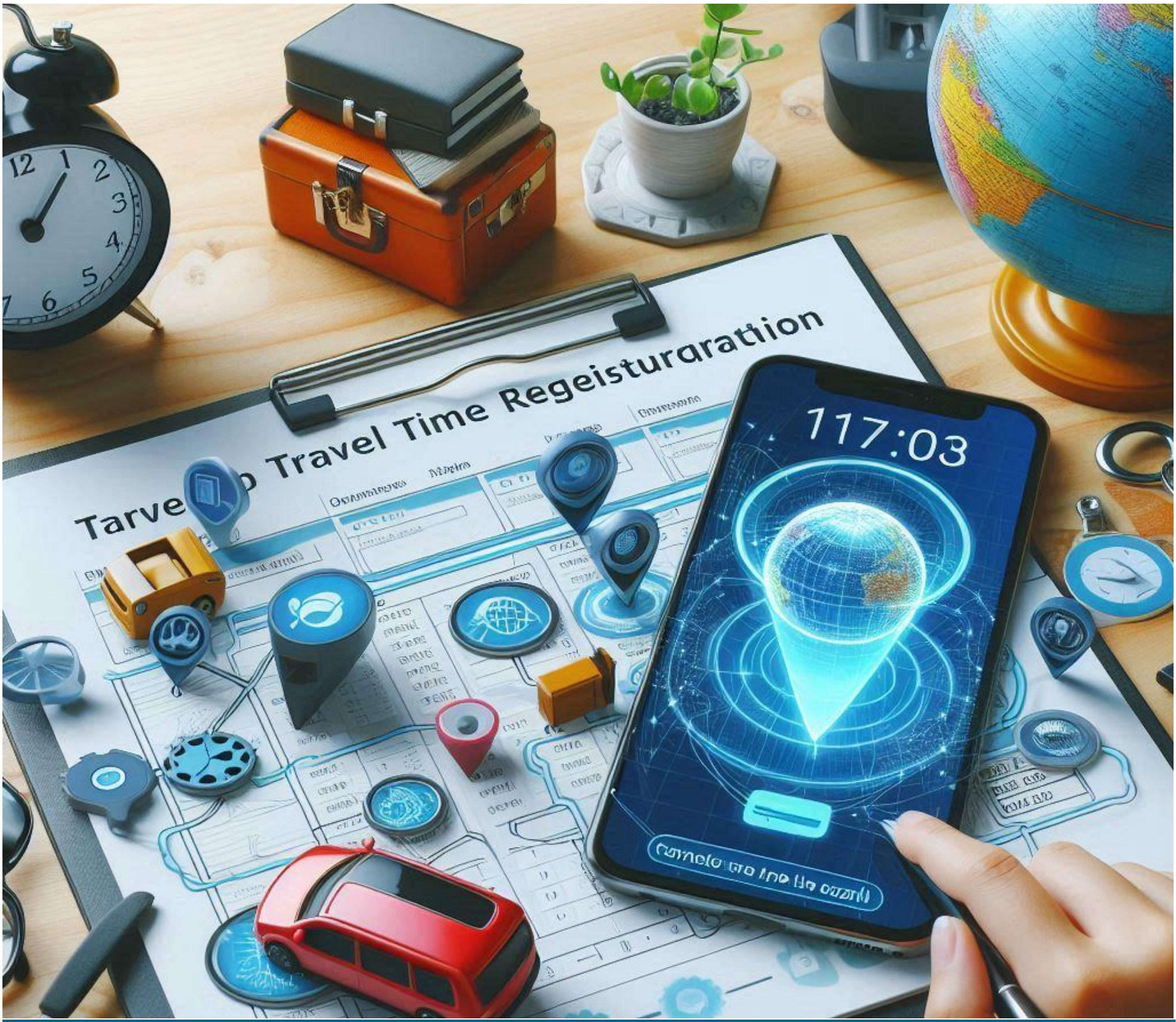

Bachelor Thesis

Improving registration for travelling hours

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8/26/24
Thesis

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Management summary

This thesis confirms that the research objective of reducing the travel hours processing time at Hegeman Constructions from 40 to 8 hours per four-week period has been achieved.

Methodology

The study uses the Design Science Research Methodology (DSRM). First, the current problem of the time spent on processing the travelling hours was analysed through interviews and observations with HRM staff and executors at construction sites. Based on this analysis, two processes were made: A generic process was developed. This generic process was specifically tailored for Hegeman in a second process, resulting in a demo model as a proof of concept. The prototype solution integrates the fleet management tool to automate the process and was tested for effectiveness.

Key Findings

The research revealed that the current process contains a lot of manual steps for the executor and the HRM team. The newly proposed solution integrates the fleet management tool (InSeeGo) and automates calculations, showing significant potential to reduce processing time by 80%.

Three main pillars for improving the travel hour process were identified:

- **Data Integration**: Integrating data from InSeeGo for processing instead of manual input.
- **Overview Pages**: Creating a centralized system to provide clear and organized information for HRM staff and executors instead of a lot of different files stored per project.
- **Automatic Calculations**: Developing algorithms to automate the calculation of travel hours based on predefined rules and scenarios.

Implementation

The three main pillars for improving the travel hour process are implemented in the new generic process design as well as the specific design for Hegeman. In this thesis, these designs were tested with a demo model. The demo model serves as a proof of concept, demonstrating the feasibility and potential benefits of the proposed system. Testing the demo led to the verification of the calculations, ensuring that the calculations for the various scenarios are accurate.

Conclusion

Based on these findings, implementing the tailored process and demo model can significantly improve the time of travel hour processing at Hegeman Constructions. The study concludes that the implementation of this tailored solution can reduce the processing time for travel hours from 40 hours to 8 hours per four-week period. This automated approach not only enhances accuracy and reliability but also allows HRM personnel to allocate their time to more strategic tasks, thereby increasing overall productivity.

Recommendations

To further enhance the efficiency and effectiveness of the travel data processing system, several steps are recommended:

1. Application Development
    a. Integrate the InSeeGo API to ensure seamless data processing.
    b. Making the application code more efficient for better performance.
    c. Facilitate integration with the accounting system 4PS.
2. Process Implementation
    a. Provide thorough training and documentation for HRM and executors.
    b. Focus on filling the tables in the application with current information.

For more detailed information and in-depth analysis, please refer to the full thesis.

Preface

I am proud to present my bachelor thesis titled "Improving Registration for Travelling Hours". This research was conducted in collaboration with CAPE Groep and Hegeman Aannemingsmaatschappij b.v. The aim of this thesis was to reduce the administrative processing time of travel hours.

During this research, I have learned a lot about the challenges within registration of travelling hours and the possibilities of software integration to improve operational processes. This thesis would not have been possible without the support and guidance of various people and organizations.

First, I would like to thank my supervisor at the University of Twente, Martijn Koot, for his valuable feedback and continuous support throughout the project. His expertise and advice have played a crucial role in the realization of this thesis.

Additionally, I would like to express my gratitude to my colleagues at CAPE Groep and the HRM department of Hegeman for their cooperation and the insights they shared. Their practical knowledge and experience have contributed to the depth and relevance of this research.

I am particularly grateful to my company supervisor, Kevin Andela, for his time and assistance, especially with Mendix. His support and guidance were instrumental in the development of the application.

I also want to thank my family and friends for their unwavering support and patience during this intensive period. Their motivation and understanding have helped me through the challenging moments.

Lastly, I would like to thank everyone who has contributed in any way to the realization of this thesis. I hope that the results of this research will have a positive impact on Hegeman and potentially other companies in the construction sector.

Paul Cardol

Enschede, August 2024

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List of abbreviations

Abbreviation	Definition
BPMN	Business process modelling notation
CLA	Collective labour agreement
DSRM	Design science research method
Hegeman	Hegeman Aannemingsmaatschappij b.v.
HRM	Human resource management
IEM	Industrial engineering and management
MPSM	Managerial problem-solving method
POI	Point of interest
ERD	Entity-Relationship Diagram
BPM	Business Process Modelling
SIPOC	Suppliers, Inputs, Process, Outputs, Customers

Table 0.1 List of abbreviations

1 Introduction

In this chapter, a brief introduction is given of CAPE Groep, Hegeman, and ECOLOGIC, all of whom are involved in this thesis and the project that this thesis is part of. Additionally, the motivation for this thesis will be explained with the research question.

1.1 CAPE Groep

CAPE Groep is the client for the Bachelor assignment. CAPE Groep is a software development and system integrator company that specializes in delivering model-driven agile solutions to the Dutch logistics and construction industry. Their expertise encompasses a wide range of areas, including agile software development, connectivity, integrations, supply chain control, business intelligence, integrated mobile apps, reporting, and cloud computing.

1.2 Hegeman Aannemingsmaatschappij b.v.

Hegeman Aannemingsmaatschappij b.v. (Hegeman) is a client of CAPE Groep where the bachelor assignment will take place. Hegeman is a construction company with approximately two hundred employees. The focus of Hegeman is on utility construction like offices, stations, factories, and many more complex projects. At Hegeman, the construction workers commute to the construction sites with company cars. There is a difference in payment between the driver and the passengers. Currently, Hegeman has difficulties with this process and is looking for a solution within this bachelor assignment.

1.3 ECOLOGIC

The bachelor assignment is part of a big project where CAPE Groep and Hegeman are two of many participants including the University of Twente. The project is called ECOLOGIC (Emission Control and Logistics Optimization for Green Infrastructure Construction), and the goal is to improve the Dutch construction logistics industry. Improvement relates to developing and demonstrating reliable data-driven insights and advanced analytics techniques for anticipatory and adaptive logistics planning. The project also has as a goal to minimize carbon footprint and to create a more competitive sector to other countries. To reach this goal, a digital twin will be made of a construction site to be reactive to near-real time changes. The ECOLOGIC project started in August 2023 and will be finished in 2026. This bachelor assignment focuses on reducing the time spent on administrative work which helps employees of Hegeman to spend more time on their core business and improve their competitiveness.

1.4 Problem context

Hegeman faces a problem with processing travel hours for construction workers. Their projects are located all around the Netherlands, resulting in significant travel by the construction workers. Travel to construction sites is done through carpooling with company cars. One driver picks up colleagues from their homes and drives to the construction site. The payment for travel time differs between the driver and the passengers. According to the Collective Labour Agreement (CLA) (Rijksoverheid, 2024), the driver should be paid for the entire trip, whereas passengers are only paid for the direct route from home to the construction site minus 30 minutes.

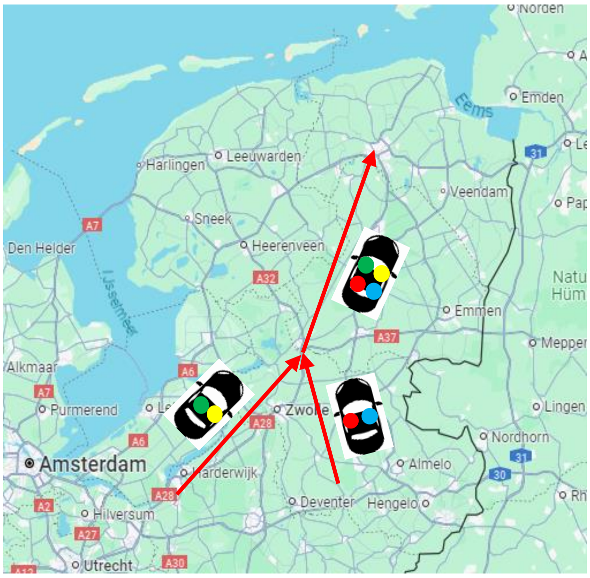


Figure 1.1 Movement of employees to project

Figure 1.2 Payment over the route per employee

To illustrate the travel payment process, consider a project in Groningen with four employees traveling there. Each employee is represented by a different colour for clarity: blue, red, yellow, and green. Blue and red depart from Nijverdal, while yellow and green depart from Ermelo. They meet at a carpool location above Zwolle, where red and blue switch cars and continue to the project site in Groningen. This route is depicted in Figure 1.1.

This project focuses on calculating the travel hour payments for such a trip. Figure 1.2 shows the payments each employee should receive:

- **Blue**: Blue is a passenger for the entire route. According to the CLA, passengers receive payment for the direct distance from home to the project, with half an hour deducted for the one-way trip. Thus, blue receives payment for the direct route from Nijverdal to Groningen, minus half an hour.
- **Red**: Red drives from Nijverdal to the carpool location near Zwolle and then continues as a passenger to Groningen. Blue receives payment as a driver for the distance from Nijverdal to the carpool location. From the carpool location to Groningen, Red is a passenger, so payment is calculated for this segment minus half an hour.
- **Yellow**: Yellow is a passenger for the entire route from Ermelo to Groningen, like bleu. Therefore, yellow receives payment for the direct route from Ermelo to Groningen, with half an hour deducted.
- **Green**: Green drives the entire route from Ermelo to Groningen. Thus, green receives payment for the entire route as a driver.

Additionally, the working council has agreed to further regulations in favour of Hegeman's employees, making it even more complex and time-consuming to process each journey. For example, some projects are classified as prone to traffic congestion, allowing workers to leave 15 minutes earlier. This 15 minute needs to be subtracted from the travelling hours since this additional regulation further complicates the calculation of travel hours and payments.

Previously Hegeman tried to solve this problem by investing in InSeeGo. InSeeGo is a company specialising in fleet management. They have a GPS box that can be installed in cars and provides tracking possibilities. This box also can use a tag system to register and unregister every employee that is in the car to create an overview of the movements of each employee. Hegeman has invested in InSeeGo and tried to use InSeeGo to automate the travelling hour system. Still, this system only works when the line-up of the car and the project are the same every time. For Hegeman everyone is used for their expertise so the planning uses a lot of different construction workers on a project and construction workers will work on a lot of different projects at the same time. The planning for expertise varies daily, which made it impossible for InSeeGo to accurately process the travel hours for Hegeman. The InSeeGo system could only handle travel hours under standard conditions. However, due to the specific exceptions at Hegeman and the errors that occur with employee tagging, it was not feasible to process the travel hours correctly. The failure of this attempt led to the creation of this assignment, as there remained a belief that, in theory, it should be possible to automate this process effectively.

At this moment, the HRM department of Hegeman spends around 40 hours cumulative on the processing of travelling hours each period of four weeks. At Hegeman the administration is not done per month but per 4 weeks, so they have thirteen periods each year. This **reality** is concluded after multiple sessions with the HRM department. The goal is to reduce this time to 8 hours per period of 4 weeks. This will be the **norm** and it is a reduction of 80%.

Hegeman wants this assignment to look for an improvement in the processing time of travelling hours. so, it will cost less money and the workload of the HRM department will be decreased. The action problem will be:

"How to reduce the processing time of travelling hours from 40 hours to 8 hours per period for the human research team of Hegeman Constructions?"

1.5 Conclusion

This chapter introduced the key stakeholders involved in this thesis—CAPE Groep, Hegeman, and the ECOLOGIC project. CAPE Groep, as the client, specializes in software development and system integration for the logistics and construction industries in the Netherlands. Hegeman, a construction company, faces challenges with travel hour processing, serving as the practical context for this research. The broader ECOLOGIC project aims at optimizing logistics and reducing emissions in the Dutch construction sector, framing the relevance and potential impact of this thesis.

Hegeman's problem centres on the inefficient and error-prone manual processing of travel hours for construction workers. This complexity is increased by the need to comply with various regulations, such as those from the Collective Labour Agreement (CLA) and additional internal agreements, making the accurate calculation of travel hours and corresponding payments difficult. Previous attempts to automate this process with InSeeGo's fleet management system have not met the needs due to the dynamic nature of Hegeman's workforce and project assignments, indicating the need for a more flexible solution.

The main objective of this thesis is to develop a solution that reduces the administrative time required for processing travel hours at Hegeman. By decreasing the processing time from 40 hours to 8 hours per four-week period, this project aims to improve efficiency, reduce costs, and enable the HRM department to focus on other tasks. This objective aligns with the goals of the ECOLOGIC project and supports Hegeman's efforts to enhance operational efficiency and competitiveness in the construction industry.

2 Research methodology

In this chapter, the methodology for addressing the problem at Hegeman Constructions is explained. The chapter will cover the problem cluster analysis, identification of the core problem, and justification for selecting the core problem. Additionally, the six-step approach of the DSRM will be detailed, along with sub-questions, research methods, validity, reliability considerations, and the theoretical framework for the research.

2.1 Problem analysis

To get to understand the problem the core problem needs to be found and a problem core could be found by making a problem cluster according to the managerial problem-solving method (MPSM)(Heerkens & Winden, 2012). The problem cluster is visible in Figure 2.1.

