is model to determine what the maximum parameter of the uniform distribution of the arrival rate should be. During the sensitivity analysis, it was found that the maximum arrival rate parameter of 0.92 work orders per hour generated an output close to 5240 work orders per year, which was the number of work orders that was actually completed during the financial year of 2018. Therefore, the following equation was developed to determine the maximum arrival rate parameter for the financial year of 2019:

$$m_2^+ = m_2^- + 0.014$$

The 0.014 represents the difference between the maximum and minimum parameter of the as-is model. Since a sensitivity analysis was done for the determination of the maximum parameter of the as-is model, the calculation of the maximum parameter for the financial year of 2019 was assumed to be relatively accurate.

Calculation of the average number of work orders per year

For the calculation of the average number of work orders that was completed per year for any of the scenarios that was tested in section 4.3 of Chapter 4, the following equation was used:

$$w_j = \frac{\sum_{r=1}^{100} O_r}{100}$$

Calculation of the average annual revenue

For the calculation of the average annual revenue that was generated for any of the scenarios that was tested in section 4.3 of Chapter 4, the following equation was used:

$$R_j = \frac{\sum_{r=1}^{100} \sum_{w=1}^{n} R_{wr}}{100}$$

Calculation of the average number of delayed work orders per human resource

For the calculation of the average number of delayed work orders per human resource for any of the scenarios that was tested in section 4.3 of Chapter 4, the following equation was used:

$$D_g = \frac{\sum_{r=1}^{100} D_{rg}}{100}$$

Calculation of the average waiting time per work order per human resource

For the calculation of the average waiting time per work orders per human resource for any of the scenarios that was tested in section 4.3 of Chapter 4, the following equation was used:

$$W_g = \frac{\sum_{r=1}^{100} W_{rg}}{\sum_{r=1}^{100} D_{rg}}$$

Calculation of the percentage difference

For the calculation of the percentage difference between the output of the model and the target values for any of the scenarios that was tested in section 4.3 of Chapter 4, the following equation was used:

$$\%\,Difference = \frac{|Target\ value - Model\ Output|}{Target\ value} \times 100$$

Chapter 4: Results and discussion

This section of the report contains a detailed discussion of the result obtained in each phase of the project by using the methodologies explained in Chapter 3.

4.1. Results of Process Definition Phase

The RSA Offshoring process is a relatively complex process subject to a large amount of variability. By using the Process Definition phase of the PADM framework to define the RSA Offshoring process, a better understanding of key aspects of the process was obtained. The results of each step within the Process Definition phase of the PADM framework will now be discussed.

1) Establish process objectives

Process objectives are the factors that are implemented within the process to achieve the process aim (Europe, 2014). The aim of the RSA Offshoring process is to deliver high quality designs and technical drawings on time at the lowest achievable cost. To further achieve the aim of the process, Telco RSA offshoring team has set the following targets for 2019:

- Telco RSA aims to increase their revenue with 40%.
- Since Telco RSA's offshoring project team is much bigger than their onshoring project team and the offshoring projects generate a higher profit for the department, they aim to spend 90% of the departments' resources on offshoring projects and the other 10% on onshoring projects.
- Telco RSA's offshoring project team must be able to handle the execution of 25% of all the telecommunication projects Telco Australia receives from clients.
- Telco RSA must be able to handle an increase in the number of work orders they will receive. The number of work orders will increase from 5240 per year to 7200 per year.
- Currently, the lead-time of the process varies between 6 hours and 6 days, but according to the Director of the Program Advisory department of Aurecon RSA, Mr. Carl Klopper, clients have requested that the process should be completed within less than three days.

Figure 11 illustrates the balanced scorecard for the RSA Offshoring process. A balanced scorecard is a management tool used to illustrate a company's strategic objectives and how these objectives relate to one another.

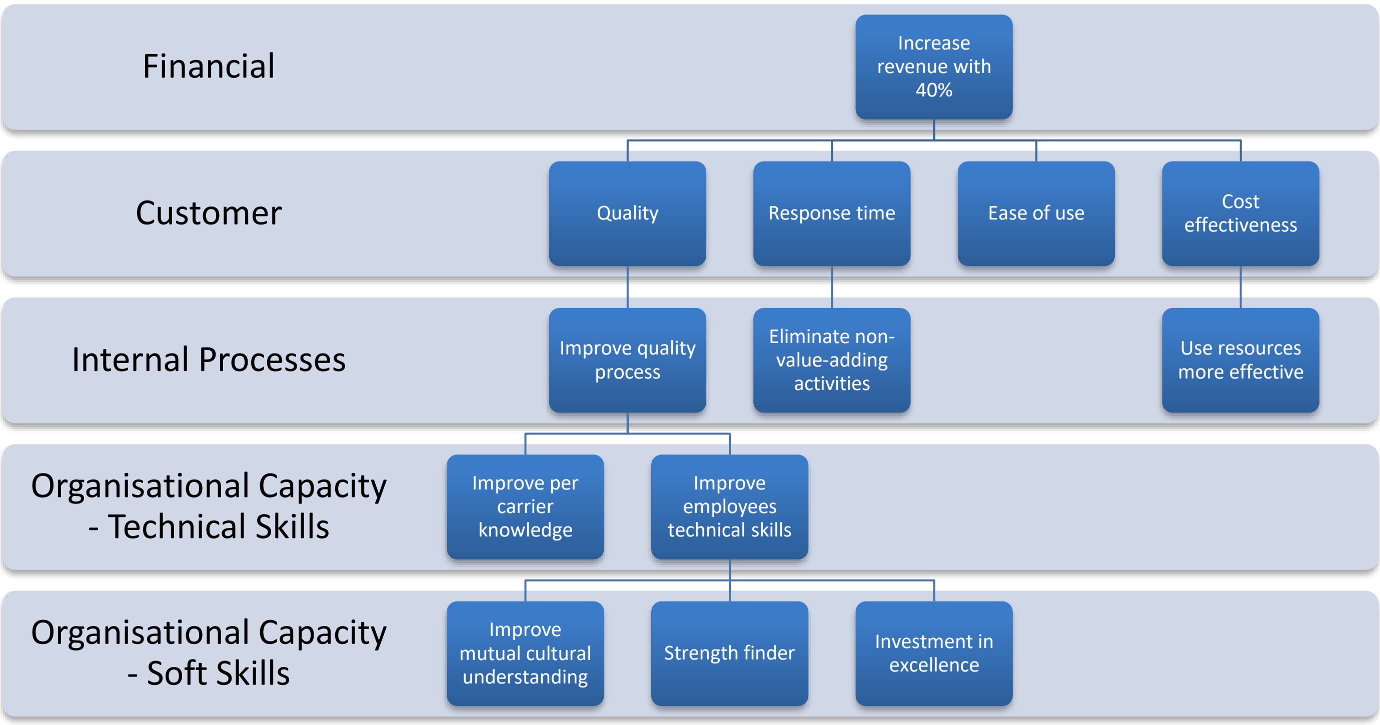


Figure 11: Balanced Scorecard of the RSA Offshoring process

From Figure 11 it is clear that the strategic objectives of the RSA Offshoring process focus on five main aspects, namely financial, the customer, the internal processes and the organisational capacity which is divided into technical skills and soft skills. The financial objective of the RSA Offshoring process is to increase the revenue with 40%. The revenue is also the key performance indicator of the process.

To increase the revenue, focus must be placed on the other three aspects illustrated in the balanced scorecard. The objectives of the RSA Offshoring process relating to customer satisfaction are the following:

- **Quality:** To improve the quality of the work orders.
- **Response time:** To decrease the time it takes to finish a work order (decrease the lead-time per work order).
- **Ease of use:** To ensure that the designs and technical drawings produced by the RSA Offshoring process are easily understandable for the client.
- **Cost-effectiveness:** To ensure that the client is satisfied with the combination of the quality of the completed work order and the cost the client had to incur to obtain it.

The objectives relating to the internal processes are the following:

- to improve the quality of work throughout the process,
- to eliminate non-value-adding activities within the process and
- to use resources, especially the human resources, within the process more effectively.

The objectives that relate to technical skills explain that focus should be placed on designs, standards and reporting within the process. Soft skills refer to enhancing mutual cultural understanding within the RSA Offshoring process, identifying the strengths and weaknesses of the team members and to encourage excellence.

2) Define process boundaries, constraints and interfaces

2.1) Process boundaries

Process boundaries can be defined as measurable and auditable characteristics that determine what falls within the scope of the process and what is excluded from the process scope (McConnell, 2010). Even though the RSA Offshoring process forms part of a telecommunication project received by Telco Australia from an Australian client, this project only focusses on the Admin and Technical Quality Process which is offshored to Telco RSA. Only from where Telco RSA receives a work order to where they send it back to Australia, is part of the admin and technical quality process.

2.2) Process constraints

Process constraints are factors that restrict or limit the ability of the process to produce outputs that will meet client requirements. These factors therefore also restrict or limit the process to meet the stated process objectives (Peters, 2011). Constraints within the RSA Offshoring process are the following:

- Time delays - This is due to the time difference between Australia and South Africa.
- Skills - Some of the employees within Telco RSA are under-skilled.
- Ineffective methods of communication, such as the use of email. This is due to the large number of emails the employees receive each day and can lead to neglecting to read an important email such as the request to correct a work order etc.

2.3) Process interfaces

Process interfaces refer to the methods of communication the participants within the process use to interact with one another (Peters, 2011). The interfaces used within the RSA Offshoring process are the following:

- Both Telco Australia and Telco RSA use ProjectWise, a data storage and management system.
- Telco RSA use Microsoft Outlook to send emails between different resources within Telco RSA as well as between Telco RSA and Telco Australia. Telco RSA also receives the work orders for projects in an Excel document via email from Telco Australia.

3) Define key process inputs, outputs and transformational factors

3.1) Process inputs

Process inputs are the information that a process requires to be executed. The work orders Telco RSA receive from Telco Australia are the main process inputs. A work order consists of all the relevant documentation and information that the employees of Telco RSA require to execute the work order. However, there are different types of work orders that Telco RSA can receive.

As mentioned in Chapter 1, a work order can be classified into one of two main work order categories, namely designs and drafts. However, these two main work order types can further be divided into the following five work order sub-categories:

- T-code work orders, that range from T1 to T31
- H-code work orders, that range from H1 to H22
- N-code work orders, that range from N1 to N19
- O-code work orders, that range from O1 to O26
- E-code work orders, that range from E1 to E10

The letter the code starts with represents a different client and each number represents the specific design or draft that needs to be executed, for example H4 refers to either a design or draft for a Standard Greenfield Rooftop for Huawei.

3.2)Transformational factors

Transformational factors are the factors within a process that takes the process inputs and transforms it into process outputs. The human resources such as the document controllers, designers, drafters and technical verifiers within the Telco RSA department as well as the design systems such as AUTO CAD are the transformational factors within the RSA Offshoring process.

However, the some of the human resources, such as the designers and drafters, can also be further divided into sub-groups. Therefore, the following is a list of all the different human resources within the process:

- Document controllers
- Senior designers
- Junior designers
- Senior drafters
- Junior drafters
- Technical verifiers

3.3)Process outputs

Process outputs are the entities that are produced by a process. Process outputs can be explained as the final product that a process delivers. The final designs and drafts the RSA Offshoring process must deliver and send back to Australia at the end of the RSA Offshoring process are the output of the process.

4) Define departments involved during the execution of the process

Telco RSA is the only department that is involved in the execution of the RSA Offshoring process. Even though incorrect documents are sent back to Telco Australia for correction, Telco Australia is seen as an external participant. However, Telco RSA can further be divided into an onshoring and offshoring project team. Only Telco RSA’s offshoring team participates in the execution of the RSA offshoring process.

The Telco RSA offshoring project team can also be further divided into four sub-teams, namely:

- The Project Management Team
- The NBN Team
- The Telstra Team
- The EME Team

The Project Management Team mainly consists of administrative employees such as the Document Controller and Technical Verifiers. The NBN, Telstra and EME Teams mainly consist of senior and junior designers as well as senior and junior drafters. The NBN team is mainly responsible for executing work orders related to NBN work order types (N-code and H-code designs and drafts). The Telstra team is mainly responsible for executing work orders related to Telstra work order types (T-code and O-code designs and drafts). The main responsibility of the EME team is to execute work orders related to electrical designs and drafts (E-code work order).

5) Define clients that will benefit

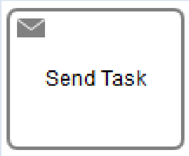
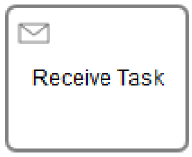
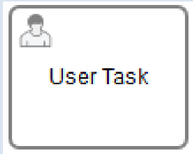
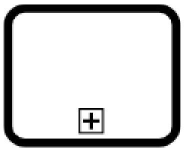
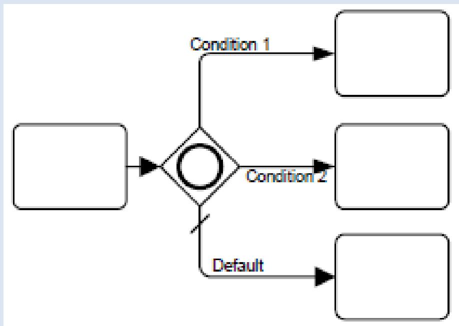
The main clients of Telco Australia are Ericsson, Vodacom, Huawei and Motorola. Since Telco Australia offshores the Admin and Technical Quality process to Telco RSA, Telco Australia is seen as the client of Telco RSA.

4.2. Results of Process Baseline Capturing Phase

As stated in Chapter 3, the aim of the BPMN models is only to illustrate the workflow of the process and to gain a better understanding of how the process is executed. Since the flow of this process is determined by the type of work order that needs to be executed, two BPMN models were used to illustrate the workflow of the admin and technical quality process.

Figure 12 illustrates the workflow of the process in the case of a design work order, which includes all the different types of design work orders mentioned in the previous phase of this chapter. Figure 13 illustrates the workflow of the process in the case of a draft work order, which also includes all the different types of draft work orders mentioned in the previous phase of this chapter. Table 19 gives a description and the notation of the elements used in the BPMN model that were not discussed in the literature review. The parts of the process highlighted in red, refer to the sequence flow of failed quality inspections.

