Optimising the planning process for the field service of REMONDIS Smart Infra

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Optimising the planning process for the field service of REMONDIS Smart Infra

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Preface

Dear reader,

You are about to read the bachelor assignment “Optimising the planning process for the field service of REMONDIS Smart Infra”. This thesis has been performed at REMONDIS Smart Infra in Lichtenvoorde, which is my final assignment for the bachelor Industrial Engineering and Management at the University of Twente. This assignment aims to optimise the planning process for REMONDIS Smart Infra’s field service.

REMONDIS Smart Infra has provided me with this opportunity and many valuable insights for which I am grateful. Above all, I would like to thank all employees of REMONDIS Smart Infra for their helpfulness and sincerity in this bachelor assignment and for answering my questions. Besides that, I am thankful that I was allowed to work on sight, which made the research process much more valuable.

Especially, I would like to thank my supervisor at REMONDIS Smart Infra Wilfred Stinissen. I thank him for guiding me during this research, being there for me when I needed help and his insightful feedback. Each meeting, the insights he provided and his willingness to help me contributed significantly to finishing this research.

For this research, I would definitely like to thank my supervisor from the University of Twente Matthieu van der Heijden. I learned a lot from our meetings and he always gave me valuable feedback. This feedback really improved the quality of this thesis. When I had any question regarding the thesis, he was always willing to answer these questions. Also, I would like to thank Ipek Seyran Topan for being my second supervisor and taking her time and effort to assess this thesis.

Finally, I would like to thank my family for their everlasting support while performing this bachelor assignment, because they kept me intensely motivated by giving inspiring feedback. An honourable mention for Ilse Grootte Bromhaar, a fellow student, who supported me in this period with her words of encouragements and remarkable insights.

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Management summary

This bachelor assignment has been performed at REMONDIS Smart Infra in Lichtenvoorde. For a company to be competitive, the company should be adaptable to its environment and should be able to react swiftly to changes in current and future events in the most efficient and effective way possible. REMONDIS Smart Infra indicated that it lacked a standardized, future proof planning process for its field service across its establishments to meet these standards. Furthermore, REMONDIS Smart Infra lacked a planning tool to support such a planning process.
To solve this problem, this research focussed on developing an alternative planning process for REMONDIS Smart Infra's field service. Such a planning process requires applying the right planning tool. As such, the right planning tool for the planning process was identified. Successfully implementing this planning process and planning tool required an action plan.
This research involved various employees of REMONDIS Smart Infra, such as the planners, the manager of the planning and the regional manager. In turn, the focus of this research lies on the planning process for REMONDIS Smart Infra's entire field service resulting in the main research question that is addressed in this research:

How can REMONDIS Smart Infra achieve, planning its field service and accompanying resources in the most efficient and effective way possible?

To get a better insight in the current situation at REMONDIS Smart Infra, a context analysis was performed. By conducting a questionnaire among all planners from REMONDIS Smart Infra, the current planning process was defined in terms of indicators. Based on the resulting measurements, the current planning process was analysed. Furthermore, REMONDIS Smart Infra's requirements for the alternative planning process and planning tool were defined by conducting semi-structured interviews among the stakeholders. Altogether, the context analysis provided a clear understanding of REMONDIS Smart Infra's current situation and aspirations.

Thereafter, the alternative planning process for REMONDIS Smart Infra could be mapped. However, a literature study was executed first to determine the most suitable process workflow diagram for this purpose. The literature study provided the available methods to map each step in the alternative planning process that would suit the planning process best. Four process workflow diagrams were evaluated: Flow chart, Integrated definition model, Business Process Modelling Notation and Trampolin. The flowchart was selected to be applied.

To plan REMONDIS Smart Infra's field service in the most efficient and effective way, an alternative planning process was developed. Based on unstructured interviews with the various stakeholders, the key activities and main steps in the alternative planning process were mapped using the flowchart. To proof its optimality, this planning process was evaluated according to a multicriteria analysis and a centralisation analysis. The most important criteria in the multicriteria analysis were 'Duration of steps in the planning process', 'Insight in the planning' and 'Utilization of resources'. The improvements made on these criteria entailed the declined duration of performing the planning process steps and the increased utilization of REMONDIS Smart Infra's resources by scoring an averaged total of 13 points on a 100 points scale over the current planning process on these two criteria. Subsequently, a recommendation for the optimal planning process was written.

REMONDIS Smart Infra indicated that it intends to use the graphical resource planning (GRP) as their planning tool, which is the planning tool within their software system, when the GRP has proven itself by sufficiently meeting REMONDIS Smart Infra's requirements. Therefore, the GRP is analysed and a foundation of the planning is built in the GRP by a study of primary resources.
Next to the design possibilities and standard functionalities in the GRP, a specific functionality had to be specifically developed in order enable the planning process of REMONDIS Smart Infra to be

performed with the GRP. The specific functionality concerns moving operations within the GRP in combination with coupled resources. A coupled resource is a truck or a colleague that usually joins the leading mechanic when performing operations.
Evaluating the GRP against REMONDIS Smart Infra's requirements, it could be concluded that the GRP can be utilized as the planning tool for the optimal planning process.

Following, an action plan consisting of four consecutive steps was developed to ensure the successful implementation of the optimal planning process and the GRP as REMONDIS Smart Infra's planning process and planning tool within its business processes.

From a satisfaction questionnaire answered by the six planners of REMONDIS Smart Infra, it appeared that the planners' satisfaction with the alternative planning process including the GRP – measured on a 10 points scale – has increased on average from a 3 to a 7 during this research.
Besides that, the following accomplishments were possible to be measured during this research, which were achieved by executing the alternative planning process while implementing the GRP instead of the current planning process. The alternative planning process is expected to:

- Reduce the duration for planning a malfunction order with 4 minutes on average.
- Reduce the duration for planning a project order with 1.5 minutes on average.

Based on the approach taken and the results of the bachelor assignment, the main conclusion of this research could be drawn. REMONDIS Smart Infra can achieve, planning its entire field service in the most efficient and effective way possible by applying the optimal planning process within its business processes while utilizing the GRP as planning tool. This way REMONDIS Smart Infra's planning process can perform according to REMONDIS' slogan: *"Working for the future"*.

There are points of interest that could not be achieved with the GRP yet, which require further research or development. The points entail the following requirements of REMONDIS Smart Infra:

- GRP does not possess a capacity overview.
- GRP cannot automatically relocate operations that have to be frequently executed.
- GRP cannot automatically assign the determined number of working days within the planning.
- REMONDIS Smart Infra cannot utilize the project overview in the GRP yet.

From the conclusion drawn, the main recommendations are presented for REMONDIS Smart Infra.

- When the GRP is in use by the planners, it is recommended to maintain the GRP design for the optimal planning process as this design has been specifically created for REMONDIS Smart Infra's field service.

- In order to ensure that the optimal planning process and the GRP remain future proof, it is recommended to maintain the standardization, flexibility, speed and quality of the planning process and the GRP design as changes occur in the different business processes.

- To successfully implement the optimal planning process, it is recommended to involve REMONDIS Smart Infra's employees during the development of the planning process, provide trainings and instructions on the planning process to these employees, provide support to the employees during the actual implementation of the planning process and provide aftercare to these employees on any challenges or struggles with the planning process.

- During the implementation phase, it is heavily suggested to teach the planners one working method to maintain a standardized planning (process) across establishments.

- Finally, it is advised to encourage frequent communication between the planners of REMONDIS Smart Infra to improve REMONDIS Smart Infra's flexibility, resource utilization and insight in their planning.

Reader’s guide

How the research is performed at REMONDIS Smart Infra is described by eight chapters. In this guide, these chapters are described in short.

Chapter 1 | Introduction

The first chapter presents the introduction to this research. REMONDIS Smart Infra and its main activities are described in short. Furthermore, the research methodology including the action problem, core problem and research design for this thesis are outlined.

Chapter 2 | Context analysis: Measuring the planning process

A context analysis at REMONDIS Smart Infra has been performed to get a better insight in the current situation. The current planning process is measured in terms of clearly defined indicators to obtain a better understanding of the current situation. Next, the requirements of REMONDIS Smart Infra for an optimal planning process including the respective planning tool are defined.

Chapter 3 | Process workflow diagrams: Literature study

The literature study is described in the third chapter. An alternative planning process for REMONDIS Smart Infra should be mapped. Therefore, the possible process workflow diagrams to map this planning process are described in this chapter. As a result, the most suitable process workflow diagram is selected.

Chapter 4 | Planning process

The alternative planning process developed for the different main activities of REMONDIS Smart Infra are presented in this chapter. To validate that this planning process is the most suitable for REMONDIS Smart Infra, a multicriteria analysis and a centralisation analysis are performed. Lastly, a recommendation is written for the optimal planning process.

Chapter 5 | Graphical resource planning

In this chapter, a foundation of the planning tool is built in the graphical resource planning (GRP) based on its design possibilities and the functionalities it offers. The design possibilities and functionalities within the GRP have been analysed and elaborated in the appendix. As a result, it can be concluded whether the GRP meets REMONDIS Smart Infra’s requirements.

Chapter 6 | Interim measurements of the planning process

This chapter presents the interim measurements of REMONDIS Smart Infra’s planning process by measuring and analysing a specific set of indicators that can be measured at this stage of the research. The interim measurements indicate the progress made in the planning process when REMONDIS Smart Infra applies the optimal planning process including the GRP.

Chapter 7 | Action plan

An action plan is written for REMONDIS Smart Infra, which outlines the steps to be taken in order to successfully implement the developed planning process with the respective planning tool within the business processes of REMONDIS Smart Infra.

Chapter 8 | Conclusions, recommendations and future research

The last chapter discusses the conclusions and recommendations about the performed research. Finally, the potential future research is described.

Contents

List of acronyms

Acronyms

BPMN	Business Process Modelling Notation
C&I	Cleaning and Inspection
C&R	Construction and Renovation
GRP	Graphical Resource Planning
IDEF	Integrated Definition
MCA	Multicriteria Analysis
MCDA	Multiple-Criteria Decision Analysis
PDCA	Plan Do Check Act
RSI	REMONDIS Smart Infra
S&M	Service and Maintenance
SO	Service Order
WO	Work Order
WP	Work Planner

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Chapter 1 | Introduction

This bachelor thesis is performed at REMONDIS Smart Infra (RSI). The focus of this research lies on optimizing the planning process, providing a foundation for the accompanying planning tool and defining the way these deliverables should be implemented. Section 1.1 introduces the company where the research is conducted. Section 1.2 describes the problem identification. Section 1.3 presents the research design and how the research will be conducted.

1.1 Company description

REMONDIS *REMONDIS: "Working for the future"*

The research is performed at REMONDIS Smart Infra, which is a part of REMONDIS. REMONDIS is an international recycling, service and water company. It has been founded in the 1930s in the German town of Lünen as a family-run business. In almost 90 years, REMONDIS has grown into a business, which is operational on four continents with approximately 900 establishments and more than 30,000 employees. REMONDIS provides its services to more than 30 million people through the many thousands of public and private sector clients (REMONDIS, n.d.). Examples of which are the local authorities as well as the industrial, commercial and business customers. Each year REMONDIS generates a turnover of approximately 7.9 billion euros (REMONDIS Industrie Service GmbH & Co. KG, n.d.).

REMONDIS Smart Infra

REMONDIS Smart Infra is part of REMONDIS' water division, which focuses on building, renovating, cleaning, inspecting, and repairing the sewers and corresponding installations that transport wastewater from people's homes towards the municipal purification plants (REMONDIS Nederland, n.d.-a).

Currently, the three main activities of RSI consist of:

- Service and maintenance. This activity is tasked with checking and maintaining the sewers and pumping stations. Such installations ought to meet supreme quality and safety requirements. In case any component is identified to be defect or does not meet the established requirements, the client will be notified about this defect (REMONDIS Nederland, n.d.-c).

- Construction and renovation. Here, new sewers and pumping stations are constructed in for example new housing estate. Also, this activity performs renovations of such installations when requested by the client. Renovations are required when for example service and maintenance has detected defect pumps that need to be replaced (REMONDIS Nederland, n.d.-b).

- Cleaning and inspection. This division is tasked with cleaning the sewers, pumping stations and purification plants. With assistance of digital recording equipment, sewer systems and their condition are inspected. As a result of periodically inspecting and cleaning installations, the reliability of installations can be guaranteed and unnecessary costs are prevented (REMONDIS Nederland, n.d.-c).

This research is performed from RSI's establishment in Lichtenvoorde while focusing on four of RSI's establishments, namely Ermelo, Hardenberg, Leek and Lichtenvoorde. REMONDIS took over these establishments from Dusseldorp in 2016. Around the same time, Dusseldorp's employees had to integrate into a new software system, which is still in use today. This research is focused on the planning process of the field service of REMONDIS Smart Infra, which plans RSI's main activities at these establishments, respectively.

1.2 The problem

This section presents the various problems at the company. Section 1.2.1 defines all problems related to the action problem and planning process. Section 1.2.2 outlines the action problem specifically. Section 1.2.3 identifies the core problem and provides corresponding motivation.

1.2.1 Problem identification

To identify the action problem and corresponding core problem, a problem cluster is created to map all problems regarding the planning process in relation to each other. The problem cluster can be seen in Figure 1 alongside a legend defining the types of problems. Now, the problems regarding the planning process are defined as the basis for the problem cluster.

General problems

The overall problem experienced by RSI entails that every planner has their own tailored planning in Microsoft Excel separately from the software system instead of a standardized planning across all establishments. Each Excel planning contains the planning for a main activity in the field service. Here, a mechanic is reserved for an activity, which depends on the layout of the tailored planning. Different versions of the planning exist based on a day, week, and year overview. Such a planning might also contain a capacity overview to see whether the full capacity has been reached.

This working method requires a planner to put a piece of information into two systems: Microsoft Excel and the software system, which takes an unnecessary amount of time and effort. Putting information into separate systems also has an increased risk of making errors in either system.

Due to the tailored planning, each planner puts information differently in his planning. Comparing all schedules would be nearly impossible. Comparability of the planning has also been limited by the lack of communication and cooperation between the planners of each establishment. The lack of communication also limits the knowledge across establishments about available mechanics or equipment and their qualities to perform a certain activity. As a result, a mechanic or a piece of equipment, also called resources, might be idle in Hardenberg when Lichtenvoorde lacks that specific mechanic or piece of equipment. This results in suboptimal use of RSI's resources. Examples of such equipment are the different kind of trucks in RSI's possession, where each truck can perform specific activities, such as maintenance, cleaning, etc.

Graphical Resource Planning (GRP)

Now, there is a possible planning tool alternative that could solve the discussed problems, which is called the graphical resource planning (GRP). The GRP is a graphical planning tool, where equipment and mechanics can quickly and simply be planned (4PS, 2020). Besides that, the GRP features the mode to plan per day, per week and per month. This planning is part of the current software system, which can solve the problem of having separate systems. It is possible to design a standardized format for each department within RSI by fixing filters and settings. As a result, the tailored planning of each planner can be incorporated into a single format.

Furthermore, it is important that the planning process should be future proof, so it can be applied to all establishments of RSI and in further updates of the software system. Soon, a newer version of the software system will be implemented alongside an improved GRP. Also, the software company continues to develop its software system and its GRP. Therefore, future planning process should be operational in the future versions of the software system.

However, the GRP is not suited to be implemented in the business processes of RSI yet. There exist shortcomings in the way it is currently constructed. The problem with the GRP is that the planners are not capable of planning with the GRP due to the lack of instruction provided to them. Now, it is being used as a viewing tool of the completed activities instead of a planning tool for future activities. Therefore, the GRP does not yet fit the way the planners of RSI would like to plan.

The GRP has been researched and it is known that the GRP possesses the qualities and functionalities to make planning with the future version of the GRP possible. However, these qualities and functionalities remain unknown to the involved employees. As a result, utilizing the research of the future GRP and its functionalities is required.

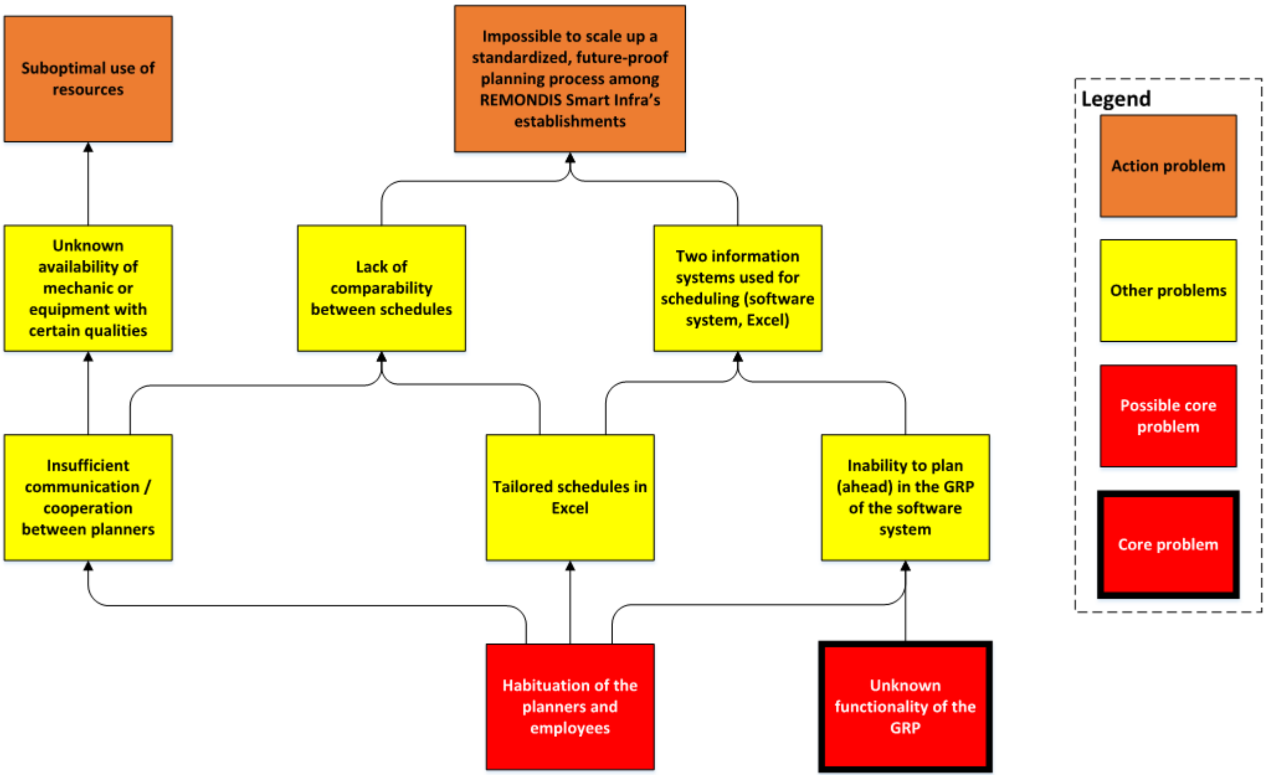

Figure 1.1: Problem cluster for the planning process of REMONDIS Smart Infra (RSI)

1.2.2 Norm and reality: Action problem

To define the action problem, the norm and reality of the planning process have to be defined (Heerkens & Winden, 2018). The reality of the planning process is that every planner has their own way of planning in Microsoft Excel, which has resulted in their own tailored planning next to the software system. Over the years, the planners have gotten used to this way of working and have very limited contact with the other planners of RSI. This way of working has great risks of making errors between the two information systems. When presenting the GRP as a possible alternative, the GRP is still unused due to its current shortcomings and the lack of instruction on its functionality.

The norm that RSI intends to achieve for the planning process of their field service is a standardized, future proof planning process that is capable of being implemented across RSI's establishments and usable by its planners. The planning process should be future proof, so it can be used with future updates of the software system and it can be flexible when the objective of the company changes.

Therefore, the action problem entails that:

It should be possible to scale up a standardized, future proof planning process among REMONDIS Smart Infra's establishments.

Main research question

The formulation of the action problem leads to the formulation of the main research question of this thesis:

How can REMONDIS Smart Infra achieve, planning its field service and accompanying resources in the most efficient and effective way possible?

1.2.3 Core problem

Based on the problem cluster, the core problem can be identified based on problems that do not have a cause (Heerkens & Winden, 2018). From the problem cluster in Figure 1.1, I can conclude that the core problem of the company is:

Unknown functionality of the GRP by REMONDIS Smart Infra's employees.

This is the core problem of RSI with regards to their planning process, because the incapability of RSI's employees to work with the GRP in the software system results in RSI refraining to be adaptable to its environment, its clients and its competitors, which leads to losses, respectively. As RSI has the aspirations to expand its business across the Netherlands, competing with the local competitors will most likely be impossible due to its planning process not being adaptable to the surroundings with the static planning process including Excel. For instance, meeting local customer demands and keeping up with competitors' development will be impossible. Therefore, the current planning process will not provide the means to achieve RSI's aspirations.

RSI currently lacks a planning tool to support their aspirations. However, RSI possesses a planning tool – namely the GRP, which shows promising traits for this purpose. For instance, the GRP is guaranteed to receive many updates from the software company in the coming years allowing for RSI's flexibility and adaptability to increase over the years. Now, RSI misses out on such a planning tool by not knowing about the GRP and its functionalities. The lack of knowledge about the GRP is mainly due to the lack of instructions currently provided by the software company. As a result, the solution direction for this core problem will entail providing RSI with the right information and instructions on the GRP when it has been proven that the GRP is the most suitable planning tool for RSI.

This conclusion can also be derived from the fact that habituation of the employees is a problem that cannot be directly influenced and so cannot be the core problem (Heerkens & Winden, 2018).

1.3 Research design

To answer the main research question while simultaneously solving the action and core problem, a research design is developed. The research design is based on a problem-solving approach of answering sub research questions. The problem-solving approach discusses each sub research question including its steps and its purpose. The sub research questions are part of a circular process, which are formulated according to the managerial problem-solving method (MPSM) of Heerkens and Winden (2018). Section 1.3.1 defines the problem-solving approach. Section 1.3.2 outlines the restrictions for this thesis. Section 1.3.3 defines the deliverables.

1.3.1 Problem solving approach: Research questions

1. What does the current planning process of REMONDIS Smart Infra look like?

An insight in the current planning process is required to solve the action problem, which entails conducting a context analysis. The indicators for the current planning process are defined and measured. A questionnaire is conducted to measure these indicators. Moreover, the conducted semi-structured interviews and observation studies among the relevant stakeholders are reviewed to gain insight in already-obtained measurements. The current planning process is defined in terms of indicators to create a concrete benchmark for the evaluation of the alternative planning process. Chapter 2 describes the context analysis in detail.

2. *What are specific requirements for the planning process including the planning tool of REMONDIS Smart Infra's field service?*

Continuing the context analysis, the requirements for the planning process and planning tool are defined by reviewing the semi-structured interviews conducted. These requirements are based on factors related to the implications of the core problem and the aspirations of RSI regarding the planning process and planning tool. These requirements defined, are assigned weights, so the alternative planning process and planning tool can be evaluated.

3. *What are the relevant process workflow diagrams for mapping the alternative planning process of REMONDIS Smart Infra's field service?*

A literature study is performed to find the best process workflow diagram to map the alternative planning process for RSI. Multiple diagrams are analysed and the best suitable diagram is applied to the alternative planning process. Chapter 3 describes this literature study.

4. *What should the planning process for REMONDIS Smart Infra's field service look like?*

Next, the alternative planning process for the different activities in the field service is designed using the selected process workflow diagram. A multicriteria analysis and a centralisation analysis are performed on the alternative planning process, which provides the means for evaluating and assessing this planning process on its suitability. These analyses incorporate the relevant criteria defined by testing the alternative planning process in unstructured interviews conducted among stakeholders involved in the planning process development. Then, a recommendation is written for the alternative planning process based on these analyses. Chapter 4 describes the alternative planning process, its evaluation and recommendation in detail.

5. *To what degree is the GRP capable of meeting the requirements of REMONDIS Smart Infra with regards to the planning process of the field service and its resources?*

To determine the compatibility of the GRP as a planning tool for RSI's planning process, the GRP and its functionalities in the new software system are researched by a study of confidential primary resources. Besides this, a session with a consultant of the software company is organized to discuss the GRP. Then, a foundation of the planning tool is constructed in the GRP. Next, the GRP is tested by implementing a current planning of one planner into the GRP. Finally, the GRP in combination with the optimal planning process is evaluated to the requirements as defined in the second research question to determine the compatibility of the GRP with RSI's optimal planning process. Chapter 5 concerns the analysis of the GRP, clarifies on the foundation constructed in the GRP and provides the evaluation of the GRP combined with the optimal planning process.

6. *What should the action plan entail to achieve the most efficient and effective planning process for the field service that suits REMONDIS Smart Infra?*

The final step is to develop an action plan. This action plan entails a descriptive roadmap on how to achieve the optimal planning process from the current situation and implement the planning tool within RSI's business processes. So, the steps that need to be taken to achieve the successful implementation of the optimal planning process within the organization are determined. Chapter 7 presents this action plan.

The final phase of the research should entail the implementation and evaluation. This phase is outside of this thesis' scope, because all previous steps will occupy the time available. The implementation and evaluation are executed by RSI when the research has been completed.

1.3.2 Restrictions

In order to solve the action and core problem, restrictions are set for performing the research. The restrictions that have to be taken into account are formulated as follows.

- **Indicators**: The impact of any planning process including a planning tool has to be measured using indicators, which will be defined in Chapter 2.
- **Direct contact with subjects**: There has to be constant involvement of the subjects during this research as their way of working is about to drastically change.
- **Action plan**: The research and its deliverables have to provide RSI with a roadmap towards an optimal planning process for its field service across its establishments.
- **Foundation in the planning tool**: Besides the alternative planning process, a foundation of the planning has to be built in the planning tool where the optimal planning process is applicable.
- **Update of software system**: RSI will receive the update on the software system in the near future. The alternative planning process and the foundation built in the GRP have to be compatible with this update.
- **Clarification**: The research has to be clear to all involved stakeholders. Therefore, explanations and analyses on various aspects of the research are required. This way possible misunderstandings are prevented and the planning process can be implemented correctly.

1.3.3 Deliverables

As a result, from the bachelor thesis performed at RSI, the following deliverables will be delivered. These deliverables are related to the problem-solving method and research questions in Section 1.3.1.

1. Context analysis of the current planning process for the field service defined in measurement values and requirements
2. Literature study on process workflow diagrams for planning process mapping
3. Alternative planning process for the field service
4. Multicriteria analysis and centralisation analysis on the alternative planning process
5. Analysis of the planning tool intended to be used with the optimal planning process
6. Foundation constructed for the planning tool to be used
7. Evaluation and recommendation of optimal planning process and planning tool
8. Action plan on the implementation of the optimal planning process and planning tool
9. Interim measurements of the optimal planning process
10. Conclusions and recommendations from the research

Chapter 2 | Context analysis: Measuring the planning process

This chapter discusses the context analysis for this research, which is performed at REMONDIS Smart Infra (RSI). Here, the first and second research question are answered.

1. *What does the current planning process of REMONDIS Smart Infra look like?*
2. *What are specific requirements for the planning process including the planning tool of REMONDIS Smart Infra's field service?*

The current planning process is defined in terms of indicators, which are used to measure this planning process. Next to that, these indicators allow for the alternative planning process to be evaluated against the current planning process.

The first research question is answered by defining and measuring these indicators. These indicators are defined in Section 2.1 based on the conducted observation studies of all planners. By conducting a questionnaire among all planners of RSI, which is a total of six employees, these indicators are measured in their respective units. These measurements are analysed in Section 2.2 resulting in an analysis of the current planning process. Section 2.3 defines the requirements of RSI for the alternative planning process including planning tool by conducting semi-structured interviews among RSI's employees that are involved in the planning process development. Section 2.4 provides the discussion for this chapter. Finally, Section 2.5 provides the conclusion.