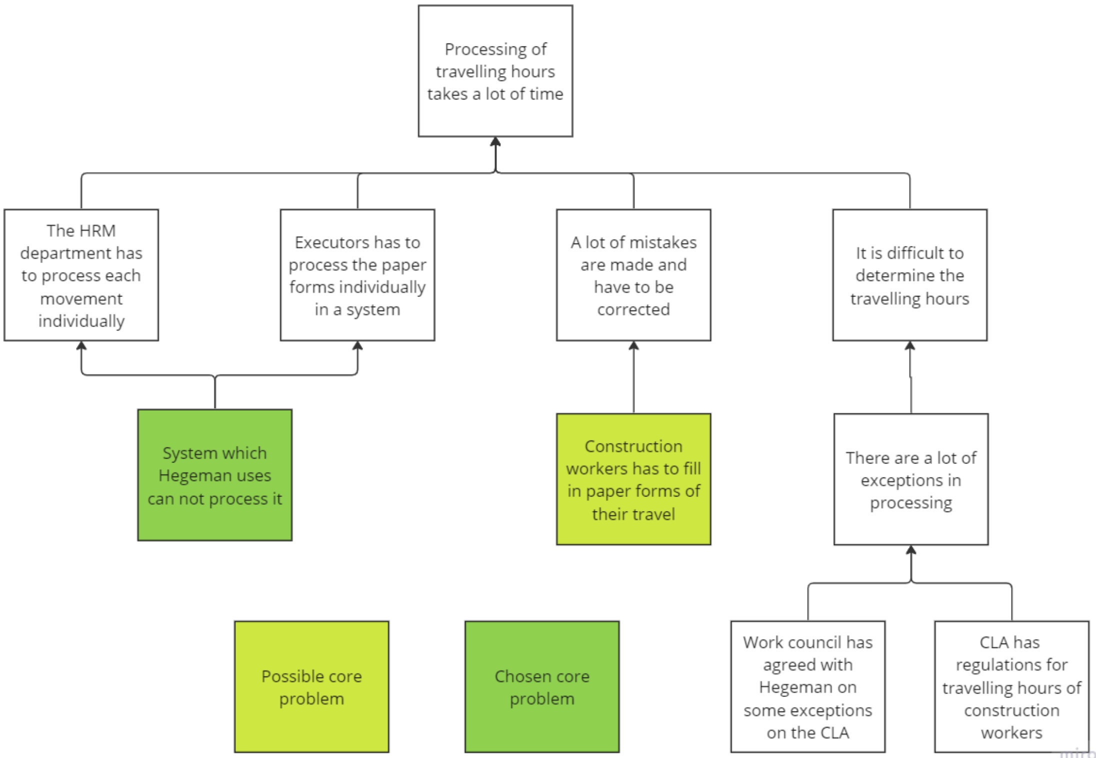


Figure 2.1 Problem cluster.

The main problem where a core problem needs to be found is that the processing of travelling hours takes a lot of time. This has four main reasons:

- The first reason is that currently, the HRM department must process each movement individually. Each period of four weeks has approximately three thousand movements that need to be processed. To process all these movements takes a lot of time.
- The second reason is that currently, executors must fill in all the movements of construction workers individually in the system which takes a lot of time. The reason for these two problems is that the current HR system cannot process the travelling hours other than manual input.
- The third reason is that mistakes are made with the input and need to be corrected afterwards. This takes a lot of time and needs to be very precise. The reason for the

mistakes is that all the construction workers who travel are currently filling in paper forms for their travel.

- The fourth reason is that it is difficult to determine the travelling hours. Each movement is different and different regulations apply to it so there are many exceptions. This is because of the regulations by the CLA and because the work council of Hegeman has agreed on some more regulations. Both the CLA and the regulations from the work council cannot be changed by this research so they are applicable to be the core problems.

There are two core problems. The problem that will be addressed in this bachelor thesis is: "The existing system used by Hegeman Constructions cannot process the travelling hours." The existing system consists of a combination of a fleet management tool and an accounting program. However, these tools are not capable of processing the travel hours according to Hegeman's standards, leading to the necessity of manual processing. This manual processing is time-consuming and prone to errors, highlighting the need for an improved solution. This problem is chosen based on three reasons:

- Feasibility for a Bachelor Thesis: The problem is suitable for an IEM bachelor thesis and is possible within the 10-week timeframe of the thesis project. In the bachelor there is a module called Business and IT and the knowledge obtained in that module could be used in this core problem. For the Bachelor Thesis it is important that knowledge from the bachelor is used so that makes it suitable.
- Alignment with CAPE Groep's Expertise: As a software development company, CAPE Groep possesses expertise in system development and optimization. Choosing this problem offers an opportunity to use the company's knowledge base, creating valuable learning experiences for me.
- Potential for Broader Impact: Successfully addressing the system's limitations may solve more than travel hour processing time. It also creates possibilities to reduce the number of errors when executed correctly.

2.2 Problem-solving Method and Design

The method that will be used is the design science research method (DSRM) (Peffers et al., 2007). The DSRM is oriented toward developing a digital artifact, but that is used to solve another problem. So, the digital artifact is not the goal of a research but the means to achieve the goal. In this research, the goal is to improve the processing time of the travelling hours and that will be accomplished by making a tool that can process the travelling hours faster. So, the DSRM is compatible with this research.

The DSRM contains six steps:

1. **Problem Identification and Motivation**: Identify and articulate the problem or opportunity that serves as the focus of the research, along with the motivation behind addressing it.
2. **Define Objectives for a Solution**: Clearly define the objectives that the solution or artifact aims to achieve in addressing the identified problem.
3. **Design and Development**: Design and develop the solution or artifact based on the defined objectives, utilizing appropriate methodologies and techniques.
4. **Demonstration**: Demonstrate the functionality and capabilities of the developed solution or artifact in addressing the identified problem.

5. **Evaluation**: Evaluate the effectiveness, efficiency, and usability of the solution or artifact in achieving the defined objectives and addressing the identified problem.
6. **Communication**: Document and communicate the research process, findings, insights, and recommendations to relevant stakeholders and the wider community.

To answer the main question, sub-questions have been made according to the stages of the DSRM. The sub-question and the methods used are explained below:

Step 1: Problem identification and motivation

In this step, the objective is to learn more about the problem. To solve and improve the traveling hours process, the current process must be clear and mapped. The process starts when the construction workers start a trip in the car, and it ends when the HRM department puts it on the pay check. What is done from the first step till the last step needs to be mapped to understand it properly. To achieve these, interviews and observations will be done with the HRM department and the executors on the construction site of Hegeman (they are responsible for the data). When the process is mapped, appointments will be made to verify it to make sure it is done properly.

Hegeman has also tried to solve this problem in the past by using InSeeGo. During this step it is also important to talk to the HRM department, which tried to use it but failed, to learn what went wrong with this approach to learn from the mistakes made then.

The sub-question for this step:

1. *How are travel hours currently recorded and processed within the company?*
2. *What has previously been tried to solve this issue and why did it not succeed?*

Step 2: Define objectives for a solution.

In this step, the objective is to learn the requirements of the solution. To make this solution useable it is necessary to learn from the HRM department and the executors on the construction sites\what they need in this solution. To learn from the executors what they want the input to be and from the HRM what they want as an output to improve it for both. To learn these requirements, interviews will be done.

Another part of this step is to learn the regulations of the CLA about travel hours and the agreement the work council of Hegeman made. This will be done by studying these sources and creating an overview of all these regulations. This is an important requirement for the solution because it needs to be legal.

To bridge the gap between understanding the current process and designing an improved process, the requirements gathered from the interviews and observations will be compared with the existing process. This comparison will help identify the specific shortcomings and challenges in the current system. By laying out the requirements side by side with the existing process, it becomes clear where adjustments and improvements are needed. This step-by-step approach ensures that the design of the new process will directly address the identified issues, leading to a more efficient and accurate travel hours processing system.

The sub-question for this step:

3. *What are the requirements for processing the travelling hours?*

Step 3: Design and Development:

In this step, the objective is to design and develop a solution for the problem. A generic process will be designed following the objectives of step 2 and the regulations outlined in the CLA, serving as the foundation for the research. Subsequently, this process will be refined to incorporate the regulations established by the Works Council of Hegeman, ensuring alignment with organizational requirements. Once the process for Hegeman is established, a tool (application) will be developed specifically for Hegeman's needs. The generic process will be made first because all the steps are also necessary for the Hegeman version, but Hegeman has extra requirements due to the agreement with the working council. So, the generic process can be the basis and the extra requirements can be added to make it workable for Hegeman in a specific process. The tool will encompass all stages of the process, emphasizing input and output considerations while excluding complexities related to data formatting and real-life data acquisition. Prioritizing efficiency, the focus is on developing a functional tool that can be validated for effectiveness, without dedicating excessive time to data refinement. To create both the processes and the tool iterative prototyping will be used. According to Christopher Fanchi (2023): "Iterative prototyping is a method of creating and testing a product in small, incremental stages. It allows developers to quickly gather feedback, adjust, and improve the overall user experience." During the design process, it will be developed in small steps, and after each step, it will be evaluated and checked if it aligns with the requirements. This will be improved before going to the next step. This is also the case with making the tool.

The sub-question for this step:

4. *How does a process of travelling hours should be designed?*
5. *How should a demo application be designed to reduce the travel hours processing time at Hegeman Constructions in alignment with the newly developed process?*

Step 4: Demonstration

In this step, the objective is to verify the tool. This will be achieved by utilizing control data, encompassing various scenarios and outcomes. To ensure consistency, the input into the tool should yield the same output as the control data. This step is pivotal as the tool's accuracy directly impacts employee payments, demanding utmost validity. To generate the control data, collaboration with HRM will be sought to cover all exceptions and scenarios. Their input will be invaluable in verifying the validity of the outputs across different possibilities. When the output differs from the control data it means that there is a mistake in the tool, and it needs to be improved.

The sub-question for this step:

6. How effectively does the tool process the travelling hours?

Step 5: Evaluation

In this step, the objective is to see the effect of the tool on the main research question. During this phase, the tool's efficacy in reducing total processing times will be assessed. This evaluation is done by identifying steps in the workflow streamlined by the tool, quantifying the time saved from their elimination, and gathering feedback from experts (The HRM team) on their expectations regarding time savings. Despite the subjective nature of evaluating time savings, particularly within a demo model, this approach, combined with expert input and objective metrics, will offer an understanding of the tool's impact on processing times.

The sub-question for this step:

7. *What will be the time required for processing traveling hours with the new process?*

Step 6: Communication

In this step, the objective is to document and communicate the findings. So, the entire research will be documented and communicated to Hegeman, CAPE Groep, and the University of Twente. This includes the creation of a comprehensive report outlining the research process and outcomes of the research. Additionally, a manual will be made on how the tool works for Hegeman. Also, recommendations will be made on how to implement this tool and if additional research is necessary.

An overview of all these questions and the research design is visible in Appendix 9.1 in Table 9.1. In this table the research questions are made specific with the research type, key construct, variables, research group, data gathering, and data analysis methods per question.

2.3 Deliverables

At the end of the thesis, a new process for the processing of travelling hours will be made. This will have all the steps/choices in it to generate the travelling hours that should be paid per employee. The second delivery is a demo model of the new process. The new process and all the steps will be in the model, but it will not work with the live data and output. To get to a fully functional tool the time of 10 weeks for the thesis is too short, but a demo tool is possible in the timeframe. Finally, a report and presentation will be made for the different stakeholders: CAPE Groep, Hegeman, and the University of Twente.

2.4 Limitations

Time is a limitation of this research. To make an entire working model to implement for Hegeman is not realistic in 10 weeks with making two new process models. To tackle this problem, a demo tool will be developed instead of a fully working tool. This creates more time to fully focus on the implementation of the new model and less on the live input and output.

Another limitation could be the change for construction workers to use the tag system. It will need time for every worker to get used to this system and to give each workers their own tag. In this research this adjusting time is not measured, but it will happen. In the demo model, a possibility will be added to change the driver and passenger in the trip and to change times so it could be changed when mistakes were made.

2.5 Validity and Reliability

Most of the data gathering is happening in the first two steps of this research. This will be done by interviews and observation. To make sure the data will be reliable, the data will first be processed and later reviewed with Hegeman.

To make sure the tool is creating valid data, a control data set will be made with Hegeman to check the outcomes with them on all the different possible outcomes. When the control set is perfect, the output of the tool can be checked with the control data. If the output differs, it is clear that the tool is not working properly yet. The tool is only valid when all the outputs are the same as the control set.

To improve the reliability, triangulation will be used, through interviewing multiple members of the HRM team regarding the processing of travelling hours. This approach improves the reliability in several ways. Firstly, it is used to check for consistency in their stories. Secondly, interviewing diverse individuals facilitates the gathering of varied perspectives and insights related to the problem, to create a better understanding of the current situation and the requirements. Finally, when the interviewees independently corroborate each other story, it validates the information as well.

2.6 Theoretical framework

In this thesis, a major component is to thoroughly understand the current process and develop a new process to reduce the administrative time associated with processing travel hours. To achieve this, it is essential to use process modelling methodologies.

Process mapping is a widely used technique across various disciplines to visualize the entire process clearly and better understand it. Lean Sigma, as described by Tsentserensky (2023), focuses on the continuous improvement of processes and the elimination of waste. Although Lean Sigma is typically associated with these principles, in this research, we will utilize process mapping as a fundamental tool within BPM (Business Process Modelling) to enhance efficiency and accuracy in process understanding and redesign.

In the initial steps of this research, such as "problem identification and motivation" and "define objectives for a solution," the SIPOC framework (Suppliers, Inputs, Process, Outputs, Customers) will serve as a fundamental tool for understanding and documenting the current state of the process. The SIPOC diagram, as described by Tsentserensky (2023), will provide a high-level overview of the process. This aligns with the approach suggested by Pyzdek & Keller (2010), which helps identify key stakeholders, define inputs and outputs, and clarify process boundaries.

To gain a detailed understanding of the process, BPM will be employed, specifically using swim lane diagrams to visualize the process flow. Swim lane diagrams are a common technique used in process modelling, particularly within the BPMN (Business Process Modelling Notation) framework (White, 2024). During the studies in Industrial Engineering and Management, experience has been gained in applying BPM techniques, including the use of swim lane diagrams, to make complex processes visible and understandable. In this research, draw.io will be used to create BPM swim lane models. BPMN includes four basic categories of elements: Flow objects, connecting objects, swimlanes, and artifacts. An explanation of these elements is provided in Appendix 9.2.

By using SIPOC and BPM, combined with the principles of Lean Sigma for continuous improvement and waste reduction, this research aims to create a comprehensive and efficient process model that addresses the identified problems and improves the overall efficiency of travel hour processing at Hegeman Constructions.

2.7 Conclusion

In this chapter, the research methodology for addressing the problem at Hegeman Constructions has been outlined. The analysis began with a problem cluster analysis, identifying the core issue as the existing system's inability to process travel hours according to Hegeman's standards. This highlighted the necessity for an improved solution that is feasible within the scope of a bachelor thesis, aligns with CAPE Groep's expertise, and has the potential for a broader impact.

The chosen framework for this research is the Design Science Research Method (DSRM), which includes a structured six-step approach to develop a digital artifact aimed at improving the travel hours processing system. Each step of the DSRM process is guided by specific sub-questions, ensuring a focused and systematic approach to solving the problem. The research aims to deliver a new process model for travel hours processing and a demo tool to demonstrate its feasibility and effectiveness within the 10-week timeframe. However, due to time constraints and the complexity of fully implementing a live tool, the development will focus on creating a demo model that can be validated for accuracy and efficiency.

To ensure the reliability and validity of the research findings, triangulation through multiple interviews and the use of control data are employed. The theoretical framework integrates process modelling methodologies, specifically SIPOC and BPM, with Lean Sigma principles for continuous improvement and waste reduction. This combined approach aims to create a comprehensive and efficient process model that addresses the identified problems and significantly improves the efficiency of travel hour processing at Hegeman Constructions. By following this structured methodology, the research not only meets academic standards but also ensures practical applicability and relevance to the industry.

3 Problem Identification and Motivation

In Chapter 3, an in-depth analysis is conducted to explore how Hegeman currently manages the recording and processing of travel hours. Utilizing the problem-solving methodology outlined previously, the existing workflow within the company is closely examined. Insights are gathered through observations and interviews with both the HRM team and executors at construction sites. These interactions provide valuable understanding of the operational procedures and their underlying rationale. Findings are presented using a SIPOC diagram and a BPM model, offering a comprehensive overview of the current process. This sets the foundation for identifying potential areas for improvement.

3.1 Current situation

In this section, the current process for recording and processing travel hours within Hegeman will be thoroughly explained and investigated. This analysis aligns with the problem-solving method outlined in Section 2.2 and aims to answer the following sub-question: "How are travel hours currently recorded and processed within the company?" Understanding the existing process is crucial for identifying areas of improvement and effectively enhancing the workflow.

To gain insight into the current situation, observations and interviews were conducted. A day was spent with the HRM team to observe how they execute each step in the process. During these observations, numerous questions were asked to understand why the process is structured the way it is and to uncover the rationale behind key decisions and important aspects. This provided a comprehensive view of the weekly checks performed by the HRM team. Additionally, a day was scheduled with an executor from Hegeman at a construction site to observe the other side of the process, specifically the entry of travel hours. This allowed for a detailed understanding of all related activities.

After mapping the process, it was verified with the initial input providers to ensure that everything was understood and documented correctly. Subsequently, the process was also verified with other stakeholders involved who had not provided initial input. They confirmed that this depiction of the process aligns with how they carry it out.