Table 19: Element used in the BPMN model of the RSA Offshoring process (Source: (Team, 2015))

Element	Description	Notation
Send task	A send task is used to send a message.	
Receive task	A receive task is a task that waits for the arrival of a certain message. A process remains inactive until a specific message is received by the engine which triggers continuation of the process beyond the receive task.	
User task	A user task is used to model work that needs to be done by a human actor.	
Call activity	A call activity can be used to reference a process that is external to the process definition. Both a call activity and an embedded sub-process call a sub-process when process execution arrives at the activity. However, the main use for the call activity is to have a reusable process definition that can be called from multiple other process definitions.	
Inclusive gateway	An inclusive gateway can be described as a combination of an exclusive and a parallel gateway. Like an exclusive gateway, an inclusive gateway will evaluate the defined conditions on outgoing sequence flows, but it can receive more than one sequence flow, like a parallel gateway.	

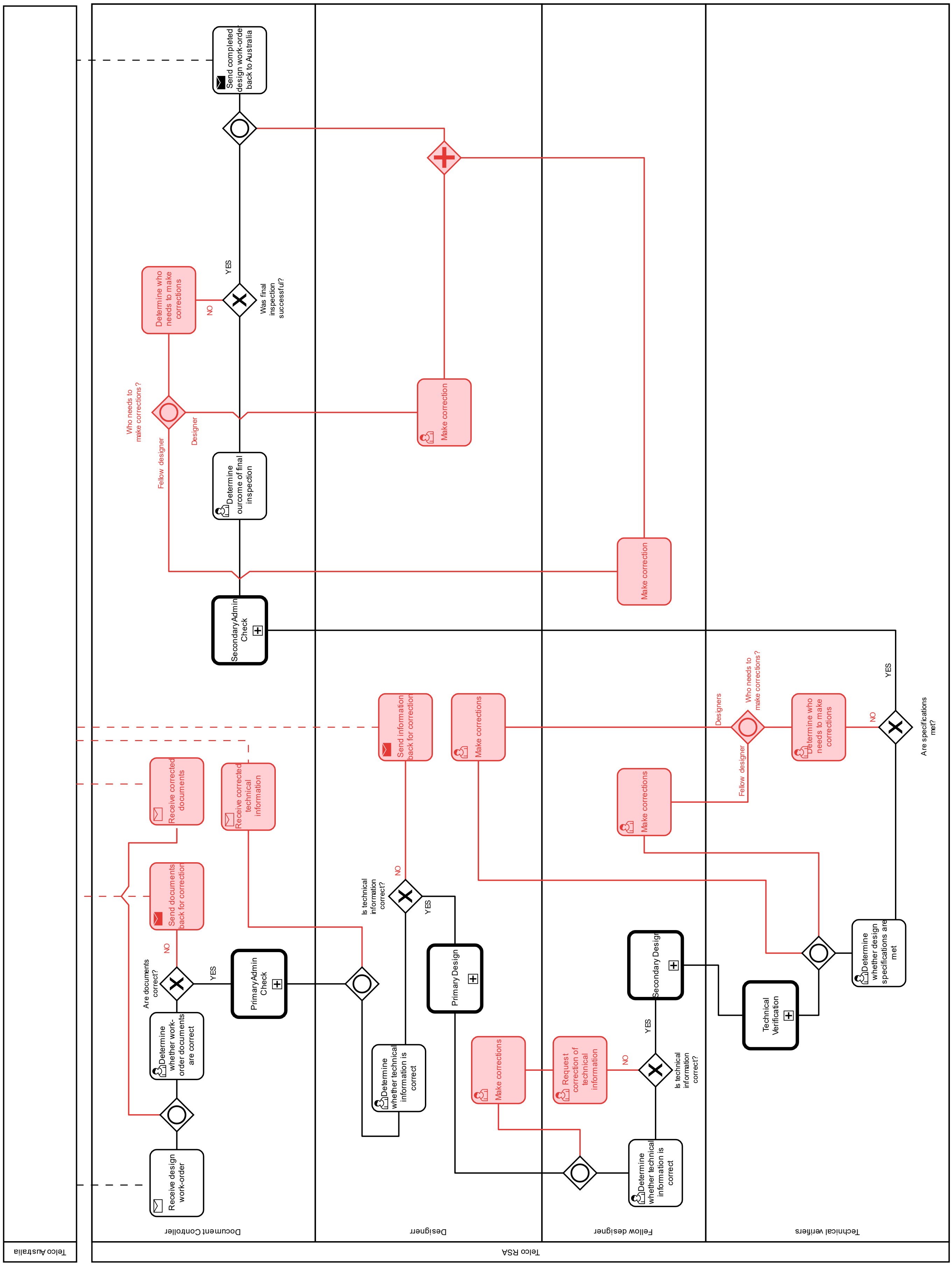


Figure 12: BPMN Model of the as-is process in the case of a design work order

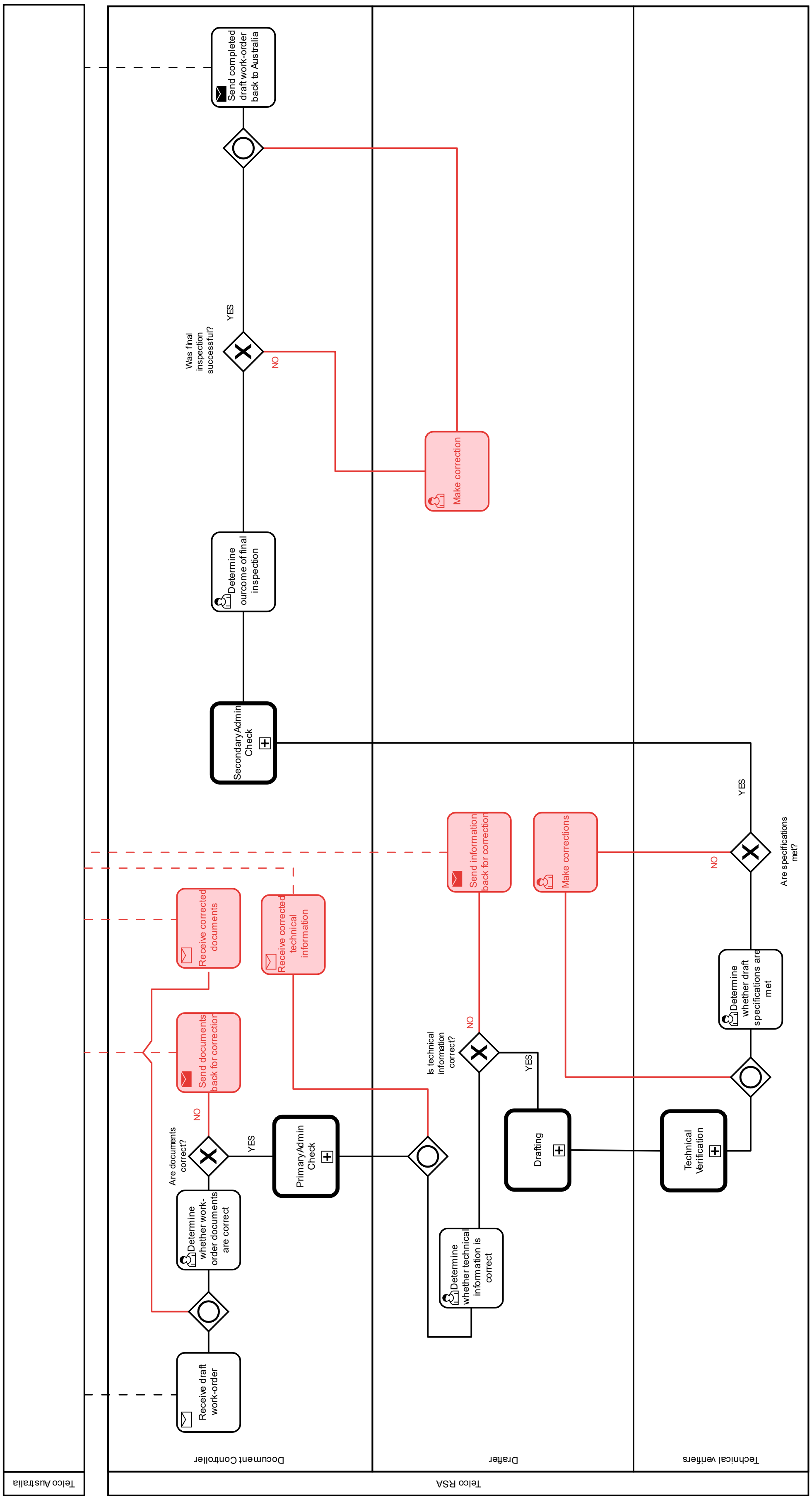


Figure 13: BPMN Model of the as-is process in the case of a draft work order

4.3. Results of Phases 3 and 4

This section of the report contains a discussion of the results of the simulation model that was developed as explained in section 3.3.2. As stated in section 3.3.1, the objective of the simulation model is to determine whether Telco RSA's offshoring team has the capacity to handle the increase in the volume of work orders and if not, to determine where human resources should be added to the process to improve the overall performance of the process.

This section of the report is divided into the following five sub-sections:

- The first sub-section contains the results of the Process Evaluation and Verification phase. In this sub-section, the output of the as-is model was evaluated and verified.
- The second sub-section contains the results of a sensitivity analysis that was done on the lead-time of the as-is process. During the sensitivity analysis, only the distribution of the work order sub-categories was adjusted. All the other model inputs were kept constant.
- The third sub-section contains the results of the volume increase. In this sub-section, the effect that the increase in the volume of work orders may have on the process, was evaluated.
- The fourth sub-section contains the results of the Process Improvement phase. In this sub-section, the results of the different process improvement scenarios that were evaluated.
- In the fifth sub-section, the recommendations that were made based on the findings from the previous sub-sections, were discussed and validated.

4.3.1. Results of Process Evaluation and Verification Phase

To verify the as-is model, the output of 100 runs was used. The data inputs given in section 3.3.1 and an arrival rate with a uniform distribution of uniform(0.906, 0.92) work orders per hour were used. These inputs represent the data inputs of the as-is process.

The model was verified based on its performance in terms of the following three variables of interest:

- The average number of work orders that was completed per year.
- The average annual revenue that was generated.
- The percentage of completed work orders that had a lead-time that fell between the given estimated minimum lead-time per work order of 6 hours and the given estimated maximum lead-time per work order of 6 days.

The distribution of the lead-time of all the completed work orders was also evaluated and discussed. As stated under the calculations in section 3.3.2, the lead-time of a work order refers to the sum of the process time, correction time and waiting time of the work order.

The targets that were achieved by Telco RSA's offshoring team in the financial year of 2018 for the first two variables of interest, are given in Table 20. However, these variables will be referred to as the number of completed work orders and the revenue that was generated, since these targets are not averages.

Table 20: The targets that were achieved by Telco RSA's offshoring team in the financial year of 2018

Variable of interest	Target achieved in the financial year of 2018
Number of completed work orders	5240
Revenue (in South African Rand)	6 199 800

The output of the model in terms of the first two variables and the percentage difference between the output of the model and the targets that were achieved in the financial year of 2018, are given in Table 21. A positive percentage difference means that the output, as produced by the model, exceeded the target value and a negative percentage difference means that the output, as produced by the model, was less than the target value. The output of the model in terms of the percentage of completed work orders that had a lead-time that fell between the minimum and maximum lead-time estimates, is also given in Table 21.

To successfully verify the as-is model, the percentage difference between the output of the model and the targets that were achieved in the financial year of 2018 for the first two variables of interest should not exceed 10%. The output of the model in terms of the percentage of completed work orders that had a lead-time that fell between the minimum and maximum lead-time estimates should not be less than 90%.

Table 21: The results of the as-is process runs

Variable of interest	Model Output (as-is process)	% Difference
Average number of completed work orders per year	5249	- 0.1803
Average annual revenue (in South African Rand)	6 050 641	-2.4059
Percentage of completed work orders with lead-time between min and max lead-time estimates	98.2429	-1.7571

As shown in Table 21, the developed model produced an average of 5249 completed work orders per year, where Telco RSA actually completed 5240 work orders in the financial year of 2018. Therefore, the output of the model in terms of the first variable of interest is relatively accurate and only deviates with 0.1803% from the actual target that was achieved by Telco RSA for this variable. The average annual revenue produced by the model was R6 050 641, where Telco RSA actually achieved a revenue of R6 199 800 in the financial year of 2018. Therefore, the output of the model in terms of the second variable of interest is also relatively accurate and only deviates with 2.4059% from the actual target that was achieved by Telco RSA for this variable.

Table 21 also shows that 98.2429% of the number of completed work orders, as produced by the model, had a lead-time that fell between the estimated minimum lead-time per work order of 6 hours and the estimated maximum lead-time per work order of 6 days.

Figure 14 illustrates the distribution of the lead-time of all the completed work orders, as produced by the model. The two vertical red lines in Figure 14 represent the estimated minimum lead-time per work order of 6 hours and the estimated maximum lead time per work order of 6 days, respectively.