Observation studies, interviews and a questionnaire provided the input for this chapter. Here, the current planning process, the current planning tool and the employees involved were analysed.

2.1 Definition of indicators

This section discusses the current planning process and defines the indicators using the observation studies among all six planners of RSI. Section 2.1.1 provides the short introduction to the current planning process. Section 2.1.2 defines the indicators to be measured.

2.1.1 Introduction to the current planning process

The planning process of RSI is divided into three processes based on the three main activities of RSI as introduced in the previous chapter. These main activities are called Service & Maintenance (S&M), Construction & Renovation (C&R) and Cleaning & Inspection (C&I). Currently, S&M and C&R are planned by the same planner. However, each main activity has their own kind of operations to plan.

Firstly, Service & Maintenance (S&M) is planned decentralized, so each establishment plans its own operations with its own planners. S&M has the following operations to plan, which are preventive maintenance, malfunctions, repair and incidental work.

- Preventive maintenance, which will be referred to as maintenance in this research, entails repetitive work where the conditions of the pumps, pumping stations and other important installations are checked and monitored.
- Malfunctions entail that a pumping station or any installation related to it has broken down and has to be fixed immediately, because the defect has seriously grave consequences.
- Repair entails a one-time job fixing a wide variety of installations with or without urgency. The difference in comparison with a malfunction is that a repair with urgency does not necessarily concern a broken installation yet but it is expected to break down very soon, which would eventually result in a malfunction when neglecting to fix it.
- Incidental work entails work that has to be performed once and usually outside of a contract, which can entail any kind of operation, such as maintenance or repair.

Secondly, Construction & Renovation (C&R) is also planned decentralized just like S&M. C&R only plans projects, which can either be construction or renovation projects. However, the kind of project does not influence the way it is planned.

- Projects entail work for multiple successive days with a predetermined start and end date, which usually require building new installations.

Thirdly, Cleaning & Inspection (C&I) is planned centralized, so its operations are planned on a national scale from a singular establishment by one or a few planners. C&I has the following operations to plan, which are projects, maintenance, incidental work and deposits.

- Projects, maintenance and incidental work are planned in fairly the same way as for S&M and C&R. However, the way C&I performs these operations is different from the other main activities. Here, projects, maintenance and incidental work specifically mean cleaning and inspecting the cleanliness of the sewers or sewage pits for various kinds of clients. Also, it should be considered that more maintenance or projects of C&I have a fixed execution date.

- Deposits entail emptying the tank of the truck at the end of the day after having performed another kind of cleaning operation, which resulted in the tank being full of slush.

2.1.2 Introduction to the Graphical Resource Planning

The graphical resource planning (GRP) is the planning tool within the software system that RSI intends to apply in their business processes. According to the software company, the GRP allows for a quick, simple and transparent way of planning employees, material (trucks) and subcontractors. As a result, the company can react instantly on the demand from the market or on demand from a project or service order (4PS, 2020).

Currently, the GRP is not used as the planning tool to plan the different operations of RSI. The reason for this is that each planner or any other employee within RSI has never received any instruction or explanation on the GRP. Therefore, RSI has never learned about the GRP and has never worked with the GRP in the years it has been available. As a result, the planners as well as other employees of RSI are very dissatisfied with the GRP.

Now, the GRP receives an update regarding its design as well as its functionalities together with the software system, which provides a good prospect for the application of the GRP in the alternative process. However, the GRP will have to be analysed first to proof its usefulness and applicability for RSI's alternative planning process. A deep analysis of the GRP, what it looks like and what it can do, is provided in Appendix E, which is related to Chapter 5.

2.1.3 Indicators

Based on the short introduction of the current planning process and GRP, the following indicators and subcomponents for the planning process are defined. Then, the questions for the questionnaire are formulated, which are meant to be answered by the planners of RSI.

1. The average duration of specific steps in the planning process per day or per operation
    - To plan a malfunction to a mechanic
    - To plan a project to one mechanic for the next day
    - To determine the long-term planning of the various operations (for approximately a month)
    - To adapt the planning to changes in the current situation, such as the instant occurrence of a malfunction that must be planned in between other operations
2. The planners' satisfaction grade regarding the current planning tool (Excel) and GRP
    - Based on clarity
    - Based on functionality
    - Based on general satisfaction, such as design quality, flexibility, processing time, etc

3. Remaining indicators
    - The average duration of uncovering critical information for the planning process, such as the exact location of a pumping station or the phone number of the client
    - The planners' satisfaction grade regarding the planners' current activities in general
    - The planners' satisfaction grade regarding the planners' current activities on the efficiency and effectiveness of these activities
    - The number of days or weeks a planner plans ahead definitely
    - The percentage of operations to plan which have to be executed at a fixed date

2.2 Analysis of the current planning process

This section outlines the measurements of the indicators, so the results of the questionnaire, and provides a better insight in the current planning process. The questionnaire has been performed among all six planners of RSI. The results of the first indicators are analysed in Section 2.2.1. The second indicator is discussed in Section 2.2.2. Section 2.2.3 outlines the third indicator. The indicators are divided into subcomponents and expressed in their own units based on the defined answers in the questionnaire.

2.2.1 The average duration of specific steps in the planning process

For the first indicator of the current planning process, the results for its subcomponents are displayed in Figures 2.1-2.4 of Appendix A. The subcomponents included in the questionnaire are specific steps in the planning process, which are actually plannable and the most common in a planner's daily activities. Note that the subcomponents measured in the questionnaire do not encompass all planning activities.

Looking at the results of the questionnaire regarding the duration of specific steps in the planning process, it can be seen that certain steps take a short amount of time, for example planning a malfunction order. However, this does not mean that the total amount of time spent per day on planning several malfunction orders will be short. Other processes have a long duration on average, such as the time a planner spends on determining the long-term planning each day.
This observation is based on the rounded averages for each duration, which is shown in Table 2.1.

Table 2.1: Duration of specific steps in the current planning process

	Current planning process (min)
Assigning a malfunction order to a mechanic	5
Assigning a project order to one mechanic for the next day	2
Determining the long-term planning	60
Adapting the planning to changes in the current situation	90

The goal is to develop an alternative planning process, which should at least result in approximately the same duration of the relevant steps in the planning process. When possible, the aim is to decrease the duration of these steps.

2.2.2 The satisfaction grade regarding the current planning tool and GRP

The satisfaction grades regarding the current planning tool, which is Microsoft Excel, can be seen in Figures 2.5-2.7 of Appendix A. The satisfaction grades regarding the GRP can be seen in Figures 2.8-2.10. The scale of these satisfaction grades is from one to ten.

Based on the results regarding the satisfaction grades, it can be concluded that the planners are currently more satisfied with the current planning process including Microsoft Excel than with the GRP on all fronts. This conclusion is based on the rounded averages for each component of the satisfaction grade as answered by all planners as can be seen in Table 2.2. Here, it can be seen that the GRP scores significantly lower than the current planning process with Microsoft Excel on clarity, functionality and general satisfaction, which is probably due to lack of proper instruction and knowledge on the GRP and due to the lack of adaptation of the GRP within the organization.

Table 2.2: Average satisfaction grades among planners regarding the current planning process and the GRP

	Current planning process with Excel	GRP
Clarity	5	3
Functionality	6	3
General satisfaction	6	3

The goal of the research is to discover the functionalities of the GRP, to develop and adapt the GRP to RSI's main activities and to provide the planners of RSI with the knowledge and instructions, so the GRP can be applied in their operations. As a result, the satisfaction grades for the GRP should increase in comparison with the satisfaction grades for the current planning process with Microsoft Excel. Possibly, the satisfaction grades for the GRP could exceed the satisfaction grades of the current planning process.

2.2.3 Remaining indicators

For the remaining indicators, the average duration of discovering critical information, such as the exact location of a pumping station or the phone number of the client, is displayed in Figure 2.11. The planners' satisfaction grade regarding their current activities in general is displayed in Figure 2.12. The planners' satisfaction grade regarding their current activities on the efficiency and effectiveness of these activities is displayed in Figure 2.13. The scale of these satisfaction grades is from one to ten.

The result of the number of days or weeks a planner plans ahead definitely can be seen in Figure 2.14 and the result of the percentage of operations to plan which have to be executed at a fixed date can be seen in Figure 2.15. These figures are presented in Appendix A.

Analysing the remaining indicators, it can be concluded that only a selection of the presented indicators can be influenced by the change in planning process and planning tool. The indicator in Figure 2.15 called 'The percentage of operations with a fixed execution date' can only change when contracts are completed or when new contracts are attained. Therefore, the remaining indicators expressed exclusively in the other figures will be included in the analysis.

From the rounded average results in Table 2.3, it can be seen that it takes the planners quite some time to uncover critical information for the planning process. Next to that, the grades for the planners' current activities are not particularly high regarding the planners' general satisfaction and the effectiveness and efficiency of these activities. Lastly, the planners definitely plan eight days ahead on average meaning that the planner knows which mechanic is going to perform which operation eight days before the actual execution. In such a situation, only possible sickness of a mechanic, a defect truck or another unpredictable event could change the planning. This analysis is based on the rounded averages calculated for the remaining indicators expressed in their own units as can been seen in Table 2.3.

Table 2.3: Remaining indicators expressed in duration, satisfaction grade and time

	The current planning process
Uncovering critical information	60 min
Planners' general satisfaction grade with their current activities	6
Planners' satisfaction grade regarding the effectiveness and efficiency of their current activities	5
The days or weeks planned ahead definitely	8 days

The goal of this research is to develop a planning tool and planning process that decreases the time it takes the planners to uncover critical information by providing instructions on the locations of all required information and making critical information more accessible. Next to that, the implementation of the alternative planning process and planning tool should increase the effectiveness and efficiency of the planners' activities, which in turn should increase the general satisfaction of the planners with the activities that they perform. Last but not least, the research intends to ensure that the planners can plan ahead definitely for at least the same number of days by offering a clear overview of the operations in the planning tool.

2.3 Requirements for the planning process and the planning tool

This section defines the requirements of RSI for the alternative planning process including the planning tool based on the semi-structured interviews conducted. The semi-structured interviews were conducted with the S&M planner of Lichtenvoorde, the S&M planner of Hardenberg, the C&I planner and the regional manager. Section 2.3.1 outlines requirements regarding aesthetics. Section 2.3.2 describes the functionality requirements and Section 2.3.3 defines the remaining wishes for the planning process. These sections were defined partially on the indicators as defined in the previous section.
With the cooperation of all employees involved during the development of the planning process and the planning tool, we were able to identify and formulate all requirements and wishes – also called need-to-haves and nice-to-have – related to the alternative planning process and planning tool. Here, a requirement can be defined as a need or necessity (www.dictionary.com, 2021a) and a wish can be defined as a request (www.dictionary.com, 2021b). All requirements and wishes are presented in Appendix B.

2.3.1 Aesthetics

In order to evaluate the entire alternative planning process on clarity, overview and design, requirements for this planning process as well as the planning tool regarding aesthetics are defined. Table 2.4 in Appendix B formulates the requirements mentioned by the four interviewed employees regarding this aesthetics in detail. The interviewees proposed these requirements by themselves without any form of suggestion. In the table, the requirement and its description are reported. For each requirement, its importance is assessed. The assessment of importance is based on the total number of interviewees proposing a specific requirement. So, the lowest score that can be given to a requirement is I, which means that a requirement has only been mentioned by a single interviewee. In contrast, the maximum score possible for a requirement is IV.

To give a broad description of what these requirements entail, the employees would like to have a planning tool in their planning process that has a clear, complete and standardized overview of the planning. Such an overview can be achieved by colour diversity within the operations and mechanics, by possessing multiple perspectives in time – day, week and month – for perceiving the operations, by having an immediate display of critical information and by having a standardized format and filters in the planning tool.

2.3.2 Functionality

In order to evaluate the alternative planning process on skills, functions and capability, requirements for this planning process and planning tool regarding functionality are defined. Table 2.5 in Appendix B formulates the requirements mentioned by the four interviewed employees of RSI regarding this functionality. Also in this table, the requirement and its description are reported. The interviewees proposed these requirements by themselves without any form of suggestion. For each requirement, its importance is assessed in the same way as for the aesthetics requirements.

Here, these requirements are described to present a general outline of what the employees of RSI would like to see in the planning tool and planning process. The planning process should be standardized for every planner within RSI. For the planning tool, it should be able to display a capacity overview, the progress of operations and the long-term planning in order to plan on a yearly perspective. Besides that, the planning tool should allow for reserving a mechanic for a certain operation and automatically relocating operations that possess an execution frequency. Also, the planning tool should be capable of letting operations be flexibly relocated in time and between resources while possibly in between other operations. Lastly, any planner should possess the skills to plan in the planning tool and any involved employee should understand how the planning tool works.

2.3.3 Wishes

Next to the defined the requirements, the four interviewed employees of RSI have expressed some wishes that they would like to see in the planning process. The interviewees proposed these wishes by themselves without any form of suggestion. These wishes are not hard requirements that the planning process should meet. However, their inclusion would contribute to value of the alternative planning process. Table 2.6 in Appendix B formulates the wishes from the four interviewed employees of RSI. Just as in the previous tables of this section, the description and the importance of each wish is reported identically to the aesthetics requirements.

In general, the employees of RSI wish to see a wide variety of aspects to be incorporated in the planning tool and planning process, such as to plan on a project or contract instead of planning on a mechanic. Next to that, these employees would like to see a centralized planning process for Cleaning & Inspection (C&I) but a decentralized planning process for Service & Maintenance (S&M) and Construction & Renovation (C&R). Also, the planner wishes to work with a planning tool that allows faster planning, which might require a better server, that is able handle the planning of 20 to 40 mechanics. Lastly, the employees of RSI would like to be involved in the development of the planning tool and alternative planning process by testing the developed planning tool and planning process. This would also contribute to their wish of improving the communication between the planners.

2.4 Limitations to the measurements

After having read this chapter there are a couple points that require further attention.

This research was performed in the second semester of 2020-2021, so during the COVID-19 pandemic, which caused some threats to the research validity. Firstly, the attendance of employees on site decreased due to sickness or working from home, forcing the employees to adapt to a new working situation. So, the measurements were not performed under normal conditions. We tried to conduct the interviews and observation study as under normal conditions.

The analysis of the current planning process depends on the planners' own assessment, which can result in similarity or disparity between the answers. Looking specifically at the results from the diagrams in Appendix A, it can be seen that there is huge disparity between the answers of the planners, except for assigning a single malfunction order to a mechanic or a project order for the next day to a mechanic. The reason for this is that each planner has their own way of planning while using the available planning tool in different ways resulting in different assessments of the various indicators. Assigning a malfunction order or a project order is a short process with the least number of necessities to be fulfilled to complete them in comparison to other specific steps in the planning process, which results in smaller deviations between the planners' assessment.

As a result of the developing the alternative planning process, where the development process is identical for every planner, the duration of specific steps in the planning process will be increasingly similar after the planners have familiarised themselves with the alternative process. Also, the design in the planning tool and the provision of standard instructions on the GRP will ensure that all planners will have the same knowledge about the GRP in order to grade the GRP on the various aspects. In turn, there will be more similar grades. Ultimately, the measurements of the alternative planning process will be more meaningful.

Subsequently, the fact that the analysis relies on the planners' assessment might result in a second validation issue called bias. However, such bias has no impact on this research as the planners' assessment of the alternative planning process will be decisive. Next to this, the indicators used for measuring the current situation, will also be used for measuring the alternative planning process in an updated questionnaire. The planners will also be asked to fill in this updated questionnaire. Due to the implementation of this planning process after completing this research, the updated questionnaire is outside of the scope of this thesis. Instead, interim measurements will be performed for these processes. Therefore, the research will still remain reliable and valid.

All planners of RSI answered the questions about the various steps in the planning process. They were asked to average their answers since there is a lot of variety in the time it takes to plan certain steps. The averaging of answers with possible outliers was taken into account when taking decisions based on the corresponding analysis to prevent possible reliability issues.

2.5 Conclusion

From obtaining a better understanding of the current situation, the conclusion can be drawn that the planners spent a long amount of time on certain steps in the planning process, such as the time spent on uncovering critical information for the planning process. In concrete terms, the planners spend on average 60 minutes per day uncovering critical information. Such critical information entails the exact location of a pumping station or a client's phone number. This information should be immediately insightful for the planners to increase their planning speed. The same holds for other planning process steps, because having the right information is critical for any step in the planning process. Therefore, there is room for improvement on time saving in the planning steps.

Also, the planners are deeply dissatisfied with the GRP on all fronts, which becomes apparent from the grades 3, 3 and 3 on the criteria 'clarity', 'functionality' and 'general satisfaction' based on a 10 points scale. These findings were expected due to the limited usage of this planning tool. Despite the low grades for the GRP, the grades for current planning process with Microsoft Excel are only moderate, which can be expressed in scores of 5, 6 and 6 for criteria 'clarity', 'functionality' and 'general satisfaction' respectively based on a 10 points scale as well. The same holds for the grades for the planners' current activities, because the grades on the criteria 'general satisfaction' and 'effectiveness and efficiency' are a 6 and 5 respectively also based on a 10 points scale. This means that the planners recognize that the planning process needs to improve, especially regarding its functionality, efficiency and effectiveness.

Finally, the interviews conducted and the many requirements defined, indicate that the employees of RSI are demanding when it comes to the functionality and design of their planning process and planning tool, which indicates that RSI values quality in their planning process and intends to develop a planning process that completely fits its business processes and the services it provides.

The most important requirements of RSI for the planning process and the planning tool entail approximately four requirements. To begin with, the standardization of the planning tool and planning process for all planners across all RSI's establishments in functionality and design has to be ensured. The standardized planning tool should include a clear and complete overview of all employees and equipment in one overview. In this overview, the (future) operations to be planned for an indefinite period of time should be presented and the available capacity of employees and equipment per day should be shown. These and the other requirements of RSI are defined in detail in Appendix B.

After this chapter, the limitations to the measurements were taken into account for the remaining research.

Chapter 3 | Process workflow diagrams: Literature study

Now that the zero-measurement of the current planning process has been defined, more information needs to be obtained on how the alternative planning process should be mapped. A literature study has been performed to find the most suitable process workflow diagram to map the alternative planning process optimally. In this chapter the following research question is answered:

3. *What are the relevant process workflow diagrams for mapping the alternative planning process of REMONDIS Smart Infra's field service?*

Section 3.1 and 3.2 define the concepts of the planning process and the planning tool, which form the basis for the literature study to find the relevant process workflow diagrams for RSI's alternative planning process and planning tool. Section 3.3 introduces the different process workflow diagrams, which can map RSI's alternative planning process. The discussion regarding the literature study and the discussed process workflow diagrams are described in Section 3.4. Finally, Section 3.5 outlines the conclusion of this literature study.

3.1 Planning process

Optimizing the planning process offers potential large savings for RSI at resource deployment level across multiple establishments. The planning process provides a systematic way of viewing demand and developing short- and long-term solutions in the form of supplying resources. It can also be viewed as a decision-making process used to help guide decisions that could be related to future objectives (MEASURE Evaluation, n.d.). Such objectives could entail maximizing resource utilization or minimizing travel time per resource.

In many organisations, the planning process is not standardized and so it is not managed in the most efficient way. The reason for this is that companies often disregard the planning process and focus on more straightforward aspects of the business, such as finance. Therefore, leaving the design and execution of the planning process to the planners without any instruction. This way each planner develops his own way of planning resulting in the impossibility of achieving common objectives. This line of reasoning is especially true for companies with multiple establishments.

When performing the context analysis, the main activities for the planning process of RSI were identified. For RSI, the planning process entails a step-by-step decision-making process to plan mechanics to various operations, so that each project or contract can be completed on time. Each operation has its own steps to achieve completion, which requires its own process. In each process, the sickness, tuition and days-off of mechanics are also considered next to the qualities of a mechanic and his truck, the travel time to the operation and the operation's urgency indicating when it has to be executed.

3.2 Planning tool

The importance of having an optimal planning tool for supervising the company's unique business processes is currently getting more and more recognition. The increasing recognition indicates that the quality, transparency and clarity of a planning tool can present a significant factor for the successful development and implementation of a standardized planning process. In turn, the specific planning tool is critical in deciding on a process workflow diagram. Now, the planning tool with the highest quality, transparency and clarity available to RSI is the GRP.

Therefore, the objective of RSI is utilizing the Graphical Resource Planning (GRP) as their planning tool in a standardized planning process for their main activities. The GRP is defined as a planning tool that aids the user in well-structured and efficient planning of for example resources, such as people, projects, contractors, or customers (4PS, 2020).

3.3 Process workflow diagrams

To map the alternative planning process, process workflow diagrams can be used. A process workflow diagram provides a graphic overview of a business process. Using standardized symbols and shapes, the workflow shows the process step by step from start to finish. It also shows who is responsible at what point in the process. A process workflow diagram helps defining, standardizing and identifying critical areas of the process. Process workflow diagrams are useful to help employees understand their roles in the process and the order in which work has to be completed, and to create more unity within different establishments (Lucid Software Inc, n.d.-a).

The flowchart is the most common process workflow diagram, which has been widely used by companies in the past (Chapin, 2003). However, the frequent use of the flowchart does not necessarily mean that it is the most suitable process workflow diagram for presenting the alternative planning process of RSI. Out of the literature review it became clear that other kinds of process workflow diagrams exist. These process workflow diagrams including the flowchart are analysed and described in the next sections.

3.3.1 Flowchart

According to Chapin (2003), a flowchart is a graphic means of documenting a sequence of operations by using outlines and therefore it is an activity diagram. Flowcharts present the time-ordering of events or actions using outlines, which can be easily communicated between people. Flowcharts have many synonyms including block diagram, flow diagram, system chart, process chart, logic chart and iteration diagram. A flowchart is constructed in such a way that there is a standard reading convention – top to bottom, left to right. Besides that, it is common practice in a flowchart to label the outlines internally to identify the different processes (Chapin, 1971).

Format of flowchart

From the literature study, the way a flowchart is constructed and which symbols are used to display processes are defined. The basic and additional outlines shown in Figure 3.1 are all applicable in a flowchart to depict the various operations, actions and outcomes of a process. Except for the decision and predefined processes, the specialized outlines as depicted in Figure 3.2 are not applied in flowcharts. The reason for this is that these outlines are reserved for specific system charts that exchange data with databases in the respective processes. In the planning process of RSI there is limited data exchange with one of their databases, so the remaining specialized outlines are not relevant (Chapin, 2003).

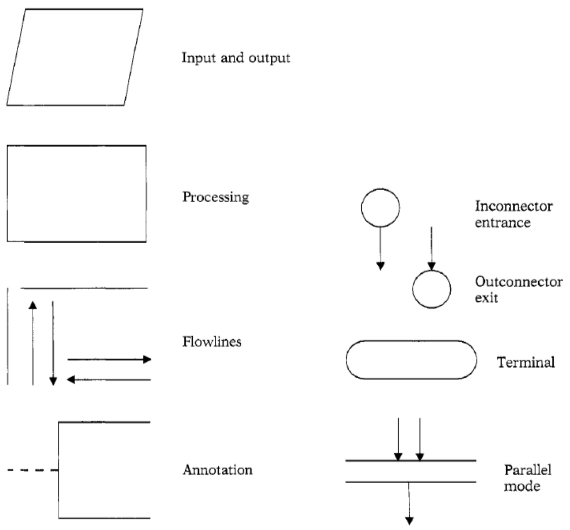

Figure 3.1: Basic outlines (left) and additional outlines (right) (Chapin, 1971)

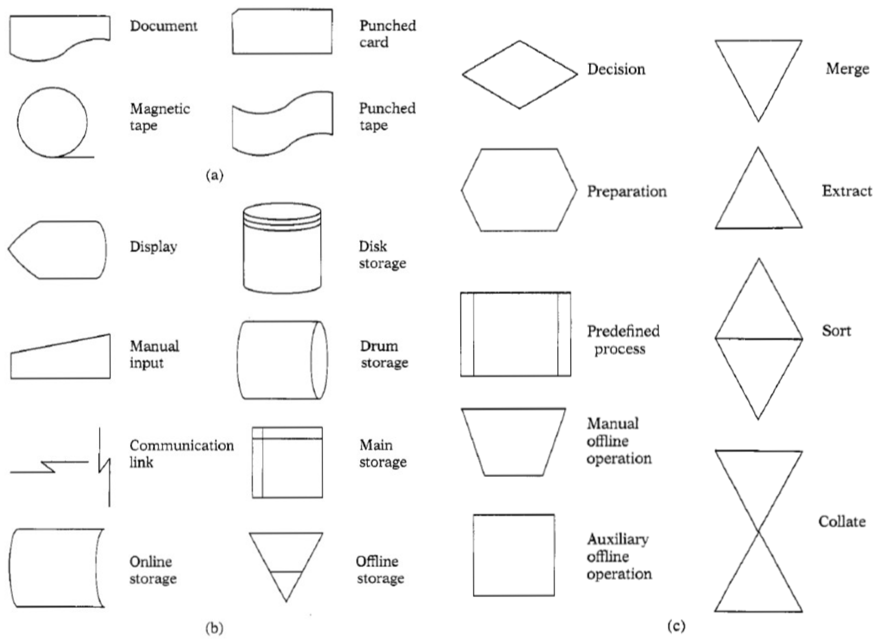

Figure 3.2: Specialized outlines. (a) Media (b) Equipment (c) Processes (Chapin, 1971)

3.3.2 Integrated definition (IDEF) model

The integrated definition (IDEF) model is a graphical language that identifies the activities to be executed, the various elements needed to execute these activities, and the efficiency of the constructed process. The methodology applied in the IDEF model can be implemented by organizations to model the various processes and activities (Thorisson et al., 2018).

In addition to the standard IDEF model, Thorisson et al. (2018) outline a methodology that includes risk identification and business process modelling, which incorporates sources of risk in business processes. This extended methodology is based on the standard IDEF model as presented in the previous paragraph. Figure 3.3 presents the main elements of the standard IDEF model as represented by a box and relating arrows. A box represents an activity and an arrow represents one of the four following meanings, which varies depending on the direction they point to (Thorisson et al., 2018):

1. *Input*: the objects that the activity transforms into output.
2. *Output*: the objects that the activity produces.
3. *Control*: the conditions required for the activity to produce the right output
4. *Mechanism*: the means applied, so the activity can be performed.

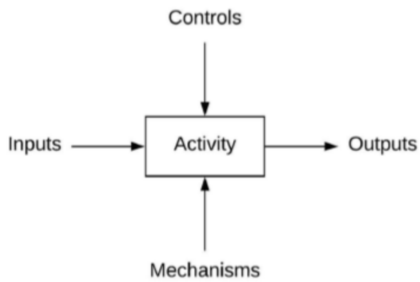

Figure 3.3: Standard IDEF modelling format (Thorisson et al., 2018)

However, this definition of the IDEF model does not account for the possible disruptions of the activity, which is identified as the sources of risk. A fifth arrow is added to the lower-left corner of the box of the IDEF model to account for the different sources of risk that disrupt the activity as can be seen in Figure 3.4 (Thorisson et al., 2018).