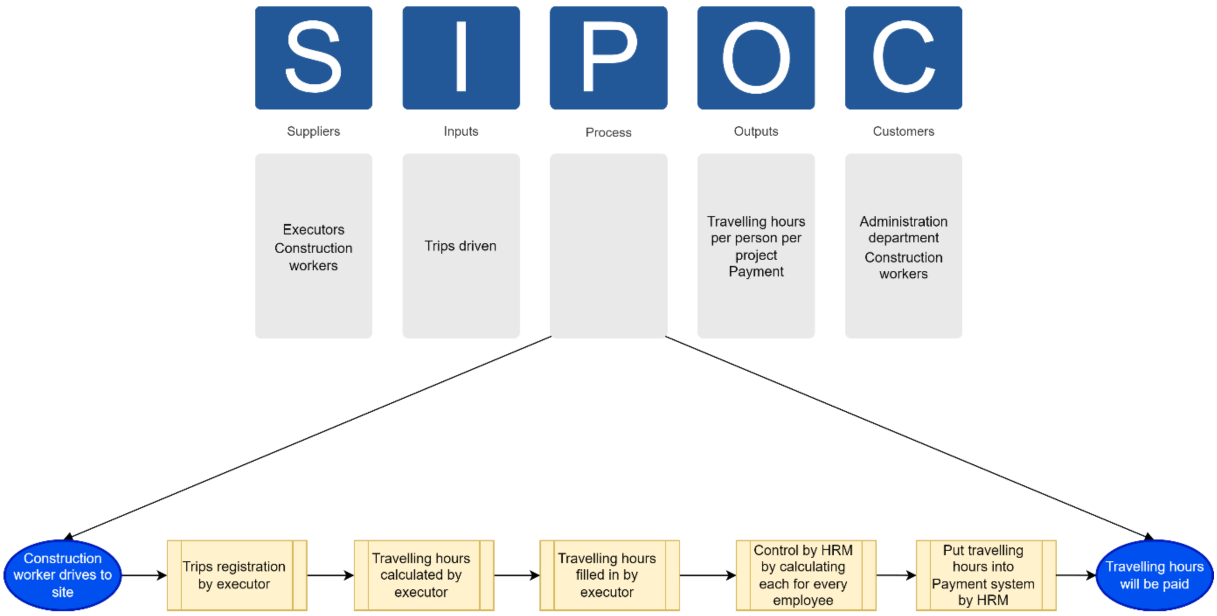


Figure 3.1 SIPOC of current process.

Figure 3.1 presents a SIPOC diagram outlining the workflow for registering and compensating travel hours for construction workers. This diagram provides a global overview of the process, with the suppliers, inputs, process steps, outputs, and consumers. The key suppliers are construction workers who travel to the construction sites and the executors who registers this, with the primary input being the trips driven by these workers. The process involves several critical steps: workers driving to the site, registering trips, calculating travelling hours, filling in travelling hours by executors, HRM controlling and verifying these hours by calculating them, and finally, entering the verified hours into the payment system.

The outputs of this process include recorded travel hours per person per project and subsequent payments to the construction workers. The main customers of these outputs are the administration department, which handles the financial transactions, and the construction workers who receive their travel compensation. This SIPOC diagram effectively maps out the entire process from a high-level view, ensuring understanding the process from inputs to outputs. This global overview of the SIPOC diagram will be further detailed in a BPM model.

The BPM model, which is visible in Figure 9.1 in Appendix 9.3, outlines the process for registering and controlling travel hours for construction workers, involving various roles such as HRM, the executor, and the employee. The process begins with the executor registering travel hours based on worked hours and known routes. These registered travel hours are then reviewed and verified by HRM, with any uncertainties clarified through communication between the executor and HRM.

Notably, the process involves a considerable number of manual verification steps. During the verification, HRM must open and search through four different files per person, which are all stored on different locations and results in extensive lookup time for each individual construction worker. Additionally, it was observed that the executor determines travel hours from work hours based on prior weeks, without input from the construction workers on their actual travel, leading to a lack of knowledge on the actual trips undertaken.

Once the travel hours are verified and confirmed, they are entered into the payment system to compensate the construction workers for their travel time. The BPM model highlights the collaboration and communication between the different roles to ensure accurate registration and timely payment. The process is then exported to the HR2day system for final processing.

Reflecting on the investigation process, it becomes evident that a deep understanding of the current workflow for recording and processing travel hours within Hegeman was crucial for identifying potential areas of improvement. By closely observing the activities of both the HRM team and the executors, as well as verifying the mapped process with the individual HRM members and the executor, an overview of the existing system was achieved. This examination aligns with the problem-solving method outlined in Section 2.2 and directly addresses the sub-question: 'How are travel hours currently recorded and processed within the company?'

To understand the potential for improvement, a gap analysis was conducted comparing the current process with the desired requirements outlined by Hegeman. This analysis revealed several key discrepancies:

- Data Integration: The current system relies heavily on manual data entry, which is time-consuming and error prone. The desired system should facilitate better data integration to streamline this process.

- Centralized Overview Pages: Currently, data is stored in different locations, making it difficult to access and find all the data. The desired solution should centralize data into one comprehensive overview page to reduce the time necessary to find the right document.
- Automatic Calculations: The existing process requires manual calculations to account for different regulations and exceptions, which takes a lot of time and has inaccuracies.

These gaps highlight specific areas where the process can be optimized. Lean principles, focusing on the elimination of waste and continuous improvement, were applied to identify inefficiencies such as unnecessary steps, delays, and errors. For example, integrating data systems can reduce the need for manual entry, while centralized overview pages can improve data accessibility and management. Automatic calculations can ensure that all regulations are consistently applied without manual intervention.

The insights gathered from this investigation, along with the gap analysis and Lean principles, will serve as a foundation for the rest of the research. These issues, and their potential solutions, will be further explored in Section 4.3, ensuring that the proposed improvements are targeted and effective.

3.2 Previous attempts to solve this problem

In the past, attempts have been made to automate the processing of travel hours. For this purpose, Hegeman acquired the service of InSeeGo, a company specializing in fleet management software. They installed black box devices in each vehicle to facilitate trip registration. Employees could check in with an RFID chip through a tag system, allowing for the registration of trips. This system is still used today to manage all Hegeman's company vehicles.

InSeeGo also offers the option to process travel hours if all passengers check in. This capability was one of the reasons Hegeman initially chose InSeeGo. However, Hegeman quickly realized that this system only works if you strictly adhere to the CLA, and there were no customization options within InSeeGo when deviations occurred. Several issues emerged:

- Everyone was required to first come to a central point from where the vehicle departed, instead of being picked up from home, which is Hegeman's usual practice.
- At Hegeman, there is a distinction between the payment for executors and construction workers, which the system could not accommodate.
- If an employee forgot to check in, there was no way to add them later, leading to discrepancies in calculating the driver's and passengers' travel hours.
- If an employee drives with their own car/ a car without tag system, there is no possibility to determine the travel hours.

These issues could not be resolved with InSeeGo, so Hegeman decided not to use it for processing travel hours and reverted to the system they had always used. The failure of this attempt led to the creation of this assignment, as there remained a belief that, in theory, it should be possible to automate this process effectively. This ties back to the problem context outlined in Section 1.4.

4 Requirements for a solution

In Chapter 4, the requirements for a solution are outlined, drawing upon a comprehensive analysis of the current situation as detailed in Chapter 3. These requirements stem from numerous interactions with the HRM team and the executors. Through observations and interviews, crucial insights have been gained, leading to the identification of key aspects that need to be addressed. This chapter presents the requirements based on the CLA in Section 4.1, regulations from the Works Council in Section 4.2, and observations from collecting data in Section 4.3. By identifying these requirements, a solid foundation is laid for developing an effective solution that can significantly enhance the workflow for processing travel hours within Hegeman.

4.1 Collective Labour Agreement

For the solution to be effective, it is crucial that it complies with the CLA Bouw & Infra agreements, which are set by employers' and employees' organizations for the period from January 1, 2024, to December 31, 2024. The solution must incorporate the following requirements from the CLA:

- Construction site workers who work outside their city are entitled to travel time compensation, which are called travelling hours.
- The driver of the vehicle is paid for the entire trip, while passengers are not paid for the first hour.
- The employer must record the number of kilometres travelled and the travel hour compensation.
- Travelling hours compensation is only for construction workers and assistant executors.
- The calculation of travel hours must use the standard for the fastest route.
- Speed standards for different modes of transportation must be applied: 60 km/h for cars, 40 km/h for motorcycles, 25 km/h for mopeds, 15 km/h for bicycles, and 5 km/h for walking.
- Table 5.10.3 of the CLA specifies the payment per kilometre for a one-way trip when using a car, and this is the guiding rate.

These requirements must be integrated into the solution to ensure compliance with the CLA agreements.

4.2 Regulation Working Council

According to Article 5.10.5 of the CLA, an alternative arrangement can be agreed upon with the working council. This is the case for Hegeman. Agreements have been made in the interest of the employees. Here are the agreements listed:

- Construction workers do not have to go to a central point. They are picked up and brought back to home.
- If the distance exceeds 106 kilometres, travel time is calculated based on the actual time taken, with a standard time based on the fastest route rather than the actual travel time.
- Together with the management, agreements are made on whether a project is prone to traffic congestion. When the project gets the label prone to traffic congestion the following rules apply:
    - Construction workers and executors are allowed to leave a quarter-hour earlier, and this time is deducted from the travel hours.

- Executors receive half of the travel hours for a passenger. According to the CLA they would receive none.

For a tailored solution for Hegeman, it is important that it meets these requirements. Otherwise, it would be a solution that, like with InSeeGo, they cannot use.

4.3 Requirements based on observations

Based on the observations made in Chapter 3, specifically the gap analysis in Section 3.1, several important aspects have become clear that should be considered when developing a solution. This resulted in three aspects: data integration, overview pages and automatic calculations which could all lead to significant reductions in the processing time. With the HRM department and executors also a list of scenarios is made which could occur for a solution.

4.3.1 Data Integration

The process for recording and processing travel hours involves multiple steps, starting when construction workers begin their journey and ending when the HRM department logs the hours into the payroll system. For an automated solution to be successful, it must streamline both the input and output aspects of this process. Specifically, raw data from InSeeGo can be used as the input, and the travel hours data needs to be formatted for export to the 4PS system. InSeeGo could be used because of their tagging system with GPS data. This dual approach ensures that data is accurately captured and easily integrated into the existing payroll system.

Currently, a significant amount of time is spent manually entering data and filling in trip registration forms. Automating this process would save considerable time and reduce the potential for human error. By integrating the raw data from InSeeGo and ensuring it is formatted correctly for the 4PS system, the entire process can become more efficient. This data can serve as the foundation for a tailor-made solution for the traveling hours process.

To explore the data available from InSeeGo, several meetings were held with the equipment manager at Hegeman. During these meetings, tables containing information like that in Table 4.1 were found, but they only included a DriverId. Currently, only the driver is tagged, because InSeeGo emits a sound like the warning for not wearing a seatbelt that is the only reason why tagging is used at the moment. Passengers are not tagged as this data is not utilized currently. Together with the equipment manager, a one-week test was conducted where two construction workers tagged in and out. The data in the table from InSeeGo did not change as a result. Subsequently, a meeting was held with InSeeGo representatives, who demonstrated the master data. It was confirmed that tags are indeed registered with the information from that table, but this data is currently not exportable. Access to the API, which can process this data, is available. It was discussed that the input from Table 4.1 could be exported, but the data needs to be processed through the API. This was confirmed by an integration expert from CAPE Groep, who verified that it is feasible, though it falls outside the scope of this thesis. Therefore, it is assumed that the data will be handled in the manner outlined in Table 4.1.

A major advantage of InSeeGo is that Hegeman can create Points of Interest (POI) within the system for specific locations. For example, they can create a polygon around a project site so that all cars that stop or depart from the project location are marked with the project indication instead of various addresses based on GPS. This is particularly useful when Hegeman is building a new residential area; this way, all cars parking there are recognized as being at the same project instead of different addresses within the neighbourhood, which also simplifies billing.

Column Name	Format	Explanation
Noteid	191158	Unique code of the vehicle.
MobileReg	AA-123-A	Registration number of vehicle.
StartMTime	01-01-2024 07:00	In check time.
StopMTime	01-01-2024 08:00	Time when the tag was tagged out or where the car stopped.
DriveTime	01:00	Time between start time and stop.
Distance	50	KM's driven in the trip.
TagID	Jan Jansen	Name of the employee who uses a RFID in the car
TripAddresStart	Cape Group	POI in InSeeGo where the tag was used first.
TripAddressFinish	Project: Groningen	POI in InSeeGo where the tag was tagged out or where the car stopped.

Table 4.1 Output of InSeeGo

The raw data visible in Table 4.1 from InSeeGo should be used to improve the process by providing accurate and detailed trip information. It will serve as the essential input data for the system that tracks and processes travel hours.

Column name	Format	Explanation
Jaar	2024	Year
Week	1	Week number
Werknemer	00000	Employee Number
Documentnr.	Uren 2024-1	Export file
Boekingsdatum	01-01-2024	Date of the input
Ontvangend bedrijf	01 Hegeman	Company of the employee
Projectnr.	PR20000000	Number of the project
Element	00.00.00	Component for finance
Kostendrager	100000	Type of employee. Difference between executors and construction workers
Looncomponent	141	Component for the salary
Omschrijving	Reisuren	Description of the payment component
Maandag till Zondag	0,75	Travel hours per day of the week
Totaal regel	1,5	Total travel hours in week

Table 4.2 Input for 4PS

The values visible in Table 4.2 needed by the 4PS system should be used as the output format for the travel hours data. By ensuring that the travel hours data is formatted correctly, it can be directly imported into the 4PS system, streamlining the entire process from data collection to payroll.

The need for a clear and organized overview arises from the current inefficiencies in accessing relevant information. Presently, both HRM personnel and executors are burdened with the task of sifting through numerous documents and files to locate the required data. This process is not only time-consuming but also prone to errors and inconsistencies.

4.3.2 Overview Pages

By implementing a comprehensive overview page as second requirement of the solution, the time used for searching the right document can be effectively addressed. Such a page would serve as a centralized hub where all essential information pertinent to each role is readily accessible. For example, it would provide executors with an overview of the trips driven, based on the data input from InSeeGo. Additionally, it would offer the HRM department the ability to access data from all different executors in one consolidated overview, eliminating the need to search for individual projects per employee.

This centralized overview not only saves time by streamlining data retrieval but also enhances accuracy and consistency by presenting information in a clear and organized manner. Executives can quickly assess trip details, while HRM personnel can efficiently manage and verify travel hours for multiple employees simultaneously. The implementation of such an overview page improves workflow efficiency and contributes to a more effective travel hours processing system.

Moreover, the overview page grants executors the capability to review and validate all recorded trips efficiently. Previously, they relied on last week's trips and roster modifications, leading to potential inaccuracies. With this enhanced overview, they can swiftly verify the correctness of trip data without the need for exhaustive manual entries. This streamlined approach ensures reliability and expedites the validation process, enhancing operational efficiency and data accuracy.

4.3.3 Automatic Calculations

Currently, the calculations for travel hours are initially conducted by the site manager, and later, all filled travel hours are reviewed and recalculated by the HRM department. An improvement opportunity lies in making the sole task of site managers to verify the hours. Once the trip data is accurately inputted into the system, the solution should facilitate automatic calculations for all projects simultaneously. Therefore, the solution must provide a means to transition from verified input to processed travel hours that can be directly imported into 4PS. This would result in time savings.

To conduct these calculations effectively, it is crucial to ensure that the system can manage a wide range of trip scenarios. All conceivable calculations should be thoroughly outlined, and the system should be able to clearly delineate which scenarios it cannot accommodate. This pre-emptive identification enables any necessary manual interventions.

4.3.4 Scenarios

The potential scenarios to be considered for incorporation into the solution are varied, reflecting the diverse nature of travel situations encountered by Hegeman's workforce. These scenarios have been carefully developed in collaboration with the HRM team to cover all situations encountered in their operations. By addressing each scenario in detail, the solution can be finely tuned to manage a wide array of circumstances efficiently. These scenarios encompass:

- Solo driver commute: *In instances where a construction worker travels alone to the construction site, the solution must accurately calculate travel hours based on the fastest route for a single occupant vehicle.*
- Passenger transport: *For scenarios involving a driver transporting multiple passengers to the construction site, the solution should differentiate compensation between the driver and passengers, adhering to the CLA.*

- Project is labelled prone to traffic congestions: *Journeys to construction sites notorious for traffic congestion necessitate special consideration. There fifteen minutes are withheld from the travelling hours, because the construction workers can leave earlier.*
- Carpooling dynamics: *Traveling to a designated carpool location before boarding the pool car, both with and without passengers.*
- Executor commute: *For executors commuting to construction sites prone to traffic congestion, the solution must account for potential delays and ensure fair compensation, considering both travel time and actual working hours.*
- Round trip rotation: *Scenarios where the driver and passengers alternate in the round-trip journey require meticulous handling. The solution should accurately track individual contributions to the travel time and adjust compensation accordingly.*
- Trip exceeds distance table: *Scenario where the driver and passenger need to travel more than the maximum kilometres from the table of the CLA, so it needs to be the actual travel time.*

By using these diverse scenarios, the solution can effectively address the complexities inherent in travel hour processing, ensuring fairness, accuracy, and efficiency across all situations encountered within Hegeman's operations.