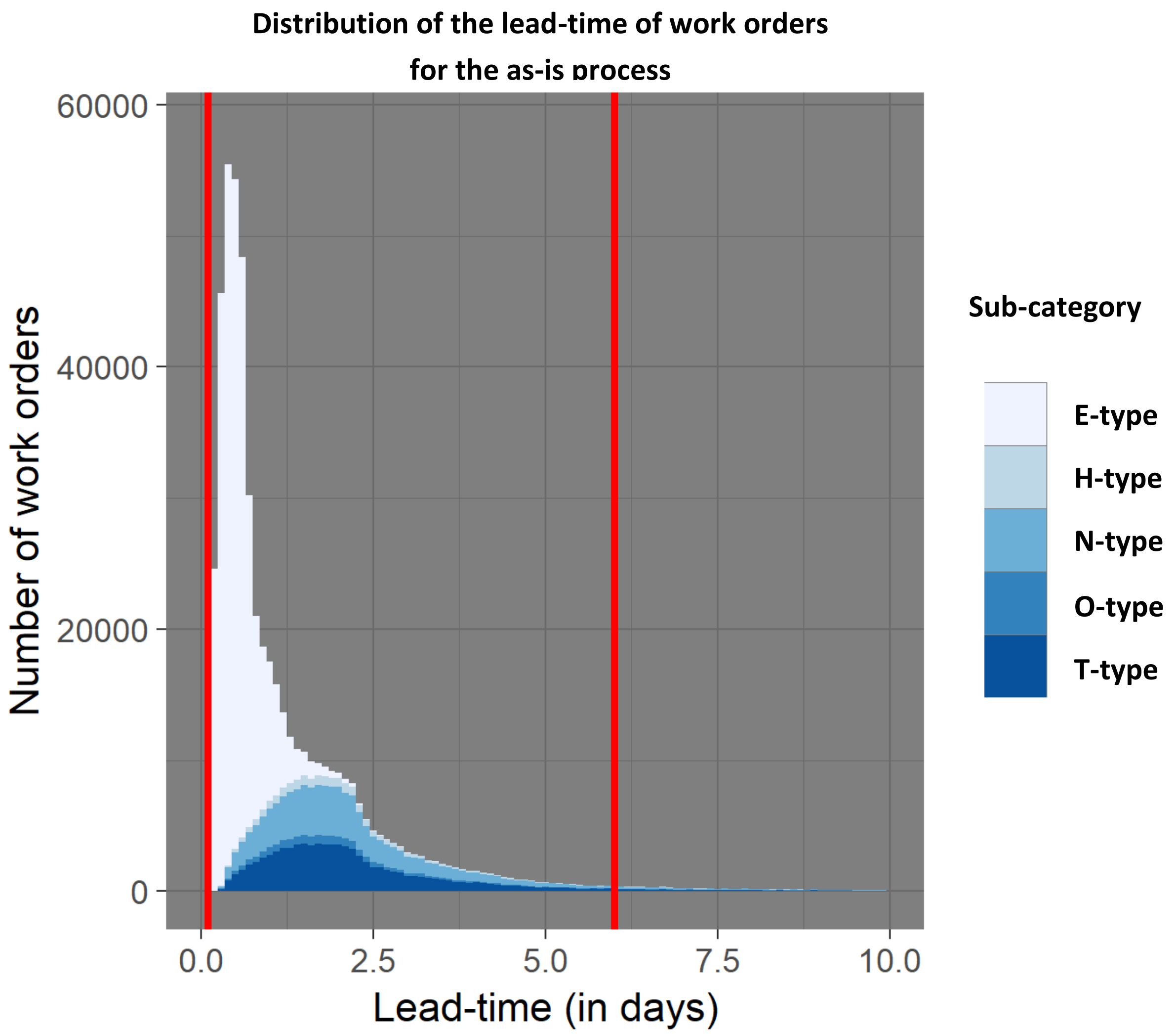


Figure 14: The distribution of the lead-time of the work orders for the as-is process runs

As illustrated by Figure 14, the overall distribution of the lead-time of the work orders, as produced by the as-is model, seems to be skew to the right. However, when focus is placed on the lead-time of each sub-category separately, it is clear that the entire distribution for the E sub-category work orders is shifted towards the left. This observation shows that the mode (the highest point in the curve) for the E sub-category work orders is to the left of the modes of the other sub-categories.

The above-mentioned observation can be assigned to the following:

- The work orders that belong to the E sub-category accounted for 60 % of all the work orders the offshoring team completed during the financial year of 2018 and contributes to the higher mode of the E sub-category work orders.

- The given estimated process times of each of the sub-processes, as executed by the EME team, are less than that of the NBN and Telstra team. This contributes to the position of the mode, being towards the lower end of the lead time.

Therefore, since 60% of the work orders that are generated by the model, belongs to the sub-category E and the time it takes to execute these work orders are much shorter than that of the other sub-categories, it explains why most of the work orders that were completed by the as-is model had a shorter lead-time. Therefore, the distribution of the lead-time of the work orders, as produced by the as-is model, is also a good representation of the reality of the process output.

The relatively accurate output of the as-is model in terms of the above-mentioned three variables of interest as well as the distribution of the lead-time of the work orders, as produced by the as-is model, can be deemed sufficient to verify the developed model.

4.3.2. Results of the sensitivity analysis on the lead-time

After the model was successfully verified, a sensitivity analysis was done on the lead-time of the work orders. For the sensitivity analysis, five scenarios were created and tested with the developed model. For each of these scenarios, the following were kept constant

- The arrival rate of the work orders was kept constant at a uniform distribution of uniform(0.906, 0.92) work orders per hour.
- The number of human resources per team was kept the same as shown in Table 5 in section 3.3.1.
- The given estimated uniform distributions of the process time and correction time of the different design and draft sub-processes and correction sub-processes were kept the same as shown in Tables 9, 10 and 11 in section 3.3.1.

Only the distribution of the sub-categories of the work orders was adjusted for each scenario. The aim of the sensitivity analysis was to test the human resources' capabilities to handle a change in the distribution of work orders and not yet to test their capabilities to handle the expected volume increase of 7200 work orders. The output of 100 runs was used to evaluate each scenario. Table 22 shows the distribution of the five work order sub-categories for each of the five scenarios.

Table 22: The distribution of the five work order sub-categories for the sensitivity analysis

Scenario	Work order sub-category	Distribution
Scenario 1 – Equal distribution	T-code (ranges from T1 to T31)	0,2
	H-code (ranges from H1 to H22	0,2
	N-code (ranges from N1 to N19)	0,2
	O-code (ranges from O1 to O26)	0,2
	E-code (range from E1 to E10)	0,2
Scenario 2 – T-code increase	T-code (ranges from T1 to T31)	0,6
	H-code (ranges from H1 to H22	0,1
	N-code (ranges from N1 to N19)	0,1
	O-code (ranges from O1 to O26)	0,1
	E-code (range from E1 to E10)	0,1
Scenario 3 – H-code increase	T-code (ranges from T1 to T31)	0,1
	H-code (ranges from H1 to H22	0,6
	N-code (ranges from N1 to N19)	0,1
	O-code (ranges from O1 to O26)	0,1
	E-code (range from E1 to E10)	0,1
Scenario 4 – N-code increase	T-code (ranges from T1 to T31)	0,1
	H-code (ranges from H1 to H22	0,1
	N-code (ranges from N1 to N19)	0,6
	O-code (ranges from O1 to O26)	0,1
	E-code (range from E1 to E10)	0,1
Scenario 5 – O-code increase	T-code (ranges from T1 to T31)	0,1
	H-code (ranges from H1 to H22	0,1
	N-code (ranges from N1 to N19)	0,1
	O-code (ranges from O1 to O26)	0,6
	E-code (range from E1 to E10)	0,1

As shown in Table 22, the five sub-categories of the work orders for scenario 1 were equally distributed. Therefore, this scenario will be referred to as the "Equal distribution" scenario. In scenarios 2 – 5 the distribution of a certain sub-category was increased to 0.6 while the distribution of the other sub-categories was assigned a value of 0.1. Therefore, in these scenarios, the scenario will be referred to as the name of the sub-category of which the distribution was increased to 0.6, for example scenario 2 will be referred to as "T-code increase".

Figures 15 to 19 illustrates the distribution of the lead-time of the completed work orders as produced by the model for the different scenarios.

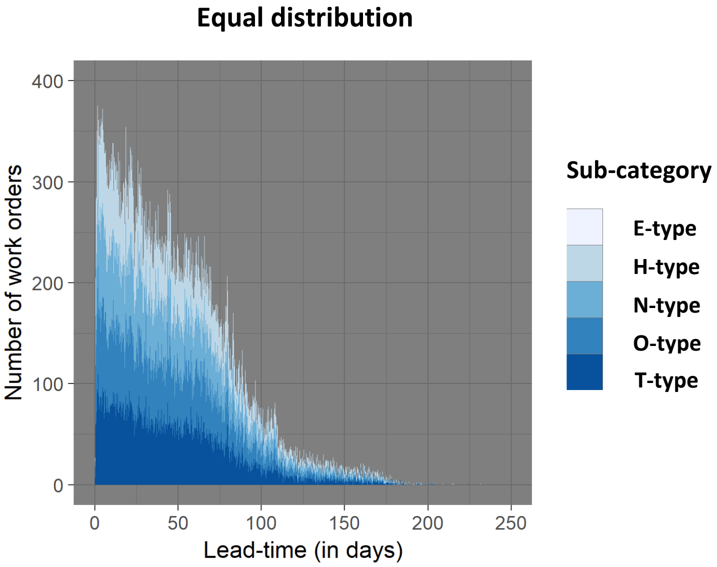


Figure 15: The distribution of the lead-time of the work orders for scenario 1

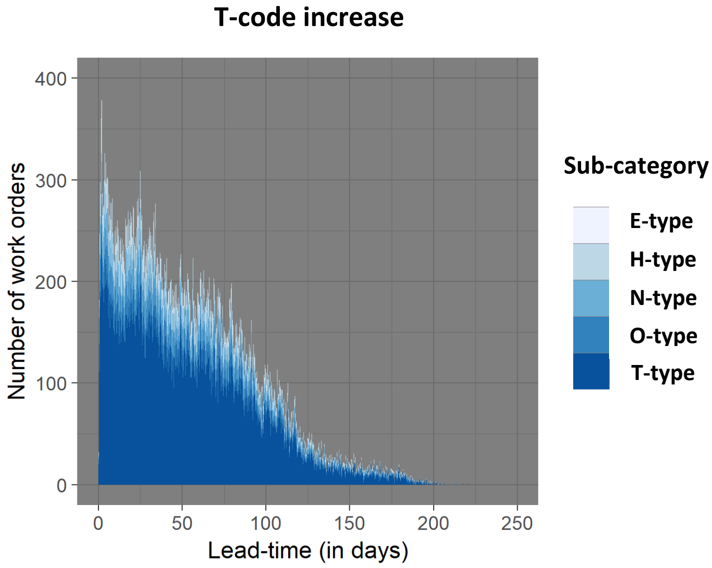


Figure 16: The distribution of the lead-time of the work orders for scenario 2

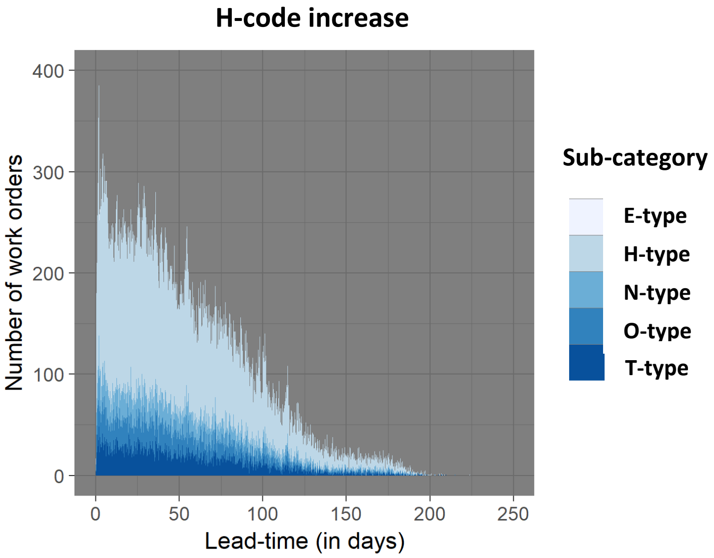


Figure 17: The distribution of the lead-time of the work orders for scenario 3

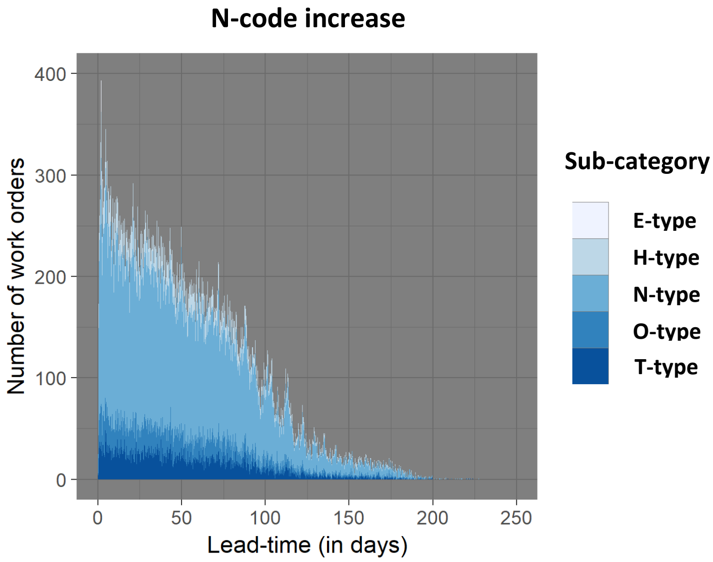


Figure 18: The distribution of the lead-time of the work orders for scenario 4

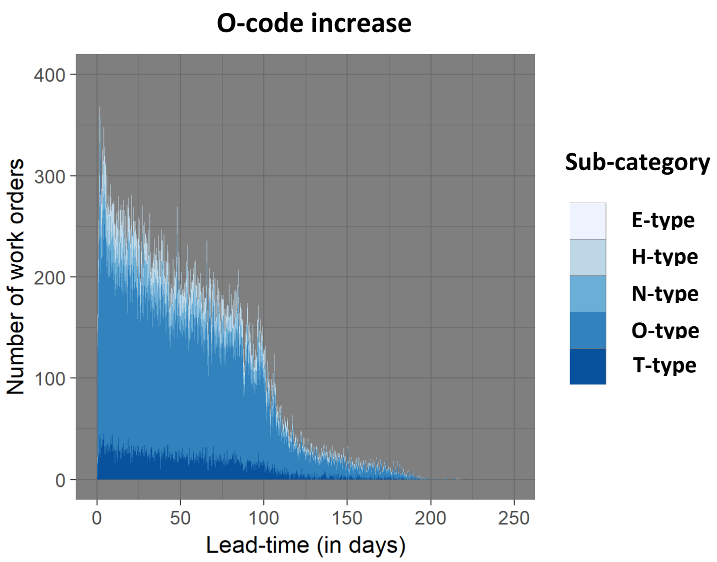


Figure 19: The distribution of the lead-time of the work orders for scenario 5

In each of the scenarios for the sensitivity analysis, the lead-time of the work orders increased from a maximum of 10 days, under the as-is, up to a maximum of 200 days. This may be due to the fact that only the NBN and Telstra team is responsible for executing all the work orders of sub-categories T, H, N and O and only the EME team executes work orders of sub-category E. So, by increasing the probability of occurrence of either some or all the work order sub-categories that the NBN and Telstra team is responsible for executing, will cause an increase in the waiting time of the work orders that belong to these sub-categories. This is due to the fact that the number of human resources per team was kept constant for each scenario of the sensitivity analysis.