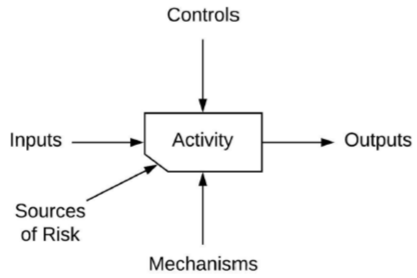

Figure 3.4: Modified IDEF modelling format including risk identification (Thorisson et al., 2018)

Now, the kind of activity, inputs, controls, mechanisms, and the sources of risk associated with the activity determine the output of the IDEF.
Even though the explained methodology takes the sources of risk into account, the consequences related to such risks are not considered, which can be called the potential disruptions of the activity. Improving this model can be done by adding a sixth arrow starting from the upper-right corner of the box and pointing outward as can be seen in Figure 3.5 (Thorisson et al., 2018).

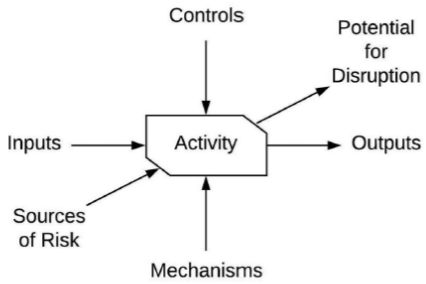

Figure 3.5: Modified IDEF modelling including risk identification and disruption potential (Thorisson et al., 2018)

Resulting in the following process workflow diagram, which is depicted by an example of the operational level activities at a container airport from the literature study of Thorisson et al.'s article.

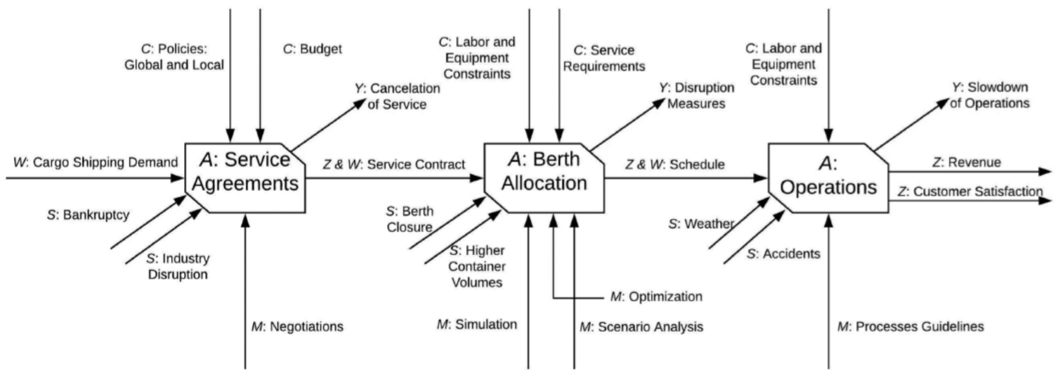

Figure 3.6: Business process model of operational level activities at a container port. The letters and descriptions in the model refer to the case described by Thorisson et al (2018).

3.3.3 Business process modelling notation (BPMN)

Business Process Modelling Notation (BPMN) is a type of flow chart that models the business process steps from start to end. BPMN graphically presents a detailed sequence of business activities and information flows required to complete a process (Lucid Software Inc., n.d.-b). Therefore, the BPMN is also an activity diagram.

The purpose of BPMN is to model ways to improve efficiency, account for new circumstances or gain competitive advantage according to Lucid Software Inc. Many business process management (BPM) tools rely on this standard graphical notation called Business Process Modelling Notation (BPMN) for representing business processes in the form of diagrams (Lucid Software Inc., n.d.-b).

Format of BPMN

BPMN includes the following four element types for the structure of business process diagrams (Lucid Software Inc., n.d.-b):

1. *Flow objects*: events, activities, gateways
2. *Connecting objects*: sequence flow, message flow, association
3. *Swimlanes*: pool or lane
4. *Artifacts*: data object, group, annotation

The individual elements and how they are applied in defining a business process are explained under the next headings:

1. **Events**

An event is a trigger that starts, modifies or ends a process. Event types include start, intermediate and end. Their symbols are depicted by different types of circles based the respective on event type (Lucid Software Inc., n.d.-b).

Figure 3.7: Events (Lucid Software Inc., n.d.-b)

2. **Activity**

An activity is a specific task performed by a person or system, which is depicted by a rectangle with rounded corners. The depiction of an activity becomes more detailed with sub-processes, loops and multiple instances (Lucid Software Inc., n.d.-b).

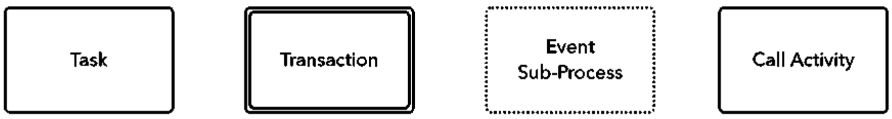

Figure 3.8: Activities (Lucid Software Inc., n.d.-b)

3. **Gateway**

A gateway is a decision point that can alter the path of the business process based on conditions or events. The respective symbols are shaped as diamonds. They can be exclusive, inclusive, parallel or complex or another form as can be seen in Figure 3.9 (Lucid Software Inc., n.d.-b).

Figure 3.9: Gateways (Lucid Software Inc., n.d.-b)

4. **Sequence flow**

A sequence flow shows the order of activities in which they are performed. It is presented as a straight line with an arrow on one end from one element to the other (Lucid Software Inc., n.d.-b).

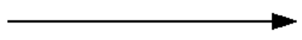

Figure 3.10: Sequence flow element (Lucid Software Inc., n.d.-b)

5. **Message flow**

The message flow presents the flow of messages across pools, see '7. Pool and swimlane', or organization boundaries, for example different departments. This flow cannot connect events or activities within the same pool. Its format is depicted by a circle at the start, a dashed line and an arrow at the end from an element to another across pools (Lucid Software Inc., n.d.-b).

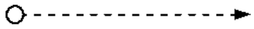

Figure 3.11: Message flow element (Lucid Software Inc., n.d.-b)

6. **Association**

An association is characterized by a dotted line, which connects an artifact or text to an event, activity or gateway (Lucid Software Inc., n.d.-b).

Figure 3.12: Association element (Lucid Software Inc., n.d.-b)

7. **Pool and swimlane**

A pool stands for an organisation or major participant in the business process. A different pools entail different companies or departments, which are involved in the process. The swimlanes stand for the various roles participating in a process and contributing to achieve a common goal, namely the end of the process. In these lanes within a pool the activities and flow for a certain role are shown, defining accountability for specific parts of the process (Lucid Software Inc., n.d.-b).

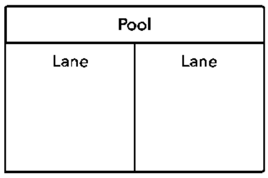

Figure 3.13: Pool and swimlane element (Lucid Software Inc., n.d.-b)

8. **Artifact**

An artifact adds the additional information to bring a necessary level of detail to the diagram. There are three types of artifacts: data object, group or annotation. The data object presents the data required for an activity. A group shows a logical grouping of activities without interfering with the diagram's flow. The annotation provides further explanation to a selected section in the diagram (Lucid Software Inc., n.d.-b).

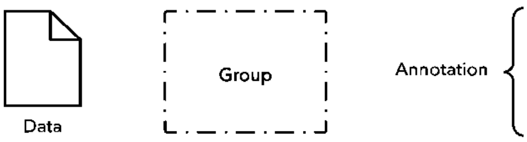

Figure 3.14: Artifact elements (Lucid Software Inc., n.d.-b)

3.3.4 Trampolin

According to Aguilar-Sommar et al (2006), Trampolin is a computer-aided tool for process modelling based on an action diagram. In their definition, action diagrams are graphical models that have a well-defined notation. This methodology of modelling intends to combine descriptions of different qualities. These descriptions should be detailed, accurate and easy to understand. Therefore, an intelligible graphical notation is preferred (Aguilar-Sommar & Poler, 2006).

Trampolin is called contextual activity modelling, which is based on an action and a communication perspective. Here, computer-based and manual functions come together to create a sensible process of activities. An activity consists of actors or doers, actions and objects. There are actors, who can perform actions. Actors utilize resources and instruments in these actions. Therefore, these actors act upon the objects available. Action objects can be material objects or information as input or result of the action. Information produced as outcome entails communication. Thus, the resultant model is a depiction of various actions and their action objects (Aguilar-Sommar & Poler, 2006).

The act of describing actions is important. This act entails describing what is performed and who performs it, which can be human actors, computer-based information systems or some other instruments (Aguilar-Sommar & Poler, 2006).

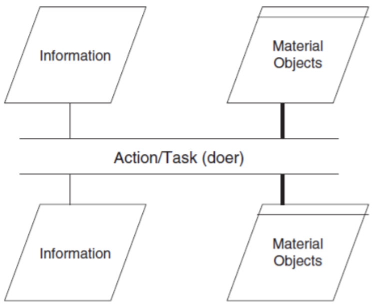

Figure 3.15: Main descriptive elements of Trampolin based on action diagrams (Aguilar-Sommar & Poler, 2006)

A complete definition of the notational guidelines can be found in Goldkuhl (1990).

3.4 Discussion

In this chapter different process workflow diagrams were presented. The flowchart is a helpful and clear process workflow diagram, because it is a well-known standardized graphic means of documenting a sequence of operations (Chapin, 2003). The integrated definition (IDEF) model is a process workflow diagram useful for mapping the potential risks and corresponding consequences related to the activities performed in the process (Thorisson et al., 2018). The business process modelling notation (BPMN) is very similar to the flowchart but this process workflow diagram focusses specifically on the different roles in the process and the information exchange between these roles next to the business activities (Lucid Software Inc., n.d.-b). Trampolin is a unique process workflow diagram due to the fact that it is a computer-aided tool. Its main focus primarily lies on mapping computer-based, mechanical as well as manual actions and the communication between these three actors (Aguilar-Sommar & Poler, 2006).

In order to solve the action problem of this bachelor thesis, the most suitable process workflow diagram has to be selected. Firstly, the flowchart is discussed. According to Chapin (2003), flowcharts can serve as a pictorial means of communicating from one person to another the time-ordering of events or actions. Due to its wide variety in standardized outlines, the flowchart allows for a detailed and understandable design of the alternative planning process. The flowchart has one disadvantage, which entails the lack of representation for the information flows in the system.

The integrated definition (IDEF) model seems like a good model for optimizing the planning process in such a way that the utilization of RSI's resources is maximized by minimizing the risks and corresponding consequences involved, which is its main advantage. However, the many risks, consequences and other inputs or outputs presented by arrows next to the lack of other types of outlines could obstruct the clarity and understandability of the process (Thorisson et al., 2018).

From the analysis of the process workflow diagrams, the business process modelling notation (BPMN) seems like the most suitable process workflow diagram, because of the clear distinction between roles in the process, the clear presentation of the information flow in the system and its reasonable wide variety in outlines, which could develop a clear planning process. The disadvantage of BPMN is that it is very similar to the flowchart. In case a planning process does not include an adequate number of roles or information flows, the BPMN does not uphold its value due to its inferior variety in outlines compared to the flowchart (Lucid Software Inc., n.d.-b).

Trampolin seems like an appropriate process workflow diagram for RSI's planning process due to its incorporation of a computer system in its design. The main advantage of Trampolin is that it allows for the detailed implementation of the software system in the process. Disadvantages to Trampolin as process workflow diagram are the limited variety in outlines and the use of specific computer language in the description of actions. Both limit the understandability of the planning process. So, when implementing Trampolin, the right notation in the outlines has to be ensured (Aguilar-Sommar & Poler, 2006).

These four process workflow diagrams have been analysed. The flowchart is selected as the process workflow diagram for the alternative planning process. Due to the fact that the IDEF model lacks in distinguishing different kinds of outlines, which might cause difficulties in the clarity and understandability of the planning process. The BPMN is a suitable method when it comes to a process with multiple roles with significant information exchange in the system. However, the planning process of RSI only occasionally involves at most three roles within one planning process, which nullifies the value of the BPMN. Just like the IDEF model, Trampolin has a very limited variety in outlines. Also, Trampolin uses a specific computer language in the description of its actions. These disadvantages limit the understandability of the planning process. Therefore, the flowchart has been selected as the process workflow diagram for mapping RSI's alternative planning process.

3.5 Conclusion

After this analysis, it can be concluded that the flowchart is the most suitable process workflow diagram to map the alternative planning process of RSI's field service. The flowchart is argued to provide the greatest variety in outlines next to being a standardized graphic means of documenting and communicating a sequence of operations, which results in the best planning process design. In Chapter 4, the flowchart is applied to present the alternative planning process in a systematic way.

Chapter 4 | Planning process

For each of the main activities and operations that REMONDIS Smart Infra (RSI) performs, the alternative planning process is developed. In this chapter the following research question is answered:

4. *What should the planning process for REMONDIS Smart Infra's field service look like?*

Retrieved from the literature study as described in Chapter 3, the flowchart has been selected in order to present the alternative planning process in a systematic way. Based on many unstructured interviews and meetings with the various stakeholders, the key activities and specific steps in the alternative planning process are mapped. Afterwards, this planning process is evaluated by conducting a multicriteria analysis and a centralisation analysis, which are also derived from the unstructured interviews with the relevant stakeholders by testing this planning process. These analyses result in a recommendation for the alternative planning process.

Section 4.1 outlines the developed alternative planning process for the different main activities of RSI. Section 4.2 presents the multicriteria analysis and the centralisation analysis performed to evaluate this planning process. The recommendation for the alternative planning process is written down in Section 4.3. Finally, the discussion and conclusion are respectively described in Section 4.4 and Section 4.5.

4.1 Planning process

This section provides the developed alternative planning process for the various main activities and their operations. The planning process per main activity is split up for the different operations that RSI performs. In this section, four out of the twelve developed processes for the different main activities are highlighted to explain the main steps to be taken in the alternative planning process. The alternative planning process in Figures 4.1-4.4 is presented in this section. Appendix C depicts the other developed processes in Figures 4.5-4.12 for the different main activities.

The flowcharts of the alternative planning process require some further explanation, especially on the colour scheme and abbreviations used. Therefore, a legend in Table 4.1 explains the format of the flowcharts in detail. The meanings of the symbols used in the flowcharts are depicted in Section 3.3.1 of Chapter 3.

Table 4.1: Legend for the flowchart format of the alternative planning process

Colours	Meaning
Blue & Dark blue	Steps that involve the planner
Orange	Steps performed by the work planner (WP)
Green	Steps performed by the administrative assistant
Abbreviations	Meaning
SO	Service order*
WO	Work order**
WP	Work planner***

**Service order determines what has to be done to complete the operation.*
***Work order determines who is going to perform the operation.*
****Work planner prepares the operations, so that they can be executed.*

There are four specific processes in the planning that require clarification due to the fact that these processes present the main steps to be taken in the alternative planning process that are also largely applicable to the rest of the alternative planning process as presented in Appendix C.

Figure 4.1 presents the planning process of Service & Maintenance (S&M) for a maintenance operation concerning a semi-government as client. There are five main steps to be taken in a planning process for a maintenance operation in general. The first step in this planning process starts at the beginning of the year when the planner constructs a year plan in Microsoft Excel for the known maintenance operations to be executed for the coming year.
Next, the maintenance operations in the year plan are put into the planning tool's respective nonplanned bucket as reservations. This indicates to the planner how many mechanics need to be reserved per day for these maintenance operations.
The third step is not executed by the planner but this step is still key to performing the operation. This step entails the creation of the maintenance batch by the administrative assistant meaning that the service orders for the maintenance operations are generated per object in the software system. Here, an object entails a pumping station for example.
When the planner starts planning the mechanic for maintenance operations, the planner assigns the reservations made in the year plan's nonplanned bucket to the mechanics, who are going to perform these maintenance operations.
Depending on what is discussed in the meeting before the start of working and whether a specific administering program has to be used, the mechanic can select an open service order that has to be executed, or the service order is exported to the mechanic specifically by the work planner or the planner.
After these planning steps, the respective maintenance operation can be performed. The status and service order become visible in the planning tool as a result of the various steps performed while executing the operation, such as 'order sent to the mechanic', 'mechanic is driving', 'execution has started and order completed'.

The next planning process to be discussed, is displayed in Figure 4.2 and is called the planning process of S&M for a repair operation for any kind of client. A repair operation is included in the contract between the client and RSI contrary to incidental work. This planning process consists of four steps where half of these steps are executed by the work planner (WP). When a repair operation is received by the WP, the WP will communicate with the respective client to obtain approval for performing the repair operation. The second step in the process will be executed when the client approves of the repair operation being performed. Otherwise, this planning process ends here.
After approval, the WP creates a new service order for the repair operation in the software system and assigns the expected execution date and time to this order.
The planner will continue this process by planning this service order to the mechanic that is going to perform this operation.
The last step in this process entails exporting the service order to the field service enabling the mechanic to perform this repair operation. Also, the status and service order become visible in the planning tool as a result of the various steps in the execution of the operation.

The third planning process, which Figure 4.3 displays, entails the alternative planning process for a malfunction operation received during office hours of S&M consisting of at most four steps to be executed. How this planning process starts depends on the way the malfunction is received by the planner. When the malfunction has been received from the malfunction service, the announcement of the malfunction already exists in the software system, so the planner creates a service order on the existing announcement. Following, the planner creates a work order for the respective service order.
The malfunction service is a group of RSI's employees and mechanics that fixes malfunctions after the office hours. The employees and mechanics that work in the malfunction service are rotated throughout the year.

When the malfunction has been received in any other direct way, the planner starts by creating a new service order in the software system preferable in the planning tool.
The two possible beginnings to this planning process come together by planning the respective service order to the mechanic that will perform the respective malfunction order. In this case, the planner always has to communicate with the respective mechanic that the malfunction order has to be performed. Then, the service order is exported to the field service and the mechanic can perform the malfunction order. The status as well as the service order of the malfunction order become visible in the planning tool as a result of the various steps performed during the execution of the operation.

Finally, the last planning process to be highlighted as one of the main processes is the alternative planning process for the projects of Construction & Renovation (C&R). This planning process is presented in Figure 4.4 and consists of four steps to be executed by the planner as well as partly by the WP. The first step of this planning process starts when a project has been obtained by RSI and all its data is known within the software system.
Then, the WP reserves a completely filled-in service order related to this project in the specific nonplanned bucket for such orders.
During the weekly meetings between the work planners and the planners, it is determined whether the project is ready for execution. If so, the planner assigns the reserved service order to a mechanic, so a work order has been created for the execution of that project.
Consequently, the planner exports the respective service order to the mechanic to execute that project. When the project consists of multiple days and therefore of multiple service orders, the work order created per service order is exported per day. At last, the status and service order become visible in the planning tool resulting from all steps performed in the execution of the operation.

These detailed steps are generally applicable to all other processes of a similar name for the different main activities as presented in Appendix C. Each planning process has their own unique features incorporated into their planning process in order to complete each kind of operation correctly. However, each elaborated step per operation discussed in this section is included to a large extent per respective planning process.

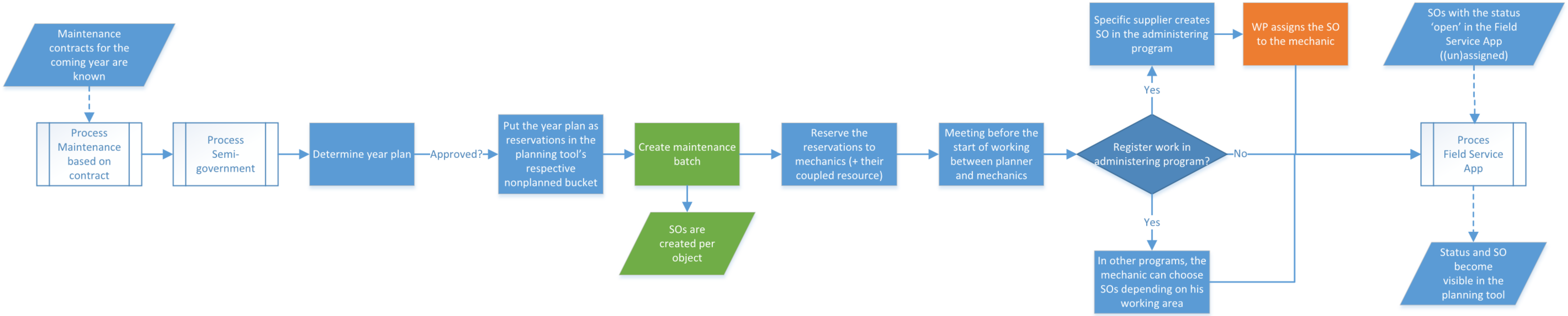

Figure 4.1: Alternative planning process for Maintenance: Semi-government of S&M

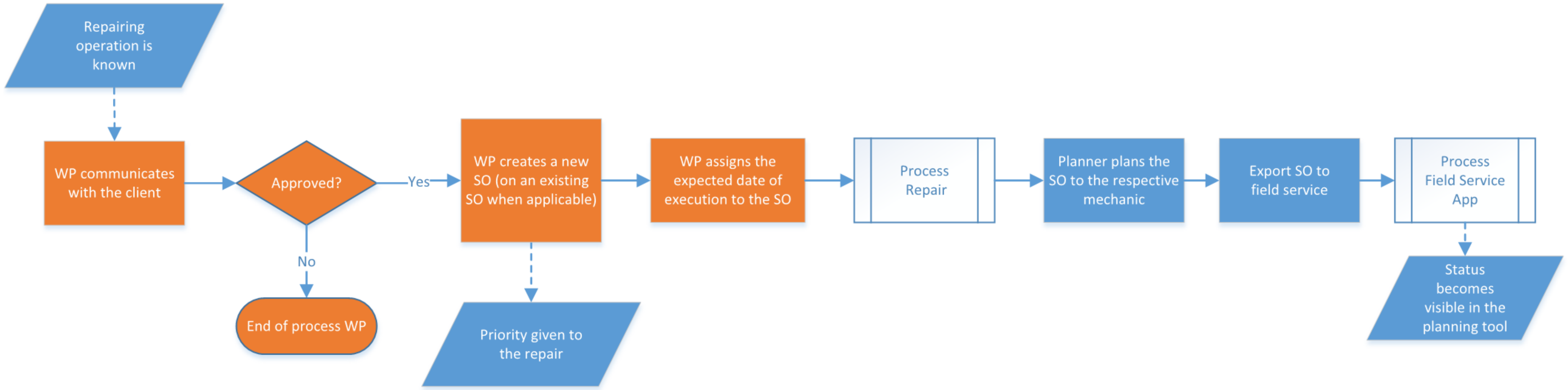

Figure 4.2: Alternative planning process for Repair of S&M

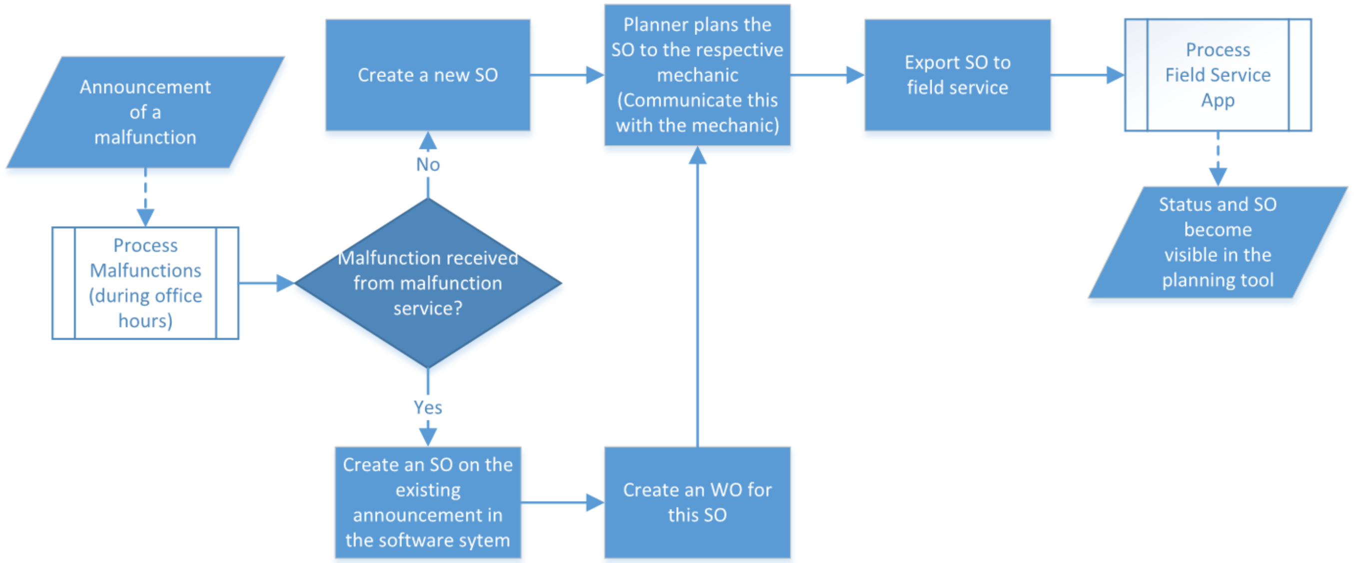

Figure 4.3: Alternative planning process for Malfunctions during office hours of S&M

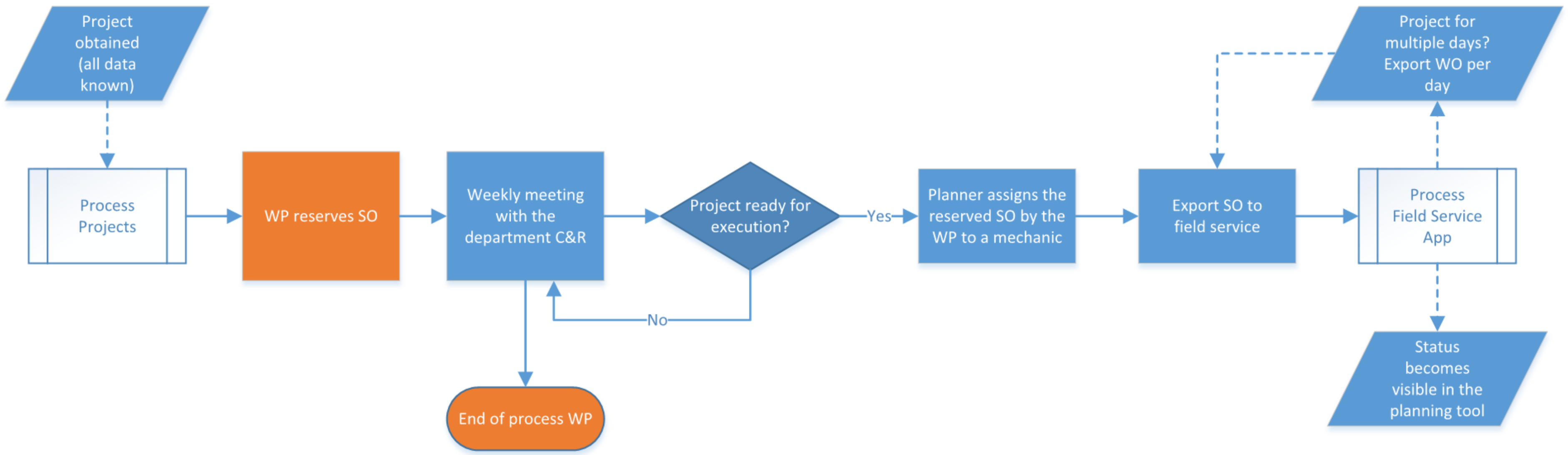

Figure 4.4: Alternative planning process for Projects of C&R

4.2 Evaluation of the planning process

In this section, the alternative planning process as given in Section 4.1 is evaluated according to two analyses, which are based on the unstructured interviews with relevant stakeholders while testing this planning process on efficiency, effectiveness and flexibility. These analyses entail the multicriteria analysis (MCA) and the centralisation analysis.