5 Design and Development

This chapter outlines the process of designing and developing a solution to improve the travel hours processing system at Hegeman Constructions. Building on the analysis of the current process and the identification of key issues presented in previous chapters, a generic process model was developed and subsequently tailored to meet Hegeman's specific requirements. This chapter is structured to provide a comprehensive overview of the methodologies used for the design, the requirements for the solution, and the implementation steps taken to create and validate the proposed solution.

The chapter begins with an overview of the generic process model, including a detailed SIPOC analysis and the use of swim lane diagrams to visually represent the processes. Following this, the specific process tailored for Hegeman is described, highlighting the unique requirements and adaptations made to address the company's operational needs. The development of the application is then detailed, including the data integration steps, the entity-relationship diagrams (ERD), and the implementation of filtering steps to accurately process travel data. Additionally, the chapter discusses the automatic calculation algorithms used to compute travel hours based on predefined rules and scenarios.

5.1 Generic process

This section delves into the development of a generic model for processing travel hours, leveraging GPS technology. The premise of this research is centred around the assumption that car trips can be accurately recorded through GPS tracking. The envisioned output of this model aligns with the format presented in Table 4.1, transitioning towards the format specified in Table 4.2, which serves as output for this process and input for the payroll processing system.

Based on the requirements outlined in Chapter 4, excluding the specifics concerning agreements with the Works Council of Hegeman, the design of the generic process is approached in a structured manner. First, a new SIPOC diagram provides an overview of the new process, alongside a detailed BPMN swimlanes diagram like those in Section 3.1. Next, the general functionality and requirements for the application will be specified. Finally, a comprehensive flowchart will be developed to illustrate the calculations, integrating all scenarios to accurately determine the travel hours per person. This generic process is intended to serve as a solution for other construction companies that use similar input variables and face comparable challenges in processing travel hours.

5.1.1 SIPOC

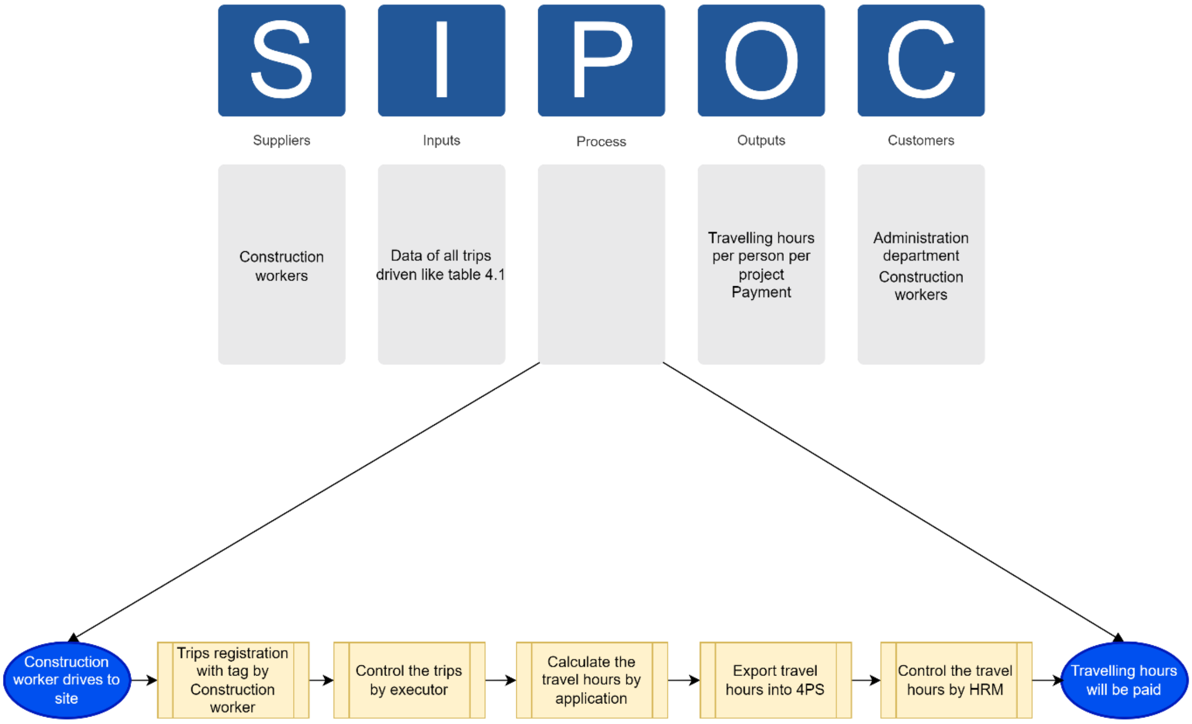


Figure 5.1 SIPOC new process.

The new process is outlined in Figure 5.1 using the SIPOC methodology from a high-level view. Several major differences with the current process from Chapter 3 are immediately apparent (cf. in Figure 3.1). For instance, the executors are no longer considered suppliers because the data for processing comes all from the tag of the construction worker. Consequently, the executors now have a controlling role instead of a data entry or calculating role. This change alone results in significant time savings. Additionally, travel hours will be calculated by an application, whereas previously this was done by both the executor during data entry and the HRM team during verification. The customer of this process will now also be the HRM team, as they will put the output into the system for further processing.

5.1.2 Swimlane

In Figure 9.2 in Appendix 9.4, the swim lane diagram of the new generic process is shown, detailing the steps performed by each role. This time, the process starts with the HRM. It can only begin once all trips have been completed and closed. Then, HRM retrieves the data from the vehicle registration system to import it into the application. As explained in the SIPOC, a significant difference for the executor is that they now only need to review and correct the trips instead of filling in and calculating everything. It is essential that if something occurs that the system cannot manage, the executor notes this and sends it to the HRM team so they can manually add it to 4PS later.

In the new process, the HRM team does not need to perform the calculations, but they are still responsible for ensuring that the referenced tables are correctly populated with information. Currently, this responsibility is already in place, and it only matters when new situations arise. For instance, if someone goes to a specific project for the first time, the information might not yet be in the table for passengers. In the current system, this must also be looked up and communicated to the executor. Now, it only needs to be entered into the table, allowing the system to always perform the calculations for that scenario.

It remains important that there is some form of verification on the HRM side to ensure that the correct salaries are being paid. This will now take place after exporting to 4PS. Here, the HRM team can check that travel hours are only listed for days worked. This is a quick and straightforward check, and if discrepancies arise, they can investigate which of the two entries is incorrect. The primary consideration in the new process is to make it more organized, reducing the need to search through various documents, automating the calculations, and integrating the data.

5.1.3 Application design

In Figure 9.3 in Appendix 9.4, the flowchart for the application is shown. The steps performed by the application can also be found in the steps described above, but there are some differences and important aspects that the application must meet, which do not necessarily impact the stakeholders' steps.

The first important aspect is sorting the data. When the data is imported from the vehicle registration system, it is still a large pile of information. This data must be sorted so that the trips are grouped by person, and the connection to a project is also important. This ensures that later the executor of a project has a clear overview. Additionally, the system must determine who the driver and passengers are. This will be done based on the check-in time. The first person to check in will be designated as the driver, and those who check in later will be passengers. If there are no passengers, the driver is designated as a passenger. This is because the payment applicable is that for a passenger.

Another important aspect is that during the calculations, there will be a check to ensure that all necessary information is present. If something is missing, an error will appear, and the HRM team must add the missing information.

Once the calculations are complete, it is important for the application to sort the data according to Table 4.2 so that 4PS or another accounting program can import it. The process for the application is complete once the data is downloaded.

5.1.4 Calculations

An important aspect of the new process is the calculations. The calculations need to be structured to accurately determine the travel hours. To address this, the scenarios in Section 4.3 were reviewed to identify which ones are specific to Hegeman and which can be used generically. For each scenario, a method is first developed to perform the calculation, and then these methods are combined into one comprehensive calculation. The scenarios are explained below:

Solo driver commute

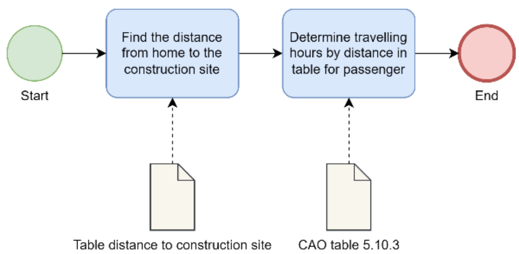


Figure 5.2 Calculations Solo driver commute.

The calculations are visible in Figure 5.2. For someone who drives alone, the rules for a passenger apply. The distance from home to the project (stored in a table in the application) is considered, and then the CLA table is used with this distance to determine the final travel hours.

Passenger transport

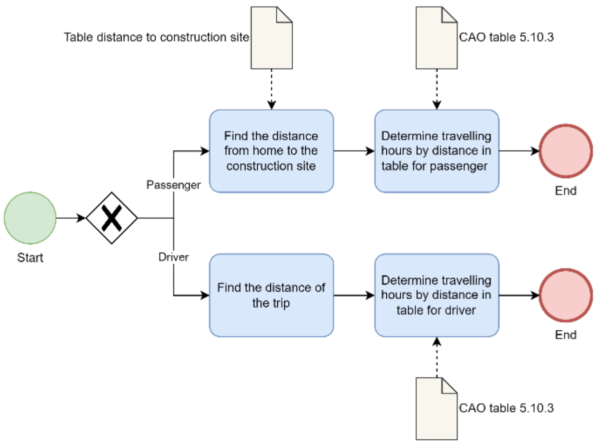


Figure 5.3 Calculation passenger transport.

The calculations are visible in Figure 5.3. For a trip with multiple people in the car, a distinction is first made between the passengers and the driver. The calculation for passengers is the same as in Figure 5.2. However, for the driver, the distance travelled is important, and this is entered into the same CLA table, but in the column for driver payment.

Round trip rotation

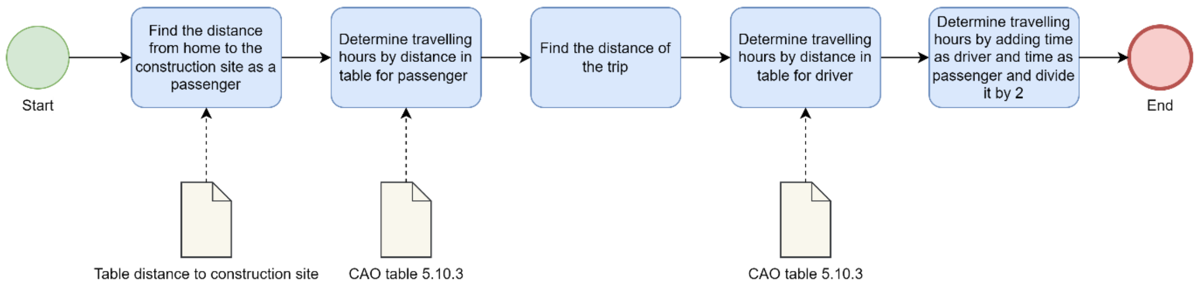


Figure 5.4 Calculation round trip rotation.

The calculations are visible in Figure 5.4. There are also trips where drivers rotate so employee A drives to the project and employee B drives back to home. To calculate this, separate calculations are made for the time spent as a passenger and for the trip as a driver. These values are then added together and divided by two to determine the travel hours. A distinction is made between the trip from and to work.

Carpooling dynamics

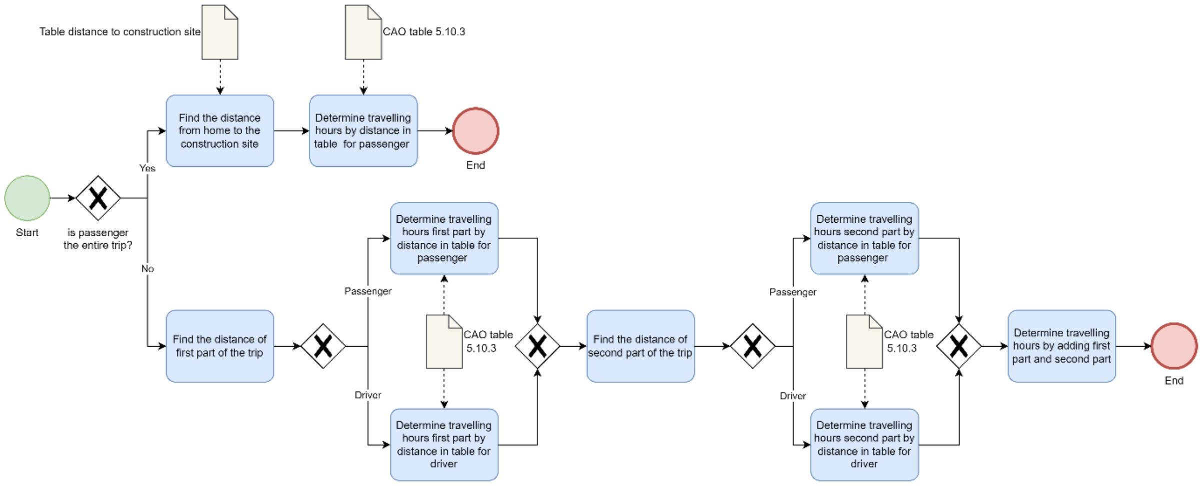


Figure 5.5 Calculations carpooling dynamics.

The calculations are visible in Figure 5.5. This scenario accounts for situations where someone might first drive to a carpool location or another person's house before continuing the journey in a different vehicle to the destination. Initially, it is determined whether someone is a passenger for the entire trip, in which case the same rules as previously described apply. If this is not the case, the trip is divided into different segments. For each segment, it is determined whether the individual is a driver or passenger based on who tagged in first. Once all segments are calculated, the total travel hours are obtained by summing these segments.

Trip exceeds distance table.

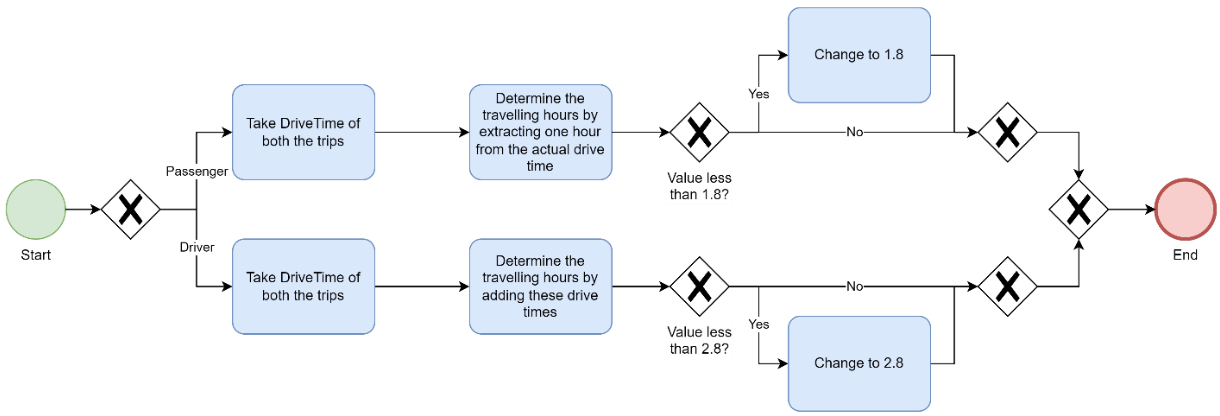


Figure 5.6 Calculation trip exceeds distance table.

There is also a scenario where the distance to a project exceeds 106 km. According to the CLA, the actual driving time must be considered in this case. There is also a minimum travel time that must be accounted for, as illustrated in Figure 5.6.

Calculations for all scenarios

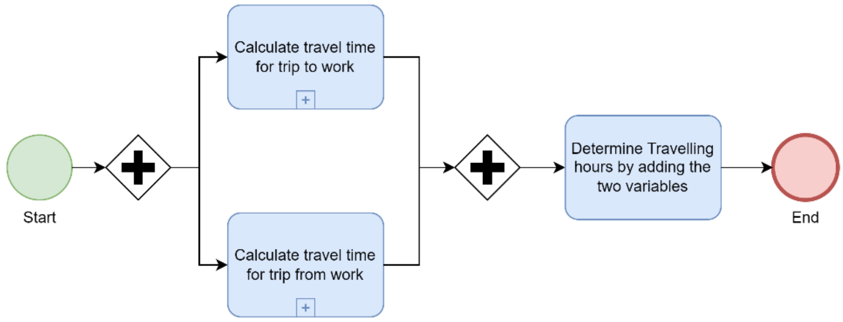


Figure 5.7 Calculation all scenarios generic process.