Therefore, the increase in the waiting time of the work orders that belong to these sub-categories, can be assigned to the NBN and Telstra team's inability to handle the increase in the number of these type of work orders. Since the lead-time of a work order refers to the sum of the process time, correction time and waiting time of the work order and the uniform distributions of the process time and correction time of the different design and draft sub-processes and correction sub-processes were also kept constant for each scenario, the increase in the lead-time of these work orders can be assigned to the increase in the waiting time of these work orders.

To further evaluate how these changes in the distribution of the five work order sub-categories may affect the performance of the process, the output of each one of these scenarios was evaluated in terms of the following three other variables of interest:

- The average number of work orders that was completed per year.
- The average annual revenue incurred.
- The percentage of completed work orders that had a lead-time that fell between the given estimated minimum lead-time per work order of 6 hours and the given estimated maximum lead-time per work order of 6 days.

Table 23 shows the results of these five scenarios in terms of the above-mentioned three variables interest.

Table 23: The results of the sensitivity analysis done on the lead-time of the work orders

Variable of interest	Model Output (Equal distribution)	Model Output (T-code increase)	Model Output (H-code increase)	Model Output (N-code increase)	Model Output (O-code increase)
Average number of completed work orders per year	3421	2765	2734	2775	2847
Average annual revenue (in South African Rand)	4 932 674	5 361 624	4 121 058	3 716 777	4 441 707
Percentage of completed work orders with lead-time between min and max lead-time estimates	37.8391	24.9547	24.9454	24.6541	24.4356

The results in Table 23 show that the change in the distribution of the sub-categories also influences the average number of work orders the offshoring team can complete as well as the average annual revenue the team generates. The one thing all five these scenarios have in common, is the fact that the number of work orders the NBN and Telstra team had to execute, increased in some way. Therefore, without evaluating the performance of the model under the volume increase, it seems that some of the human resources within the NBN and Telstra team may be bottlenecks.

Another interesting observation that can be made from the results given in Table 23, is that an increase in the number of a certain type of work order seems to have an influence on the average number of work orders that can be completed per year as well as the average annual revenue the team generates. For scenarios 2 to 5 the average number of work orders that was completed, was between 2700 and 2900 work orders per year, but for scenario 1 the average number of work orders that was completed, was 3421 work orders per year. The main difference between scenario 1 and scenarios 2 to 5, is that the distribution of the E sub-category work orders was higher in scenario 1 than it was in scenarios 2 to 5. This again shows that the capacity constraints may be located within the NBN and Telstra team.

Lastly, when considering the average annual revenue that was generated in each scenario, it seems that scenario 2 performed the best. However, this scenario did not perform the best in terms of the average number of work orders that was completed, meaning the offshoring team generated more revenue for executing less work orders in this scenario. This may be due to the fact that the T-type work orders have a larger budget that is allocated to these work order types, making it possible for the offshoring team to generate more revenue when completing T-type work orders.

4.3.3. Results of the volume increase

The objective of this sub-section is to determine whether Telco RSA's offshoring team has the capacity to handle the increase in the volume of work orders and if not, to determine where the potential bottlenecks are located within the process. To evaluate the effect of the volume increase, the output of 100 runs was used. The data inputs given in section 3.3.1 as well as an arrival rate with a uniform distribution of uniform(1.245, 1.256) work orders per hour was used. This arrival rate represents the volume increase of 7200 work orders per year. According to the offshoring team, the expected distribution for the five sub-categories for the financial year of 2019 will be as shown in Table 24.

Table 24: The distribution of the five work order sub-categories for the financial year of 2019

Scenario	Work order sub-category	Distribution
Volume increase	T-code (ranges from T1 to T31)	0,2
	H-code (ranges from H1 to H22	0,12
	N-code (ranges from N1 to N19)	0,04
	O-code (ranges from O1 to O26)	0,04
	E-code (range from E1 to E10)	0,6

Similar to the previous sub-sections, the output of the model for the volume increase scenario, was evaluated based on its performance in terms of the following three variables of interest:

- The average number of work orders that was completed per year.
- The average annual revenue that was generated.
- The percentage of completed work orders that had a lead-time that fell between the given estimated minimum lead-time per work order of 6 hours and the given estimated maximum lead-time per work order of 6 days.

The distribution of the lead-time of all the completed work orders was also evaluated and discussed. As stated under the calculations in section 3.3.2, the lead-time of a work order refers to the sum of the process time, correction time and waiting time of the work order.

The targets Telco RSA's offshoring team wants to achieve in the financial year of 2019 for the first two variables of interest, are given in Table 25. However, these variables will be referred to as the number of work orders to be completed by the offshoring team and the revenue that needs to be generated by the team, since these targets are not averages.

Table 25: The targets Telco RSA's offshoring team wants to achieve in the financial year of 2019

Variable of interest	Target for 2019
Number of work orders to be completed	7200
Revenue (in South African Rand)	8 679 720

The output of the model in terms of the first two variables as well as the percentage difference between the output of the model and the targets the offshoring team wants to achieve in the financial year of 2019, are given in Table 26. As previously stated, a positive percentage difference means that the output, as produced by the model, exceeded the target value and a negative percentage difference means that the output, as produced by the model, was less than the target value. The output of the model in terms of the percentage of completed work orders that had a lead-time that fell between the minimum and maximum lead-time estimates, is also given in Table 26.

Table 26: The results of the volume increase scenario

Variable of interest	Model Output (Volume increase)	% Difference
Average number of completed work orders per year	6411	-10.954
Average annual revenue (in South African Rand)	7 639 926	-11.980
Percentage of completed work orders with lead-time between min and max lead-time estimates	25.9641	-74.036

As shown in Table 26, an average of 6411 completed work orders per year was produced by the model under the volume increase, where in reality Telco RSA aims to complete 7200 work orders in the financial year of 2019. Therefore, the output of the model in terms of the first variable of interest deviates with 10.954% from the target value.

The average annual revenue, as produced by the model, was R7 639 926 where in reality Telco RSA aims to achieve a revenue of R8 679 720 in the financial year of 2019. Therefore, the output of the model in terms of the second variable of interest deviates with 11.980% from the target value. Table 26 also shows that only 25.9641% of the work orders that were completed, as produced by the model, had a lead-time that fell between the estimated minimum lead-time per work order of 6 hours and the estimated maximum lead-time per work order of 6 days.

Figure 20 illustrates the distribution of the lead-time of all the completed work orders as produced by the model. The two vertical red lines in Figure 20 represent the estimated minimum lead-time per work order of 6 hours and the estimated maximum lead time per work order of 6 days, respectively.

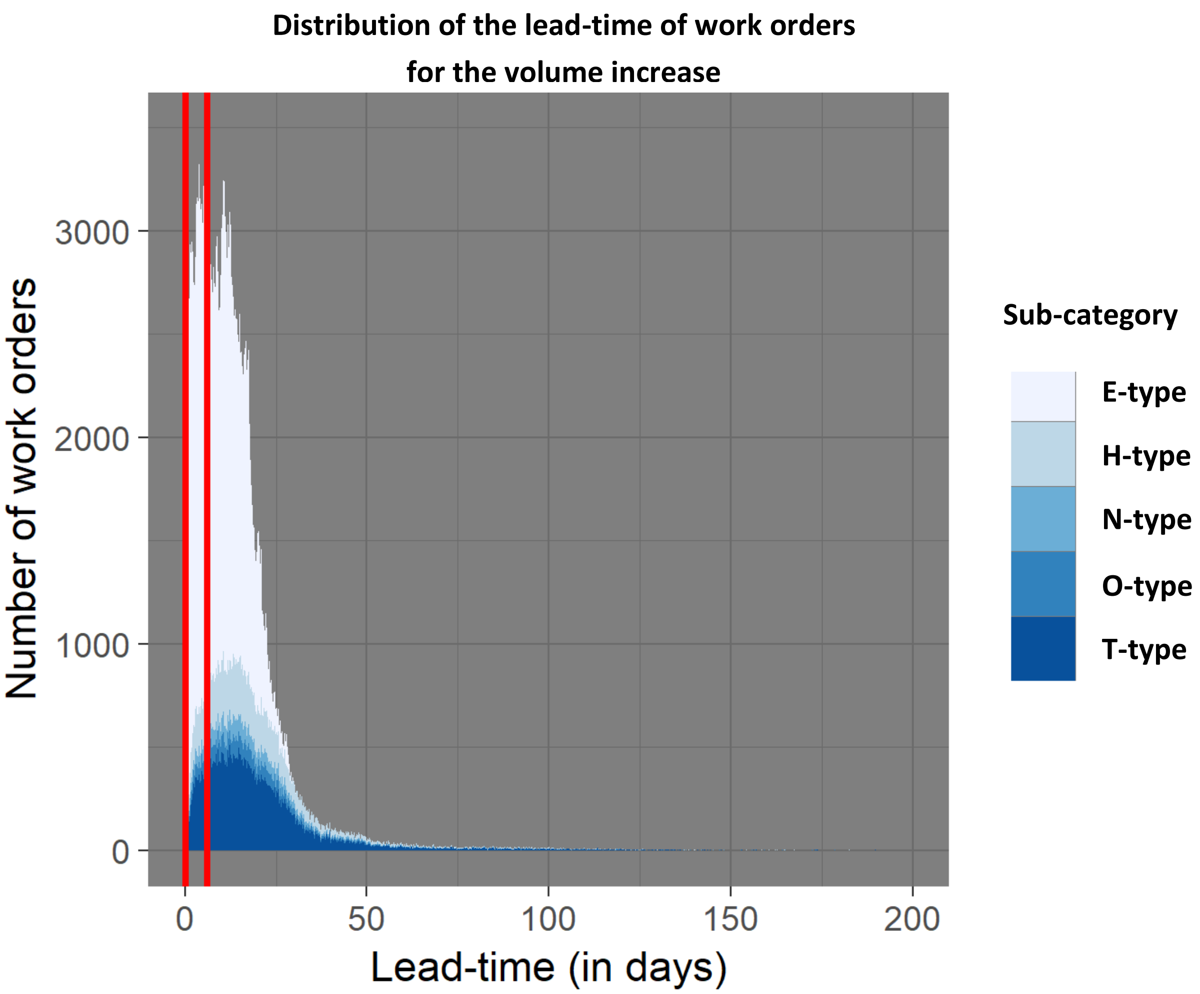


Figure 20: The distribution of the lead-time of work orders for the volume increase

As illustrated by Figure 20, the lead-time of the work orders increased from a maximum of 10 days, under the as-is, up to a maximum of 200 days. From the results in Table 26 as well as the distribution of the lead-time of the work orders as illustrated in Figure 20, it seems that Telco RSA's offshoring team will not have the capacity to handle the volume increase they will face in the financial year of 2019. The poor performance of the process can be assigned to bottlenecks within the process.

To identify the bottlenecks within the process, after the volume increase, the following variables were evaluated:

- The average number of work orders that had to wait at each specific human resource before the human resource was able to execute these work orders. These work orders only consist of the work orders that were completed by the model. This variable will be referred to as the number of delayed work orders at each human resource.
- The average waiting time of a work order at each human resource. As previously mentioned, the waiting time of a work order at a human resource refers to the time the work order had to wait at the specific human resource before the resource was able to execute the work order.

The reason for using these two variables to identify the bottlenecks within the process, is due to the fact that waiting time refers to non-value-adding time. Even though only the process time is used to calculate the revenue per work order, a prolong waiting time has the following influences:

- It reduces the number of work orders the offshoring team can complete. Therefore, it indirectly affects the revenue the team can generate.
- It increases the lead-time of a work order. Since clients have requested that work orders should be completed within less than three days, an increase in the lead-time of the work order can lead to customer dissatisfaction.

Figures 21 and 22 illustrate the performance of the process in terms of the average number of delayed work orders at each human resource and the average waiting time of a work order at each human resource for the volume increase scenario, respectively.

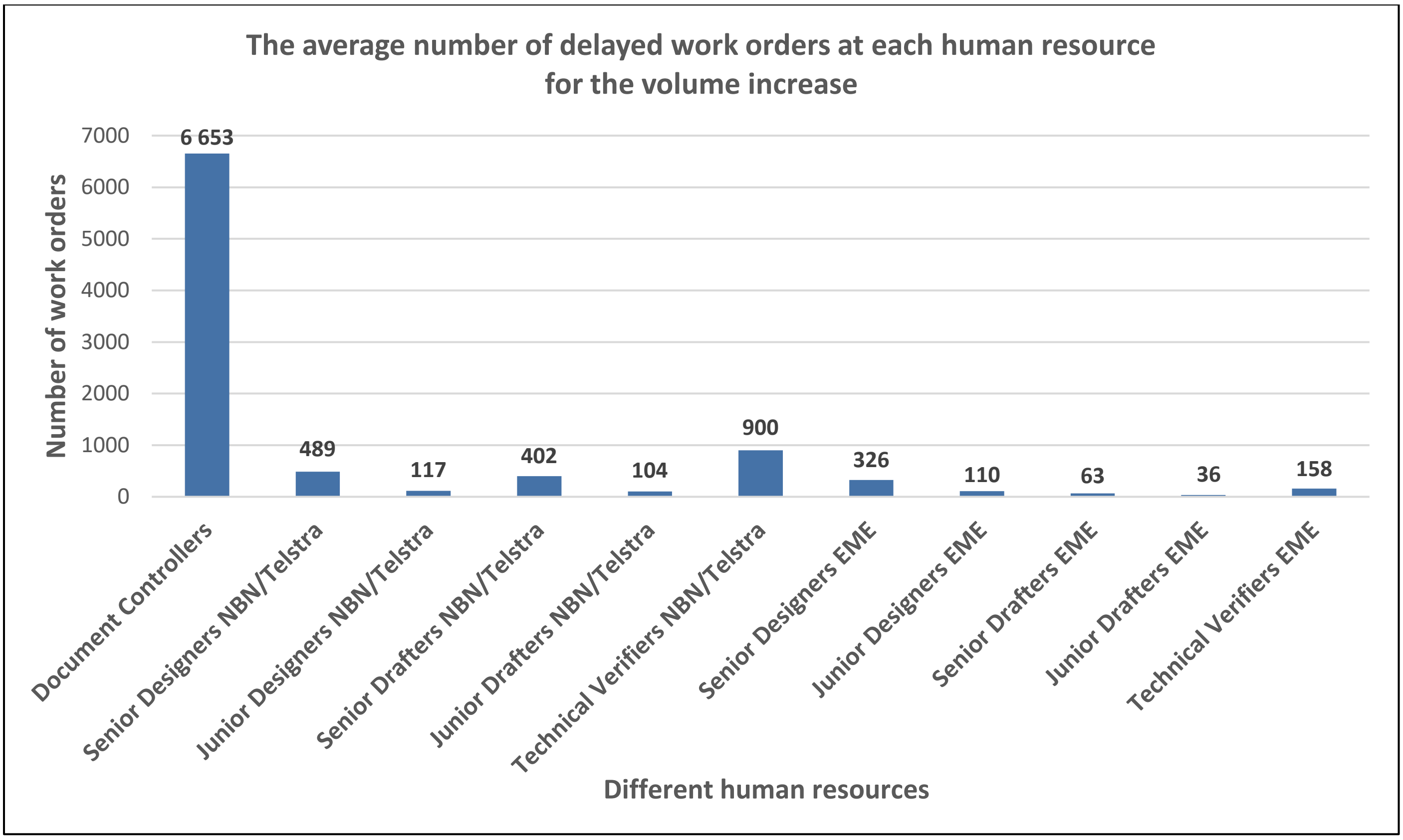


Figure 21: The average number of delayed work orders per human resource for the volume increase