An MCA, also called a multiple-criteria decision analysis (MCDA), is a scientific method for evaluation, which allows for making a sensible choice between several discreet alternatives based on two or more distinguishing criterion (ENCYCLO, n.d.). The alternatives in this analysis entail the current planning process with Microsoft Excel and the alternative planning process.

A centralisation analysis entails assessing the advantages and disadvantages of executing the alternative planning process centralized or decentralized within RSI's different establishments.

Section 4.2.1 discusses the multicriteria analysis of the alternative planning process while Section 4.2.2 outlines the centralisation analysis of this planning process.

4.2.1 Multicriteria analysis

The multicriteria analysis (MCA) can be performed for the current planning process with Microsoft Excel and the alternative planning process when the criteria associated with an efficient and effective planning process are identified. These criteria have been defined by conducting unstructured interviews with the relevant stakeholders resulting in the following criteria:

- Duration of steps in the planning process
- Insight in the planning
- Utilization of resources
- Time needed to learn working with the planning process (includes the planning tool)

Relatively speaking, the lower the duration of steps in the respective planning process the higher the score given to that alternative. In turn, the higher the duration of steps in the respective planning process the lower the score given to that alternative. This way of grading also holds for the criterion 'Time needed to learn working with the planning process'. On the contrary, the higher the insight in the planning or the higher the utilization of resources, the higher the score assigned to the alternative for that respective criterion. Also, the lower the insight in the planning or the lower the utilization of resources, the lower the score for that criterion.

Now that the criteria have been defined, the analysis can be executed by weighing and valuing these criteria for the different planning processes. Here, the scores for the weights and for the criteria per alternative are determined by conducting unstructured interviews with all six planners of RSI individually. Each planner is asked to assess each planning process by giving a score from 0 to 100 to each criterion per alternative, which depends on the alternative's performance per criterion. Besides that, the planners have to individually assign a weight to each criterion from 0 to 100 depending on its perceived importance relative to the other criteria according to that planner. Adding all weights should result in a total weight of 100 to ensure the complete coverage of a planning process by these criteria (Janse, 2021a).
The scores and the weights are given by the planners in steps of 5.
The total weighted score for each alternative per individual assessment is calculated applying the following equation, where i represents the number of criteria in the respective order from left to right as noted in Table 4.2.

$$Total\ score = \sum_{i=1}^{4} \frac{Weight_i}{100} * Score_i$$

Equation 4.1: Calculate total weighted score for the MCA (Janse, 2021a)

The results of each individual assessment of the planning processes are outlined in Tables 4.4-4.9 as presented in Appendix D.

Table 4.2 presents the average results for the weight scores and the criteria scores per alternative. Here, the average criteria scores and average weight scores are rounded to steps of 5. These scores form the basis for the evaluation of the different planning processes in the MCA. In this table, the alternatives, the criteria, the weights per criterion, the scores given to the alternatives per criterion and the weighted total scores per alternative are presented.

Table 4.2: Average assessment of planning process alternatives against multiple criteria in the MCA

Options	Duration of steps in the planning process	Insight in the planning	Utilization of resources	Time needed to learn working with the planning process	**Total score (weighted)**
Current process	50	55	85	75	63
Alternative process	70	50	90	65	71
Weight	40	25	30	5	100

Table 4.3 defines what it means for an alternative to have a high or low score for each criterion. For example, an alternative receives a high score for the 'Duration of steps in the planning process' when that alternative has a low duration of steps in the planning process. In any case, a high score for a criterion always means that the alternative performs well on that criterion and a low score for a criterion always means that the alternative performs poorly on that criterion.

Table 4.3: Legend for defining the high and low scores for each criterion

Criteria	Low score (0-50)	High score (50-100)
Duration of steps in the planning process	High duration	Low duration
Insight in the planning	Low insight	High insight
Utilization of resources	Low utilization	High utilization
Time needed to learn working with the planning process	High amount of time	Low amount of time

Based on the calculated total weighted score in Table 4.2 from evaluating the different planning processes, the alternative planning process is concluded to be the most suitable planning process for RSI's field service due to receiving the highest scores on the major criteria.

With respect to the criteria 'Insight in the planning' and 'Time needed to learn working with the planning process', the alternative planning process lacks performance compared to the current planning process with Microsoft Excel. For the criterion 'Insight in the planning', the alternative planning process, which includes the graphical resource planning (GRP) as the planning tool, lacks a capacity overview. Such a capacity overview is crucial to the planning process of RSI and is included in the current planning process with Microsoft Excel. So, the capacity overview in Microsoft Excel has to be used next to the GRP to maximize the 'Insight in the planning'. This argument is further clarified in the next chapter, which analyses and evaluates the GRP thoroughly.

The 'Time needed to learn working with the planning process' is relatively high for the alternative planning process, which results in a lower score for this criterion than the score for the current planning process with Microsoft Excel. This is due to the limited instructions and trainings provided at this moment. Developing more elaborate instructions and providing more trainings on the alternative planning process for the relevant employees of RSI will shorten the time it takes these employees to learn working with the alternative planning process.

By considering these points of improvement during the remainder of this research, the alternative planning process will become the optimal planning process for RSI. Therefore, the alternative planning process should be implemented as RSI's planning process for all main activities.

4.2.2 Centralisation analysis

In order to perform a centralisation analysis on the alternative planning process for RSI's field service, the definition of a centralized and decentralized planning process has to be explained.

A centralized planning process is characterized by a planning process where the outcome of the process is known to a large extent. Such a planning process is executed from one establishment with a few planners for multiple establishments per predefined region. In this definition, a region is a specific area of the Netherlands that contains at least one establishment (Corporate Finance Institute, 2020).
A decentralized planning process entails that the outcome of the planning process is uncertain. Furthermore, a decentralized planning process is executed by each individual establishment with their own planners (Corporate Finance Institute, 2020).
Now, the planning process of Service & Maintenance (S&M) and Construction & Renovation (C&R) is decentralized. On the other hand, Cleaning & Inspection (C&I) is planned centralized on a national level unlike S&M and C&R.

Service & Maintenance and Construction & Renovation
For RSI's field service, the optimal planning process would be a centralized planning process, because it allows for more insight in the total utilization of RSI's resources. Also, the progress of different projects and contracts between the different establishments per region can be forecasted due to the predictable nature of a centralized planning process next to the fact that the progress of the operations can be monitored in the planning tool.

Furthermore, the exchange of resources between different establishments would be simpler. As a result, performing the planning process of RSI would become more efficient, which would not be possible with a decentralized planning process. Therefore, a centralized planning process per predefined region is the goal. As a result, the planning process of C&I will maintain its form.

However, a centralized planning process entails minimal direct human interaction between the different employees of RSI, which could result in demotivated and unsatisfied employees. Also, every activity within the organization is performed on a distance resulting in the fact that everyone has to wait. Consequently, the efficiency, effectiveness and flexible employability of RSI's resources would significantly decrease. So, turning the decentralized planning process of S&M and C&R into an entirely centralized process at this stage would be disastrous for the services provided by RSI.

Next to that, an advantage to a decentralized planning process is the essential contact between the different employees that contributes to RSI's employee satisfaction and motivation to work as hard as possible. Another asset of the decentralized planning process is that it embraces the culture and knowledge of the specific area where each establishment is located. This would allow RSI to conclude contracts and obtain projects more easily with the local clients due to the likeness in personality, behaviour and approach.

Therefore, the recommended form for the planning process of S&M and N&R is a hybrid between a centralized and decentralized planning process, which can be described as follows. This form of a planning process consists of two components, which entails one planning per region but at least one planner per establishment. This way the information systems involved in the planning process are centralized while the working experience of the planners, mechanics and other employees is maintained. As a result, the best of both worlds can be achieved as centralizing the information systems allows for insight in RSI's entire planning including RSI's resource utilization and work progress. On the other hand, keeping the planning process itself decentralized ensures good contact with the local clients and the employees remain motivated for their work.

A condition for realizing a hybrid form of the planning process of S&M and N&R entails one working method for all planners in all establishments per region. In short, the working method should be centralized alongside the planning process. Implementing this form of the planning process requires providing standard instructions according to the developed alternative planning process as depicted in Section 4.1 and Appendix C to all relevant employees to ensure that each planner performs this process in the exact same way. As a potential result, each planner could plan for another establishment when the planner of that establishment is absent for any reason.

The second condition for implementing the hybrid form of this planning process is that the communication between planners should be frequent in order to exchange resources and to update each other on the progress of the different operations. This way the threshold remains low between the planners when one planner is absent and has to be temporarily substituted or when this planner needs help with the planning.

Cleaning & Inspection
Coming back to the planning process of C&I, which will remain to be performed centralized, its execution form is depicted as follows. In C&I, the information systems as well as the planning process are centralized. This planning process is performed nationwide by one planner at one establishment for RSI, who creates one planning for the entire main activity. As a result, all advantages to a centralized planning process are included in the planning process for C&I. Here, the planner of C&I has daily telephonically contact with each mechanic about the kind of operations the mechanic has to perform in order to maintain the mechanic's motivation, efficiency, effectiveness and flexibility.

The advantages of a decentralized planning process do not hold for C&I, because C&I is focussed on a national level with its approach to clients and with the operations that this main activity performs. Therefore, the regional culture that surrounds the executive establishment is not as significant for concluding contracts or obtaining projects as is the case for S&M and N&R.

The condition for this planning process is that the planner of C&I performs this planning process according to the working method of the developed alternative planning process for C&I. Otherwise, working with the centralized information systems in the software system would be considered impossible. As a result, the advantages that come with a centralized planning process would nullify.

4.3 Recommendation for the planning process
Based on the evaluations performed on the alternative planning process for the field service of RSI, the alternative planning process is recommended to be used instead of the current planning process. The argumentation for this statement is provided in this section.

For starters, the alternative planning process aids in solving RSI's action problem, which entails the lack of a standardized and future-proof planning process for planning RSI's operations. With the alternative planning process, a standardized and future-proof planning process has been developed for all establishments of RSI. The steps in the alternative planning process have been developed excluding the direct application of a planning tool ensuring that the standardized alternative planning process is future-proof. The line of reasoning behind this statement entails that this standardized alternative planning process can be applied to any suitable planning tool at any moment in time. In turn, RSI's freedom for choosing such a planning tool remains preserved.

According to the analyses performed, the alternative planning process has proven its value for planning each main activity of RSI. The alternative planning process has achieved this by outscoring the current planning process with a score of 71 to 63 in the multicriteria analysis. The centralisation analysis argues that the alternative planning process can be implemented in its most suitable form for RSI as the centralized form for C&I and the hybrid centralized form for S&M and C&R . This means that each aspect has been considered in evaluating the alternative planning process, such as duration of the planning process steps, insight in the planning, resource utilization and so on. Every aspect of the evaluation concluded that the developed alternative planning process is the optimal planning process for planning the operations of RSI's field service.

Nevertheless, the alternative planning process has to meet certain conditions to uphold this recommendation. One condition that this recommendation depends on is that the provision of standardized instructions and trainings is required to ensure that the planners all perform the same working method across all establishments of RSI based on the alternative planning process.

Moreover, the alternative planning process has to be applied in either the hybrid centralized and decentralized form or the centralized form depending on the main activity of RSI, which has to be combined with good communication between the planners. This way the most optimal way of planning currently possible can be achieved regarding efficiency, effectiveness, flexibility and acceptance among the employees of REMONIS Smart Infra.

4.4 Discussion

The alternative planning process for RSI's field service has been developed, evaluated and recommended in this chapter. A discussion can be written regarding the planning process developed and the approach taken towards the evaluation. The alternative planning process and analyses have been based on frequent unstructured interviews, meetings and discussions with the stakeholders of this bachelor thesis, such as the planners, the manager of the planning and the regional manager. The reason for this is that the employee acceptance of the alternative planning process is the most crucial aspect to the successful implementation of this process. Therefore, the involved employees have been given a voice in developing of the alternative planning process.

Nevertheless, the input and suggestions from the employees of RSI have been assessed and analysed on their feasibility, optimality and applicability first before being considered in the implementation into the alternative planning process or any of its analyses.

4.5 Conclusion

This chapter developed and evaluated the alternative planning process according to a multicriteria analysis and a centralisation analysis. Based on these analyses, a recommendation for this process has been written. The main changes proposed by the alternative planning process related to the current situation are the standardization of the planning process among all planners, the (partial) centralization of the planning process for the different main activities and the registration of RSI's planning process in general as the current planning process was never mapped by RSI.

The gains that can be obtained from implementing this alternative planning process are the improvements on RSI's resource utilization and the decreases in the duration of specific planning process steps. The durations of specific planning process steps are expected to decrease after the planners have familiarized themselves with the alternative planning process. Also, the time needed to learn working with the planning process will decrease after the planner have received instructions and trainings on the alternative planning process. This alternative planning process also values maintaining good contact with local clients and maintaining the employees' motivation and satisfaction with their work.

From the analyses, it can be concluded that the optimal planning process for RSI's field service should look like the alternative planning process developed in Section 4.1 and Appendix C. This planning process should be implemented according to the form described in the centralisation analysis as depicted in Section 4.2.2.

The reason for coming to this conclusion is that this planning process has proven itself to be the best version in terms of efficiency, effectiveness and flexibility as it has been developed according to the conducted unstructured interviews and the performed analyses. Therefore, the alternative planning process is the optimal planning process for RSI that should be utilized as the standardized and future-proof planning process for its field service, which majorly contributes to the solution of the action problem.

Chapter 5 | Graphical Resource Planning

The relevant planning tool for REMONDIS Smart Infra (RSI) and its functionalities have to be investigated and analysed in order to determine whether the optimal planning process can be applied in the respective planning tool. The reason for this is that the planning tool is key to optimization of the complete planning process. REMONDIS Smart Infra indicated that they intend to use the graphical resource planning (GRP) as their planning tool when the GRP has proven itself to be the right planning tool for REMONDIS Smart Infra. Therefore, the GRP is analysed and a foundation of the planning is built in the GRP to determine whether the GRP meets REMONDIS Smart Infra's requirements. In this chapter, the fourth research question is answered:

5. *To what degree is the GRP capable of meeting the requirements of REMONDIS Smart Infra with regards to the planning process of the field service?*

To provide the proof of the GRP's value and to answer the research question, the GRP has been analysed and built by means of a study of confidential primary resources consisting of existing manuals and recorded sessions on the GRP provided by the software company. Section 5.1 presents the foundation of a planning built in the GRP. The discussion and conclusion are described in Section 5.2 and Section 5.3. Appendix E outlines the analysis of the GRP used to build the foundation in the GRP.

5.1 Foundation built in the Graphical Resource Planning

In this section, the foundation of the graphical resource planning (GRP) is built, which is based on the analysis of the GRP as described in Appendix E. The foundation consists of three components: Design of the GRP, Standard functionalities that will be used within RSI and Specific functionality developed particularly for the optimal planning process of RSI. The specific functionality is developed to facilitate a key aspect to RSI's planning process, which is called coupled resources. The concept of coupled resources entails that a mechanic has a regular truck or colleague, that the mechanic usually works with. In the software system this resource is attached to the mechanic, where the mechanic is the leading resource. So, when the planner plans the mechanic to an operation, the coupled resource will be automatically planned to the same operation.

Section 5.1.1 presents the created design of the GRP. The standard functionalities and the specific functionality in the GRP, which can be applied in the optimal planning process of RSI's operations, are described in Section 5.1.2 and Section 5.1.3 respectively.

5.1.1 Design of the Graphical Resource Planning

The foundation built in the GRP starts with the design that is created for the GRP in the software system. Therefore, the approach taken for designing the GRP is explained here. Furthermore, the settings applied in the software system to create this design are described in Appendix F. Finally, the resulting design of the GRP is presented in this section.

Approach

The approach taken for designing the GRP is the Minimum input, Maximum output approach. This approach entails designing the GRP in a way that the maximum value is achieved while applying the least number of inputs. For the GRP, applying this approach means including the least amount of information and functionalities in the GRP to present the clearest overview of the planning possible. However, it is critical for the GRP to include and display information and functionalities that are essential to the performance of the planning process in terms of quality, clarity, flexibility and speed. Finding the right balance for the GRP design is key to the success of the GRP as the planning tool for RSI's optimal planning process.

While designing the GRP, the requirements of RSI are considered as the basis for the GRP design.

GRP design

Based on the approach taken for designing the GRP and the settings implemented into the software system as identified in the GRP analysis in Appendix E, Figure 5.1 presents the final GRP design. For the GRP design, one workweek of RSI's main activity S&M has been planned and built into the GRP. The settings implemented into the software system to obtain this view in the GRP are elaborated on in detail in Appendix F.

To clarify the GRP design as depicted in Figure 5.1, a legend has been developed in Table 5.1 to explain the colours, the kind of resources and the kind of orders displayed. The orders are displayed in the planning window and the resources are displayed in the first column of the planning tool.

Table 5.1: Legend for the GRP design

Kind of order		Notes
Grey	Absence of resource	Holiday*, day-off**, sick, etc.
Blue	Service order (SO)	Not in this view
Any other colour in this view	Reservation	
Lock symbol (person)	Firm planned on a mechanic	
Lock symbol (clock)	Firm planned in time	Not in this view
Colours of reservations		**Notes**
Dark green	Maintenance	
Dark blue	Repair	
Orange	Malfunction	
Turquoise	Incidental work	Not in this view
Yellow	Remaining or Note	
Kind of resource		**Notes**
Person symbol	Mechanic	
Tool symbol	Vehicle	Not in this view
Jaarplanning S&O LVD	Year plan S&M Lichtenvoorde	First nonplanned bucket
Ongepland LVD	Nonplanned Lichtenvoorde	Second nonplanned bucket

**Feestdag in the GRP (Figure 5.1) means Holiday*
***Verlof in the GRP (Figure 5.1) means Day-off*

Example

To give a better insight of the GRP design, the following example is presented. In the first row of the GRP, Figure 5.1 displays mechanic X, which means that this mechanic is going to perform the operation that is planned as a reservation or a service order (SO) in that specific row. An impression of what a workweek of a mechanic could look like, entails that mechanic X is reserved for fixing malfunctions of pumping stations for Monday the tenth of May, which is visible from the colour of the reservation. The next day a grey order has been planned for mechanic X meaning that the mechanic will be absent due to having a day-off. For Wednesday the twelfth and Friday the fourteenth of May, this mechanic has been reserved to fix malfunctions again. Completing the workweek, mechanic X is free on Thursday the thirteenth just like the other mechanics, because of a national holiday as can be observed by the grey order displaying 'Feestdag'. This way the workweek of all mechanics is constructed based on the different kinds of orders and operations.

Figure 5.1: Final GRP design

5.1.2 Standard functionalities

The standard functionalities already included within the GRP that RSI can apply in their planning process are identical to the functionalities of the GRP as described and explained in Section E.2 of Appendix E. These functionalities entail moving, copying, selecting and deselecting one or multiple events of operations in the GRP. Also, one functionality allows the planner to determine what kind of event to plan for the different operations, such as a request or a service order.

These functionalities contribute to the improvement of RSI's planning process, because these functionalities offered by the GRP aid in the speed, flexibility and clarity of performing the planning process with the GRP. For example, moving an event by clicking on it and dragging it to another resource or time in the planning improves the flexibility of the planning process. Just like that, each functionality as mentioned in this paragraph supports the planning process.

A detailed description of these functionalities is given in Section E.2 of Appendix E.

5.1.3 Specific functionality

Next to the standard functionalities that the software system provides in the graphical resource planning (GRP), a specific functionality had to be specifically developed in order enable the planning process of RSI to be performed with the GRP. The specific functionality concerns moving events in combination with coupled resources. Here, the mechanic is often the leading resource, which is referred to as resource in this section. The truck or the colleague is usually the coupled resource, which is what they are referred to in this section.

Moving an event from a resource without a coupled resource to another resource can be performed without any issue in the different views of the 'Employee view'. These views are called the 'Resources employee' and 'Coupled resources: (establishment of RSI)' as described in Section 4.2.1. This functionality is called 'Moving events', which is described in detail in Section E.2 of Appendix E.

On the other hand, moving an event from a resource that has a coupled resource to another resource that also has a coupled resource can only be performed in the view 'Coupled resources: (establishment of RSI)', which presents the resource and its coupled resource directly below each other. The reason for this is that the design of this view allows the user of the GRP to move the events for a resource and its coupled resource correctly and simultaneously.

For moving an event from a resource with a coupled resource to another resource that also has a coupled resource in 'Coupled resources: (establishment of RSI)', the steps that have to be applied in order to ensure that it is performed correctly are outlined in Section E.3 of Appendix E.

5.2 Discussion

In this chapter the focus lies on the graphical resource planning (GRP), its analysis and the foundation built in this planning tool. The analysis and foundation were factually split into two components, namely the design possibilities and the functionalities within the GRP. From the analysis and foundation built, it can be seen that the GRP offers a wide variety of possibilities regarding the design and functionalities that can be implemented into the planning process.

One downside to the GRP is that the foundation built based on the general settings in Section E.1 of Appendix E can be adjusted as the general settings are freely accessible to any authorized user of the GRP. However, the view of the GRP built as is done in this chapter, is the standard and most optimal view of the planning tool to which the users can return when desired. On the other hand, the fixed settings can only be adjusted by specifically authorized employees.

In order to determine the compatibility of the GRP with the business processes of RSI, the GRP applied as the planning tool in the optimal planning process has to be evaluated against the requirements of RSI. These requirements have been defined in Section 2.3 and are written down in the tables of Appendix B. After comparing each requirement against the design possibilities and functionalities of the GRP in Tables 5.2-5.4 of Appendix G by determining whether the GRP possesses an equivalent for each requirement, it can be said that the GRP meets the majority of these requirements.

The requirements that the GRP does currently not meet are:

- Need for a separate capacity overview
- Ability to add notes in the planning view
- GRP automatically relocating operations that have to be frequently executed
- GRP automatically assigning the determined number of working days within the planning
- Implementation of autocorrect

Having a capacity overview that displays the total sum of hours of resources used per day is essential for the execution of the planning process, especially for projects, because a capacity overview provides insight in the resource utilization of RSI. This deficiency can temporarily be solved by maintaining the capacity overview already built in Microsoft Excel besides the GRP as the main planning tool. The GRP can be implemented as the planning tool for RSI together with the capacity overview in Excel until the software company develops a feature within the software system equivalent to the capacity overview in Microsoft Excel. This is a development to consider for future research.

Even though it is not directly possible to add notes in the GRP, the planner can add a reservation or service order to the planning view that displays the message. Thus, this deficiency is solved. The other requirements regarding automation, that the GRP lacks, can be considered nice-to-haves since the GRP is completely functional without possessing these automation functionalities. However, improving the automation of the GRP can increase the speed of the planning process and would increase the planners' satisfaction with performing their daily activities in the GRP. So, the automation requirements should be considered for future research.

As a result of this discussion, the implementation of the GRP within RSI and its business processes is recommended and feasible although the application of the capacity overview in Microsoft Excel is currently required.

5.3 Conclusion

From this chapter, the fifth research question can be answered. It can be concluded that the graphical resource planning (GRP) meets the requirements for RSI's planning process of the field service to an ample sufficient extent. This conclusion is based on the analysis performed on the GRP, the standard foundation built in the GRP and the evaluation of the GRP against RSI's requirements supported by Appendices E, F and G, respectively. Therefore, the GRP can be utilized as the planning tool for RSI's optimal planning process together with the capacity overview in Microsoft Excel.

Chapter 6 | Interim measurements of the planning process

Now that the planning process and planning tool for REMONDIS Smart Infra (RSI) are defined, this chapter intends to indicate the progress made in RSI's planning process when RSI applies the optimal planning process including the GRP instead of the current planning process.

Due to the fact that the software system update is set to be implemented after completing this bachelor assignment, the optimal planning process could not be implemented and evaluated within the timespan of this thesis. Therefore, interim measurements of the optimal planning process including the GRP have been performed. These measurements have been done using the test environment of the software system update. The results of these measurements are presented and discussed in Section 6.1, Section 6.2 and Section 6.3. Based on the results from the interim measurements, the progress made from the current situation can be outlined, which is discussed in the conclusion to this chapter in Section 6.4.

The goal of the interim measurements aligns with the goal of this chapter, which is to present the overall progress made with the optimal planning process.

Certain measurements were executed by performing experiments in the GRP for specific steps of the planning process. The experiments were performed by me in the test environment of the software system update. The steps of the planning process included in the measurements entail the following indicators from Chapter 2:

- The average duration of specific steps in the planning process per operation
    - To plan a malfunction to a mechanic
    - To plan a project to one mechanic for the next day

Next to performing experiments, a questionnaire is conducted among the planners of RSI to measure the interim satisfaction grades regarding the planning process with Microsoft Excel and the GRP. The respective indicators defined in Chapter 2 that have been measured are:

- The planners' satisfaction grade regarding the current planning tool and graphical resource planning (GRP)
    - Based on clarity
    - Based on functionality
    - Based on general satisfaction

Just the indicators for assigning a malfunction order, for assigning a project order and for the satisfaction grades have been possible to be measured. All these indicators are the only indicators that might have been affected or have changed while performing this bachelor assignment. This is due to the involvement of the planners in the development process. Furthermore, the planners have received trainings on the optimal planning process and the GRP. As a result, their views of Microsoft Excel and the GRP as their planning tool might have changed.

Following, certain indicators cannot be measured or are not influenced until the actual implementation of the optimal planning process including the GRP. Examples of such indicators are 'The planners' satisfaction grade regarding the planners' current activities in general' and 'The percentage of operations to plan which have to be executed at a fixed date'.

6.1 Assigning a malfunction order to a mechanic

For planning a malfunction order, the measurement starts when the information concerning the malfunction has been received and the planner is ready to plan a malfunction order in the GRP. This measurement ends when the malfunction order has been sent to the respective field service, so the malfunction order can be executed. The complete measurement has been repeated five times to ensure the reliability of this measurement.

The results of these measurements are depicted in Table 6.1 alongside the result for planning a malfunction order from the current situation as presented in Chapter 2.

Table 6.1: Duration of assigning a malfunction order to a mechanic (Interim measurement)

Measurement	New time (minutes : seconds . centiseconds)	Old time (minutes)
1	01:33.18	5
2	01:30.47	
3	01:22.77	
4	01:20.71	
5	01:19.25	

From Table 6.1, it can be seen that the duration for assigning a malfunction order to a mechanic with the GRP takes approximately 01:20.00. This result depends on performing this planning step correct immediately while taking a few seconds to determine which mechanic is going to execute the malfunction order.
To account for possible deviations from the measured times, the standard deviation for the duration of assigning a malfunction order to a mechanic is calculated with the following equation for the sample standard deviation. The sample standard deviation is applied, because the potential number of results for this indicator is unlimited. For example, planning a malfunction order can be done an unlimited number of times (Calculator.net, 2008).

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2}$$

Equation 6.1 Sample standard deviation (Calculator.net, 2008)

Now, a statement can be made about these results. The standard deviation for this indicator is approximately 6.3 seconds. This entails that a variation in the duration of assigning a malfunction order to a mechanic is expected of 6.3 seconds. The standard deviation therefore predicts that a duration from 01:12.95 until 01:39.48 is possible when performing this step in the planning process.

Next to the average time it takes to plan a malfunction order to a mechanic, it can be seen that the measurement times started decreasing after the second measurement. This observation is explained by the fact that performing the obligatory steps and filling in the fields for an order went automatically after that second measurement.