The calculations are visible in Figure 5.7. Now that all scenarios have been detailed, it is important to integrate them. A model has been created that uses choices and tables to call upon calculations. During the scenarios, the round-trip rotation was calculated, indicating that scenarios can switch between the trip to and from work. To address this, it was decided to calculate both the trips separately using all scenarios, then halve those values and sum them up. This is because the calculations and the CLA table are based on a return trip, so it needs to be averaged. The advantage for calculating the trips separately is that every combination of scenarios can be made. For example, an employee drives alone to the construction site and goes back to home via a carpool site. Then it is still calculated correctly.

The calculations are done in a subprocess, which can be found in Figure 9.4 in Appendix 9.4. It is important that the trip to and from work are calculated in the same way but only using the parameters of each individual trip. The result is designed so that they receive half the value compared to the normal calculation, where the entire trip is considered. This process can occur in parallel since there is no overlap. Once both are calculated, the values can be summed up to yield the correct travel hours.

5.2 Process for Hegeman

Now that the generic process has been created, it is important to tailor it specifically for Hegeman, as described in Section 2.2. For Hegeman, the SIPOC, the swimlanes, and the application functionality will remain the same, but additional scenarios will need to be incorporated as outlined in Chapter 3.

When analysing the scenarios in Section 5.1.4, all scenarios can remain unchanged. However, for the "trip exceeds distance table" scenario, a new calculation will need to be implemented due to agreements Hegeman has made with the working council. Additionally, the scenarios "project is labelled prone to traffic congestion" and "executor commute" must be added to the calculations to make the process customized for Hegeman.

Trip exceeds distance table.

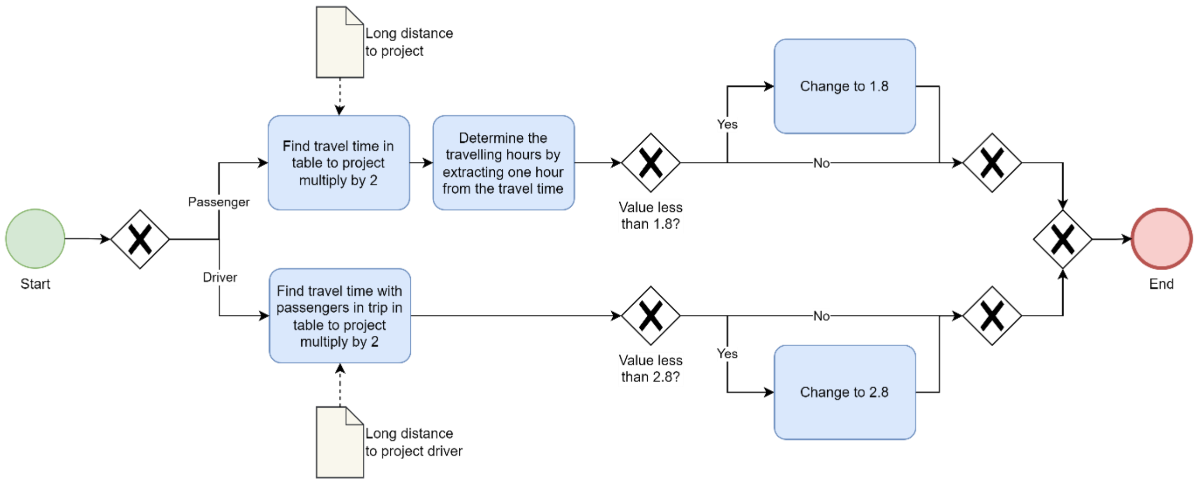


Figure 5.8 Calculations Trip exceeds distance table for Hegeman.

The calculations are visible in Figure 5.8. The major difference with the generic solution is that the time there is based on the actual travel time driven. For Hegeman, this is different. Hegeman has an agreement that everyone can always be picked up from their home. However, as a counter-agreement with the work council, it has been decided that for distances longer than 106 km, the travel time is based on the time it would take according to the ANWB route planner. This time is stored in the "long distance to project" and "Long distance to project driver" table by HRM and is used to retrieve the information when the trip exceeds 106 km. In the table "Long distance to project driver" also the passengers are in there because the driver will get paid for the route with picking up the passengers. This will be multiplied by two, because the time that is in the table is only for one trip. The minimum of 1.8 hours as a passenger and 2.8 hours as a driver are according to the CLA regulations.

Project is labelled prone to traffic congestion.

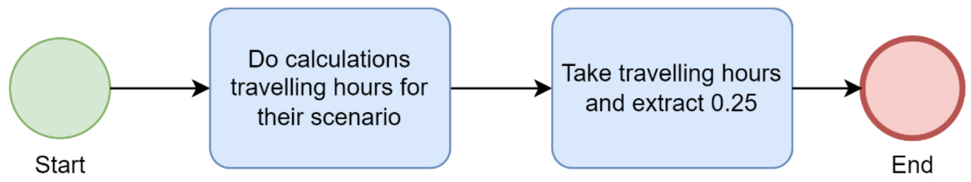


Figure 5.9 Calculations Project is prone to traffic congestion.

The calculations are visible in Figure 5.9. At Hegeman, when a new project begins, it is checked whether the route to the location is prone to traffic congestion. If so, there is an agreement that employees can work fifteen minutes less and leave earlier. They still get paid for 8 hours, although they work 7.75 hours. This fifteen-minute deduction is then subtracted from the travel hours to prevent double payment for that quarter hour. This is because the hourly wage for travel time differs from that for working time. To perform this calculation, fifteen minutes will be subtracted after the initial calculation. In the overall calculation, it will be indicated whether this is applicable based on project information, which will include whether the route to the project is prone to traffic congestion.

Executor commute

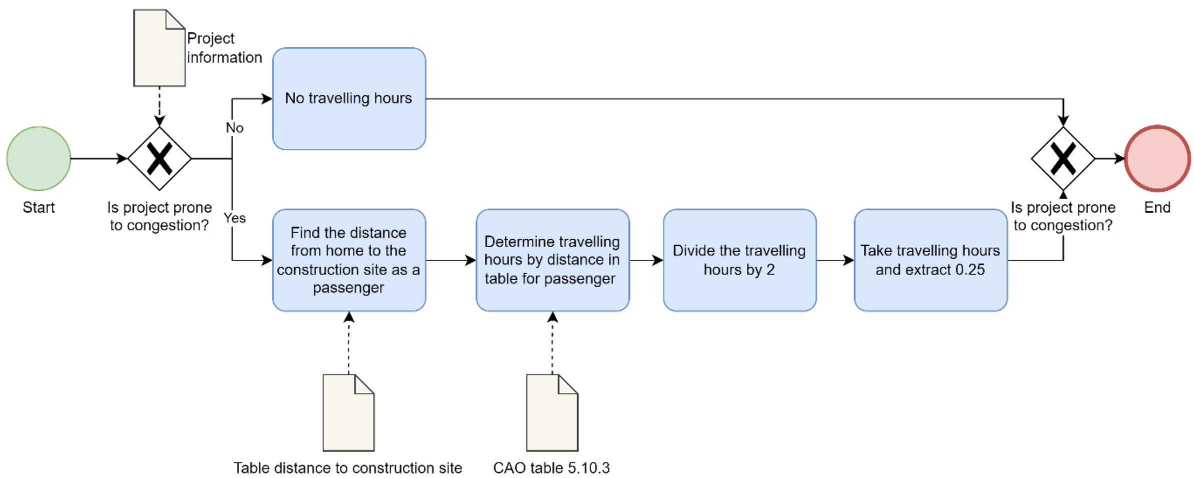


Figure 5.10 Calculations executor commute for Hegeman.

The calculations are visible in Figure 5.10. Another part of the agreement for when a project is prone to congestion is that, unlike the standard CLA, executors will get paid travel hours. However, they only receive half of the travel hours compared to those of a passenger. This is a gesture from Hegeman, agreed upon with the work council. To calculate this, a check will be performed for executors to see if the project is applicable. If it is not, they will not receive any travel hours. At Hegeman when the project is prone to congestion, they are allowed to leave 15 minutes early and they still get paid their normal salary so 0,25 is extracted from the travelling hours, otherwise they would be paid double.

Calculations for all scenarios

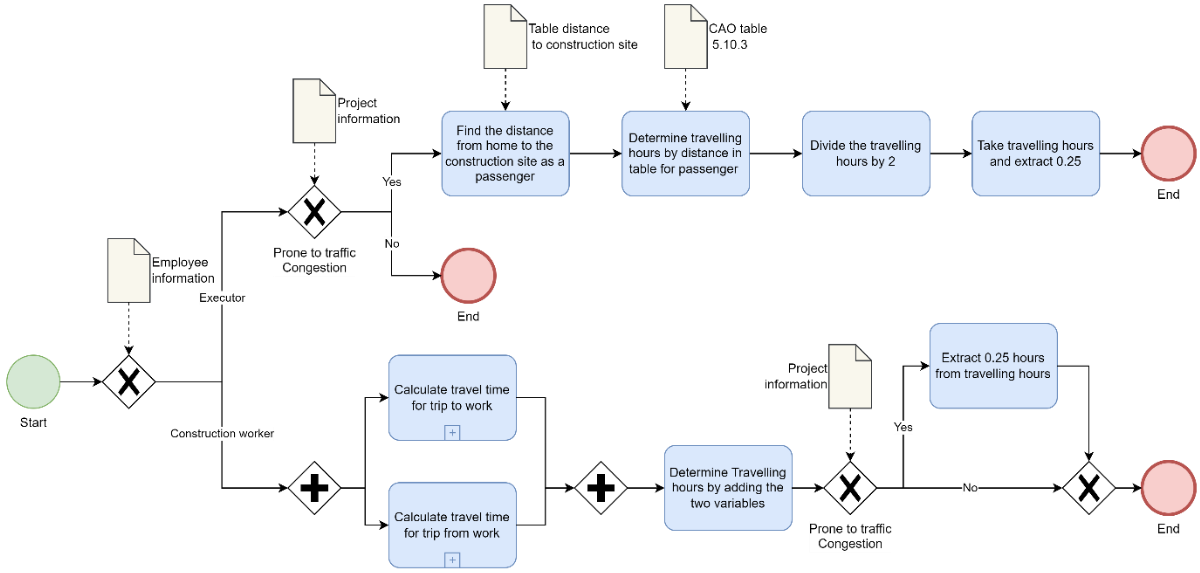


Figure 5.11 Calculations for all the scenarios of Hegeman.

The calculations are visible in Figure 5.11. Now that all scenarios have been detailed, they need to be integrated into a single process. There is a subprocess for calculating travel hours for a single trip, like the generic solution. However, the part of the calculation for trips longer than 106 km has been changed. The other scenarios do not affect the calculation of travel hours per trip but are adjustments that occur after the calculation. Therefore, as shown in Figure 5.10, these are processed afterward. First, the employee's role is checked to apply the executor commute scenario. For construction workers, after determining the travel hours, it is checked whether the project is prone to traffic congestion to see if fifteen minutes need to be subtracted, as described in the scenario "Project is labelled prone to traffic congestion".

5.3 Tool (Demo application)

Based on the findings in Sections 5.1 and 5.2, an application has been developed in Mendix to process travel hours. This chapter will explain how this application was built to answer the research question: *How should a demo application be designed to reduce the travel hours processing time at Hegeman Constructions in alignment with the newly developed process?* Four key elements will be covered: data input for the application, data filtering, the calculations performed by the application on the travel hours, and how the output is generated. Additionally, the chapter will include a detailed explanation of the entity-relationship diagram (ERD), which illustrates the relationships between different data entities within the system. It is important to note that this application functions as a demo model and serves as a proof of concept.

5.3.1 Data Input

One of the main goals of the application is data integration, ensuring that data from InSeeGo can be imported into the application for processing. In the long term, this integration will be managed via an API. However, since this falls outside the scope of the demo version, a representative dataset was created. This dataset aligns with the input requirements detailed in Table 4.1 and must be anonymous, containing no real employee data from Hegeman. The advantage of this created dataset is that it contains every scenario so all the scenarios can be tested afterwards.

To ensure anonymity, the names of PEC Zwolle football players were used, making it clear that the dataset does not represent actual employees. This choice maintains privacy and avoids any confusion.

When creating the dataset, it was crucial to address all potential scenarios the application might encounter. This comprehensive approach ensures that all scenarios are tested and verified, as outlined in Chapter 6. Through iterative programming, each scenario can be individually programmed and refined. Table 5.1 lists all the scenarios associated with employees in the dataset, corresponding to those described in Section 4.3.4.

Scenario	Employees
Executor writes to construction site, Project is not labelled prone to traffic congestion	Van Polen en Boer
Solo commute	Reijnders
Passenger transport	McNulty en Lam
Round trip rotation + Executor commute + Project is labelled prone to traffic congestion	Schendelaar en Kersten
Carpooling dynamics	Van den berg, Krastev, Thy en Velios
Trip exceeds distance table	Velanas en Namli

Table 5.1 Scenarios per employee in data set

To convert the scenarios from Table 5.1 into the data format required by Table 4.1, the tag moments of the employees over an entire week were analysed, following the structure in Table 5.2. Given that this is an anonymous dataset and InSeeGo works with POIs, addresses were simplified to general locations.

NodeId	MobileReg	DriveDate	StartMTime	StopMTime	DriveTime	Distance	TagId	TripAddress start	TripAddress Finish
000001	AA-001-A	10-06-24	06:00:00	07:00:00	1:00	80	Bram van Polen	Van Polen huis	Project 1
000001	AA-001-A	10-06-24	06:01:00	07:00:00	0:59	80	Diederik Boer	Boer huis	Project 1
000001	AA-001-A	10-06-24	16:00:00	17:35:00	1:35	85	Bram van Polen	Project 1	Van Polen huis
000001	AA-001-A	10-06-24	16:00:00	17:35:00	1:35	85	Diederik Boer	Project 1	Boer huis
000001	AA-001-A	11-06-24	06:00:00	07:00:00	1:00	82	Bram van Polen	Van Polen huis	Project 1

Table 5.2 Part of the data set

The calculations in Section 5.2 necessitate several tables for accurate computations. These tables were also created for data integration purposes. An example is Table 5.3, which contains project information, such as whether a project is prone to traffic congestion. This data is crucial for the application's output and serves as input for the 4PS accounting system.

Projectnr.	Naam	Adres/POI	Ontvangend bedrijf	Element	Prone to traffic congestion
PR20000000	Project 1	Project 1	01 Hegeman	00.00.00	No
PR20000001	Project 2	Project 2	01 Hegeman	00.00.00	Yes

Table 5.3 Project information

All these tables were created in the application and can be filled and adjusted on their respective pages. The data imported corresponds to the format in Table 5.2. An Excel importer was built in Mendix to facilitate loading this data into the application efficiently.

5.3.2 Entity-relationship diagram

An essential part of the application is understanding the relationships between different data entities. The entity-relationship diagram (ERD) illustrates these relationships, providing a clear picture of how data from various sources is interconnected and managed within the system. The ERD for this application is visible in Figure 5.12.

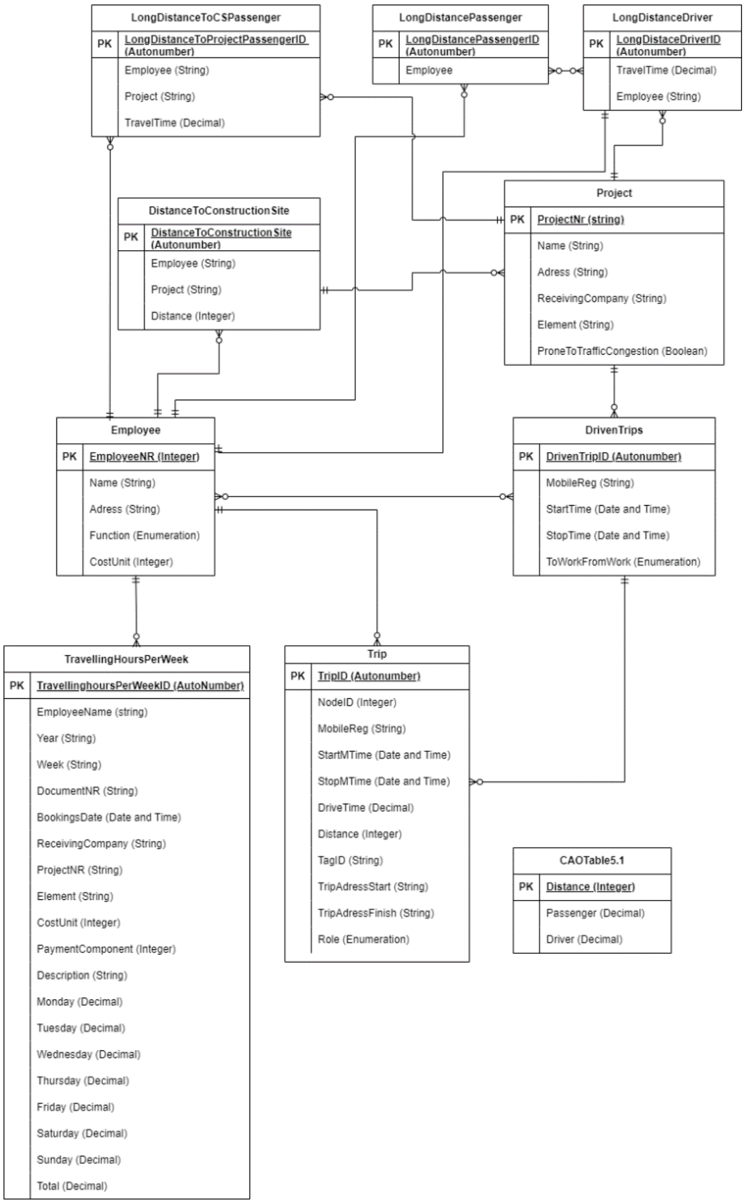


Figure 5.12 Entity-Relationship Diagram for the application.