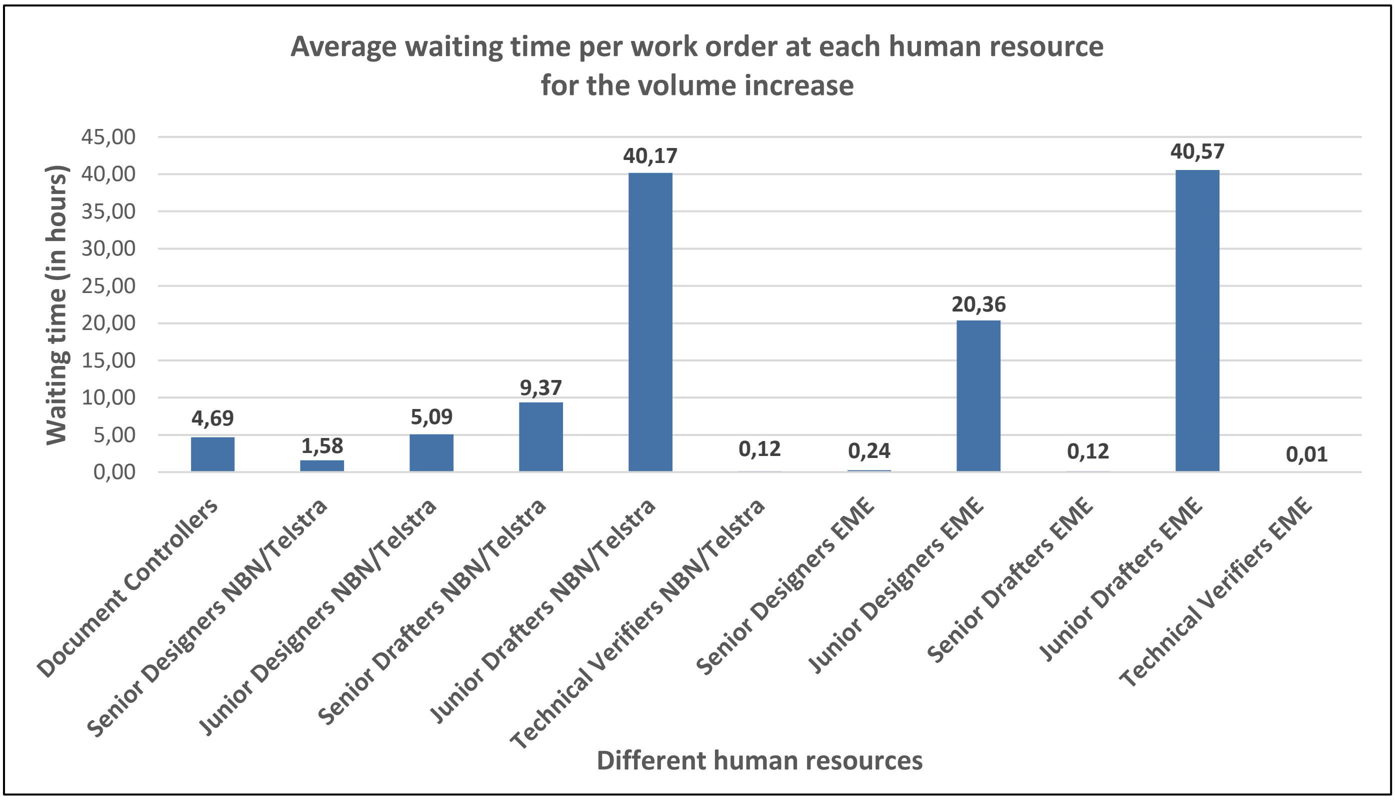


Figure 22: The average waiting time work orders per human resource for the volume increase

Figure 21 shows that most of the work orders waited at the document controllers per year. This can be assigned to the fact that the document controllers are responsible for executing the Primary Admin Check sub-process that occurs at the beginning of the process as well as for executing the Secondary Admin Check sub-process that occurs at the end of the process. All the work orders that enter the process must go through both of these sub-processes which then results in a bottleneck that occurs at the document controllers.

However, when the average time a work order must wait, is considered, the waiting time per work order at the document controllers are not the highest. Even though the waiting time per work order at the document controllers are still approximately 4.69 hours, the longest waiting time per work order occurs at the junior drafter of the NBN and Telstra team, the junior designer of the EME team and the junior drafter of the EME team. The average waiting time per work order for each of these human resources are 40.17 hours, 20.36 hours and 40.57 hours, respectively.

The process improvement scenarios were developed based on these initial findings. These scenarios will now be discussed in the following sub-section.

4.3.4. Results of Process Improvement and Validation Phase

This sub-section contains the results of each of the improvement scenarios that were tested with the developed model. Three improvement scenarios were developed, each scenario with a specific aim.

The aim of the first scenario was to determine how the process will perform if human resources were added to the four parts of the process that were identified as bottlenecks after the volume increase scenario. If the process still performs below the desired targets for the financial year of 2019 after the first improvement, the aim of the second improvement scenario will be to determine how the process can further be improved. Scenario 3 represents an alternative scenario that was developed for scenario 2, since scenario 2 also accounts for the improvements that were made in scenario 1.

Similar to the previous sub-sections, the output of the scenarios was evaluated based on the performance of the process in terms of the following three variables of interest:

- The average number of work orders that was completed per year.
- The average annual revenue that was generated.
- The percentage of completed work orders that had a lead-time that fell between the given estimated minimum lead-time per work order of 6 hours and the given estimated maximum lead-time per work order of 6 days.

The distribution of the lead-time of all the completed work orders for each improvement scenario was also evaluated and discussed.

The targets Telco RSA's offshoring team wants to achieve in the financial year of 2019 for the first two variables of interest are given in Table 27. However, these variables will still be referred to as the number of work orders to be completed by the offshoring team and the revenue that needs to be generated by the team, since these targets are not averages.

Table 27: The targets Telco RSA's offshoring team wants to achieve in the financial year of 2019

Variable of interest	Target for 2019
Number of work orders to be completed	7200
Revenue (in South African Rand)	8 679 720

For each improvement scenario the output of the model in terms of the first two variables as well as the percentage difference between the output of the model and the targets the offshoring team wants to achieve in the financial year of 2019, were given in a table. The output of the model in terms of the percentage of completed work orders that had a lead-time that fell between the minimum and maximum lead-time estimates, was also given in the same table as the first two variables for the specific improvement scenario.

Also, to identify the new bottlenecks within the process after each improvement, the following factors were also evaluated:

- The average number of delayed work orders at each resource.
- The average waiting time of a work order at each resource.

Since the revenue Telco RSA's offshoring team generate for completing work orders, is the key performance indicator of admin and technical quality process, the first objective of each improvement scenario was to achieve the revenue target for 2019. The average number of work orders that was completed per year, as produced by the model for each improvement scenario, and the percentage of completed work orders that had a lead-time that fell between the given estimated minimum lead-time per work order of 6 hours and the given estimated maximum lead-time per work order of 6 days, will be used as the two trade-off factors to determine for which improving scenario is more beneficial.

1) Improvement scenario 1

After the volume increase scenario, the document controllers, junior drafter of the NBN and Telstra team, junior designer of the EME team as well as the junior drafter of the EME team were identified as bottlenecks within the process. This was due to either a high average number of work orders that occurred at these human resources or the fact that the waiting time per work order at these human resources was the highest. Therefore, for the first improvement scenario, an extra human resource was added to each of these four human resources. The results of the first improvement scenario are shown in Table 28.

Table 28: The results of improvement scenario 1

Variable of interest	Model Output (Improvement 1)	% Difference
Number of completed work orders per year	6953	-3.4304
Average annual revenue (in South African Rand)	8 347 317	-3.8297
Percentage of completed work orders with lead-time between min and max lead-time estimates	76.0915	-23.9085

The results in Table 28 shows that the process still did not reach the targets that was set for the financial year of 2019 after the first improvement was made. However, for the first two variables of interest, the output of the improved model deviated less than 4% from the targets, which can be used to verify this improvement as a good improvement. Where the model significantly performed under target, was in terms of the percentage of work orders that had a lead-time that fell between the minimum lead-time per work order of 6 hours and the maximum lead-time per work order of 6 days. Figure 23 illustrated the distribution of the lead-time of the work orders for improvement scenario 1.

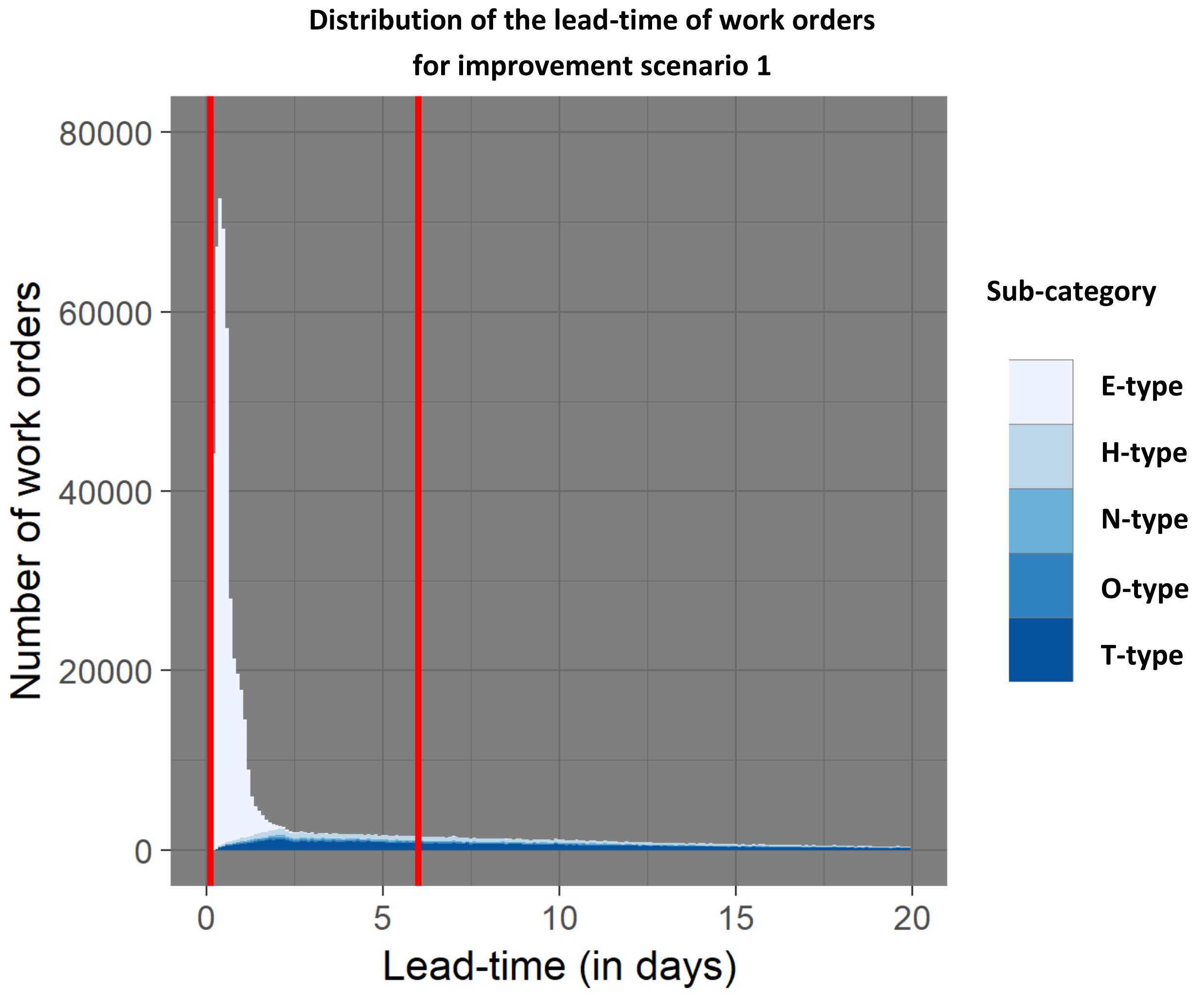


Figure 23: The distribution of the lead-time of the work orders for improvement scenario 1

Figure 23 illustrates that there are still one or more significant bottlenecks within the process that cause the process to still perform under the desired target in terms of the lead-time of a work order. To identify these bottlenecks, the average number of delayed work orders as well as the average waiting time per work order at each of the resources within the process were calculated. Figure 24 illustrates the average number of delayed work orders at each human resource after improvement scenario 1 and Figure 25 illustrates the average waiting time per work order at each human resource after improvement scenario 1.