From these results, it can be assumed that the planners of RSI can perform this step in the planning process just as fast when the planners have gotten used to performing the optimal planning process in the updated software system and in the GRP. Comparing these results to the current situation of planning a malfunction order as presented in Table 2.1 of Chapter 2 and in Table 6.1, it can be concluded that assigning a malfunction order according to the optimal planning process in the GRP should be 4 minutes faster on average than assigning a malfunction order with the current planning process.

6.2 Assigning a project order to one mechanic

For planning a project order, the measurement starts when the project order has been reserved in the GRP by the work planner in the non-planned bucket and the planner is ready to plan the project order for the next day. This measurement ends when the project order has been sent to the field service, so the project order can be executed. The complete measurement has been repeated five times to ensure the reliability of this measurement.
The results of these measurements are depicted in Table 6.2 alongside the result for planning a project order from the current situation as presented in Chapter 2.

Table 6.2: Duration of assigning a project order to one mechanic for the next day (Interim measurement)

Measurement	New time (minutes : seconds . centiseconds)	Old time (minutes)
1	00:26.12	2
2	00:24.67	
3	00:22.10	
4	00:20.39	
5	00:20.33	

Looking at Table 6.2, the duration of assigning a project order to a mechanic for the next day with the GRP is perceived to take approximately 21 seconds. This results depends on how fast the planner determines which mechanic is going to perform which project. During the measurements, a few seconds were taken to determine which project had to be planned and which mechanic would execute it. Moreover, the duration depends on performing this step in the planning process correctly at once.
Applying the same equation for the standard deviation as for assigning a malfunction order to account for possible deviations, the standard deviation for this indicator is calculated to be equal to approximately 2.6 seconds. In turn, the resulting variation is from 00:17.73 until 00:28.72 for assigning a project order to a mechanic for the next day.

When all measured times are considered instead of the average time for assigning a project order, it can be seen that the measurement times decrease every measurement with approximately 2 seconds until the fifth measurement. In this measurement, the time stabilizes at a duration of 20 seconds. The decrease in measurement time can be explained by deciding faster what project will be performed and which mechanic will execute this project.

As can be seen from the results, there is little margin for improvement due to this planning step taking a maximum duration of 30 seconds. Therefore, the assumption can be made that the planners of RSI can execute this planning step just as fast when having familiarized themselves with the planning process in the GRP. Comparing these results to the current situation of planning a project order as presented in Table 2.1 of Chapter 2 and Table 6.2, it can be concluded that the time assigning a project order should reduce with 1.5 minute on average.

6.3 Average satisfaction grades among planners

Finally, a questionnaire regarding the satisfaction grades for the planning process with the GRP as defined in the introduction to this chapter is conducted among all six planners of RSI. This questionnaire reused questions from the questionnaire that measured the current situation. The average results regarding the planners' current satisfaction grades for the GRP are registered in Table 6.3 alongside the already-obtained satisfaction grades for the current planning process with Microsoft Excel and for the old GRP in Chapter 2. The grades for the current planning process and the old GRP are indicated with (Old) and the grades for the optimal planning process with the new GRP are indicated with (New) due to their time of measurement. The average results for the optimal planning process with the GRP have been derived from the results of the individual interim measurements as presented in Figures 6.1-6.3 of Appendix H. The individual results for the current planning process and the old GRP can be seen in Figure 2.5-2.10 of Appendix A. The scale of these satisfaction grades is from one to ten.

Table 6.3: Average satisfaction grades among planners regarding the current planning process and the GRP (Interim measurement)

	(Old) Current planning process with Excel	(Old) GRP	(New) GRP
Clarity	5	3	7
Functionality	6	3	6
General satisfaction	6	3	6

Table 6.3 presents the average satisfaction grades from the planners regarding the current planning processes with Microsoft Excel, the old GRP and the optimal planning process with the GRP, which are categorized into the criteria 'clarity', 'functionality' and 'general satisfaction'. The averages grades from the planners range between a 5 and 7 for Microsoft Excel, a 3 for the old GRP and a 6 and 7 for the new GRP.

Table 6.3 clearly shows that the satisfaction grades for the optimal planning process with the GRP have significantly risen in comparison to the GRP's current situation and the current planning process with Microsoft Excel. To begin with, the planners' satisfaction with the GRP has increased from a 3 to a 6 or 7 depending on the criterion, which means that the planners have become aware of the GRP's value and usefulness to their planning process.
Besides that, it is notable that the satisfaction grades for the optimal planning process with the GRP have increased to at least equal the satisfaction grades for the current planning process. The satisfaction grade regarding the GRP's clarity is a 7 compared to a 6 for the current planning process's clarity. Next, the satisfaction grades regarding the GRP's and the current planning process's functionality are equal to a 6. At last, the satisfaction grade regarding the GRP's general satisfaction as well as regarding the current planning process's general satisfaction are a 6.

Essentially, the GRP and the optimal planning process have been valued equally or better than the current planning process with Microsoft Excel. Therefore, the goal set in Chapter 2 for the satisfaction grades of the GRP has been achieved to a large extent, which means that the planners of RSI have obtained a better insight in the GRP and what it can contribute to their planning process. So, the optimal planning process with the GRP is assessed to be a suitable planning process for RSI according to RSI's planners based on the criteria: 'clarity', 'functionality' and 'general satisfaction'.

6.4 Conclusion

From the analysis of the interim measurements, the following conclusions can be drawn:

- Assigning a malfunction order according to the optimal planning process while applying the GRP is 4 minutes faster on average than assigning a malfunction order with the current planning process using Microsoft Excel.
- The time it takes to assign a project order to one mechanic for the next day reduces with 1.5 minute on average compared to the current situation. Here, the optimal planning process and the GRP are applied as RSI's planning process and planning tool.
- The optimal planning process with the GRP is assessed to be a suitable planning process for RSI according to RSI's planners based on the criteria: 'clarity', 'functionality' and 'general satisfaction' by scoring a 7, a 6 and a 6 respectively compared to the old GRP scoring a 3 on all criteria and the current planning process scoring a 5, a 6 and a 6, respectively.

In turn, this chapter concludes that the planning process of RSI has made significant progress in terms of planning a malfunction order, planning a project order and the planners' satisfaction grades as expressed in concrete values. This progress has been achieved by using the optimal planning process with the GRP instead of the current planning process with Microsoft Excel.

Discussion

As mentioned in the introduction to this chapter, these interim measurements were done to indicate the progress made in RSI's planning process by applying the optimal planning process instead of RSI's current planning process. This chapter does not present the full evaluation of the optimal planning process as well as the implementation of this planning process within RSI, because the implementation of the updated software system and the optimal planning process will take place after completing this bachelor assignment. Thus, the actual implementation and full evaluation of the optimal planning process is outside the scope of this thesis.

Chapter 7 | Action plan

Currently, the graphical resource planning (GRP) foundation has been designed and the optimal planning process has been developed for the different main activities of REMONDIS Smart Infra (RSI). Now, an action plan has to be elaborated to implement this planning tool and planning process within the organization. This way REMONDIS Smart Infra is provided with a tailored guide that helps implementing the GRP and optimal planning process for planning their operations. In this chapter the following research question is answered:

6. *What should the action plan entail to achieve the most efficient and effective planning process for the field service that suits REMONDIS Smart Infra?*

The action plan entails the recommended steps to be taken to achieve the goal of the complete and successful implementation of the optimal planning process including the graphical resource planning (GRP) within RSI's business processes (Janse, 2020b) (The Strategic CFO, 2020). This plan has been constructed based on conducting unstructured interviews with the company supervisor, the manager of the planning and the planners of RSI.

Section 7.1 describes the first step in the action plan that has been executed during this bachelor assignment, namely involving the employees of RSI in the development of the planning tool and optimal planning process. In Section 7.2, the second step of the action plan is explained, which entails the provision of trainings and instructions about the optimal planning process combined with the graphical resource planning (GRP). The first and second step in this action plan are performed during this research.

Section 7.3 outlines the third step in the action plan, which is intended to be executed in the period after this bachelor assignment. Here, support is provided to the planners and other involved employees regarding the planning process and planning tool during the implementation of the software system update within the organization. Section 7.4 entails the last step in the action plan where after care has to be facilitated to the relevant employees for any kind of trouble with the planning process or planning tool. In Section 7.5 and Section 7.6, the discussion and conclusion to this chapter are described, respectively.

7.1 Step 1: Involve employees during the development

The first step in the action plan entails that the relevant employees, such as the planners, manager of the planning and regional manager, should be involved during the development of the optimal planning process and the GRP. This way these employees will get familiar with the goal that RSI intends to achieve with the planning process. The involvement of the relevant employees is realized as follows. These employees will be updated on the various steps in the development process. The update presents and explains what has been developed and why it has been developed this way. Besides that, the employees are encouraged to be present at meetings, because these meetings give them the opportunity to provide their inputs and feedback and express their opinions on the planning process and the GRP.

As a result of involving the relevant employees in the development process, the acceptance of the GRP and the optimal planning process will increase, because the relevant employees will have contributed to the developed planning process and GRP foundation. Observing that their input and feedback is being taken seriously and implemented into the final product will lower the acceptance threshold. Furthermore, the increased acceptance of the optimal planning process and GRP will ease teaching these employees about the planning process and GRP.

Moreover, the relevant employees will start to familiarize themselves with the optimal planning process and the foundation built in the GRP when being repeatedly provided with updates on this planning process and planning tool.

All these advantages contribute to the successful implementation of the developed planning process and planning tool within the organization.

7.2 Step 2: Provide trainings and instructions

The next step in ensuring that the implementation of the optimal planning process and the GRP will be successful entails providing trainings and instructions to the planners and other employees within RSI involved in this planning process within the software system. This step in the action plan is approached by creating work instructions for the planning process, which contains detailed descriptions of the steps to be taken in the software system and the GRP for the respective process. In these work instructions, screenshots are included as the visual representation of these steps. Based on the optimal planning process, the foundation built in the GRP and the work instructions made for the optimal planning process, trainings are given on the GRP while performing the optimal planning process with this planning tool.

Consequently, the planners and other relevant employees are taught how to apply the optimal planning process together with the GRP. This way these employees are optimally prepared for using the optimal planning process and the GRP when the update of the software system is implemented within the organization. In turn, this allows for a smoother transition and successful implementation from the current situation to the new planning process in the software system update. Furthermore, the work instructions created, are the basis for taking decisions in the planning process. Each employee can refer back to these instructions when in need for guidance.

7.3 Step 3: Support during the implementation of the software system update

Step 1 and step 2 of this action plan conclude the preparation for the implementation of the optimal planning process alongside the GRP in advance of the actual implementation of the software system update.

In order to make the implementation of this planning process including the GRP a success, providing the right support to the planners and involved employees during the implementation of the software system update is crucial. The support provided during this phase of the action plan entails checking and ensuring that every setting related to the GRP and the planning process is transferred completely and correctly. Moreover, the optimal planning process has to be tested within the updated software system to guarantee that this process can be applied properly. The testing of the optimal planning process can be executed according to the work instructions as developed in the previous step. When necessary, alterations can be made to the work instructions or the design of the GRP to ensure that the planning process and the GRP can be used correctly and optimally within the updated software system.

Making sure that every aspect to the planning process works correctly, allows the planners and involved employees to resume their daily activities immediately from the start, which contributes to the satisfaction of RSI’s employees. Besides that, a functional planning process results in the immediate continuation of RSI’s main activities. So, there will be no loss of productivity and no loss in the utilization of RSI’s resources.

Just like in step 1 of the action plan, all these advantages contribute to increasing the chance of the successful implementation of the optimal planning process and planning tool within the organization.

7.4 Step 4: After care

After the optimal planning process and GRP have been correctly implemented together in the software system update and the planners have started working with the optimal planning process and the GRP, the final step of the action plan can be executed.

The last step of the action plan entails the after care for the planners and other relevant employees. After care means the upkeep of an appliance or product (Collins English Dictionary, 2021), such as the software system and the GRP. Here, the remaining questions from the planners and other employees regarding the GRP and optimal planning process are answered and the emerging unexpected errors with the optimal planning process and GRP are fixed.

This phase also offers the opportunity to develop the optimal planning process and the GRP further based on the questions and errors appearing while the planning process and the GRP are being applied. Also, promising developments that can provide added value to the planning process and to the employees of RSI, which have been put aside in this bachelor assignment due to the defined scope of this assignment, can be resumed in this phase. These promising developments will be discussed in Section 8.4 called 'Future research'.

Providing after care to the employees of RSI ensures the continued use of the GRP and optimal planning process, and prevents the return to the current situation, because the employees of RSI receive continuous support. Support regarding the planning process and the GRP is provided by a central person within the organization. This way the employees of RSI can perform their daily activities as smooth as possible, which contributes to the increasing employee satisfaction regarding their daily activities, the planning process and GRP. In turn, this last step in the action plan guarantees the successful implementation of the optimal planning process and the GRP.

7.5 Discussion

In this chapter the action plan for the implementation of the optimal planning process and the GRP are developed to ensure that the implementation within the organization of RSI is smooth and successful. Each step in the action plan has been developed based on the circular Plan, Do, Check, Act (PDCA) approach. The Plan phase entails identifying and understanding the presented opportunity, which means exploring the information available and presented by the relevant employees and incorporating this information in the developed process or product. Next, the Do phase includes testing the developed process or product thoroughly in the form of a pilot or training in order to show the stakeholders whether the proposed developments achieve their desired outcome. Besides that, this phase includes teaching the relevant employees how the developed process or product works. In the Check phase, the developed process or product is analysed against the expectations, which is in this case in another software environment. When the check is successful continue to the Act phase, otherwise return to the Plan phase to improve the developed product. Finally, the Act phase entails the actual implementation and use of the developed process or product. Here, it should be remembered that this approach is circular, so the improved process or product becomes the new basis but the strive is to look for ways to make the process or product even better. Each step in the PDCA approach is essential for the successful execution of this approach (Mind Tools Content Team, n.d.). According to these defined phases, each step in the action plan has to be executed to obtain the successful implementation of the optimal planning process and the GRP.

7.6 Conclusion

Based on the action plan presented in this chapter, it can be concluded that the action plan entails a step-by-step plan consisting of four key steps, which are all crucial to the successful implementation of the optimal planning process including the GRP. This tailored action plan for RSI's planning process includes the following consecutive steps to be performed by the relevant stakeholders within RSI, such as the manager of the planning:

- Involve employees during the development of the planning process
- Provide trainings and instructions on the planning tool and planning process
- Provide support during the implementation of the software system update
- Provide after care to the employees on the planning process

The focus of each step in this action plan lies on the acceptance of the optimal planning process including the GRP by the employees of RSI next to a smooth transition from the current situation to the updated software system. In turn, the conclusion can be drawn that performing all steps involved in the action plan results in the successful implementation of the optimal planning process and the GRP within the organization of RSI.

Chapter 8 | Conclusions, recommendations and future research

In this bachelor assignment the alternative planning process has been developed to optimize and standardize the planning process of REMONDIS Smart Infra's (RSI) field service based on the selected process workflow diagram. In turn, the graphical resource planning (GRP) has been analysed to build the foundation for REMONDIS Smart Infra's planning tool to be applied in the optimal planning process. The optimal planning process and the GRP developed in this bachelor assignment were presented to REMONDIS Smart Infra and its employees.

Every chapter in this bachelor thesis answers a research question. In contrast, this chapter concludes this bachelor thesis by considering the conclusions of the previous chapters, because these conclusions contribute to answering the main research question of this research. In this chapter the main research question of this thesis is answered:

How can REMONDIS Smart Infra achieve, planning its field service and accompanying resources in the most efficient and effective way possible?

The conclusions and recommendations deduced from this bachelor assignment, which provide the answer to the main research question are presented in Section 8.1 and Section 8.2, respectively. Section 8.3 discusses the contribution of this bachelor assignment to research. Finally, Section 8.4 outlines the potential for future research.

8.1 Conclusions

This section provides the answer to the main research question as presented in the introduction to this chapter based on the intermediate conclusions per chapter of this thesis. The current planning process is defined in terms of current situation measurements. Following, REMONDIS Smart Infra's (RSI) requirements for the optimal planning process including the respective planning tool are identified and weighted. From the literature, the possible process workflow diagrams that can be applied in RSI's alternative planning process are presented. Then, the alternative planning process for the different main activities of RSI is developed. This planning process is evaluated according to a multicriteria analysis and a centralisation analysis. The GRP, its design possibilities and functionalities have been analysed. As follows, a foundation of the GRP is built in the software system. The GRP together with the optimal planning process are evaluated in interim measurements. Finally, the steps to be taken for the successful implementation of the optimal planning process are elaborated. Based on all this research, the following intermediate conclusions can be formulated in the order of the chapters discussed:

- From the measurements of the current situation, the need for an optimal planning process is recognized, especially regarding its functionality, efficiency and effectiveness. These measurements are the benchmark for the evaluation of the optimal planning process after its implementation.

- The requirements of RSI can be categorized into three groups: aesthetics, functionalities and wishes. From these requirements, it can be concluded that RSI values quality and desires a planning process that is efficient, effective and completely fits its business processes. These requirements serve as the benchmark for evaluating the planning tool together with the optimal planning process.

- The flowchart provides the graphic means of documenting and communicating a sequence of operations, which results in the most suitable process workflow diagram for RSI to map its planning process.

- After thorough development and evaluation using different analyses, the alternative planning process should be utilized as the optimal planning process for RSI's field service.

- After evaluating the GRP within the optimal planning process to the requirements of RSI, the GRP can be utilized as the planning tool for RSI's planning process currently exclusively using the capacity overview in Microsoft Excel.
- Applying the action plan developed, which entails a step-by-step plan consisting of four key steps, results in the successful implementation of the optimal planning process.

In turn, the main research question can be answered, which is the conclusion to this research.

How can REMONDIS Smart Infra achieve, planning its field service and accompanying resources in the most efficient and effective way possible?

REMONDIS Smart Infra (RSI) can achieve, planning its field service and accompanying resources in the most efficient and effective way possible by applying the optimal planning process within RSI's business processes as developed in Chapter 4. Furthermore, the GRP should be utilized as RSI's planning tool within the optimal planning process as argued by Chapter 5. Finally, RSI should execute the action plan for the successful implementation of the optimal planning process and the GRP as presented in Chapter 7.

8.2 Recommendations

From the intermediate conclusions stated and the answer to the main research question, the recommendations for REMONDIS Smart Infra (RSI) can be formulated.

- To obtain the optimal results for applying the optimal planning process in RSI's business processes, perform the planning process for S&M and C&R in a hybrid form between a centralized and decentralized planning process as is explained in Chapter 4. In turn, perform the planning process for C&I as a centralized planning process.
- When the GRP is in use by the planners, it is recommended to maintain the GRP design for the optimal planning process as this design has been specifically designed for RSI's field service. This design is based on the different settings in Appendix E and F.
- For the GRP to be used correctly, the specific functionality as elaborated in Chapter 5 and in Appendix E has to be applied when moving an order from one mechanic with a coupled resource to another mechanic with another coupled resource.
- For the time being, it is suggested to keep using the capacity overview in Microsoft Excel besides the planning in the GRP until a better alternative is developed.
- In order to ensure that the optimal planning process and the GRP remain future proof, it is recommended to maintain the standardization, flexibility, speed and quality of the planning process and the GRP design as changes occur in the different business processes.
- To successfully implement the optimal planning process, it is recommended to execute the steps in the action plan as formulated in Chapter 7 and to update this action plan for future use to ensure that the plan remains applicable and valid to different situations.
- During the implementation phase, it is heavily suggested to teach the planners one working method to maintain a standardized and centralized planning (process) across establishments.
- Finally, it is advised to encourage frequent communication between the planners and frequent communication with the mechanics of RSI's establishments to optimize RSI's flexibility, resource utilization and insight in their planning.

8.3 Contributions

In this section, the theoretical and practical contribution of this thesis to research is outlined.

Theoretical contribution
A literature study has been performed within this research on the possible process workflow diagrams for mapping the optimal planning process. The flowchart is the kind of process workflow diagram that has been applied for this purpose. This research proves that it is possible to define the planning process for the field service of a sewage company using the flowchart.

Furthermore, another theoretical contribution has been made by performing a multicriteria analysis and a centralisation analysis on a planning process. In turn, the application of these analyses to the planning process for the field service of a sewage company provides the proof for the successful evaluation of such a planning process using these analyses.

Practical contribution
The practical contribution of this research is to REMONDIS Smart Infra (RSI), because this research is performed for this company. This contribution entails the analysis of the graphical resource planning (GRP) and the foundation built in the GRP. Besides that, the alternative planning process developed for the field service of RSI in combination with the action plan allows RSI to implement this optimal planning process successfully. By implementing the alternative planning process including the GRP as the planning process for their field service, the company can improve their planning process based on the performed research in terms of ensuring that the planning across all establishments is standardized and future-proof.

8.4 Future research

This bachelor assignment has been performed in the scope of ten weeks at REMONDIS Smart Infra (RSI), which prevented the execution of an extensive research. Furthermore, this research has been executed largely during the COVID-19 pandemic resulting in the measurements being performed under deviating conditions. Consequently, some measurements might be invalid. This section outlines the possible future research.

- During the ten weeks of executing this thesis, the updated software system is not yet implemented within the organization of RSI. The implementation and full evaluation of the optimal planning process was therefore not possible. Future research can pursue this subject.
- This research is specifically focussed on developing the alternative planning process for RSI with respect to handling time, clarity, functionality, practicality and standardization. Future research can be done to investigate the impact of the optimal planning process beyond these aspects, like resource utilization, to optimize RSI's planning process in its entirety.
- RSI desires the implementation of a manual planning tool that supports the planners with a clear graphical interface instead of the implementation of decision support within the software system. Decision support could contribute to automating the planning process to a large extent, which is a development that can be pursued in future research.
- After performing the research on the graphical resource planning (GRP), the GRP did not meet all requirements of RSI, such as a separate capacity overview, automation in the form of autocorrect or other requirements. Future research can pursue further development of the GRP in cooperation with the software company, so these requirements are met.
- From investigating the GRP, it can be concluded that there exists a project overview in the GRP in the form of the 'Gantt chart'. However, this overview cannot be applied yet in RSI's business processes due to the way RSI registers its projects within the software system. So, further research needs to determine the right working method within the updated software system to optimally use the 'Gantt chart' in the planning process. In the future, this working method can be investigated and worked out.