The ERD helps to visualize the structure of the database, making it easier to understand how different entities interact with each other. This diagram is crucial for designing the database schema and ensuring efficient data handling within the application.

The entities at the top of the diagram represent the tables that are used in the calculations. These include:

- LongDistanceToCSPassenger: Contains data for long-distance travel to construction sites.
- LongDistancePassenger: Stores information about passengers on long-distance trips.

- LongDistanceDriver: Stores information about drivers on long-distance trips.
- DistanceToConstructionSite: Records the distance between employees' homes and construction sites.
- Project: Contains details about various projects, including if they are prone to traffic congestion.

The Trip entity is used for inputting data into the application, capturing details about each trip made by the employees, such as start and stop times, distances, and roles (driver or passenger). The roles are not in it with the import but are determined later as explained in Section 5.3.3.

The TravellingHoursPerWeek entity is used for output, summarizing the travel hours per week for each employee. This data is the same as the input for 4PS.

All these entities are connected through the Employee entity, ensuring that the data is linked per employee. This linkage is essential as the travel data is imported and processed on a per-employee basis.

The CAO Table5.1 entity is not linked to any other entity, but it is essential for the calculations. When a table provides a distance, this distance is used to reference the correct payment in the CAO Table 5.1. This table ensures that the appropriate compensation is calculated based on the specified distances.

The data for entities such as Employee, Project, and the calculation-related tables are pre-filled in the dataset and maintained by the HRM department. This ensures that the application has access to accurate and up-to-date information necessary for processing travel hours efficiently.

5.3.3 Transforming the data

In the previous Section 5.3.2, the Entity-Relationship Diagram (ERD) was thoroughly explained. However, when importing the data into the application, the connections between the entities are not yet established. This is where data transformation comes into play. This section provides an overview of how data is transformed for each component, with detailed steps available in the Appendix 9.6.

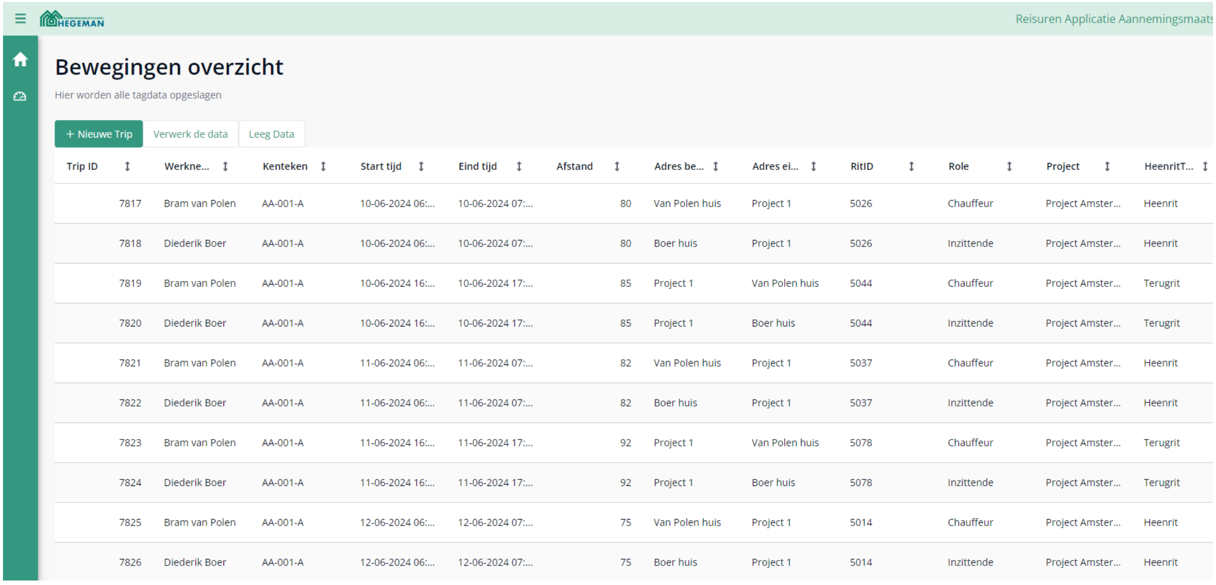
The transformation process involves several key steps to ensure that the data is accurately categorized and linked for precise calculations and billing:

- Creating the Driven Trips: All individual trip entries are scanned and grouped based on matching license plates within overlapping times to form complete driven trips. This ensures each trip correctly reflects the passengers and driver involved.
- Determining Roles (Driver or Passenger): For each driven trip, the start times are analysed to assign roles. The first person to enter the vehicle is designated as the driver, and subsequent individuals are assigned as passengers. Special cases where only one person is in the trip are also handled.
- Linking to Projects: Trips are linked to specific projects by comparing the trip start and finish addresses with project addresses. This ensures accurate billing and proper application of project-specific rules, such as those for traffic congestion.
- Processing Carpool Trips: When carpooling is involved, trips are linked based on transfer times between vehicles. This step ensures that all segments of the trip are properly associated with the relevant project and calculated correctly.

- Creating To Work and From Work Trips: Trips are categorized as either "To Work" or "From Work" based on their start and end addresses. This distinction is crucial for handling different travel scenarios and ensuring accurate calculations.

These transformation steps are crucial for preparing the data for accurate and efficient processing of travel hours. Each step is designed to ensure that all necessary information is correctly organized and linked, enabling precise calculations, and reducing manual intervention.

To provide a clear understanding of how the data looks in the application after the transformation, it is visible in Figure 5.13. This illustration shows the organized and linked data ready for further processing.



Trip ID	Werkne...	Kenteken	Start tijd	Eind tijd	Afstand	Adres be...	Adres ei...	RitID	Role	Project	HeenritT...
7817	Bram van Polen	AA-001-A	10-06-2024 06:...	10-06-2024 07:...	80	Van Polen huis	Project 1	5026	Chauffeur	Project Amster...	Heenrit
7818	Diederik Boer	AA-001-A	10-06-2024 06:...	10-06-2024 07:...	80	Boer huis	Project 1	5026	Inzittende	Project Amster...	Heenrit
7819	Bram van Polen	AA-001-A	10-06-2024 16:...	10-06-2024 17:...	85	Project 1	Van Polen huis	5044	Chauffeur	Project Amster...	Terugrit
7820	Diederik Boer	AA-001-A	10-06-2024 16:...	10-06-2024 17:...	85	Project 1	Boer huis	5044	Inzittende	Project Amster...	Terugrit
7821	Bram van Polen	AA-001-A	11-06-2024 06:...	11-06-2024 07:...	82	Van Polen huis	Project 1	5037	Chauffeur	Project Amster...	Heenrit
7822	Diederik Boer	AA-001-A	11-06-2024 06:...	11-06-2024 07:...	82	Boer huis	Project 1	5037	Inzittende	Project Amster...	Heenrit
7823	Bram van Polen	AA-001-A	11-06-2024 16:...	11-06-2024 17:...	92	Project 1	Van Polen huis	5078	Chauffeur	Project Amster...	Terugrit
7824	Diederik Boer	AA-001-A	11-06-2024 16:...	11-06-2024 17:...	92	Project 1	Boer huis	5078	Inzittende	Project Amster...	Terugrit
7825	Bram van Polen	AA-001-A	12-06-2024 06:...	12-06-2024 07:...	75	Van Polen huis	Project 1	5014	Chauffeur	Project Amster...	Heenrit
7826	Diederik Boer	AA-001-A	12-06-2024 06:...	12-06-2024 07:...	75	Boer huis	Project 1	5014	Inzittende	Project Amster...	Heenrit

Figure 5.13 Imported and transformed data in the application.

For a detailed explanation of each transformation step, including specific procedures and considerations, please refer to Appendix 9.6.

5.3.4 Calculations

The calculations in this section are based on previous research detailed in Section 5.2. This section provides a high-level overview of the calculation process, with specific steps and procedures detailed in Appendix 9.7.

The calculation process involves several key steps to ensure accurate determination of travel hours:

- Filtering Trips: Selecting trips from each day for the calculation. This involves identifying all trips made by each employee on a given day and filtering out irrelevant trips.
- Categorizing Trips: Dividing trips into "To Work" and "From Work" lists. Each trip is categorized based on its start and end addresses to ensure the correct application of calculation rules.
- Carpooling Dynamics: Calculating travel times considering carpooling scenarios. This includes checking if an employee is an executor, determining the role (driver or passenger), summing distances, and looking up values in the CAO Table 5.1.

- Executor Commute: Handling specific rules for executors, including checking for traffic congestion, consulting the DistanceToProject list, and looking up values in the CAO Table 5.1.
- Trips exceeds distance table: Applying different flows for passengers and drivers, consulting the LongDistanceToCSPassenger and LongDistanceDriver tables, and ensuring minimum travel times are met.
- Passenger Transport: Calculating travel times for trips less than 106 km by entering distances into the CAO Table 5.1 and consulting the DistanceToConstructionSite table.
- Project is prone to traffic congestion: Averaging daily travel times and adjusting for traffic congestion scenarios, such as subtracting 0.25 hours from the daily travel time for projects prone to traffic congestion.

For a detailed explanation of each calculation step, including specific procedures and considerations, please refer to Appendix 9.7.

5.3.5 Output

The final output table for 4PS integration is populated using data from previous calculations and transformations (Sections 5.3.3 and 5.3.4), as well as employee and project information from the respective tables defined in the ERD. The travel hours data, categorized into "To Work" and "From Work" trips, is derived from the transformation processes, while calculated travel times and necessary adjustments are sourced from the detailed calculation steps. Employee details, such as employee ID, name, and department, are retrieved from the Employee table, ensuring that the travel data is correctly associated with each relevant employee. Similarly, project details, including project ID, name, and specific attributes like traffic congestion status, are sourced from the Project table. Each entry in the final output table represents a unique record for an employee on a specific day, including their travel data and associated project details. If an employee works on different projects on different days, a new entry is created for each day with the relevant project details.

This table serves as the final output of the application and is formatted according to the specifications required by the 4PS system to ensure seamless data transfer and integration. By consolidating travel data, employee information, and project details into a single table, the application meets the integration and reporting requirements for 4PS. The structured format allows for efficient and accurate processing of travel hours, providing a comprehensive solution for managing travel hour payments.

5.4 Conclusion

In this chapter, the process of designing and developing a solution to improve the travel hour processing system at Hegeman Constructions has been outlined. The findings are based on a detailed analysis of the current situation and the specific requirements of Hegeman.

A generic process model was developed to serve as the foundation for processing travel hours using GPS technology. This model is broadly applicable within the construction sector, incorporating all necessary steps and calculations to accurately record travel hours. The research question "*How should a process for travel hours be designed?*" is addressed by integrating GPS technology to automatically capture travel data, including steps for data collection, filtering, automatic calculations, and standardized output generation. Subsequently, this generic model was tailored to meet the specific requirements of Hegeman, as stipulated in the Collective Labour Agreement (CLA) and agreements with the Works Council. This customized model accounts for exceptions such as traffic congestion and the different compensations for drivers and passengers.

A demo application was developed in Mendix to support the new process. The application integrates data from the InSeeGo fleet management system and automates the calculations of travel hours. Functionalities for efficient data input, data filtering, automatic calculations, and generating output compatible with the 4PS system were implemented. The application's design includes centralized overview pages and ensures accurate data management through a well-defined Entity-Relationship Diagram (ERD), illustrating the relationships between different data entities. This approach answers the research question *"How should a demo application be designed to reduce the travel hours processing time at Hegeman Constructions in alignment with the newly developed process?"* by providing a user-friendly interface that automates data entry and calculations, streamlining the workflow and enhancing efficiency.

6 Demonstration and Evaluation

This chapter explores the impact of the new process and accompanying application on the main research question: “How to reduce the processing time of travelling hours from 40 hours to 8 hours per period for the human research team of Hegeman Constructions?” Additionally, it examines the implementation in the application of the data integration, overview pages and automatic calculations. Also, the verification of the application is discussed to ensure its accuracy and effectiveness.

6.1 Data integration

Current Process

In the current process, data is entered by the supervisors. They create the trip records based on the previous week's data and fill in the details using their knowledge and the recorded working hours. HRM is responsible for tracking the distances to projects. They maintain records of the time it takes each construction worker to reach a project, calculating this using the ANWB route planner and the CAO table as a standard. Each time a driver travels with a new group, HRM had to calculate the kilometres driven to establish the proper records.

New process

In the new process, trips are no longer created by the supervisor based on their knowledge. Instead, the data is sourced from the fleet management tool InSeeGo. HRM exports this data and imports it into the application. This change saves supervisors a significant amount of time, as they no longer need to manually input times. However, supervisors still receive an overview of the recorded trips to verify the data, ensuring that tagging was done correctly, and the correct driver is assigned. They can also create trips for instances where someone drove without a tag.

HRM still needs to create records for trips to projects when someone travels there for the first time. This only applies to passengers, and for drivers, only if the distance is greater than 106 km. For drivers, the calculation is based on the kilometres driven, so no manual record creation is necessary. These calculations now occur during the data processing phase rather than during data integration.

Differences

In the current process, HRM staff are responsible for manually finding employee addresses, using the ANWB route planner to determine routes, and calculating distances, which they then enter various documents and send to executors for verification. In the new process, these tasks are automated through the InSeeGo fleet management system. HRM staff now simply export the trip data and import it into the application, which performs the necessary calculations and stores the data in a centralized location. This shift significantly reduces the manual workload and potential for errors.

Additionally, executors manually review and enter travel hours into 4PS, relying on previous weeks' data and making necessary adjustments based on their knowledge. This involves extensive manual effort and frequent consultations with construction workers to resolve uncertainties. In the new process, executors review and confirm automatically imported trip data within the application. The system manages the calculations and adjustments, allowing executors to focus on verification and addressing any uncertainties directly within the application, greatly reducing their manual workload. These differences are illustrated in Figure 9.6 in Appendix 9.8

Benefits

For executors, the time savings are substantial, as they only need to verify data instead of entering and researching all details. This can save up to half an hour to 45 minutes per week per supervisor.

For HRM, the time savings in this part are not as significant. Importing data takes approximately 15 minutes, and filling in new data in tables also takes about 15 minutes, according to HRM. Therefore, there is no notable time savings for HRM in this area.

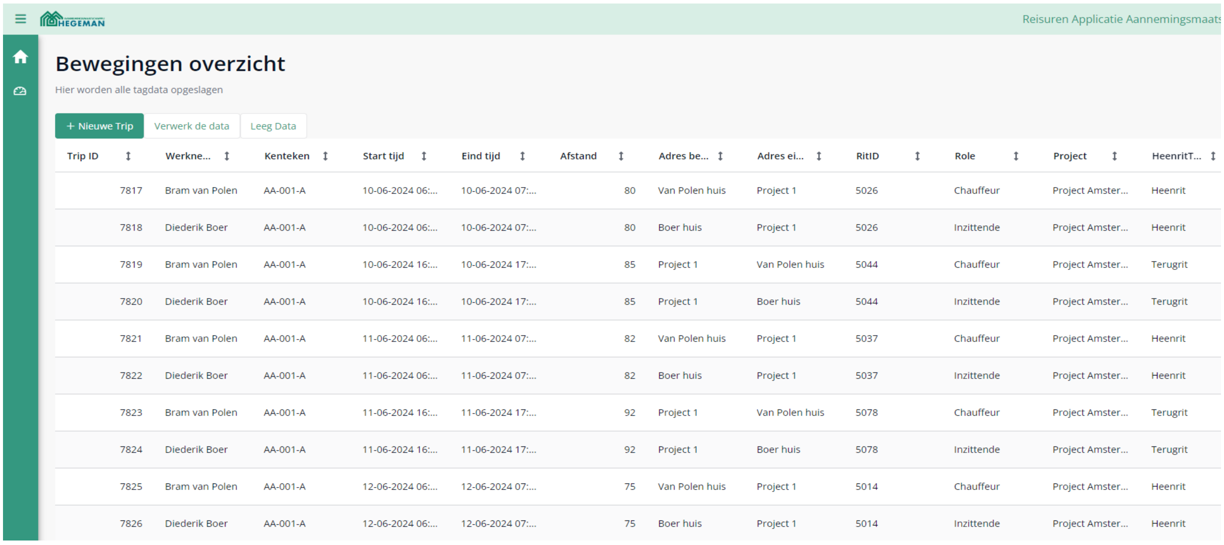
The new system's automated data input from the InSeeGo fleet management system, combined with a verification step, enhances accuracy by minimizing human error, ensuring consistency. Automated data capture provides real-time, standardized input, eliminating variability and the risk of manual entry mistakes. The verification step allows executors to catch discrepancies, adding an extra layer of review that was missing in the manual process.