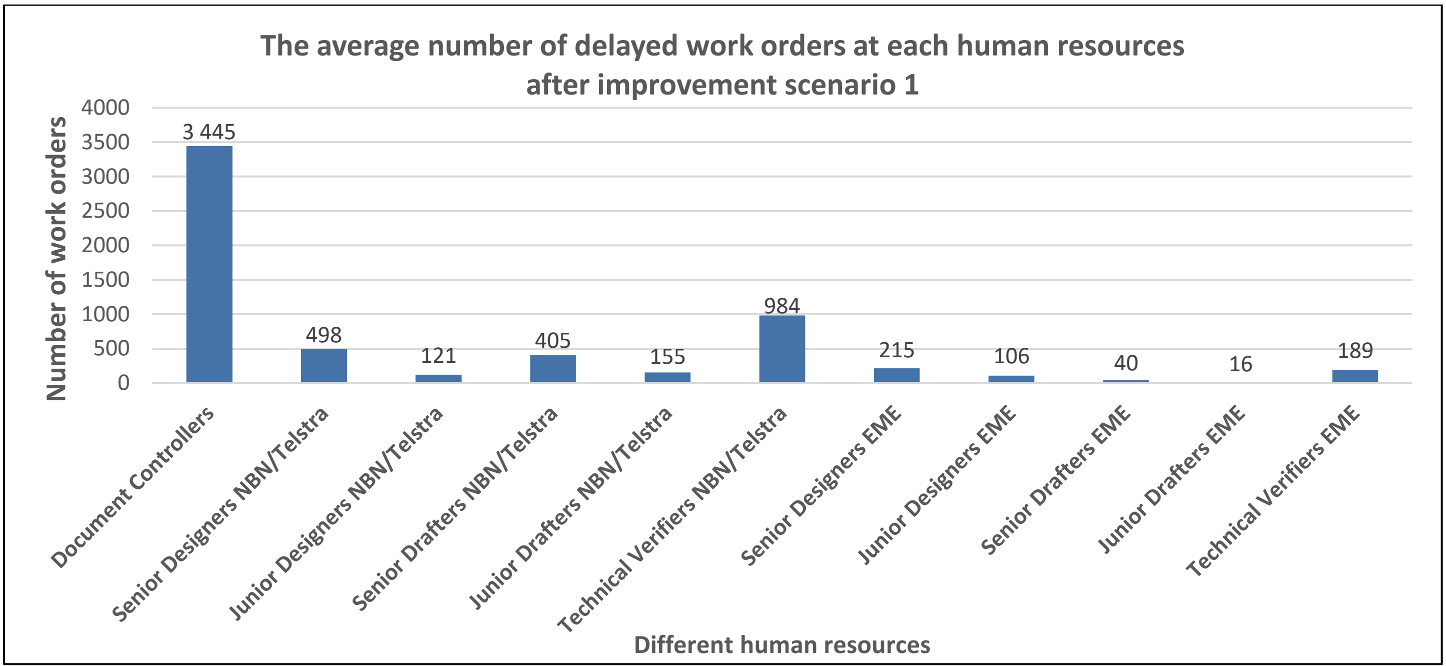


Figure 24: The average number of delayed work orders per human resource for improvement scenario 1

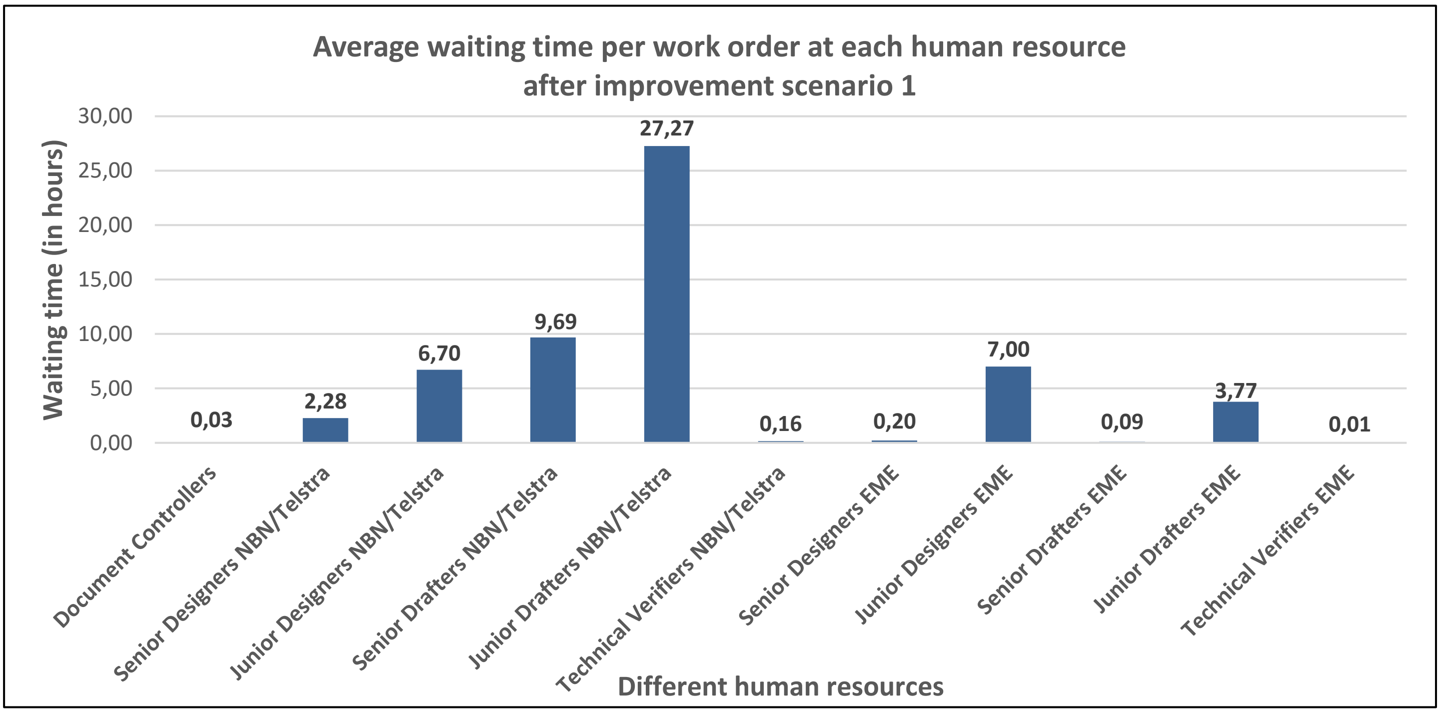


Figure 25: The average waiting time work orders per human resource for improvement scenario 1

Figure 24 shows that the average number of delayed work orders at the document controllers decreased from 6653 work orders to 3445 work orders. Figure 25 also shows that the average waiting time per work order also decreased from 4.69 hours to 1.87 minutes. Therefore, it seems that an additional document controller within the process, eliminated the capacity constrain at the document controllers.

Figure 25 also shows that the average waiting time per work order of the junior drafters of the NBN and Telstra team, the junior designers of the EME team as well as the junior drafters of the EME decreased from 40.17 hours per work order, 20.36 hours per work order and 40.57 hours per work order, respectively to 27.27 hours per work order, 7 hours per work order and 3.77 hours per work order, respectively.

However, from Figure 25 it is clear that longest average waiting time per work order still occurs at the junior drafters of the NBN and Telstra team. The junior designers of the EME team also seems to still be a constraint within the process. Figure 25 also shows that the senior drafters of the NBN and Telstra team as well as the junior designers of the NBN and Telstra team are new capacity constraints within the process. To reduce the effect of these four newly identified bottlenecks, improvement scenario 2 was created.

2) Improvement scenario 2

Since the junior drafters, the junior designers and the senior drafters of the NBN and Telstra team as well as the junior designers of the EME team were identified as the bottlenecks after improvement scenario 1, the second improvement scenario will aim to further improve the performance of the process by further reducing the effect of these bottlenecks. Therefore, for the second improvement scenario, another resource was added to the junior drafters of the NBN and Telstra team as well as to the junior designers of the EME team. An extra resource was also added to the senior drafters and junior designers of the NBN and Telstra team. The results of the second improvement scenario are shown in Table 29.

Table 29: The results of improvement 2

Variable of interest	Model Output (Improvement 2)	% Difference
Number of completed work orders per year	7186	-0.1938
Average annual revenue (in South African Rand)	8 884 491	+2.3048
Percentage of completed work orders with lead-time between min and max lead-time estimates	92.525	-7.475

The results in Table 29 show that the process perform close to the targets that was set for the financial year of 2019 after the first improvement was made. For the first variable of interest, the output of the second improved model only deviated 0.1938% from the targets. Also, the average annual revenue, as produced by the model for improvement scenario 2, exceeded the target with 2.3048%. Table 29 also shows that 92.525% of the number of completed work orders, as produced by the model, that had a lead-time that fell between the estimated minimum lead-time per work order of 6 hours and the estimated maximum lead-time per work order of 6 days. Figure 26 illustrated the distribution of the lead-time of the work orders for improvement scenario 2.

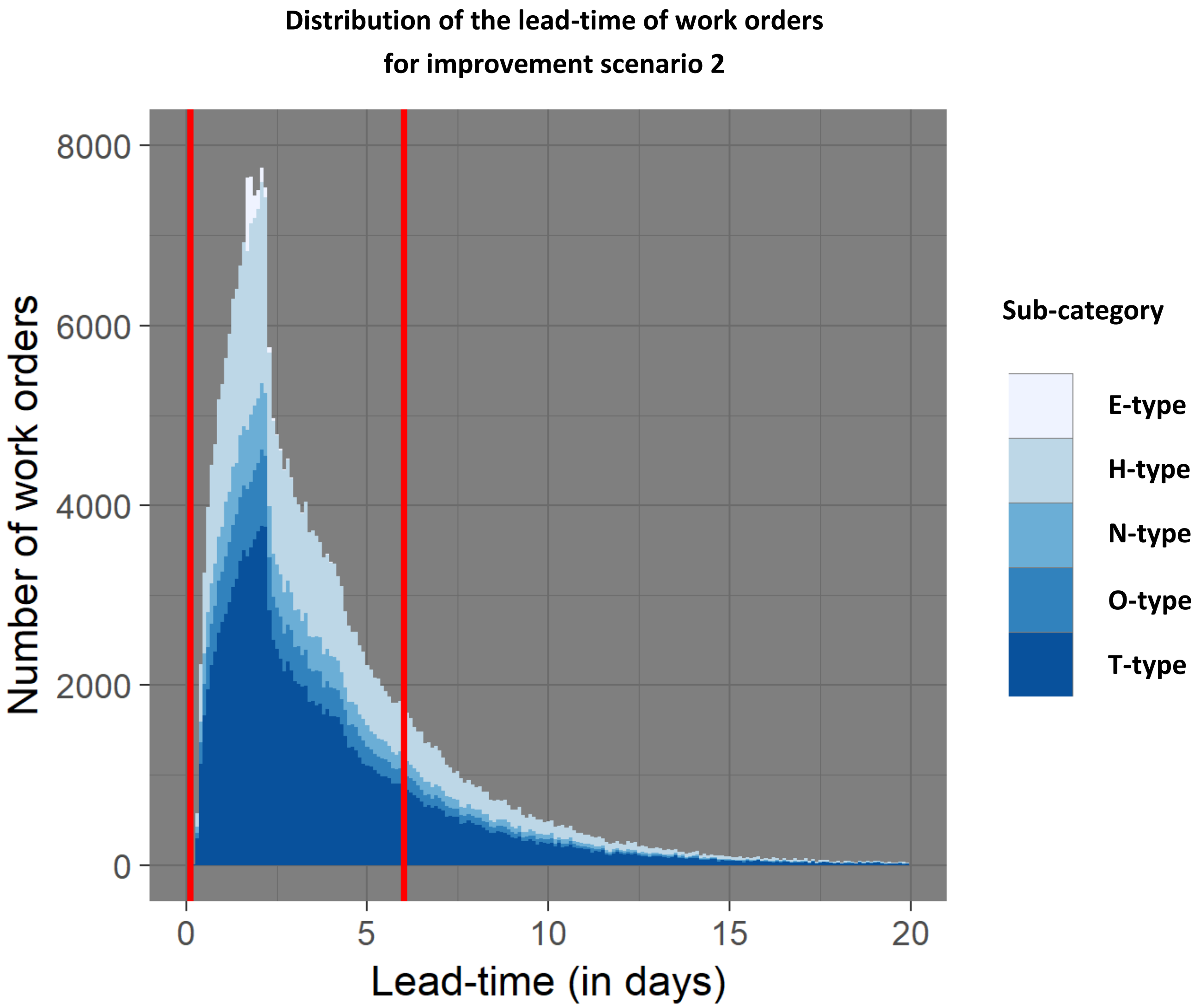


Figure 26: The distribution of the lead-time of work orders for improvement scenario 2

Therefore, the results shown in Table 29 and illustrated by Figure 26 for improvement scenario 2, proves that Telco RSA's offshoring team will be able to achieve their revenue target for the financial year of 2019 by adding human resources as done in the first two improvement scenarios.

To determine how the process improved in terms of the waiting time of work orders, the average number of delayed work orders as well as the average waiting time per work order at each of the resources within the process were once again calculated. Figure 27 illustrates the average number of delayed work orders at each human resource after improvement scenario 2 and Figure 28 illustrates the average waiting time per work order at each human resource after improvement scenario 2.