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Appendix

Appendix A – Measurements of the current situation

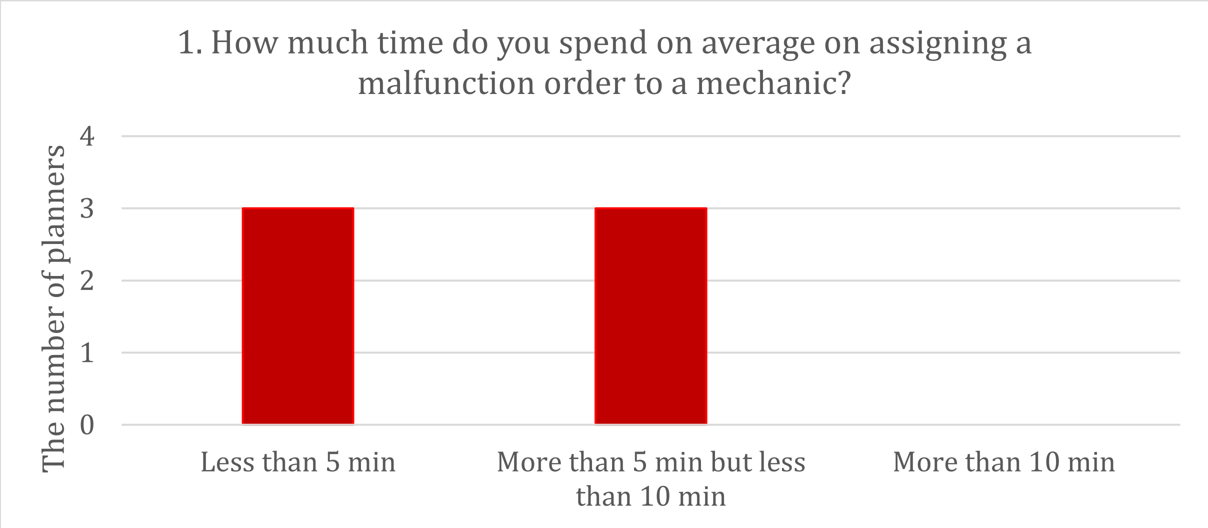

Figure 2.1: Duration of planning a malfunction order

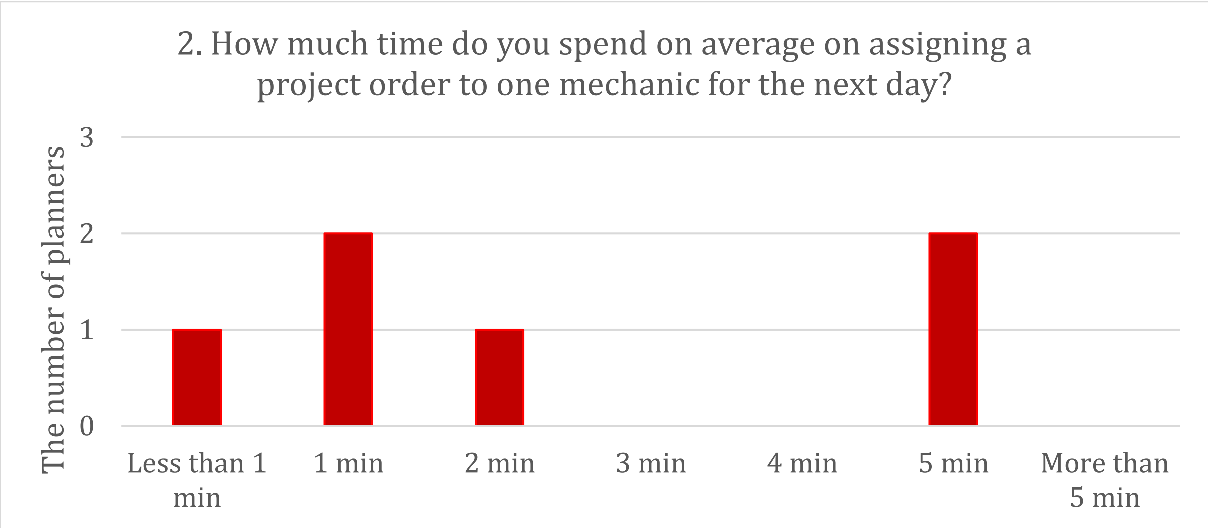

Figure 2.2: Duration of planning a project order to one mechanic

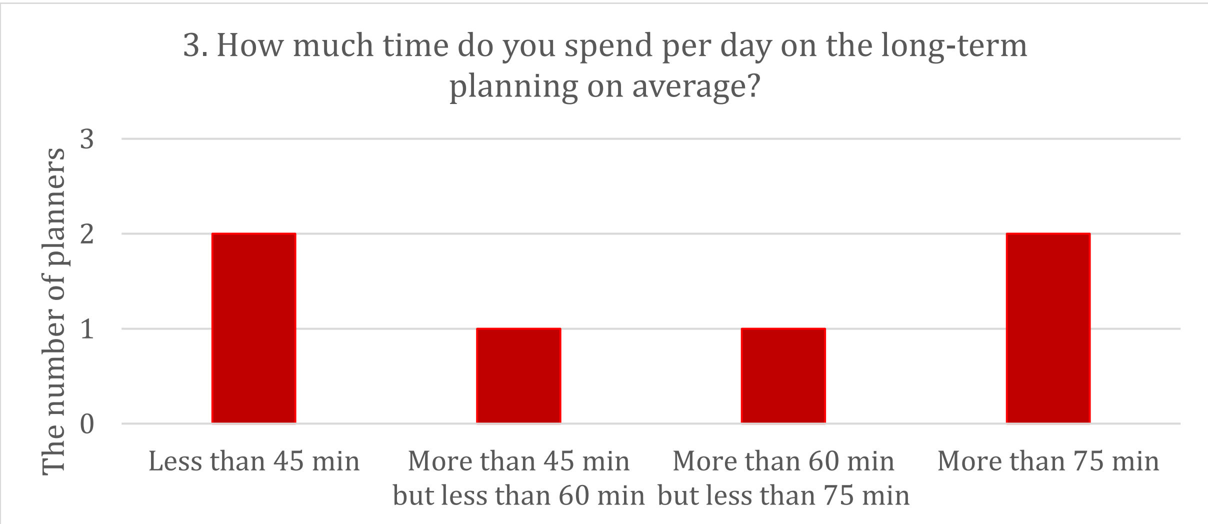

Figure 2.3: Duration of determining the long-term planning per day

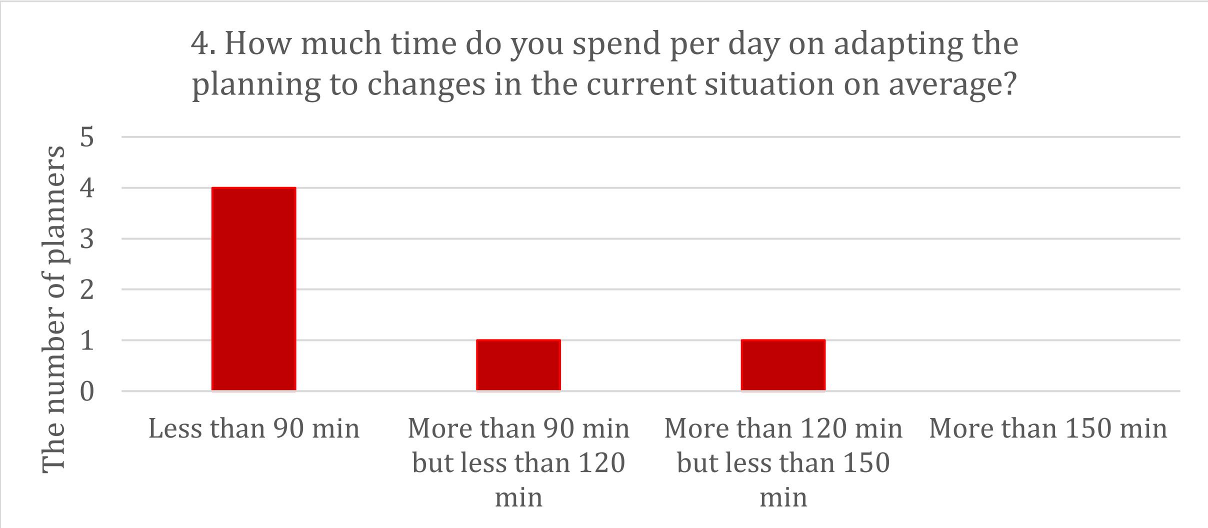

Figure 2.4: Duration of adapting the planning of the various operations per day

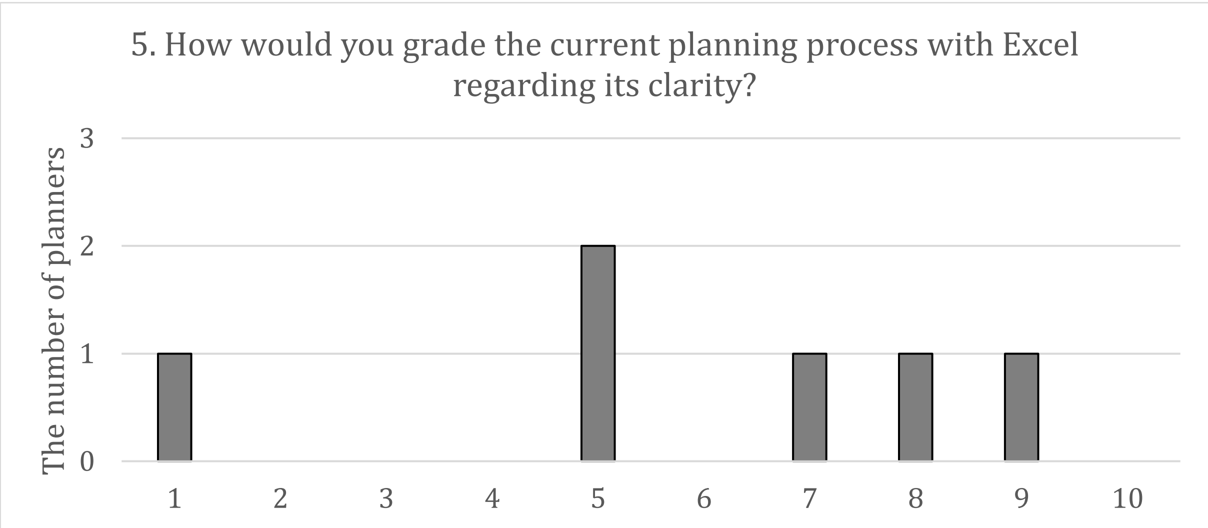

Figure 2.5: Satisfaction grade for the current planning process regarding its clarity

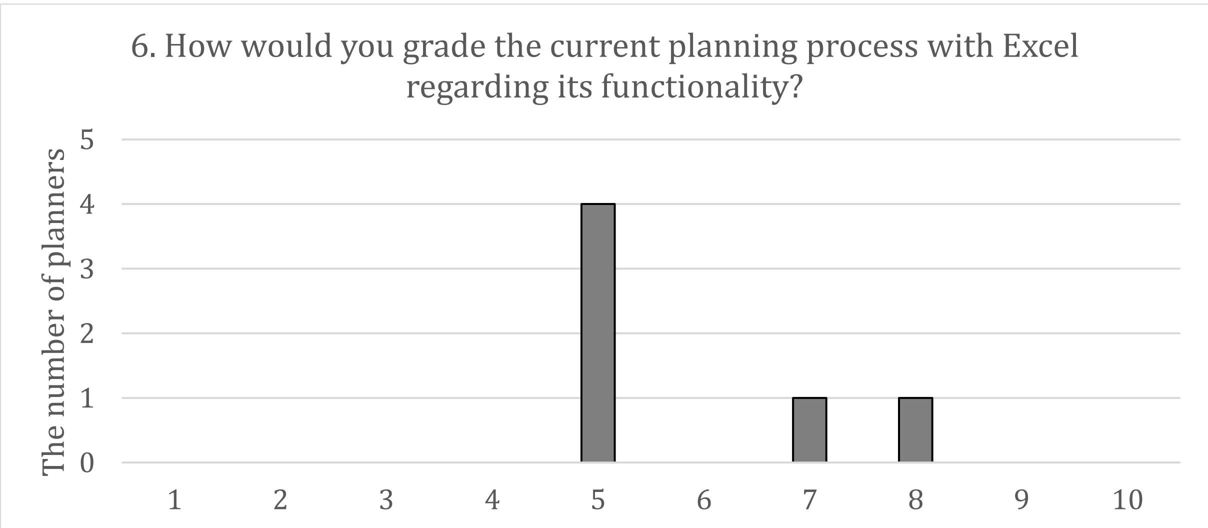

Figure 2.6: Satisfaction grade for the current planning process regarding its functionality

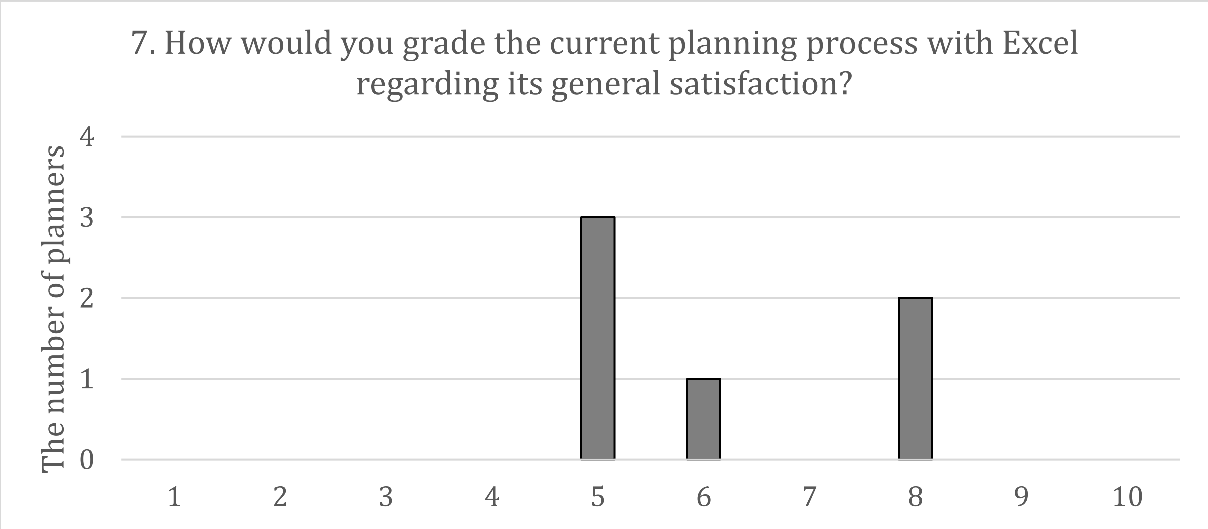

Figure 2.7: Satisfaction grade for the current planning process in general

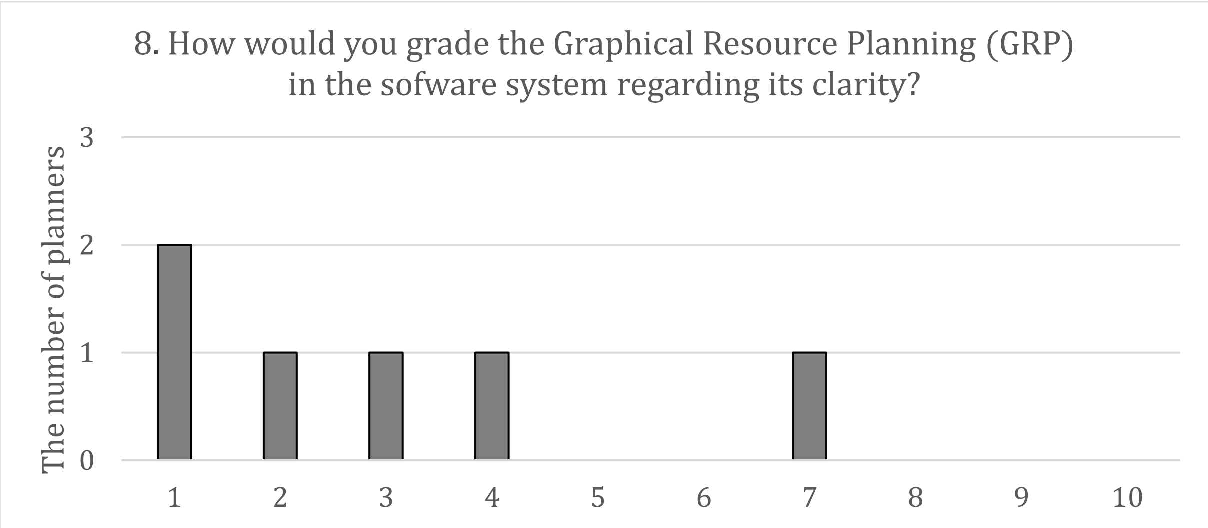

Figure 2.8: Satisfaction grade for the GRP regarding its clarity

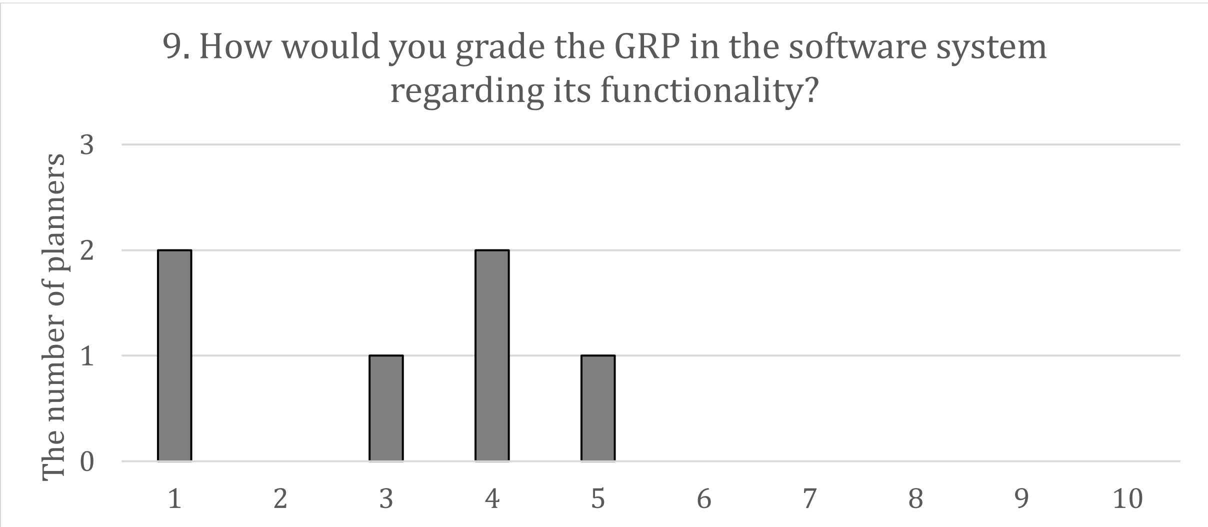

Figure 2.9: Satisfaction grade for the GRP regarding its functionality

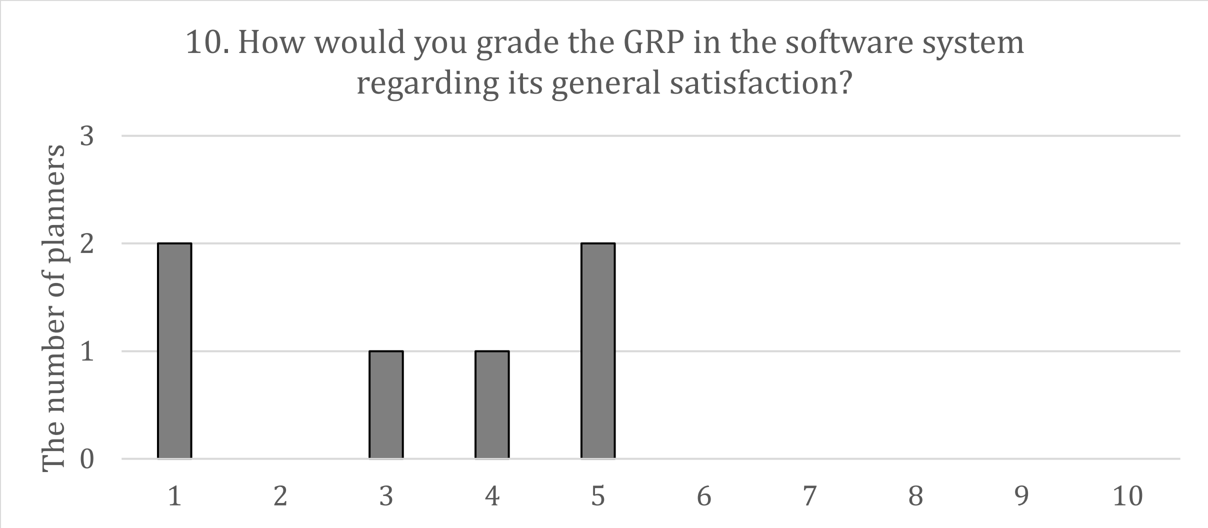

Figure 2.10: Satisfaction grade for the GRP in general

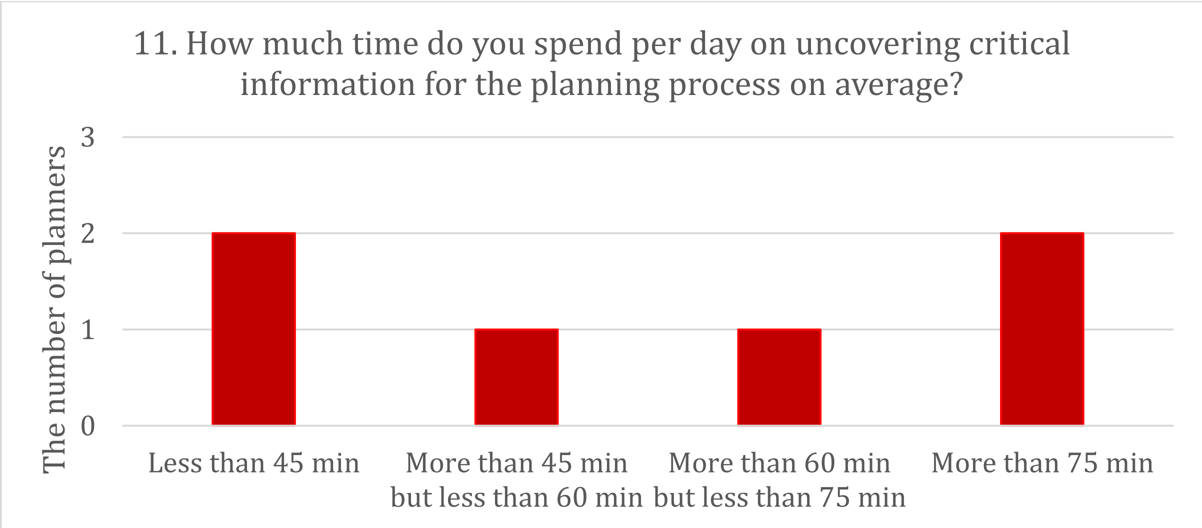

Figure 2.11: Duration of uncovering critical information for the planning process

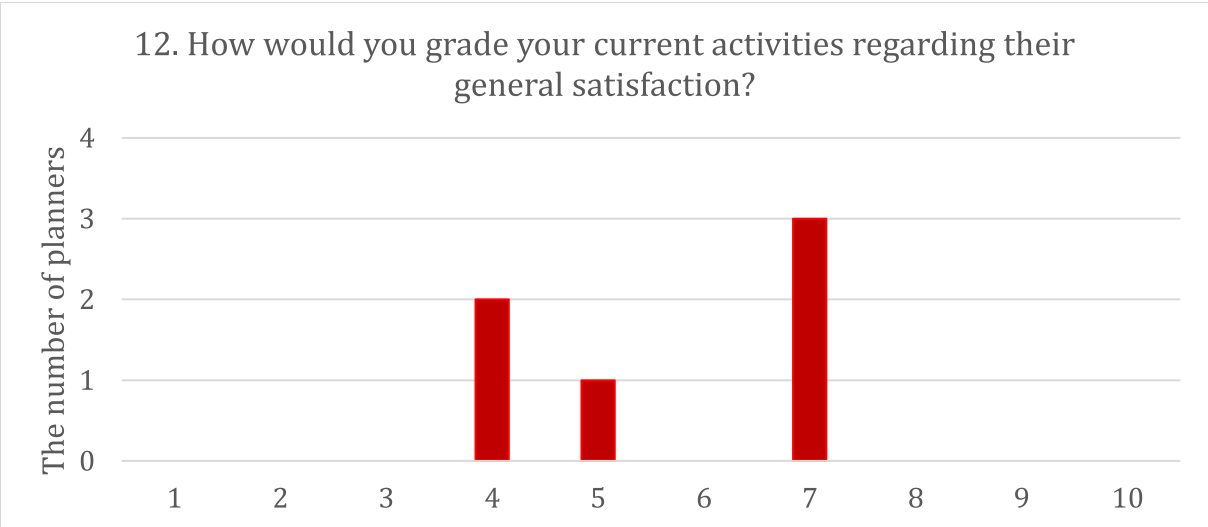

Figure 2.12: Satisfaction grade for the planners' current activities in general

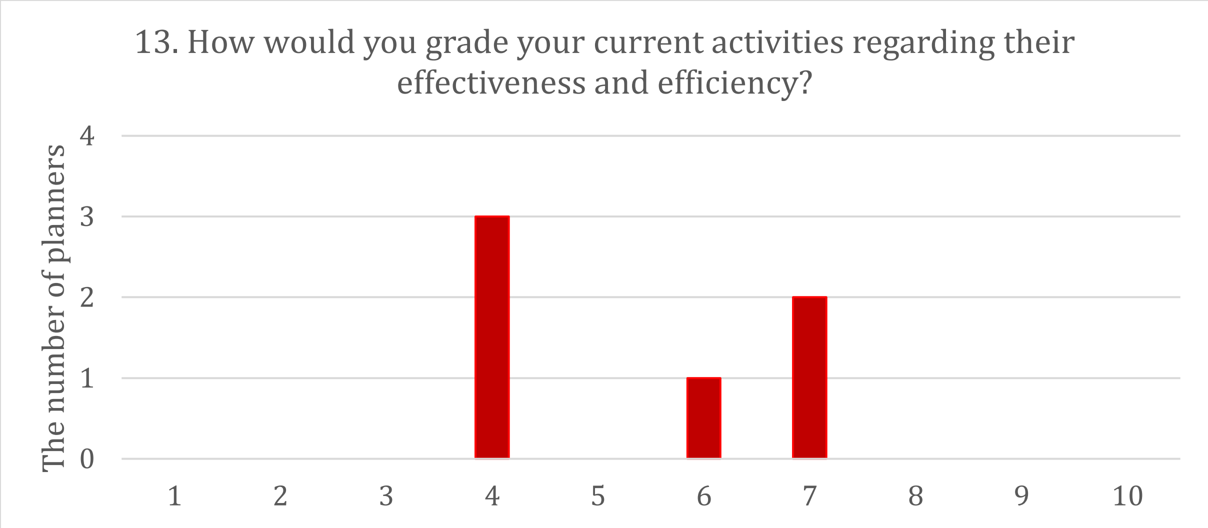

Figure 2.13: Satisfaction grade for the planners' current activities on effectiveness and efficiency

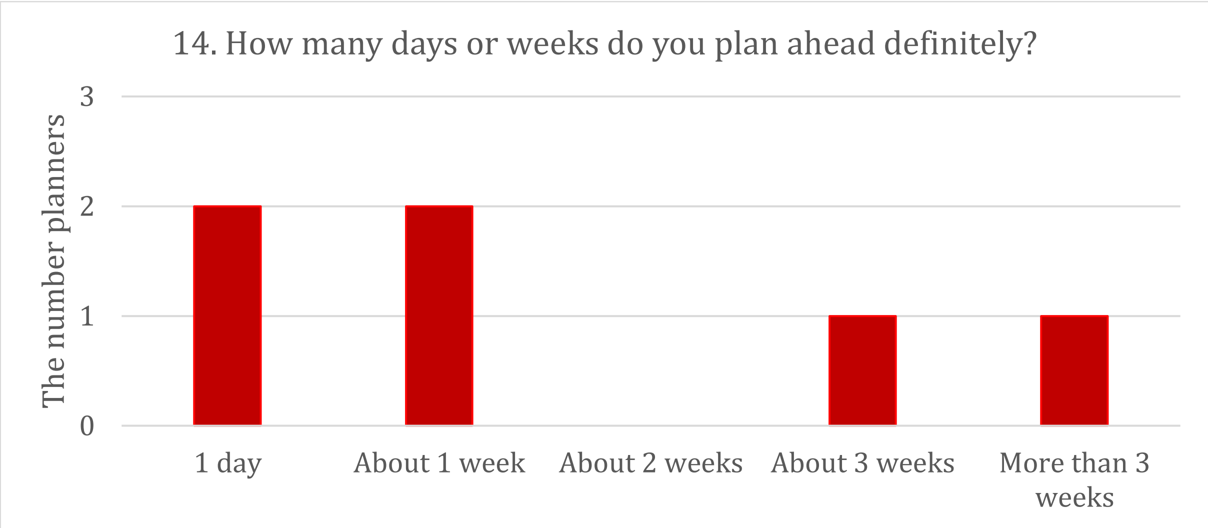

Figure 2.14: Number of days or weeks a planner plan ahead definitely

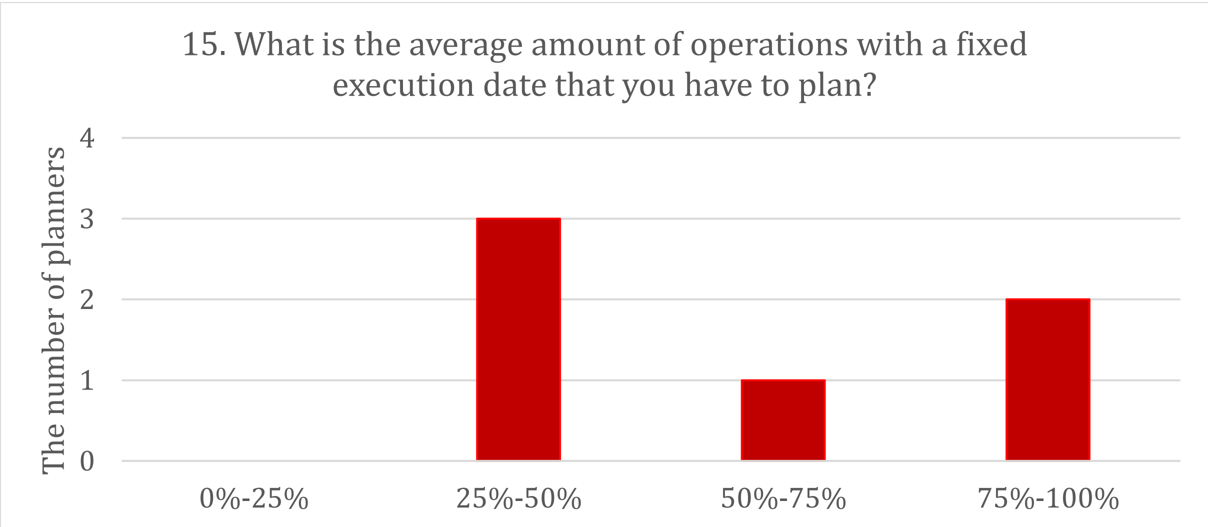

Figure 2.15: Percentage of operations with a fixed execution date

Appendix B – Requirements and wishes for the planning process including GRP

Table 2.4: Aesthetics requirements for the planning process and GRP

Aesthetics	Description	Importance
Colour diversity	Use different colours for different operations and mechanics.	III
Clarity in display	Having a clear overview of operations in various viewing modes (evenly sized blocks in day/week/month mode).	IV
Add notes	Ability to add notes to operations in the planning.	I
Standardized format in planning	Create a standardized format for all planners in the planning tool.	IV
Standardized filters of the planning per establishment	Identical application of filters only distinguished per establishment.	IV
Security and protection of the planning	Determine who is allowed to change the planning and who is only allowed to view (possibly with lock or password).	II
Total and complete overview	Overview of all clients, (not yet planned) contracts, projects and separate work. Also, including the weeks, mechanics and resources to be planned (including their absence).	IV
Immediate view of critical information	View critical information of an operation at once in the planning tool, such as the client name, the location of an operation, the priority of an operation, et cetera. (No clicking on the event in order to see this information).	III