Implementation in the App

In the application, data is imported using an importer specifically designed to manage the format of the InSeeGo fleet management data. This importer ensures that all relevant trip data is accurately captured and transferred into the system. Once the data is loaded, it is displayed in a comprehensive overview that includes all trips. Users can then use a dedicated button to transform the data, which processes it according to the predefined rules and calculations established for the new travel hours process.

After the transformation, the application provides a project-specific page where all trips related to a particular project are clearly visible. This page allows executors to filter and view trips by project, making it easier to verify and manage the travel data for each project individually. Executors can quickly assess the accuracy of the recorded trips, make any necessary adjustments, and even add new trips directly within the application, ensuring that all travel data for their projects is up-to-date and accurate.

Screenshots of the application interface are available below in Figures 6.1 and 6.2. Figure 6.1 shows the initial data import and overview page, while Figure 6.2 illustrates the project-specific page where all trips are displayed, allowing executors to manage and adjust the data as needed.



Trip ID	Werkne...	Kenteken	Start tijd	Eind tijd	Afstand	Adres be...	Adres ei...	RitID	Role	Project	HeenritT...
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7823	Bram van Polen	AA-001-A	11-06-2024 16:...	11-06-2024 17:...	92	Project 1	Van Polen huis	5078	Chauffeur	Project Amster...	Terugrit
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7826	Diederik Boer	AA-001-A	12-06-2024 06:...	12-06-2024 07:...	75	Boer huis	Project 1	5014	Inzittende	Project Amster...	Heenrit

Figure 6.1 Imported and transformed data in the application.

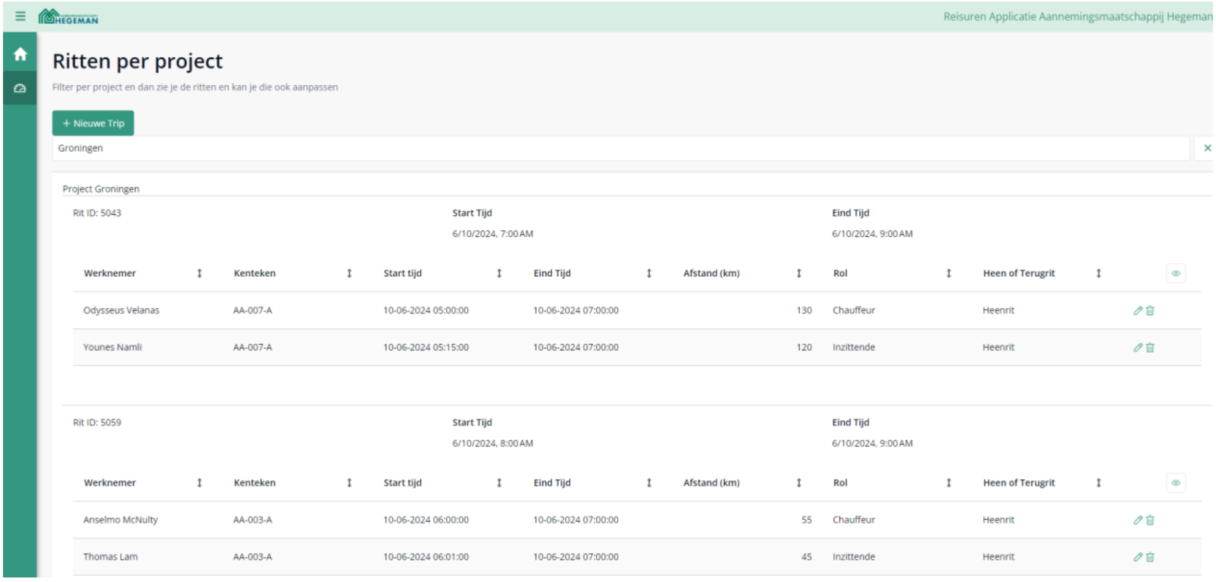


Figure 6.2 Driven trips page per project for the executor.

6.2 Overview pages

Current Process

In the current process, HRM personnel must manually search through multiple tables and documents to find and verify the travel records for each employee. This involves looking up trip details, calculating distances, and cross-referencing various sources to ensure accuracy. Each project has its own Excel files with distance records that must be individually accessed and reviewed for every employee. Additionally, executors are responsible for maintaining these tables to perform later calculations, adding to their workload.

New Process

In the new process, all relevant travel data is centralised in overview pages within the application. These pages provide a comprehensive view of all trips for each employee, project, and executor. HRM personnel can now easily access and review travel records in one place, significantly simplifying the verification process. The application contains tables where all the necessary data is consolidated and can be accessed at once, eliminating the need to refer to individual Excel files for each project.

Executors no longer need to maintain these tables for later calculations, as the application now handles all necessary calculations automatically. While this does not significantly reduce their time spent, it does offer some time savings and reduces the potential for errors in manual record-keeping.

Differences

In the current process, HRM staff must manually search for and verify travel records by looking up employee addresses, using the ANWB route planner to determine routes, and calculating distances. These steps involve accessing multiple tables and documents, cross-referencing various sources, and entering data into several Excel files for each project. This method is time-consuming. Executors are also responsible for maintaining these tables for later calculations, adding to their workload.

In the new process, all relevant data is centralized in the application, eliminating the need for HRM staff to search through various sources. Instead of manually looking up information for each person in various locations, all data is now available in one place within the application. This centralization reduces the time and effort required to verify travel records. Additionally, the application manages all necessary calculations automatically, ensuring accurate records.

Executors no longer need to maintain tables for later calculations. In the previous process, they were responsible for keeping these records updated, which added to their workload. The new system automates this task, allowing executors to focus solely on verifying and adjusting data directly within the system if needed.

These differences illustrate changes in efficiency, with the centralization and automation of data handling tasks reducing the time associated with the current manual process. These differences are illustrated in Figure 9.7 in Appendix 9.8

Benefits

For executors, there is no significant change in time by the overview pages.

The time savings for HRM personnel are substantial, as they no longer need to manually search through various tables, documents, and Excel files for each project. Given that it takes between 45 – 60 seconds per person to look up three files, and with 150 to 200 construction workers being checked each week, this results in an estimated time savings of approximately 3 hours per week.

The implementation of overview pages in the new process not only streamlines the workflow for HRM personnel. By centralising all relevant data in one location, the process becomes more efficient.

Implementation in the App

In the application, all relevant travel data is centralized in comprehensive overview pages, which simplifies managing and verifying travel records. These pages provide a single, consolidated view of all trips for each employee and project, eliminating the need to search through multiple sources.

The overview pages include detailed tables that compile all necessary information such as travel times, distances, and associated project data. HRM personnel can easily access and review all relevant records in one place, reducing the effort and time previously required to locate and verify data across various Excel files and documents. This centralization ensures that all information needed for accurate travel hour processing is readily available and organized efficiently.

This centralization also means that executors no longer need to maintain separate tables for later calculations, as all required calculations are now handled automatically by the application. The comprehensive design of these overview pages ensures that all relevant travel data is centralized, easily accessible, and accurately maintained, significantly improving the efficiency and reliability of travel hour processing.

Screenshots of the overview pages can be seen below in Figures 6.3 and 6.4. Figure 6.3 shows the distance from home to project table, while Figure 6.4 illustrates the long-distance table with the time per passenger in the trip, allowing HRM personnel to manage and adjust the data as needed.

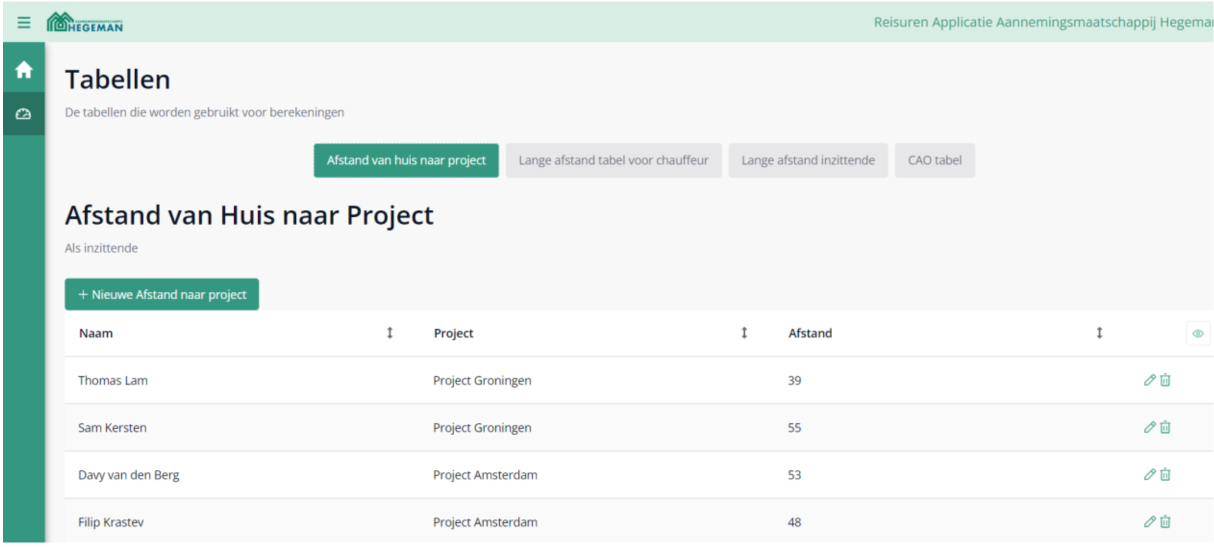


Figure 6.3 Distance from home to project table.

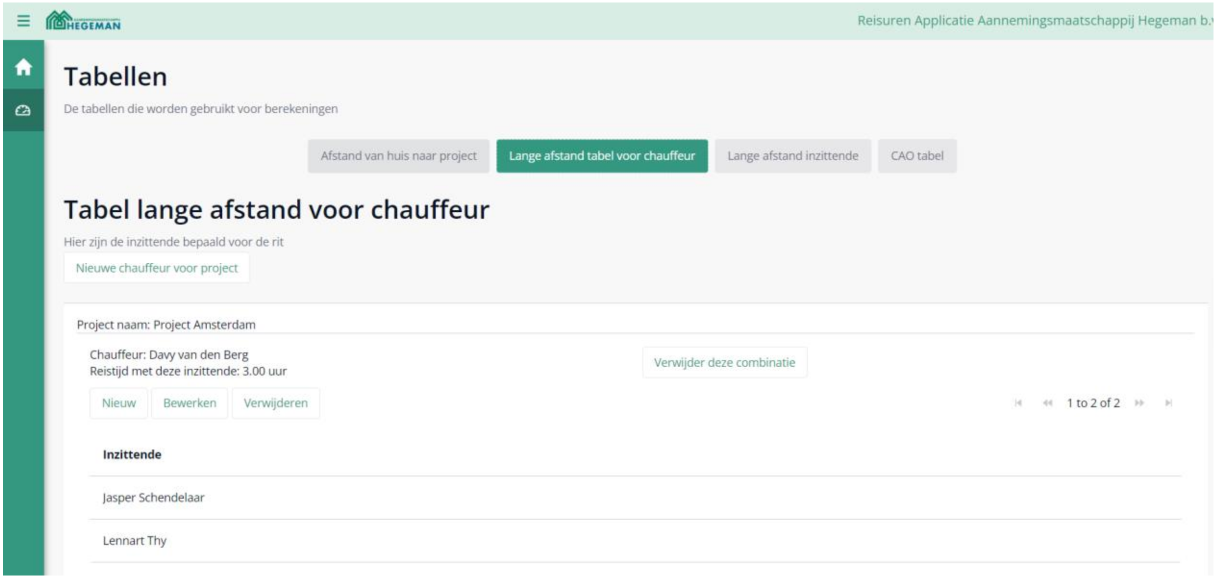


Figure 6.4 long distance table with the time per passenger in the trip.

6.3 Automatic calculations

Current Process

In the current process, HRM personnel and executors manually calculate travel hours and corresponding payments. This involves several steps, including determining the correct role (driver or passenger), calculating travel times, and applying the appropriate CAO regulations and company policies. Each calculation must be individually reviewed and verified, which is time-consuming and prone to errors.

New Process

In the new process, the application automates the calculations for travel hours and payments. The system determines the correct roles, calculates the travel times, and applies the relevant regulations automatically. This eliminates the need for manual calculations, significantly reducing the time and effort required from HRM personnel and executors.

However, when a required piece of information is missing from a table, the system generates a notification with an explanation. HR must then manually fill in the missing information using the ANWB route planner to calculate the distance. This step is a new addition in the process.

Differences

From the HRM perspective, the current process requires a significant amount of time for reviewing and correcting the manually calculated travel hours provided by the supervisors. The HRM team must also ensure that all travel hour calculations comply with the relevant regulations, which is both time-consuming and prone to errors. In the new process, HRM's role shifts to a one-time calculation setup, where they enter necessary information into the application, which then manages all subsequent calculations automatically. This shift reduces HRM's workload.

From the executor's perspective, the current process involves manually calculating travel hours based on working hours and estimated travel times. Executors must look at hours worked, fill in travel hours based on prior knowledge, change trips based on working days and known changes, and communicate with HRM to clear any uncertainties. In the new process, executors are no longer responsible for calculating travel hours. So, this entire step is reduced.

The differences between the current and new processes, highlighting the automation of calculations and the reduction of manual intervention, are illustrated in Appendix 9.8 with Figure 9.8 and Figure 9.9.

Benefits

The automation of calculations saves a significant amount of time for both HRM personnel and executors. Given that manual calculations take approximately 1.5 to 2 minutes per person and there are 150 to 200 construction workers being checked each week, the time savings are substantial. Automated calculations reduce this time to about 10 seconds per person, resulting in an estimated time savings of 3.75 to 6.67 hours per week. Even with the new step of manually inputting missing information, which takes approximately 10-15 minutes per week, the overall time savings remain considerable. To be on the safe side, this process is estimated to save around 5 hours per week.

Additionally, executors also benefit from these automated calculations, saving approximately half an hour per week as they no longer need to perform manual calculations.

Automatic calculations also reduce the risk of human error. Manual calculations are prone to mistakes, which can lead to inaccurate travel records and payments. By automating this process, the application ensures that calculations are consistent and accurate, improving the reliability of travel records and reducing the need for corrections. The notification system for missing information ensures that any gaps are promptly addressed, maintaining the integrity of the data.

The implementation of automatic calculations in the new process not only streamlines the workflow for HRM personnel and executors but also enhances the overall accuracy and reliability of travel records. By automating the calculation process and providing notifications for missing data, the application reduces the administrative burden and allows staff to focus on more critical tasks, improving operational efficiency.

Implementation in the App

In the application, travel data is processed automatically. The system assigns the correct roles, calculates the travel hours, and applies any necessary exceptions, such as long-distance travel or traffic delays. If information is missing, the application generates a notification with an explanation, prompting HR to manually input the required data using the ANWB route planner. These automatic calculations ensure consistency and accuracy in travel records. Screenshot of the page with the calculation and the output of the automatic calculation features can be seen in Figure 6.5.

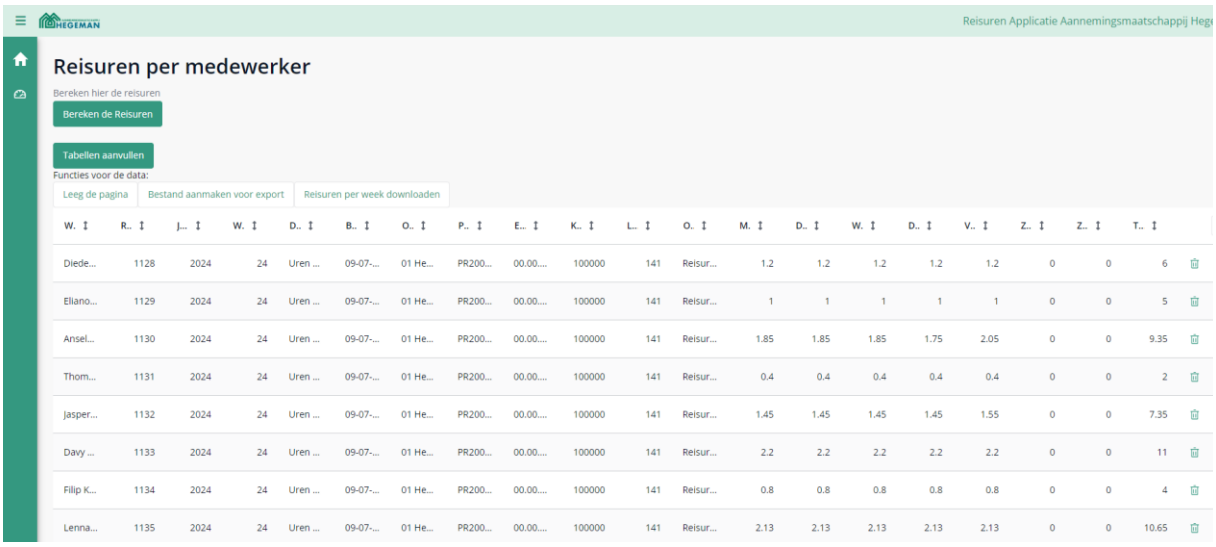


Figure 6.5 Calculation page.