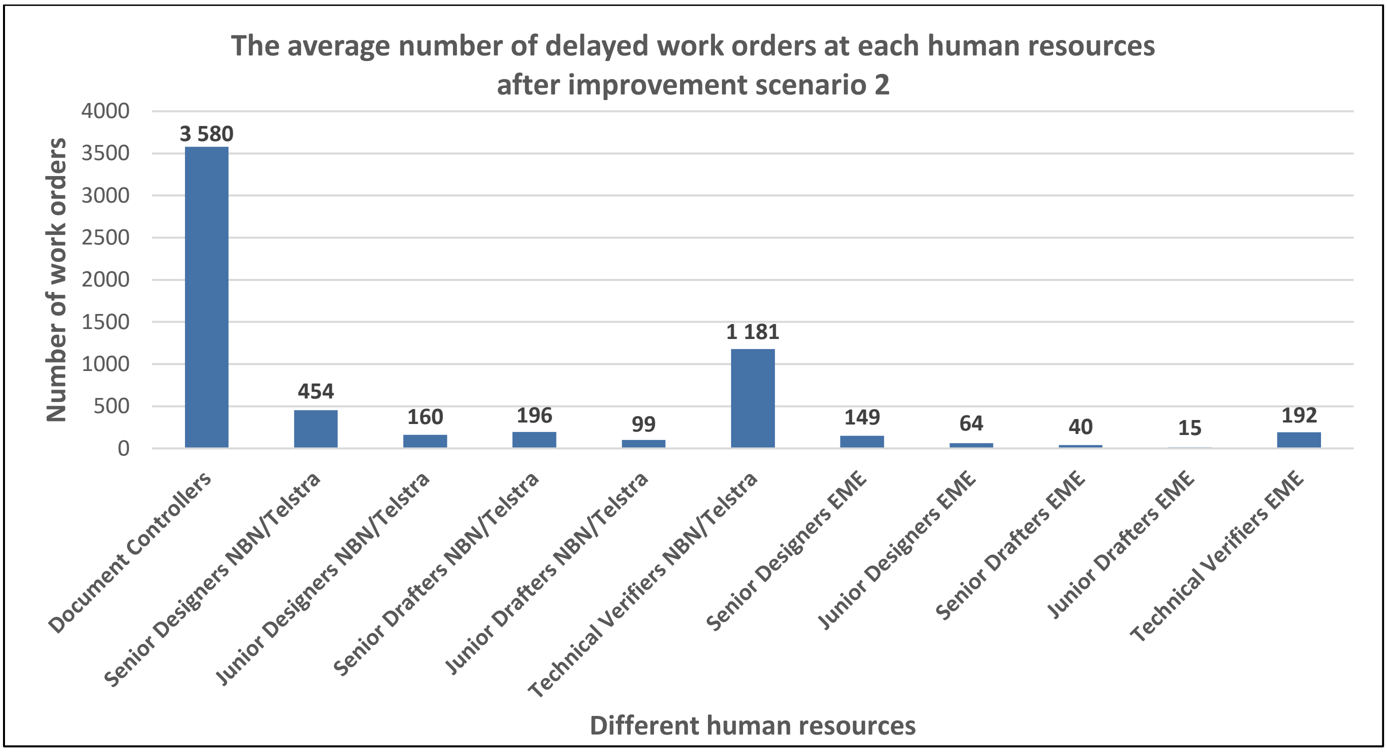


Figure 27: The average number of delayed work orders per human resource for improvement scenario 2

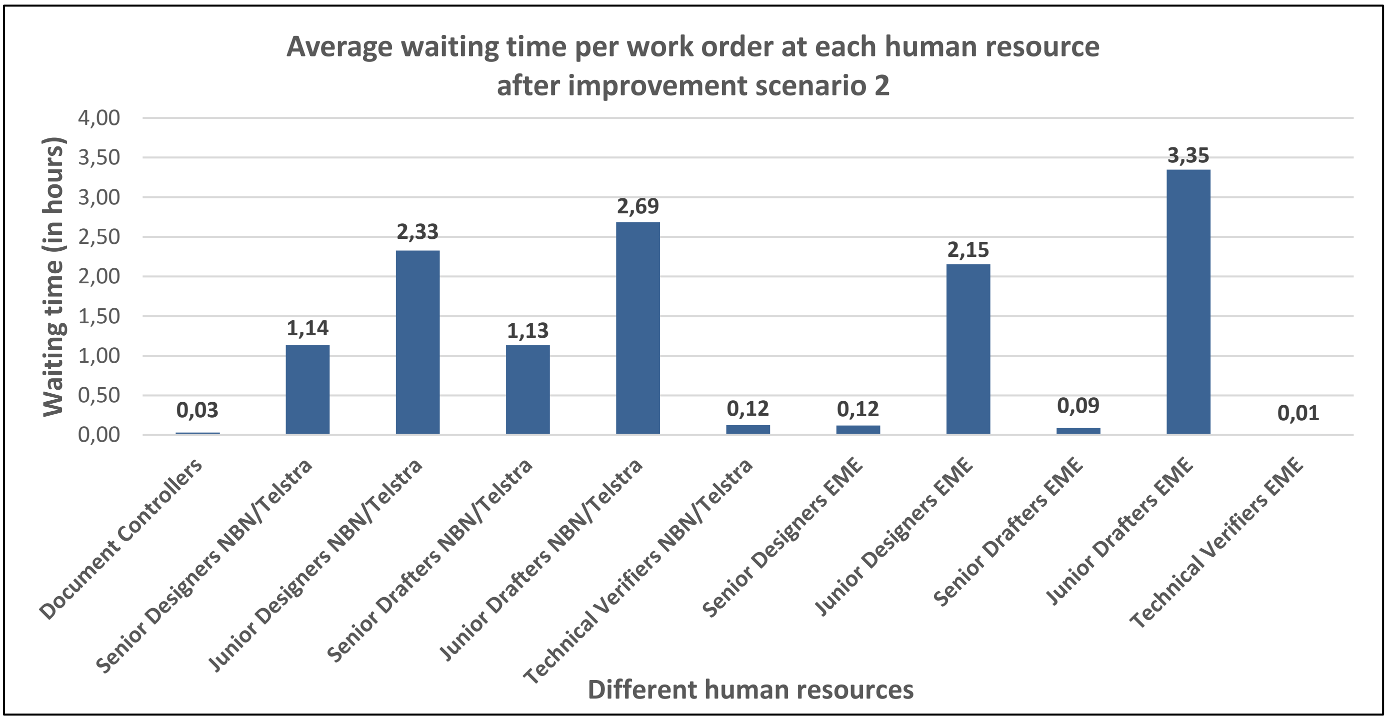


Figure 28: The average waiting time work orders per human resource for improvement scenario 2

Figure 28 illustrates that the average waiting time per work order at the junior drafters, the junior designers and the senior drafters of the NBN and Telstra team as well as the junior designers of the EME team decreased from 27.27 hours per work order, 6.70 hours per work order, 9.69 hours per work order and 7 hours per work order to 2.69 hours per work order, 2.33 hours per work order, 1.13 hours per work order and 2.15 hours per work order, respectively. These results further justify the improvements made to develop improvement scenario 2 as successful improvement.

As stated previously, a third improvement scenario was developed as alternative for the first two improvement scenarios. This third improvement scenario will be discussed in the following sub-section. Thereafter, the better scenario between 2 and 3 will be determined based on how each performed in terms of average number of work orders that was completed, the revenue that was generated and the percentage of work orders that fell between the min and max lead-time estimates.

3) Improvement scenario 3

Improvement scenario 3 represents an alternative scenario that was developed for improvement scenario 2. Since improvement scenario 2 was developed as an improvement of the first improvement scenario, the total number of specific human resources that were added, in effect, to develop improvement scenario 2, are the following:

- One document controller was added to the project management team.
- Two junior drafters were added to the NBN and Telstra team.
- One senior drafter was added to the NBN and Telstra team.
- One junior designer was added to the NBN and Telstra team.
- One junior drafter was added to the EME team.
- Two junior designers were added to the EME team.

Therefore, a total eight human resources were added to the process for the first two improvement scenarios. For improvement scenario 3, the effect of rather adding senior human resources than junior human resources to the teams, where the improvements were made for the first two improvement scenarios, was determined. For example, if a junior drafter was added to the EME team for the first two improvement scenarios, the effect of rather adding a senior drafter instead of a junior drafter to the EME was determined during improvement scenario 3.

The reason for rather adding senior human resources than junior human resources to the team, is due to the fact that the senior human resources take less time to execute a work order than a junior human resource. Therefore, for improvement scenario 3 human resources were added to the different teams in the following way:

- One document controller was added to the project management team.
- Two senior drafters were added to the NBN and Telstra team.
- One senior designer was added to the NBN and Telstra team.
- One senior drafter was added to the EME team.
- One senior designer was added to the EME team.

Therefore, a total of six human resources were added to the process for improvement scenario 3. Since the senior human resources take less time to execute a work order, one senior human resource was used to replace two junior human resources. However, since two junior drafters and a senior drafter were added to the NBN and Telstra team in scenario 2, two senior drafters was added to the NBN and Telstra team for scenario 3. The results of the third improvement scenario are shown in Table 30.

Table 30: The results of improvement 3

Variable of interest	Model Output (Improvement 3)	% Difference
Number of completed work orders per year	7200	0
Annual revenue (in South African Rand)	8 803 832	+1.43
Percentage of completed work orders with lead-time between min and max lead-time estimates	97.573	-2.427

The results in Table 30 show that the process also performed either better or very close to the targets that were set for the financial year of 2019, after the first improvement was made. As shown in Table 30, the average number of completed work orders, as produced by the model, was 100% the same as the target that was set for the financial year of 2019. Also, the average annual revenue, as produced by the model for improvement scenario 3 exceeded the target with 1.43%. Table 30 also shows that 97.573% of the number of completed work orders, as produced by the model, that had a lead-time that fell between the estimated minimum lead-time per work order of 6 hours and the estimated maximum lead-time per work order of 6 days.

Figure 29 illustrated the distribution of the lead-time of the work orders for improvement scenario 2.

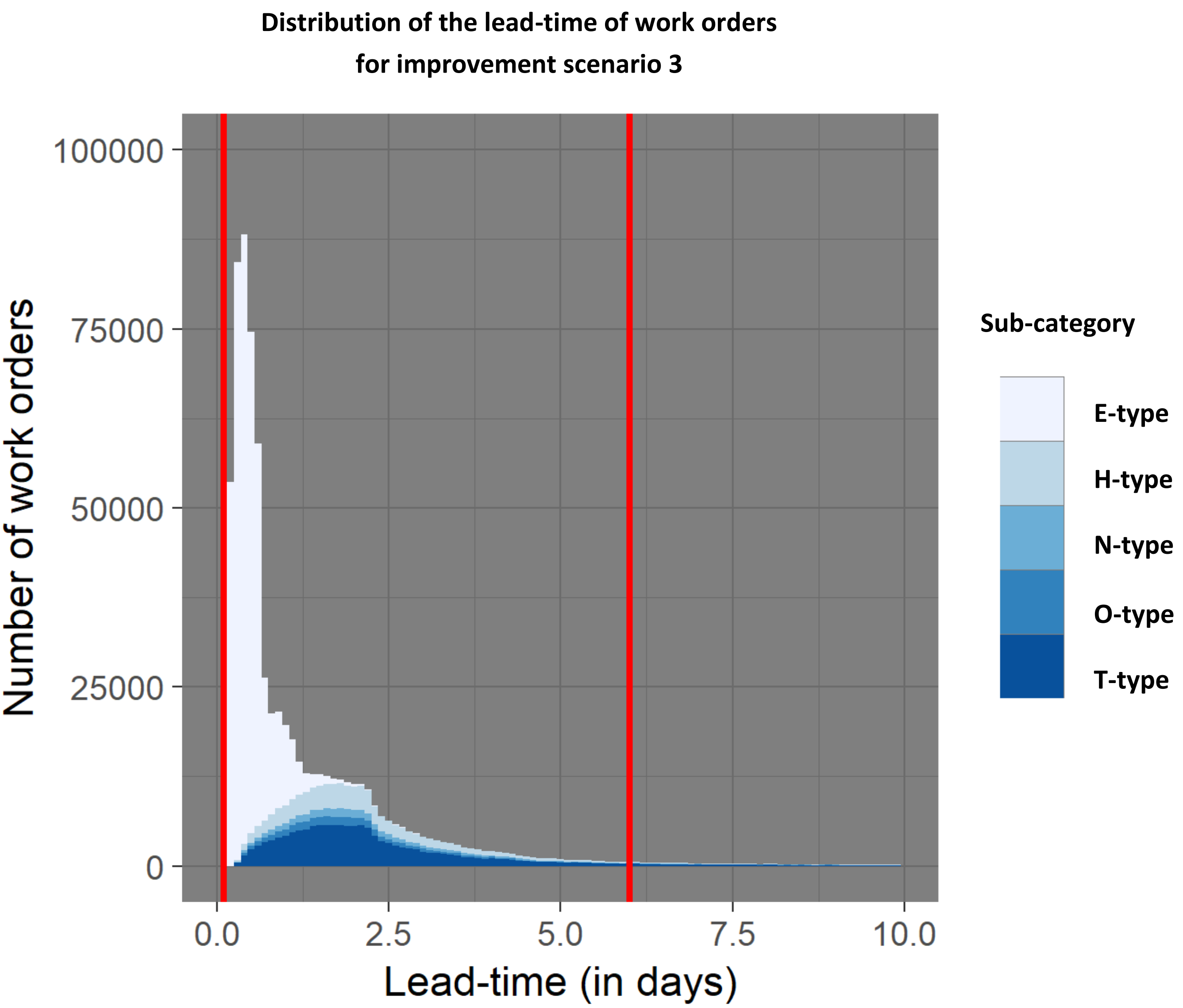


Figure 29: The distribution of the lead-time of work orders for improvement scenario 3

Therefore, the results shown in Table 30 and illustrated by Figure 29 for improvement scenario 3, proves that Telco RSA's offshoring team will also be able to achieve their revenue target for the financial year of 2019 by adding fewer human resources than there were added for the first two improvement scenarios.

To determine how the process improved in terms of the waiting time of work orders, the average number of delayed work orders as well as the average waiting time per work order at each of the resources within the process were once again calculated. Figure 30 illustrates the average number of delayed work orders at each human resource after improvement scenario 3 and Figure 31 illustrates the average waiting time per work order at each human resource after improvement scenario 3.