Table 2.5: Functionality requirements for the planning process and GRP

Functionality	Description	Importance
Standardized planning process	Enable a standardized way of planning among the planners.	I
Capacity overview in GRP	Overview of the capacity used that includes the free days of the employees (total sum of hours of resources used per day).	IV
Relocate operations in the planning in time (GRP)	Moving planned projects, contracts or other work flexibly and automatically through time.	III
Relocate operations in the planning between resources (GRP)	Moving planned projects, contracts or other work flexibly and correctly between resources.	II
Automatically relocating frequent operations (GRP)	Capability of relocating operations with a frequency automatically in the planning when one's date has been changed.	III
Assigning malfunctions to resources in between other planned operations	Adding malfunctions and other operations smoothly into the planning between current operations. The current operations move automatically.	IV
Reserving a mechanic in the GRP	Plan an event as a reservation of a mechanic without a definitively assigned operation.	II
Planning for the coming year	Ability to plan on a yearly perspective (insight in free days, future project/contracts, planned mechanics).	IV
Planner's ability to plan in GRP	Possessing the ability and skills to actually plan from the GRP.	III
Update of progress in GRP	Show the number of operations needed to be done for completion of a project or contract.	III
Knowledge of the planning tool	Any (involved) employee should understand the planning tool and know how to work with it.	III
Automatically determining and assigning working days	Determining the number of working days for a resource automatically when the number of operations is known and assign these working days to mechanic right away.	II
Implementation of autocorrect	Automation of autocorrect introduced in GRP	I
Distance between consecutive steps in GRP	Distance on the screen of the planning tool between consecutive steps in the planning process are short.	III

Table 2.6: Wishes for the planning process and GRP

Wish	Description	Importance
Plan per project or per contract	Assign a mechanic to a project or a contract.	II
Centralized planning for Cleaning & Inspection	Executing the planning process from one establishment for multiple establishments and all their operations.	II
Decentralized planning for Service & Maintenance and Construction & Renovation	Executing the planning process from each individual establishment with its own planners for its own operations.	II
Allow faster operating in the planning process and planning tool	Enlarged capacity and power of the server is required.	III
Test GRP in advance	Implement the existing Excel planning in the GRP during development.	I
Involve the employees in the development process	Include employees of RSI in development of the GRP and planning process.	III
Improve communication between planners	An action plan on how to increase the contact between planners.	III
Allow the planning of an increased number of mechanics	Possibility to scale up the planning of mechanics from 20 to 40 mechanics.	I

Appendix C – Alternative planning process

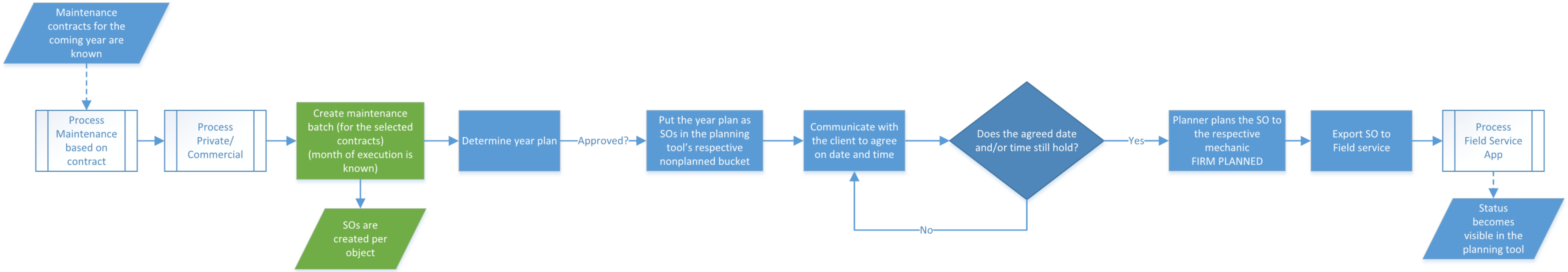

Figure 4.5: Alternative planning process for Maintenance: Private/Commercial of S&M

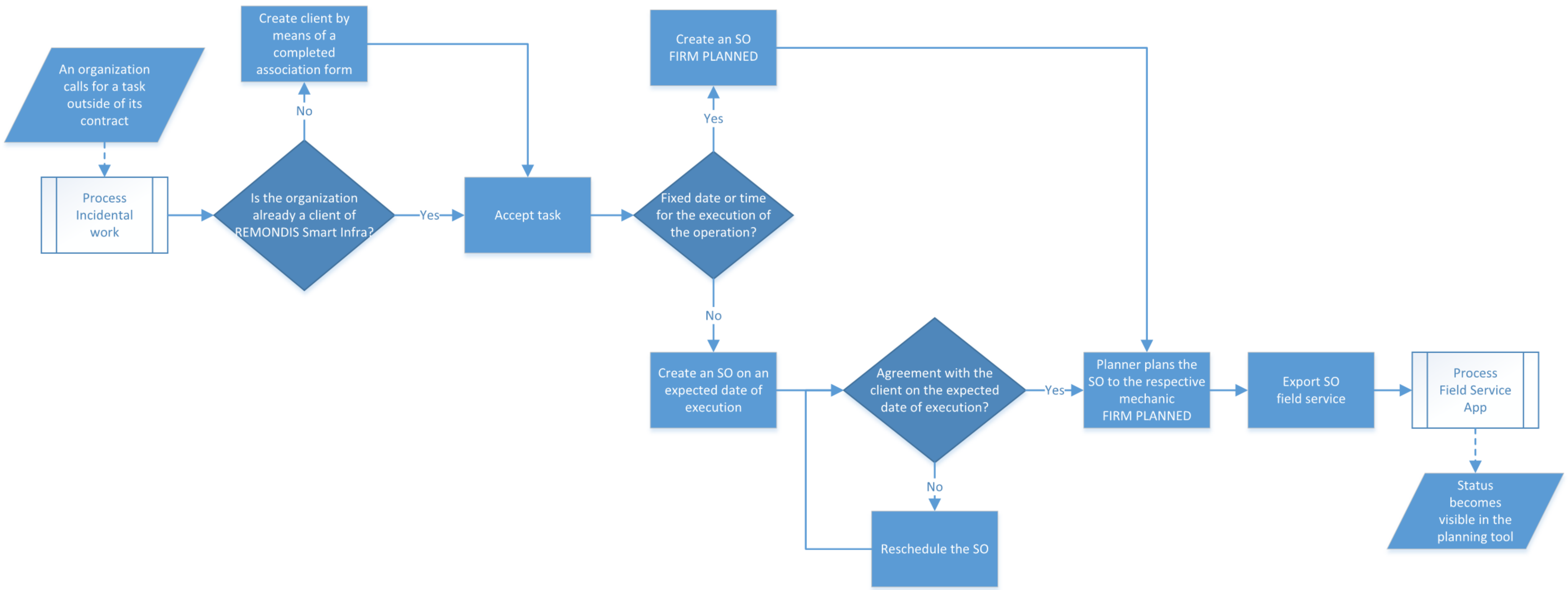

Figure 4.6: Alternative planning process for Incidental work of S&M

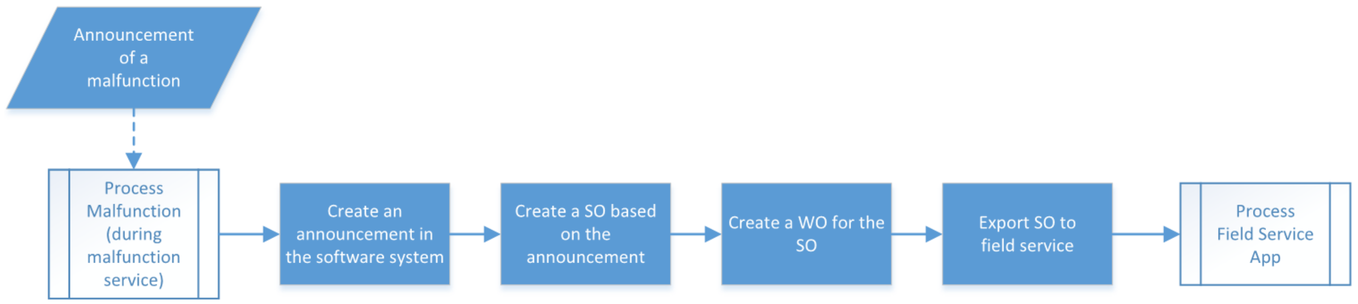

Figure 4.7: Alternative planning process for Malfunction during malfunction service of S&M

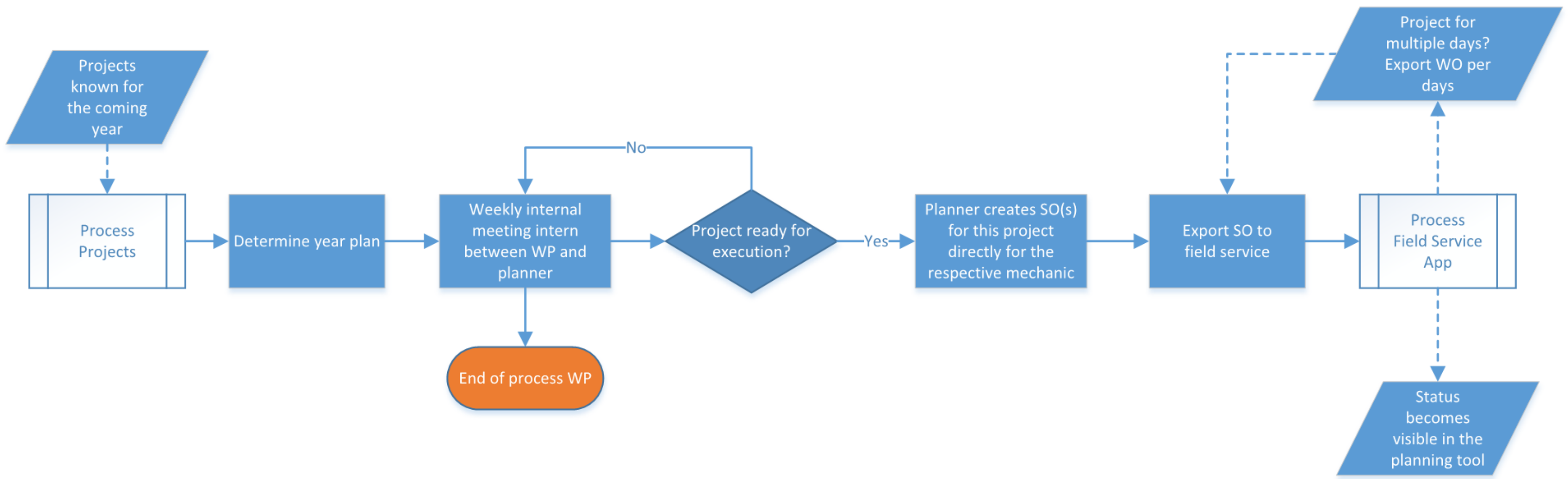

Figure 4.8: Alternative planning process for Projects of C&I

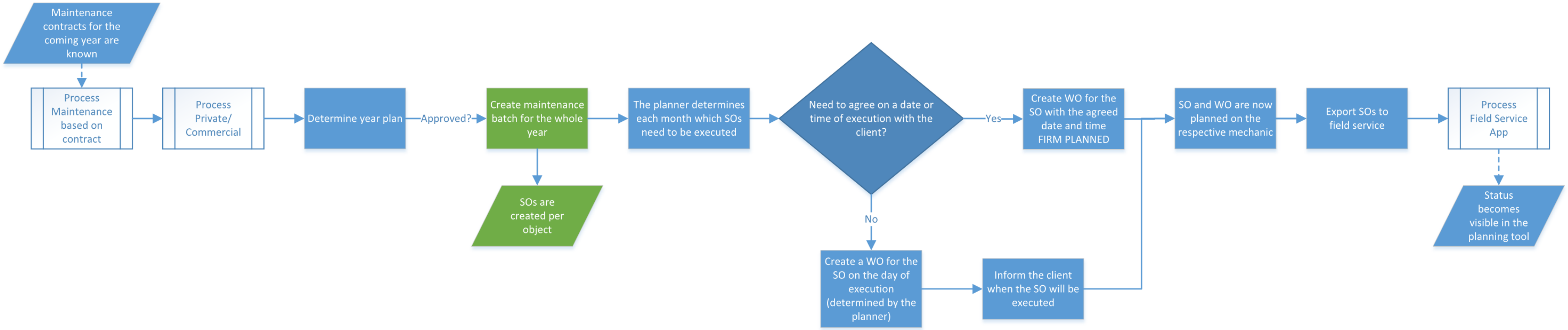

Figure 4.9: Alternative planning process for Maintenance: Private/Commercial of C&I

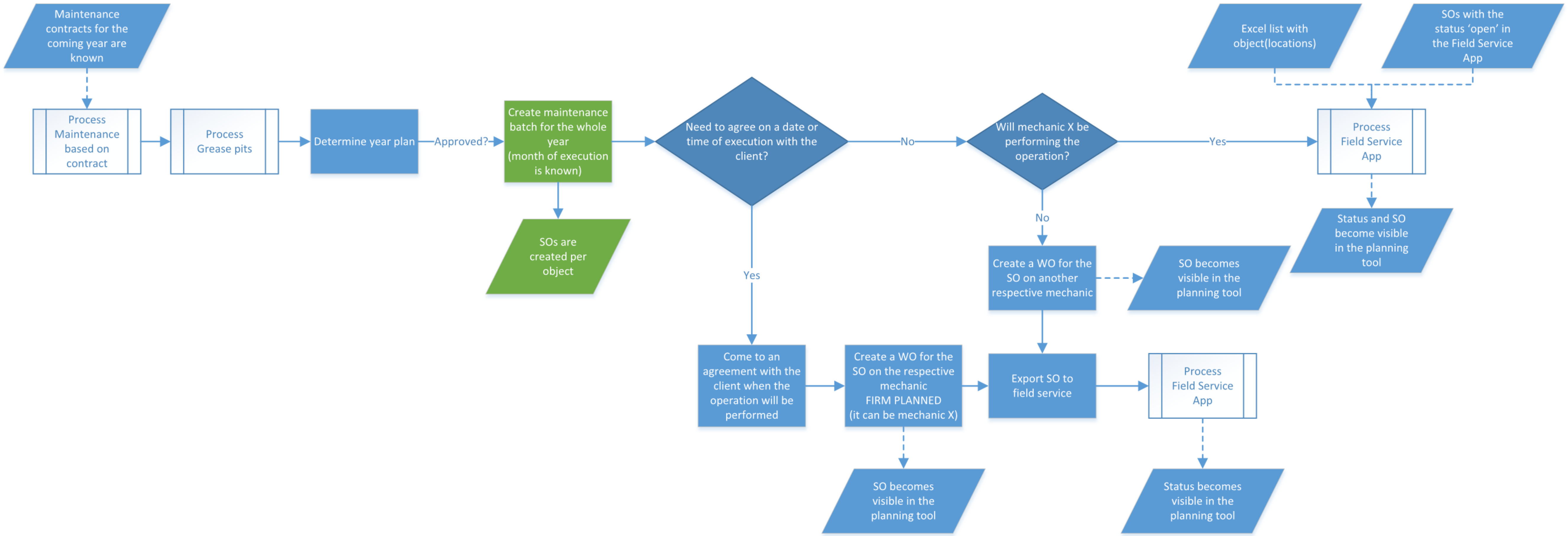

Figure 4.10: Alternative planning process for Maintenance: Grease pits of C&I

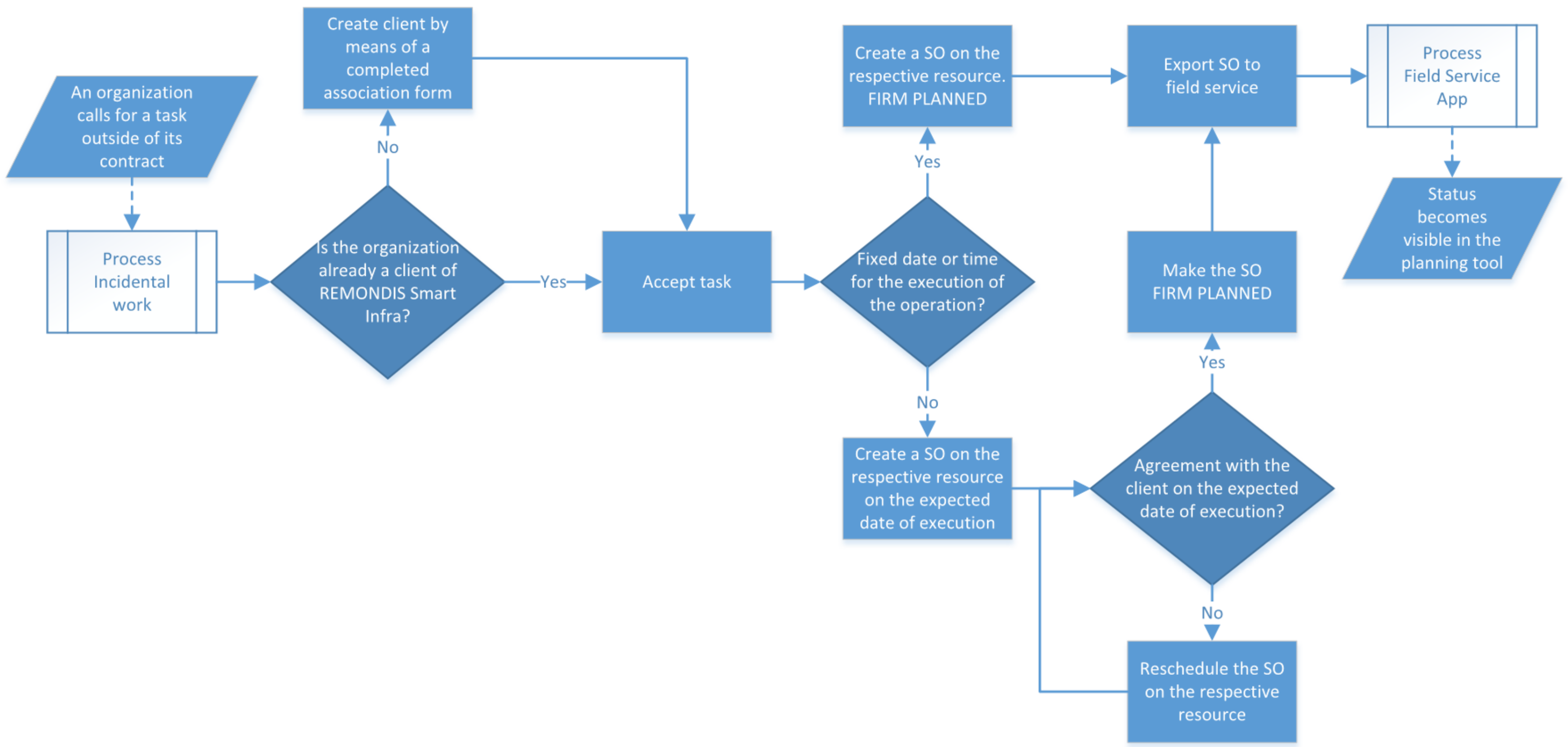

Figure 4.11: Alternative planning process for Incidental work of C&I

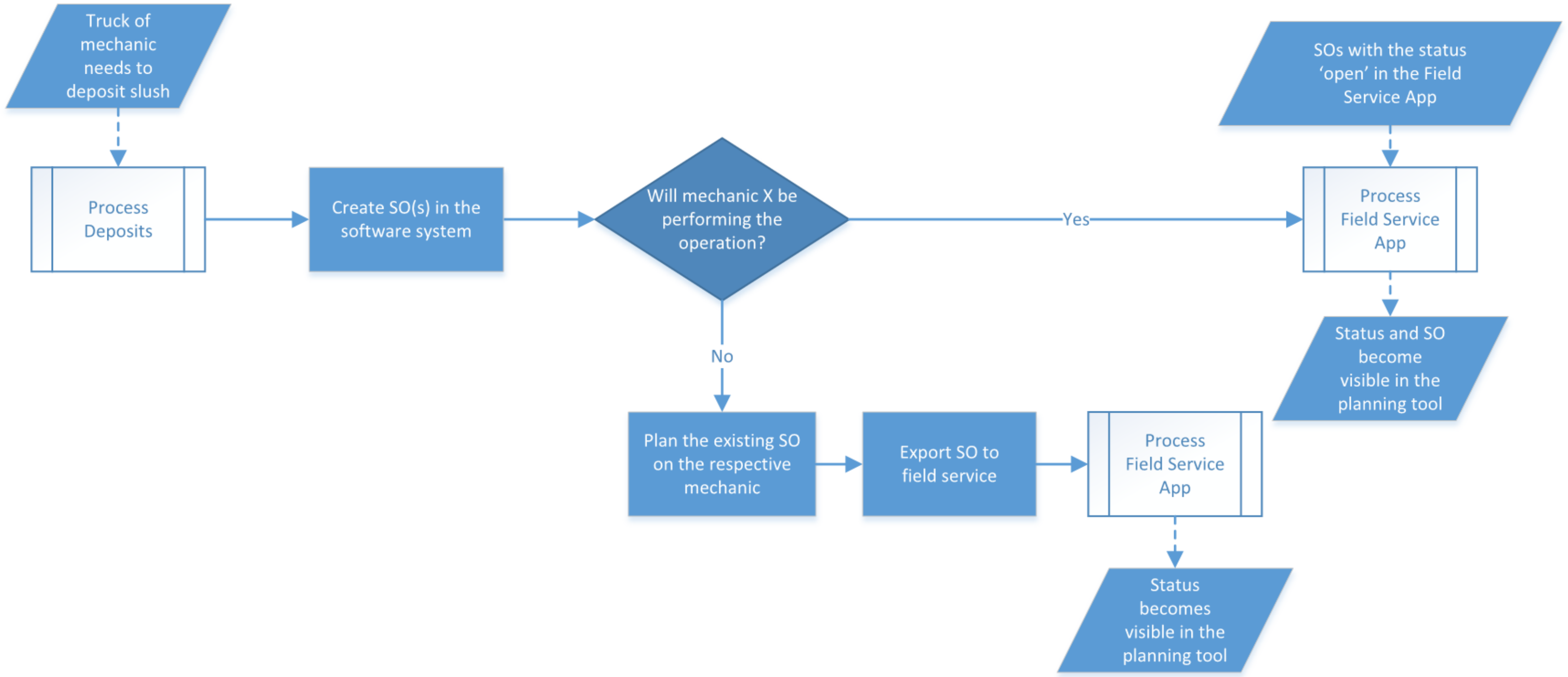

Figure 4.12: Alternative planning process for Deposits of C&I

Appendix D – Assessment of the planning process alternatives

Table 4.4: Planner 1's assessment of the planning process alternatives

Options	Duration of steps in the planning process	Insight in the planning	Utilization of resources	Time needed to learn working with the planning process	**Total score (weighted)**
Current process	50	45	85	65	59
Alternative process	75	45	90	55	71
Weight	45	20	25	10	100

Table 4.5: Planner 2's assessment of the planning process alternatives

Options	Duration of steps in the planning process	Insight in the planning	Utilization of resources	Time needed to learn working with the planning process	**Total score (weighted)**
Current process	45	50	90	75	62
Alternative process	70	55	95	70	73
Weight	35	30	30	5	100

Table 4.6: Planner 3's assessment of the planning process alternatives

Options	Duration of steps in the planning process	Insight in the planning	Utilization of resources	Time needed to learn working with the planning process	**Total score (weighted)**
Current process	50	55	80	80	63
Alternative process	60	45	90	65	68
Weight	40	20	35	5	100

Table 4.7: Planner 4's assessment of the planning process alternatives

Options	Duration of steps in the planning process	Insight in the planning	Utilization of resources	Time needed to learn working with the planning process	**Total score (weighted)**
Current process	55	55	85	80	67
Alternative process	75	50	85	70	71
Weight	35	25	30	10	100

Table 4.8: Planner 5's assessment of the planning process alternatives

Options	Duration of steps in the planning process	Insight in the planning	Utilization of resources	Time needed to learn working with the planning process	**Total score (weighted)**
Current process	60	60	90	75	68
Alternative process	70	55	85	65	70
Weight	45	25	25	5	100

Table 4.9: Planner 6's assessment of the planning process alternatives

Options	Duration of steps in the planning process	Insight in the planning	Utilization of resources	Time needed to learn working with the planning process	**Total score (weighted)**
Current process	40	55	80	75	56
Alternative process	70	50	95	65	70
Weight	40	30	25	5	100

Appendix E – Analysis of the Graphical Resource Planning

In this appendix, the analysis of the graphical resource planning (GRP) is outlined. The analysis consists of two components, namely the design possibilities in the GRP and the functionalities of the GRP. The design of the GRP can be formed based on the possible settings in the software system, which will eventually determine the foundation built in the GRP. The functionalities of the GRP have a fixed composition, which should be identified in order to incorporate the GRP into the optimal planning process. Section E.1 describes the design possibilities in the GRP by means of the different settings available in the software system for the GRP. Section E.2 describes all functionalities possible in the GRP to facilitate the optimal planning process. Section E.3 outlines the steps to be performed in the specific functionality as presented in Chapter 5, which has been developed in the GRP to enable RSI's planning process with the GRP.

E.1 Design possibilities

One of the aspects to the GRP entails the many design possibilities. Here, the design possibilities for general and fixed components of the GRP are described.

General settings

Within the GRP itself, there is a direct option to adjust the design of the GRP, which influences the 'Employee vs project view', the 'Views per user' and the 'Day, week and month view'. This can be done in the general settings menu within the GRP. The general settings that influence all views are called:

- 'Resourceview'
- 'Standard planning horizon'
- 'Full screen'
- 'Display time while moving events'
- 'Automatic refreshing'

The 'Resourceview' is explained under the section 'Views per user'. The 'Standard planning horizon' allows the user to determine how far the user would like to view the planning into the past or future. The total number of days to distribute over the past and future is 91 days. The 'Full screen' is an on/off switch where the user can indicate whether the user would like to view the GRP on the entire screen or not.

Next to that, the 'Display time while moving events' is also an on/off button, where the user can define whether the user would like to see the start and end time over a selected period. Finally, the 'Automatic refreshing' is an on/off button too that allows the user to determine whether the GRP should refresh automatically or the user should do this manually. When the user chooses for the automatic refreshing of the GRP, the user can determine the refreshing interval in seconds.

More specific settings are explicitly described under the following sections.

Employee view vs Gantt chart

The GRP has two main views, which are called the 'Employee view' and the 'Gantt chart'. The user will be able to switch between these views with one press of a button in the GRP. The 'Employee view' displays the planning from the perspective of the mechanics, trucks and other possible resources depending on the 'Resourceview' as explained in section 'Views per user'. This allows the user to plan an operation on a mechanic or another resource. The 'Gantt chart' displays the planning from the perspective of the projects, orders, reservations and absences. This view allows the user to plan a mechanic or another resource to a specific operation. A restriction to this view is that an operation can only be viewed and planned in this view when that operation has been planned to a mechanic or another resource in the 'Employee view'.

Views per user

The views per user are determined in the 'Resourceview' in the GRP general settings menu, which are predetermined and fixed in the user settings of the software system. The 'Resourceview' allows the user of the GRP to switch between different kinds of views of the mechanics and trucks. Examples of this are the 'Classic view' and the 'Resources employee'. Within the user settings, the software system allows the user to build his own 'Resource view'. An example of this is a view for the coupled resources. In short, coupled resources entail that a mechanic and a truck or colleague are attached to each other in the software system, because they usually work together.

Day, week and month view

In the GRP, the user can switch between the day, week and month view. These views can be designed separately, because the day, week and month view have their own settings menus within the general settings menu in the GRP. Under 'Daysettings', it is possible to design the day view. The following settings can be adjusted to design the ideal day view:

- 'Timescale'
- 'Show working hours'
- 'Limit hours on screen'
- 'Show weekend'
- 'Align on grid'
- 'Columnwidth'
- 'Row height'

The 'Timescale' allows the user to determine at which scale the user would like to view the planning, such as eight hours, twelve hours or one day. The 'Show working times' is an on/off button that indicates whether the working times in the planning are explicitly shown by marking non-working hours grey. The 'Limit hours on screen' is also an on/off button which allows the user to define the hours of day that are shown on screen when the switch is turned on, for example from 6:00 until 18:00. Next, the 'Show weekend' is an on/off button too, which results in the weekend being shown or removed from the planning. The 'Align on grid' on/off button provides the user with the option to plan an event by selecting a minimal timestep of a day or a minimal timestep as defined by the user in 'Minimal step (in minutes) for timing events', which can be for example fifteen minutes, thirty minutes or one hour. Lastly, the 'Columnwidth' and the 'Row height' determine the size of the columns and rows in the planning. These settings are expressed in percentages, where 100% represents the standard size.

'Weeksettings' allows the user to design the week view. This settings menu includes the following settings to design the optimal week view:

- 'Show working times'
- 'Limit hours on screen'
- 'Show weekend'
- 'Align on grid'
- 'Columnwidth'
- 'Row height'

These settings have an identical function as in the settings menu 'Daysettings'.

Finally, the 'Monthsettings' presents the settings for which the design of the month view can be optimised. These settings entail:

- 'Limit hours on screen'
- 'Show weekend'
- 'Align on grid'
- 'Columnwidth'
- 'Row height'

All these settings function in the same way as in the settings menu 'Daysettings', except for the 'Align on grid' setting. In the 'Monthsettings', the 'Align on grid' on/off button provides the user with the option to plan an event by selecting a minimal step of a month or a minimal step of a minute.

Fixed settings

As previously mentioned under the section 'Views per user', the software system allows for certain settings to be fixed in the GRP. As a result, the GRP design can be standardized. The fixed settings are determined in the user settings per user. After the fixed settings have been determined for one user, these setting can be copied to other users of the GRP.

The general fixed settings are called:

- 'Automatic refreshing'
- 'Full screen'
- 'Show new window'

The 'Automatic refreshing' and the 'Full screen' settings function in the same way as explained in in section 'General settings'. The 'Show new window' determines whether a new tab window in the internet browser will be opened when for example a new window is about to open for creating a new event to plan an operation.

Events

In the fixed settings of the GRP within the software system, the events of the GRP can be designed. An event in the planning is a representation of a planned operation at a certain moment in time in the form of a rectangular block. The design of an event entails the following aspects, namely the information presented on the event and the colour of the event. For the information presented on the event, it is possible to display two lines of text, which can display:

- 'Work order number + description'
- 'Work order description + number'
- 'Client'
- 'Source'
- 'Address'
- 'Log moment'
- 'Event type'
- 'Service order priority'
- 'Ordertype'
- 'Order sort'
- 'Location'

The colour of an event can be defined based on different attributes of the event, which are called:

- 'Log moment'
- 'Sub sort'
- 'Order sort'
- 'Priority'

Each attribute has multiple components to which a different colour can be defined. Examples of this are 'Malfunction' and 'Maintenance' defined as 'Sub sort', where 'Malfunction' is assigned the colour red and 'Maintenance is assigned the colour green. When for example the 'Sub sort' 'Malfunction' is chosen while creating an event, the event will appear red in the planning. In the software system, it is possible to assign any colour imaginable to each component of an attribute.

Next to the design of an event itself, there exists an event pop-up, which displays more detailed information about the event. The event pop-up can also be designed in the fixed settings of the GRP within the software system, where the information presented in this pop-up is the only aspect that can be designed. Here, it is possible to display six lines of text. The options for the text include:

- 'Source'
- 'Client'
- 'Work order'
- 'Date'
- 'Log moment'
- 'Event type'
- 'Address'
- 'Inspection number'
- 'Lead time'
- 'Charging to a project'
- 'Remarks'
- 'Priority'
- 'Ordertype'

Mechanics
Next to the events, the resources of RSI on the left side of the 'Employee view' in the GRP – also called the first column – can be designed too in the fixed settings of the software system. This can be done for the mechanics as well as the trucks separately. Just like the event pop-up, the information presented in the first column for the mechanics can solely be adjusted. In this first column in the 'Employee view' of the GRP, it is possible for the mechanics to display two lines of text, which can contain the:

- 'Employee number'
- 'First name'
- 'Last name'
- 'Full name'
- 'Resource number'
- 'Company name'
- 'Postal code'
- 'Location'
- 'External'

Also, there exists a pop-up for the mechanics in this first column, which presents more detailed information about the mechanic. The fixed settings for the GRP in the software system allow for the mechanic pop-up to be designed regarding the information presented in this pop-up. In the mechanic pop-up, it is possible to display six lines of text, which can include the:

- 'Employee number'
- 'First name'
- 'Last name'
- 'Resource number'
- 'Company name'
- 'Discipline'
- 'Qualifications'

Furthermore, a specific option for the mechanics presented in the first column of the 'Employee view' exists. This option entails the creation of a non-planned bucket, which can be constructed as a non-existing mechanic. Therefore, this non-planned bucket will appear at the bottom of the first column alongside the actual mechanics. This non-planned bucket allows the planner to reserve an operation as an event in the GRP at a specific time and date without knowing who is going to execute that operation. This way the planner creates a clear overview of the operations that still have to be planned to a mechanic for the operation to be executed.

Trucks
Lastly, the design of the trucks in the GRP can also be adjusted in the fixed settings of the software system regarding the GRP. These trucks are also located in the first column of the 'Employee view' in the GRP, which is the most left column in the view, alongside the mechanics. The information presented on the first column for these trucks is the only aspect that can be designed. For the trucks in the first column in the 'Employee view' of the GRP, it is possible to display two lines of text. These lines of text can show the:

- 'Material number'
- 'Material type'
- 'Resource number'
- 'Company name'
- Inspection number'
- 'Resource name'

For the trucks, there also appears a pop-up of the truck in the 'Employee view' when standing on a truck with the computer mouse, which shows more detailed information about the truck. What detailed information is presented in the truck pop-up can be defined in the fixed settings of the software system. In the truck pop-up, it is possible to display five lines of text that can show the following information:

- 'Material number'
- 'Material type'
- 'Resource number'
- 'Company name'
- 'Inspection number'

E.2 Functionalities offered

In this section, the standard functionalities in the graphical resource planning are explained in detail. These functionalities will also be applied in the planning process of RSI, because these functionalities provide the process with increased flexibility, speed and clarity in the planning. The following functionalities are described in this section:

- ‘Input screen settings’
- ‘Moving events’
  - ‘Moving events while maintaining a fixed period in time’
- ‘Copying events’
- ‘Selecting multiple events’
  - ‘Deselecting events’

Input screen settings

When creating an event for planning an operation by selecting a certain period in time for a resource in the GRP, a new screen will appear in front of the GRP where the following information has to be completed. This information and what has to be filled in requires further explanation.

- ‘Source type’: The source type can be a:
  - **Reservation:** A reservation is made for the selected resource. This option is shown as the standard option.
  - **Service order:** The resource is planned for a service order.
  - **Project:** The resource is planned for a project.
  - **Absence:** The resource is registered as absent for the selected period.
- ‘New source’: When this box is checked, this event is a new source.
- ‘Existing source’: When this box is checked, the event to be planned already exists in the software system. The box ‘New source’ is automatically deselected and vice versa.
- ‘Reservation/Service order/Project/Absence reason’: The name of this field is dependent on the ‘Source type’ that has been selected. This field will be grey and unavailable when the event is a ‘New source’. When the event is an ‘Existing source’, the respective event can be selected in this field.
- ‘Events per day’: When this box is checked, events are made per day for the selected period of time. When this box remains unchecked, one large event is created for the selected period of time.
- ‘Coupled resources’: Check this box when the coupled resource has to be planned or reserved for that operation as well.
  - As a reminder, coupled resources entail that a mechanic and a truck or colleague are attached to each other in the software system, because they usually work together.
- ‘Firm planned’: When this box is checked, the event cannot be moved in time anymore. However, it will still be possible to move the event to another resource. To see if an order is ‘Firm planned’, the event planned in the GRP will show a symbol that combines a lock and clock in the bottom right corner of the event.
- The ‘Source type’ Absence has its own way of being ‘Firm planned’. In this case, when a resource has been registered as absent, this event cannot be moved to another resource. However, it is possible to move this event in time. This kind of ‘Firm planned’ is displayed by a symbol that combines a lock and person in the bottom right corner of the event.

Any grey field in the input screen means that the respective field cannot be filled in for that specific ‘Source type’.

Moving events

Moving on to the functionalities, it is possible to move an event from one resource to another resource (mechanic) in the ‘Employee view’. Here, it applies that the event can be moved:

- From mechanic to mechanic
- From material to material (truck)
- From one point in time to another point in time

Moving an event from one point in time to another point in time is only possible when the event is not ‘Firm planned’ as explained in ‘Input screen settings’.

Performing the following steps allows the user to move an event:

1. Select the event in the GRP that has to be moved by clicking on it.
2. Drag the event to the preferred mechanic, material (truck) or period in time.
3. A pop-up appears with the question to also plan the coupled resource of the planned resource. Click on ‘Yes’ to plan the coupled resource of that resource.
4. The event has now been moved and the process of moving an event ends here.

Moving events while maintaining a fixed period in time

In case an event has not been ‘Firm planned’ and the planner wants to ensure that an operation will still be performed on the same day while moving an event to another resource (mechanic or truck), an extra step in the process of moving an event has to be executed.

The steps that have to be performed in order to move an event solely to another mechanic or truck, so not moving to another period in time, are formulated as follows:

1. Select the event in the GRP that has to be moved by clicking on it.
2. Press the shift button on the keyboard and keep pressing it until the end of the process.
3. Drag the event to the preferred mechanic or truck.
4. A pop-up appears with the question to also plan the coupled resource of the planned resource. Click on ‘Yes’ to plan the coupled resource of that resource.
5. The event has now been moved solely to another resource and this process of moving an event ends here.

Copying events

In the ‘Employee view’ of the GRP, it is also possible to copy an event and assign it to another resource or another period of time. Copying events can be done applying the following steps:

1. Press the ctrl button on the keyboard and keep pressing it until the end of the process.
2. Select the event in the GRP that has to be copied by clicking on it.
3. Drag the event to the preferred mechanic, truck or period in time.
4. A pop-up appears with the question to also plan the coupled resource of the ‘new’ resource. Click on ‘Yes’ to plan the coupled resource of that resource.
5. The event has now been copied and assigned to a resource and a period in time.
   The process of copying an event ends here.

Selecting multiple events

A separate functionality within the GRP is called selecting multiple events, which entails the possibility to select multiple events in order to perform another functionality or activity in the planning for multiple events simultaneously, such as deleting multiple events. Selecting multiple events can be done with the following steps:

1. Press the shift button on the keyboard and keep pressing it until the end of the process.
2. In the planning window of the GRP, click nearby the events that have to be selected.
3. Drag the mouse over the events that have to be selected.
4. Let go of the mouse to finish selecting the events
   - In the upper left corner of the planning window in the GRP, the number of selected events is displayed
   - The selected events also display a checkmark in their upper left corner.
5. The events have now been selected and the process of selecting multiple events ends here.

By selecting multiple events in this way, it enables the planner to move or copy these events simultaneously. Choose one of the selected events to move or copy all selected events at once.

In turn, for the functionality ‘Moving events’, continue that respective process from step 2. For the process of ‘Copying events’ start at step 1, subsequently skip step 2 and continue this process at step 3. These processes are altered in this way, because the events that have to be moved or copied are already selected. Combining these functionalities can significantly improve the planners’ operational speed.

Deselecting events

In order to deselect events, when for example the wrong event has been selected, apply one of the following two methods. The first method applies the following steps to deselect event:

1. Press the shift button on the keyboard and keep pressing it until the end of the process.
2. Drag a small rectangle with the mouse on an empty area in the GRP.
3. Let go of the mouse to finish deselecting all events.
4. The events have now been deselected and the process of deselecting events ends here.

To deselect events with the second method, perform the next steps:

1. Move the mouse to the box in the upper left corner of the planning window in the GRP.
2. Click on this box to check this box, which selects all events.
3. Click this box again to uncheck this box, which deselects all events.
4. The events have now been deselected and the process of deselecting events ends here.

E.3 Specific functionality

In this section, the specific functionality developed for RSI's planning process with the GRP is outlined in detail as introduced and explained in Chapter 5. The steps that have to be performed in the GRP in order to correctly move an event from a resource with a coupled resource to another resource that also has a coupled resource are presented. These steps must be performed in the 'Coupled resources: (establishment of RSI)' view in the GRP to succeed.

There are eight steps to be executed in the GRP to correctly execute and complete this functionality. These steps entail:

1. Open the 'Coupled resources: (establishment of RSI)' in the general settings of the GRP.
2. Press the shift button on the keyboard and keep pressing it until the end of the process.
3. In this planning window of the GRP, click nearby the events of the resource and coupled resource that have to be selected and eventually moved.
4. Drag the mouse over these events to select them.
5. Click on one of the events – preferably the event of the resource – and drag both events to the preferred mechanic, truck or period in time.
6. A pop-up appears with the question to also plan the coupled resource of the planned resource. Click on 'No' since an event for the coupled resource has already been planned in this process.
7. Deselect the events by performing a method from 'Deselecting events' in Section E.2 of Appendix E.
8. The events have been moved, so the process of moving events with coupled resources ends.

Appendix F – Determined GRP settings for REMONDIS Smart Infra

In this appendix, the settings implemented in the software system to build the final GRP design in Chapter 5 are described based on the type of setting. The types of setting considered are the general settings and fixed settings as explained in Section E.1 of Appendix E.

F.1 General settings

In the general settings menu, the 'Standard planning horizon' has been set to a specific date range that fits RSI best, namely minus seven days and plus fourteen days, which means that the planning shows up to seven days into the past and fourteen days ahead. This choice is justified based on the context analysis as performed in Section 2.2 of Chapter 2, where the average days a planner plans ahead is 8 days and the maximum days a planner plans ahead is twenty-one days resulting in the intermediate number of days equal to fourteen days. The view of one week into the past allows the planner to review the operations performed. Besides that, the planning tool allows the user to move to past or future periods in time using this total date range of twenty-one days.

The setting 'Full screen' has been switched on resulting in the GRP filling the entire screen immediately when the GRP is opened from the software system. This way the planner does not have to make the GRP full screen manually.

Also, 'Display time while moving events' is turned on for the GRP. As a result, the start time and end time over a selected period is displayed in the GRP, so the planner can plan an event on a specific time. Besides that, this is the only setting that allows for an indication of time in the GRP, which is essential to planning operations correctly.

To ease working with the GRP for the planners and implement a form of automation in the GRP, 'Automatic refreshing' has been turned on where the GRP will automatically refresh every ninety-five seconds. So, any change made by another authorized employee to the planning will appear in the planning after that period in time has passed. A change made by the planner himself will immediately appear in his planning view.

Considering the 'Employee view vs Gantt chart', the 'Employee view' has been chosen to be the main view in the planning process as it provides the greatest capacity overview. This view enables any authorized employee to observe the efficiency with which the mechanics are planned, so to see whether the planning for the coming week(s) is filled with operations to perform for clients. The Gantt chart could be used to see how long a certain project, service order or reservation lasts. However, in order to use this view in the planning process, a specific working method with the software system has to be changed within the organization, which falls outside of the scope of this bachelor assignment. Therefore, the use of the Gantt chart will be postponed.

For the views per user, two 'Resource views' have been built in the 'Employee view', which are called 'Coupled resources: (establishment of RSI)' and 'Resources employee'. In the 'Coupled resources: (establishment of RSI)' view, the mechanics and their respective coupled resource are alternately visible, which means that a mechanic and its coupled resource are directly below each other. This way the utilization of the trucks and other resources is also insightful. The 'Resources employee' view is a view of the mechanics only, which enables quick and easy planning of mechanic for reservations, service orders and projects.

In each 'Resource view' at least one non-planned bucket is added. A non-planned bucket is filled with events, such as service orders and reservations, which have not been assigned to a mechanic or another resource yet. Such a bucket should aid the planners while planning their respective operations. S&M has two non-planned buckets. The first bucket is the general non-planned bucket for any service order. The second bucket is a non-planned bucket for storing the maintenance operations from the year plan as reservations in the GRP. The C&R and C&I 'Resource views' will only include the non-planned bucket due to the lack of reservations for these main activities.

For the 'Day, week and month view', the following settings have been implemented to create the most optimal look for the GRP for these three views. In the day view these settings are chosen:

- 'Timescale': 1 day
- 'Show working hours': "on"
- 'Limit hours on screen': "on"
  - From 06:00 until 18:00
- 'Show weekend': "on"
- 'Align on grid': "off"
- 'Minimal step for timing events': 30 min
- 'Columnwidth': 400%
- 'Row height': 90%

The week view is designed by the application of the following settings:

- 'Show working times': "on"
- 'Limit hours on screen': "on"
  - From 06:00 until 18:00
- 'Show weekend': "off"
- 'Align on grid': "on"
- 'Columnwidth': 600%
- 'Row height': 95%

Finally, the month view is designed by the implementation of the following settings:

- 'Limit hours on screen': "on"
  - From 06:00 until 18:00
- 'Show weekend': "off"
- 'Align on grid': "on"
- 'Columnwidth': 600%
- 'Row height': 55%

F.2 Fixed settings

For the fixed settings, the 'Automatic refreshing' and 'Full screen' have been activated to enable the settings 'Automatic refreshing' and 'Full screen' to be applied on in the general settings menu. Next to that, the 'Show new window' setting remains switched off, which means that any window that is opened from the GRP will be displayed on the same page, so over the GRP.

Now, considering the settings for the events, the layout of an event will display the following information, namely the 'Order sort' and 'Address' respectively, where the Address entails the location of the operation. The reason for displaying this information is that this information is the most critical for the planner to see in the planning as it ensures distinction between the different events and it shows the planner immediately where a mechanic is working.

The event colours for the different attributes of the event are designed as follows. Due to fact that the colours for 'Order sort' do not appear in the 'Employee view' but in the 'Gantt chart' no colours are yet defined for the 'Order sort' since the 'Gantt chart' will not be used immediately.
For the 'Log moment' the following colours are defined:

- **Blue**: open orders (10)
- **Gold**: order sent to the mechanic (15)
- **Red**: order refused by mechanic (30)
- **Light purple**: mechanic is driving (50)
- **Light blue**: execution has started (60)
- **Brown**: order completed but follow-up work (65)
- **Light brown**: follow-up order has been made (67)
- **Light green**: order completed (70)
- **Light red**: execution discontinued (100)

The ‘Sub sort’ includes the following colours:

- **Dark green**: ‘Maintenance’
- **Orange**: ‘Malfunction’
- **Dark blue**: ‘Repair’
- **Turquoise**: ‘Incidental work’
- **Yellow**: ‘Remaining’

The event pop-up shows the more specific information about the respective event, which entails the ‘Address’, ‘Client’, ‘Priority’, ‘Work order’ and ‘Log moment’ in that order. The ‘Address’ entails the street name and house number where the operation is performed. This information is significant when focussing specifically on that event and operation.

Next to the events, the kind of information displayed about the mechanics in the views of the GRP, is determined to be ‘Full name’ and Employee number’ as this information tells the planner who the mechanic is.

Also, the mechanics have a pop-up that shows detailed information about the mechanic for the planner or any other authorized employee. In this pop-up, the information presented, includes ‘Employee number’, ‘First name’, ‘Last name’, ‘Full name’, ‘Resource number’ and ‘Company name’.

Finally, different information is displayed about the trucks in the GRP than about the mechanics. For the trucks, the kind of information displayed about the truck in the views of the GRP is ‘Resource number’ and ‘Resource name’. This way the planner instantly knows what truck is being displayed in the GRP.

In the truck pop-up, more detailed information is displayed about the trucks as is similar to the event and mechanic pop-up. The kind of information presented in the truck pop-up entails ‘Material number’, ‘Material type’, ‘Resource number’, ‘Company name’ and ‘Inspection number’.

Appendix G – Assessment of the GRP applied in the optimal planning process

Table 5.2: Assessment of the aesthetics requirements for the planning process and GRP

Aesthetics	Importance	Assessment
Colour diversity	III	√
Clarity in display	IV	√
Add notes	I	X
Standardized format in planning	IV	√
Standardized filters of the planning per establishment	IV	√
Security and protection of the planning	II	√
Total and complete overview	IV	√
Immediate view of critical information	III	√

Table 5.3: Assessment of the functionality requirements for the planning process and GRP

Functionality	Importance	Assessment
Standardized planning process	I	√
Capacity overview in GRP	IV	X
Relocate operations in the planning in time (GRP)	III	√
Relocate operations in the planning between resources (GRP)	II	√
Automatically relocating frequent operations (GRP)	III	X
Assigning malfunctions to resources in between other planned operations	IV	√
Reserving a mechanic in the GRP	II	√
Planning for the coming year	IV	√
Planner's ability to plan in GRP	III	√
Update of progress in GRP	III	√
Knowledge of the planning tool	III	√
Automatically determining and assigning working days	II	X
Implementation of autocorrect	I	X
Distance between consecutive steps in GRP	III	√

Table 5.4: Assessment of the wishes for the planning process and GRP

Wish	Importance	Assessment
Plan per project or per contract	II	√
Centralized planning for Cleaning & Inspection	II	√
Decentralized planning for Service & Maintenance and Construction & Renovation	II	√
Allow faster operating in the planning process and planning tool	III	√
Test GRP in advance	I	√
Involve the employees in the development process	III	√
Improve communication between planners	III	√
Allow the planning of an increased number of mechanics	I	√

Appendix H – Interim measurements

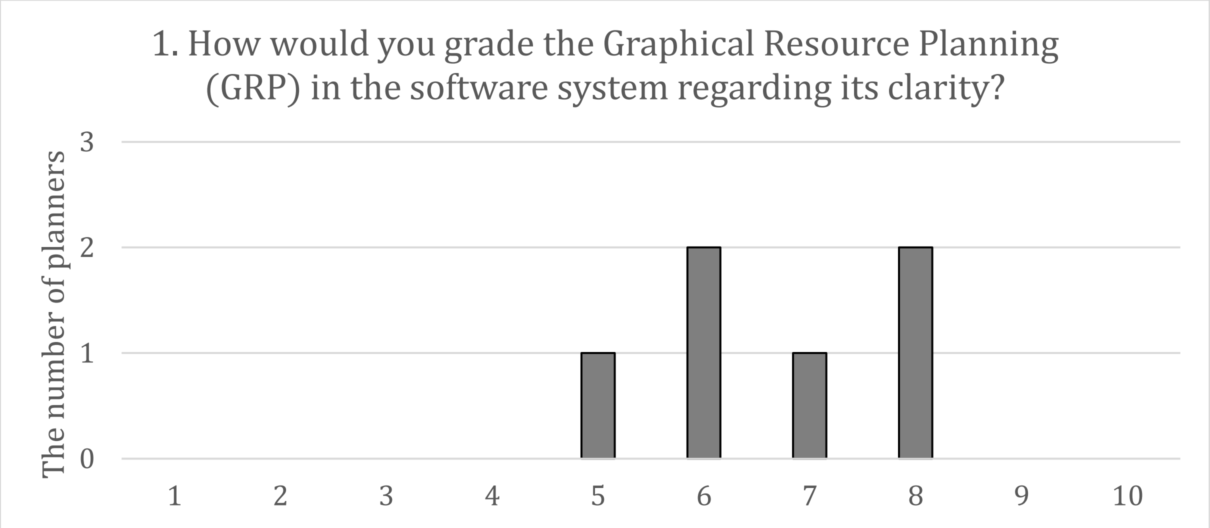

Figure 6.1: Satisfaction grade for the GRP regarding its clarity

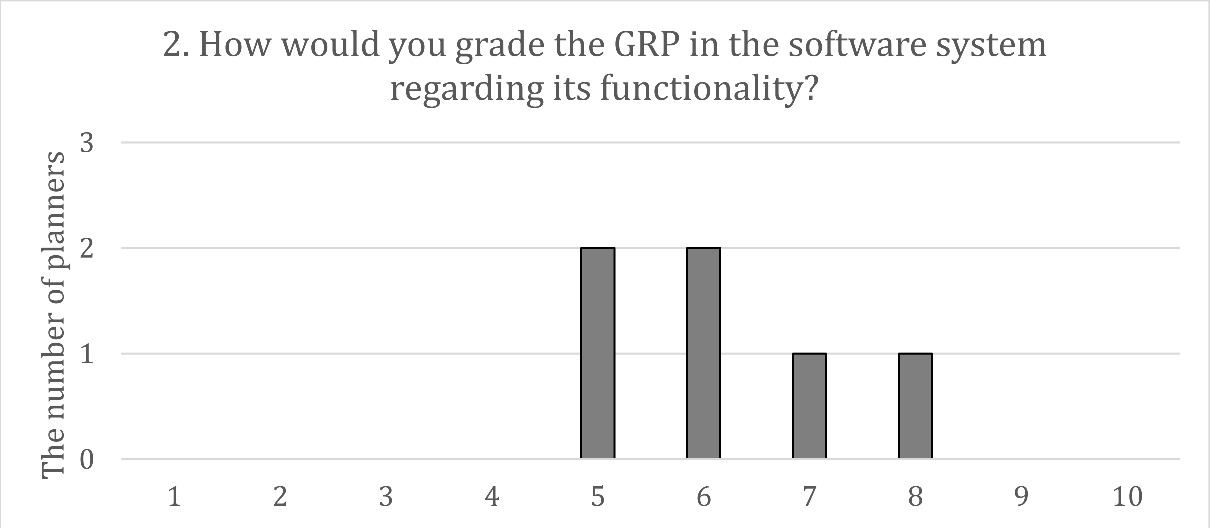

Figure 6.2: Satisfaction grade for the GRP regarding its functionality

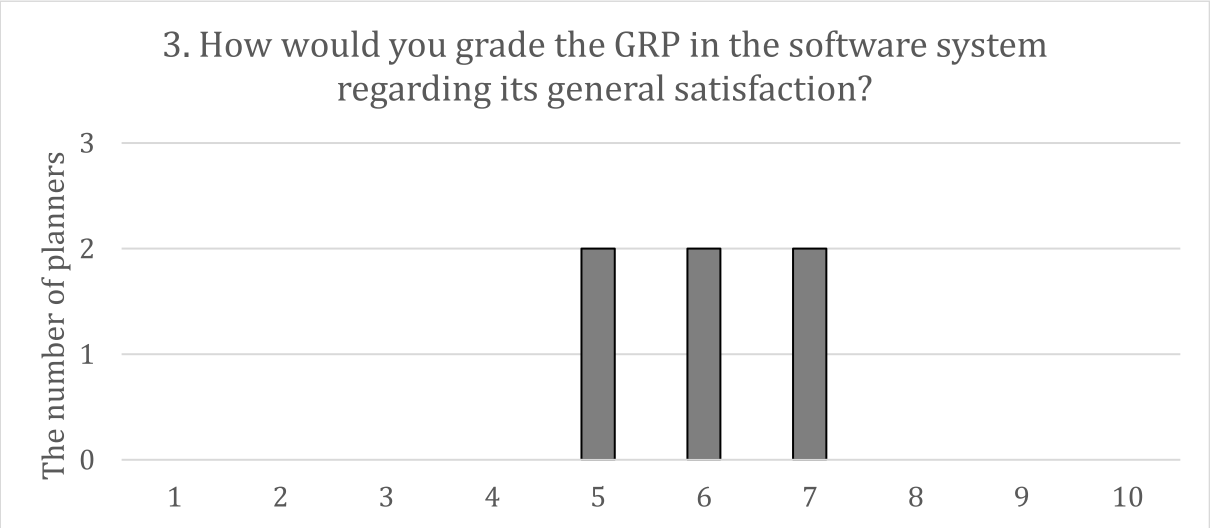

Figure 6.3: Satisfaction grade for the GRP in general