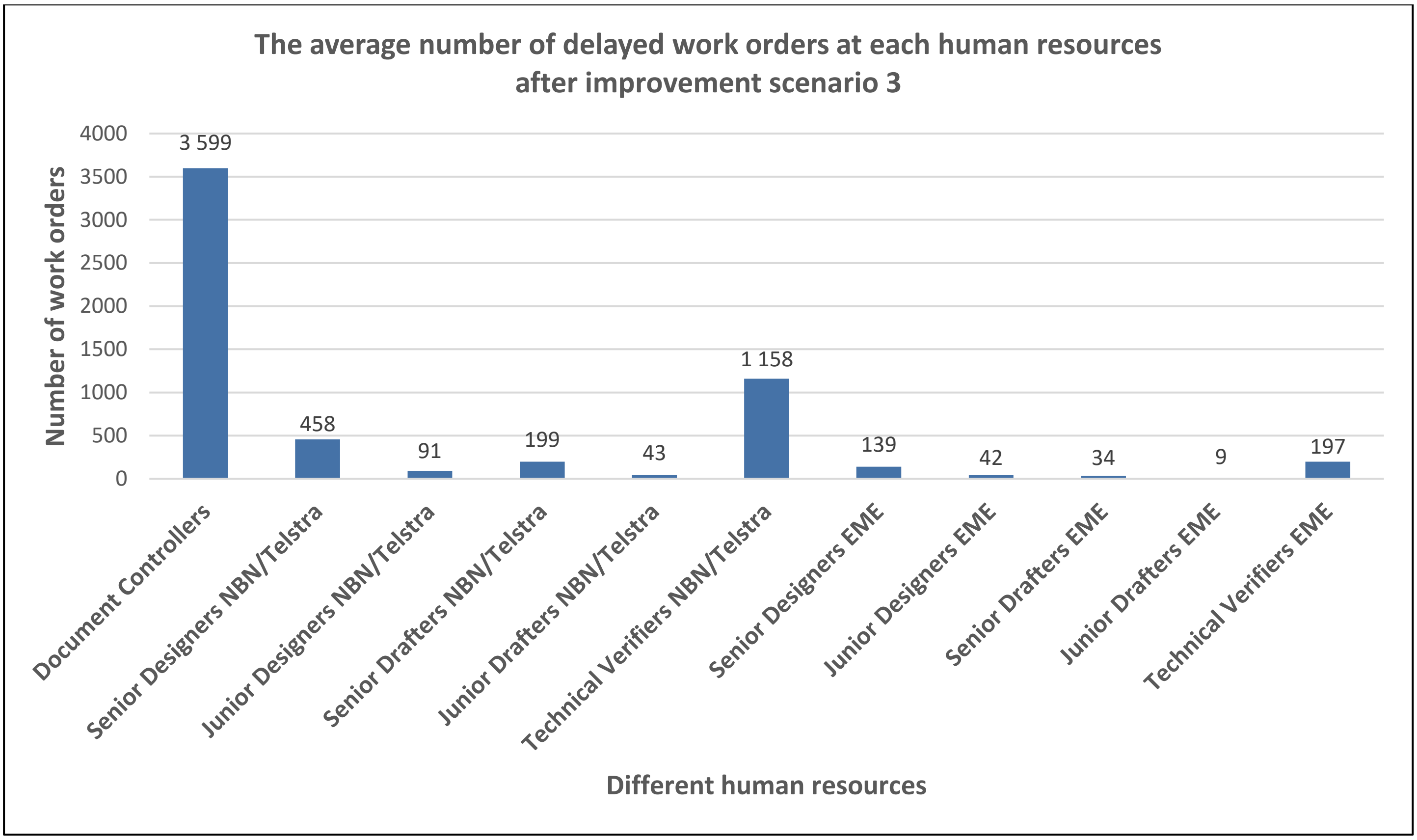


Figure 30: The average number of delayed work orders per human resource for improvement scenario 3

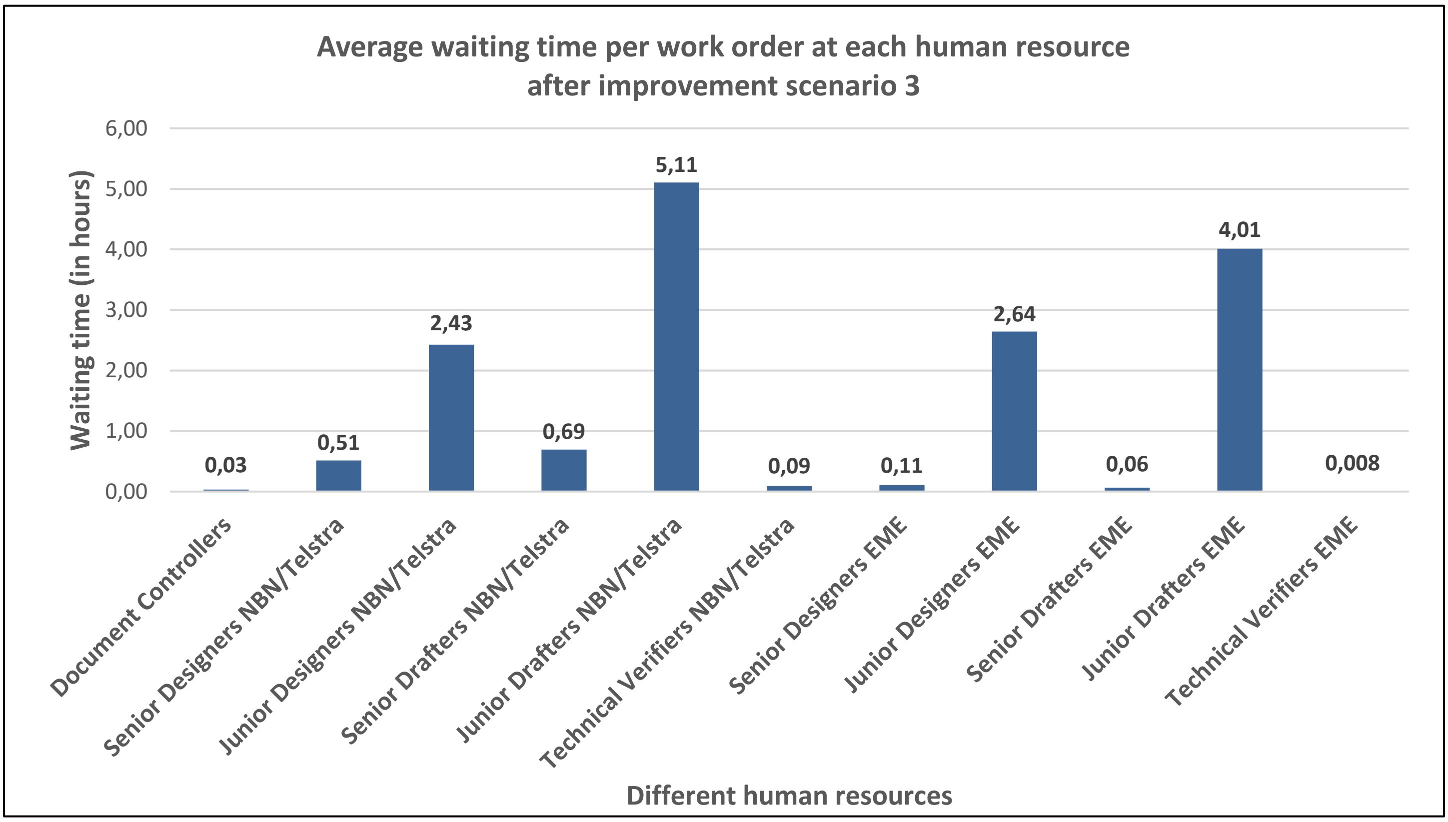


Figure 31: The average waiting time work orders per human resource for improvement scenario 3

When the output, in terms of the variables shown in Figure 30 and 31, of improvement scenario 3 is compared to the output of the volume increase and improvement scenario 2, the process improved in the following way after adding the human resources as stated in improvement scenario 3:

- The average number of delayed work orders at the document controllers decreased from 6653 work orders per year to 3599, which is 19 work orders per year less than what was produced for improvement scenario 2.

- By rather adding two senior drafters to the NBN and Telstra team, the average waiting time per work order at the junior drafters of the NBN and Telstra team decreased from 40.17 hours to 5.11 hours. However, for improvement scenario 2 the average waiting time per work order at the junior drafters of the NBN and Telstra team was decreased from 40.17 hours to 2.69 hours. Therefore, improvement scenario 2 performed better than 3.

- By rather adding one senior designer to the NBN and Telstra team, the average waiting time per work order at the junior designers of the NBN and Telstra team decreased from 5.09 hours to 2.43 hours. However, for improvement scenario 2 the average waiting time per work order at the junior drafters of the NBN and Telstra team was decreased from 5.09 hours to 2.33 hours. Therefore, improvement scenario 2 performed better than 3.

- By rather adding a senior drafter to the EME team, the average waiting time per work order at the junior drafters of the EME team decreased from 40.57 hours to 4.01 hours. However, for improvement scenario 2 the average waiting time per work order at the junior drafters of the EME team was decreased from 40.57 hours to 3.35 hours. Therefore, improvement scenario 2 performed better than 3.

- By rather adding one senior designer to the EME team, the average waiting time per work order at the junior designer of the EME team decreased from 20.36 hours to 2.64 hours. However, for improvement scenario 2 the average waiting time per work order at the junior designers of the EME team was decreased from 20.36 hours to 2.15 hours. Therefore, improvement scenario 2 performed better than 3.

4.3.5. Recommendations

Both improvement scenarios 2 and 3 achieved an average revenue that exceeded the revenue target that Telco RSA aims to achieve for the financial year of 2019. However, the average annual revenue, as produced by the model, for improvement scenario 2 was R80 659 more than what the model produced for improvement scenario 3.

In terms of the average number of work orders, as produced by the model, the process performed better for improvement scenario 3 than improvement scenario 2. Also, when the lead-time of the work orders is considered, improvement scenario 3 produced a higher percentage of completed work orders that had a lead-time that fell between the estimated minimum lead-time per work order of 6 hours and the estimated maximum lead-time per work order of 6 days, than improvement scenario 2. The combination of human resources that was added to the process for improvement scenario 2 seemed to decrease the average time a work order had to wait at the different bottlenecks that were identified the most.

From the above-mentioned observations, it seems that improvement scenario 2 is the better improvement between scenario 2 and 3. However, since the three performance indicators for the process are the revenue, the number of completed work orders and the lead-time of a work order, scenario 3 would be the better improvement since it not only exceeded the revenue target, but also performed the best in terms of the number of work orders that was completed as well as the percentage of completed work orders that had a lead-time that fell between the estimated minimum lead-time per work order of 6 hours and the estimated maximum lead-time per work order of 6 days. Therefore, the addition of human resource to the process as stated for improvement scenario 3, was recommended.

A validation presentation was given to four members of the Telco RSA team, including three members of the offshoring team as well as the director of advisory. During this presentation the output of the as-is model as well as the improvements were presented to the team. According to the team, the output of the as-is model validates the model and the output of the improvements seems realistic. The meeting record of the presentation was appended to this report.

However, since the model was based on several assumptions and a lot of the input data was estimates given by the offshoring team, it is also recommended that the offshoring team should gather real data of the admin and technical quality process. The model should then be improved and the real data should be used to enhance the accuracy of the model. The model can then be used to assist with future decisions about the admin and technical quality process.

Chapter 5: Conclusion

The number of work orders the offshoring team of Aurecon RSA's telecommunication department will receive in the financial year of 2019, will increase to 7200 work orders. Since the team's target for the financial year of 2018 was only 5240 work orders, there was a need to determine whether the offshoring team would be able to handle the increase in the volume of work orders with their current capacity in terms of human resources.

The process definition phase of the process analysis and design methodology, process mapping and business process modelling and notation were used to gain a better understanding of the admin and technical quality process. Thereafter, a simulation model was developed and used to determine whether the offshoring team will have capacity to handle the volume increase and if not, to determine where additional human resource should be allocated to the process to mainly achieve the revenue target the offshoring team had set for the financial year of 2019.

For the scenario of the volume increase, the output as produced by the model, showed that Telco RSA will not have the capacity to handle the volume increase and therefore improvement scenarios had to be developed. Three improvement scenarios were developed of which scenario 2 was an improvement of scenario 1 and scenario 3 was an alternative scenario for the first two scenarios. Both scenario 2 and 3 achieved the revenue target for the financial year of 2019, but scenario 2 generated R80 659 more revenue than scenario 3. However, with the improvements made for scenario 3, the model produced an average number of completed work orders of 7200, which is 100% on target. For scenario 3, the model also produced a higher percentage of completed work orders that had a lead-time that fell between the estimated minimum lead-time per work order of 6 hours and the estimated maximum lead-time per work order of 6 days.

Therefore, the addition of one document controller to the project management team, two senior drafters and one senior to the NBN and Telstra team as well as the addition of one senior drafter and one senior designer to the EME team, as stated in scenario 3, was the final recommendations that were made. It seems that these additional resources may enable Telco RSA's offshoring team to achieve the targets that were set for the financial year of 2019.

However, since the model was based on several assumptions and a lot of the input data was estimates given by the time, it is also recommended that the offshoring team gather real data about the performance of the process. The model should then be improved and the real data should be used to enhance the accuracy of the model. Then model can then be used to test various other improvements to the process that may assist with future decisions about the admin and technical quality process.

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Final Year Project Mentorship Form
2018

Introduction

An industry mentor is the key contact person within a company for a final year project student. The mentor should be the person that could provide the best guidance on the project to the student and is most likely to gain from the success of the project.

The project mentor has the following important responsibilities:

1. To select a suitable student/candidate to conduct the project.
2. To confirm his/her role as project mentor, duly authorised by the company by signing this **Project Mentor Form**. Multiple mentors can be appointed, but is not advised.
3. To ensure that the **Project Definition** adequately describes the project.
4. To review and approve the **Project Proposal**, ensuring that it clearly defines the problem to be investigated by the student and that the project aim, scope, deliverables and approach is acceptable.
5. To review and approve all subsequent project reports, particularly the **Final Project Report** at the end of the second semester, thereby ensuring that information is accurate and the solution addresses the problems and/or design requirements of the defined project.
6. Ensure that sensitive confidential information or intellectual property of the company is not disclosed in the document and/or that the necessary arrangements are made with the Department regarding the handling of the reports.

Project Mentor Details

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Project Description:	Analysis and modelling of Aurecon's RSA Offshoring Admin and Technical Quality Process for optimisation and streamlining.
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Meeting Record

Project number	**LEARNDEV**	Meeting date	**2018-09-18**
Project name	**Adele Final Year Presentation**	Recorded by	Typist's initials
Meeting/subject	**Presentation and feedback**	Total pages	**1**

Present	Apology	Copy	Name	Organisation	Contact details	Signature
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Item	Topic	Action by
1	Welcoming	Bianca Nel
2	Introduce Adele	Bianca Nel
3	Adele presentation	Adele v Jaarsveld
4	Q&A	Adele v Jaarsveld
5	Validation	Aurecon Team
6	Conclusion	Bianca Nel