6.4 Output and verification

As described in Section 2.5, verifying the tool is crucial. This process involves creating a control dataset for the main dataset, where outcomes are manually calculated to match the expected results in the application. This control dataset was reviewed and confirmed by HRM to ensure its accuracy. The control data is visible in in Table 6.1.

Werknemer	Jaar	Week	Document	Boekingsdatum	Ontvangendbedrijf	ProjectNr	Element	Kostendrager	Looncomponent	Omschrijving	Maandag	Dinsdag	Woensdag	Donderdag	Vrijdag	Zaterdag	Zondag	Totaal
Bram van Polen	2024	24	Uren 2024-	19-6-2024	01 Hegeman	PR 200000	00.00.00	100001	141	Reisuren	0	0	0	0	0	0	0	0
Diederik Boer	2024	24	Uren 2024-	19-6-2024	01 Hegeman	PR 200000	00.00.00	100000	141	Reisuren	1,4	1,4	1,4	1,4	1,4	0	0	7
Eliano Reijnders	2024	24	Uren 2024-	19-6-2024	1 Hegeman	PR 200000	00.00.00	100000	141	Reisuren	1	1	1	1	1	0	0	5
Anselmo Mcnulty	2024	24	Uren 2024-	19-6-2024	1 Hegeman	PR 200001	00.00.00	100000	141	Reisuren	1,85	1,85	1,85	1,75	2,05	0	0	9,35
Thomas Lam	2024	24	Uren 2024-	19-6-2024	1 Hegeman	PR 200001	00.00.00	100000	141	Reisuren	0,4	0,4	0,4	0,4	0,4	0	0	2
Jasper Schendelaa	2024	24	Uren 2024-	19-6-2024	1 Hegeman	PR 200001	00.00.00	100000	141	Reisuren	1,45	1,45	1,45	1,45	1,55	0	0	7,35
Davy van den Berg	2024	24	Uren 2024-	19-6-2024	1 Hegeman	PR 200000	00.00.00	100000	141	Reisuren	2,2	2,2	2,2	2,2	2,2	0	0	11
Filip Krastev	2024	24	Uren 2024-	19-6-2024	1 Hegeman	PR 200000	00.00.00	100000	141	Reisuren	0,8	0,8	0,8	0,8	0,8	0	0	4
Lennart Thy	2024	24	Uren 2024-	19-6-2024	1 Hegeman	PR 200000	00.00.00	100000	141	Reisuren	2,13	2,13	2,13	2,13	2,13	0	0	10,65
Apostolos Vellios	2024	24	Uren 2024-	19-6-2024	1 Hegeman	PR 200000	00.00.00	100000	141	Reisuren	1,2	1,2	1,2	1,2	1,2	0	0	6
Odysseus Velanas	2024	24	Uren 2024-	19-6-2024	1 Hegeman	PR 200001	00.00.00	100000	141	Reisuren	3,75	3,75	3,75	3,75	3,75	0	0	18,75
Younes Namli	2024	24	Uren 2024-	19-6-2024	1 Hegeman	PR 200001	00.00.00	100000	141	Reisuren	2,45	2,45	2,45	2,45	2,45	0	0	12,25
Sam Kersten	2024	24	Uren 2024-	19-6-2024	1 Hegeman	PR 200001	00.00.00	100001	141	Reisuren	0,25	0,25	0,25	0,25	0,25	0	0	1,25

Table 6.1 Control data set

During this verification process, a discrepancy was discovered regarding the calculation of executor commutes, which are prone to congestion. It was clarified that these should be paid as passengers, which was not initially clear. As a result, both the report and the application were updated to reflect this correction.

Further verification of the data revealed that the application calculations were entirely accurate except for long-distance trips. Initially, the calculation incorrectly considered a single trip for the entire day instead of accounting for round trips. This error was identified and corrected through iterative programming, ensuring the calculations produced the correct values.

By verifying the application's output against manually calculated results for all scenarios, it was confirmed that the application works correctly and can be trusted for automatic calculations. If this verification had not been successful, the application would have been invalid.

HRM initially expressed concerns about the need for ongoing verification, questioning whether they could completely rely on the automated system. It was assured that even after the data is loaded into 4PS, it can still be cross-checked with the workdays to ensure consistency. This additional verification step provided HRM with greater confidence in the system, knowing that they could still verify and correct any discrepancies if necessary.

6.5 Implementation

Successful implementation of the new processes will require thorough training and documentation for HRM and executors. Additionally, changes in behaviour among construction site workers and initial setup efforts will be necessary to ensure a smooth transition.

Training and documentation are essential to facilitate the adoption of the new system. Detailed instructions and comprehensive documentation should be provided to both executors and HRM staff. Training sessions should cover how to use the new application, including data input, verification, and handling exceptions. Understanding the integration with the InSeeGo API and the 4PS system, along with best practices for ensuring data accuracy and compliance with relevant regulations, will be crucial. Clear and accessible documentation will serve as a reference for users, helping them navigate the new process and troubleshoot any issues that may arise.

Encouraging consistent behavioural changes among construction site workers is crucial for accurate data collection. Workers need to tag each trip consistently to ensure the system captures all necessary travel data and understand the importance of accurate tagging for proper travel hour calculation and payment. Regular communication and reinforcement of these practices will help embed these behaviours into the daily routine of the workers.

The initial setup will involve migrating all current information from disparate documents into the new application. HRM staff will need to transfer existing data into the application and address any notifications for missing information, which may result in an initial increase in workload. Over time, as the system stabilizes and missing information is addressed, the workload will decrease, and the process will become more efficient.

HRM staff will need to adjust their workflow to directly input personal data into the travel hours application. This adjustment will streamline the data entry process and reduce the time spent on manual calculations and corrections. Integrating data input directly into the application rather than using multiple documents, utilizing the application's automated features to verify and calculate travel hours, and ensuring all data is up-to-date and accurate will be key to maintaining compliance and efficiency.

6.6 Conclusion

The implementation of the new processes and the accompanying application has led to time savings and efficiency improvements for both HRM personnel and executors. The integration of data through the overview pages saves HRM personnel approximately 3 hours per week, while the automation of calculations saves an additional 5 hours per week. As a result, the total time spent by HRM on these tasks is reduced from 40 hours to 8 hours per four-week period. This is even better than the norm of 8 hours per four weeks.

For executors, the automated calculations save 1 to 1.25 hours per week by eliminating the need for manual calculations and the data integration. This enables executors to allocate more time to oversight and ensure the accuracy of recorded trips, thereby reducing the potential for human error. These reductions are.

Time savings (in hours per week)	HRM (cumalitive)	For each executor
Data integration	0	0,5-0,75
Overview pages	3	0
Automatic calculation	5	0,5
Total savings	**8**	**1 - 1,25**

Table 6.2 Total time savings

The verification process, including the creation of a control dataset manually calculated and reviewed by HRM, has further enhanced the accuracy and reliability of the application. The identification and correction of errors during the verification process have ensured that the application produces reliable results.

Overall, the new system not only saves time for both HRM personnel and executors but also improves the accuracy and reliability of travel records. These improvements address the research question by demonstrating the effectiveness of automating travel data calculations and integration in reducing administrative burdens and enhancing data accuracy. The successful implementation and validation of the application underscore its value as a dependable tool for automating travel data processes, leading to more efficient operations and greater confidence in the system's outputs.

7 Conclusions and recommendations

This chapter summarizes the findings and provides actionable recommendations based on the research conducted to reduce the processing time for travel hours at Hegeman Constructions from 40 hours to 8 hours per four-week period. Key process improvements include the shift from manual to automated data collection and calculation, significantly reducing workload and errors for HRM personnel and executors. The demonstration of a proof-of-concept application further validates these improvements. The chapter concludes with recommendations for both application development and process implementation to use this thesis in practice and further research possibilities.

7.1 Conclusion

This thesis demonstrated that the proposed solution significantly reduces the time required to process travel hours at Hegeman Constructions from 40 hours to just 8 hours per four-week period for HRM.

The primary objective of this research was to address the main question: "How to reduce the processing time of travelling hours from 40 hours to 8 hours per period for the human research team of Hegeman Constructions?" This chapter summarizes the key findings from both the process improvements and the implementation of a proof-of-concept application and discusses the broader implications of the results.

Process Improvements

The research revealed significant process improvements. By shifting from manual data entry to automated data collection through the fleet management tool InSeeGo, the process of recording travel hours has become more efficient. Executors no longer need to manually input data, significantly reducing their workload and the risk of errors. Additionally, the automatic calculation of travel hours and payments has streamlined the workflow for HRM personnel. This automation has saved around 5 hours per week, reducing the overall administrative burden, and enhancing data accuracy. By no longer needing to search for and cross-reference multiple files, they also save approximately 3 hours per week. This all makes a reduction of 8 hours per week and reducing the time from 40 hours to approximately 8 hours per four-week period.

Executors will also experience benefits from the process changes. The transition from manually entering, calculating, and forwarding travel data to simply verifying and controlling the data has simplified their tasks significantly. This shift has saved executors 1 to 1.25 hours per week, as they are now primarily focused on ensuring the correctness of pre-calculated data rather than performing the calculations themselves.

Application Proof of Concept

The application serves as a proof of concept that demonstrates the viability of the new process. The automated system verifies that the new process setup effectively reduces processing time. The verification process, including the creation of a control dataset manually calculated and reviewed by HRM, has confirmed that the application produces valid results. This proof of concept shows that the combined process improvements and application setup can achieve the targeted time savings.

Overall findings

The implications of these findings are substantial. The integration of new processes and the application proof of concept has drastically improved operational efficiency for HRM personnel and executors, allowing for better allocation of resources and focus on more strategic tasks. The combination of process improvements and automated systems reduces the potential for human error in data entry and calculations, leading to more accurate and reliable travel records. The reduction in administrative burden also aligns with the goals of the ECOLOGIC project discussed in Section 1.3.

7.2 Recommendation

Based on the findings of this research, several recommendations are made to further enhance the efficiency and effectiveness of the travel data processing system. These recommendations focus on the development and refinement of the application, as well as the implementation of new processes.

Application Development

To ensure the application operates effectively, several technical improvements are necessary. These include integrating the InSeeGo API for seamless data processing, optimizing the application code for enhanced performance, and ensuring compatibility with the 4PS system. During the development of the proof of concept, the focus was primarily on functionality rather than efficiency. As a result, the code contains many areas that can be improved. Optimizing the code is essential before going live to enhance performance, reduce processing time, and ensure the application runs smoothly in a production environment.

- API Integration: Use the InSeeGo API to process raw data into the format required by the application, ensuring seamless data integration.
- Code Optimization: Improve the efficiency of the proof-of-concept application to enhance performance and reduce energy consumption, aligning with the goals of the ECOLOGIC project.
- 4PS Integration: Ensure the output from the application can be imported into 4PS. The IT specialist from Hegeman should consult with a 4PS expert to facilitate this importation.

Process Implementation

Successful implementation of the new processes will require thorough training and documentation for HRM and executors. Additionally, changes in behaviour among construction site workers and initial setup efforts will be necessary to ensure a smooth transition.

- Training and Documentation: Provide detailed instructions to executors and HRM on how to implement the new process.
- Behavioural Change: Encourage construction site workers to consistently tag each trip to ensure accurate data collection.
- Initial Setup Effort: HRM will need to migrate all current information from disparate documents into the application, which may result in initial workload spikes due to missing information notifications. Over time, this will stabilize.
- Process Adjustment for HRM: HRM staff should adapt their workflow to directly input personal data into the travel hours application, streamlining the data entry process.

7.3 Further research

While the current research on travel hours is detailed, there are still areas that could benefit from further investigation. Key areas for further research include:

Reliability Testing

- Explanation: Conduct extensive testing during the implementation phase to ensure that the system produces consistent and reliable results over time. This involves using the new system alongside the old manual system for a period to compare and verify results.
- Purpose: Ensuring both the validity and reliability of the system by identifying any discrepancies and rectifying them to maintain consistent performance.

Integration of Work Hours Registration:

- Explanation: Explore the integration of work hours registration to provide a more comprehensive approach to employee time tracking. This could include integrating systems like tourniquets that automatically log work hours as employees enter and leave the workplace.
- Purpose: Streamlining the process further and reducing the administrative burden on HRM and executors by combining travel and work hour data.

Utilizing InSeeGo Data for Emissions Tracking

- Explanation: Investigate the feasibility of using the existing InSeeGo tracking system data to calculate the carbon footprint for each employee's commute. By leveraging the detailed travel data already being collected, the system can be enhanced to include emissions tracking and compliance with the Corporate Sustainability Reporting Directive (CSRD).
- Purpose: Enabling the company to monitor and reduce its environmental impact by using travel data to inform sustainability initiatives. This would help identify high-emission travel patterns, promote more eco-friendly commuting options, and ensure compliance with CSRD requirements.

Further research in these areas would validate and enhance the current system and open up new possibilities for improving operational efficiency, accuracy in travel and work hours processing, and tracking and reducing emissions per employee through existing tracking systems.

8 Bibliography

Dall-E. (2024). Generative AI:Onderzoek naar reisuren registratie met het bouwen van een app. In *https://copilot.microsoft.com/*. Microsoft Copilot.

Fanchi, C. (2023, February 7). *The importance of iterative prototyping in application development*. https://backendless.com/the-importance-of-iterative-prototyping-in-application-development/

Heerkens, H., & Winden, A. van. (2012). *Geen Probleem*. VWC.

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A design science research methodology for information systems research. *Journal of Management Information Systems*, *24*(3), 45–77. https://doi.org/10.2753/MIS0742-1222240302

Pyzdek, Thomas., & Keller, P. A. (2010). *The Six Sigma handbook: a complete guide for green belts, black belts, and managers at all levels*. McGraw-Hill Companies.

Tsentserensky, S. (2023, September 11). *Lean, Six Sigma & Lean Six Sigma process mapping*. Https://Slickplan.Com/Blog/Lean-Six-Sigma-Process-Mapping.

White, S. A. (2024). *Introduction to BPMN*.

9 Appendix

9.1 Research design table

Step of the DSRM	Research questions	Key construct	Variables	Research type
Step 1: Problem identification and motivation	How are travel hours currently recorded and processed within the company?	Learn the current situation of the entire process	N/A	Exploratory
	What has previously been tried to solve this issue and why did it not succeed?	To learn from the mistakes made in the past and prevent it now.	Previously tried solutions	Exploratory
Step 2: Define the objectives for a solution	What are the requirements for processing the travelling hours?	Find out the requirements for the model	Specific requirements	Descriptive
Step 3: Design and development	How does a process of travelling hours should be designed?	Create a new model	The process of travelling hours	Design
	How should a demo application be designed to reduce the travel hours processing time at Hegeman Constructions in alignment with the newly developed process?	Create a tool which collaborates with the new model	Functional requirements, User Feedback	Design
Step 4: Demonstration	How effectively does the tool process the travelling hours?	Correctness of the tool's processing	N/A	Evaluative
Step 5: Evaluation	What will be the time required for processing traveling hours with the new process?	Processing time reduction by the tool	New tool and processing time	Evaluative

Research Group	**Data gathering**	**Data Analysis**
Executors and HRM department	Interview and observation	Qualitative
HRM department	Interview	Qualitative
Executors, HRM department, CLA and the work council	Interview and primary source analysis	Qualitative
Executors and HRM department	Iterative prototyping	Qualitative
Executors and HRM department	Iterative prototyping	Qualitative
N/A	Secondary source data analysis	Qualitative
HRM department	Interview and data analysis	Quantitative

Table 9.1 Research design

9.2 BPMN elements

Flow objects

There are three core elements, which are the flow objects. The three flow objects are:

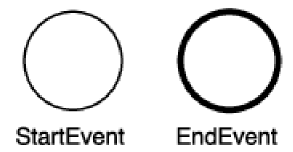
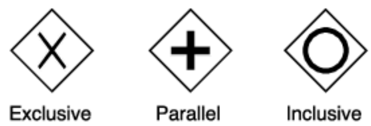
Object	**Explanation**	**Picture**
Event	It is marked by a circle and represents something that occurs in a business process. Events can impact the flow of a process and usually have a cause or an impact	
Activity	It is marked by a round-corner rectangle and is a term for work that is performed	
Gateway	It is marked by a diamond shape and is used to control the divergence and convergence of sequence flow.	

Table 9.2 Flow objects

Connecting objects

The flow objects are connected. There are three connecting objects:

Object	**Explanation**	**Picture**
Sequence flow	It is marked by a solid line with a solid arrowhead. It is used to show the order of the activities in a process	

Message flow	It is marked by a dashed line with an open arrowhead. It is used to show the flow of messages between two different process participants	
Association	It is marked by a dotted line with a line arrowhead. It is used to associate artifacts with flow objects.	

Table 9.3 connecting objects.

Swimlanes

Swimlanes are used to organize activities into different visual categories. There are two types of Swimlanes:

Object	**Explanation**	**Picture**
Pool	A pool represents a participant in the process. It could be a department, functional unit, or an external organization	
Lane	A lane is a subdivision in a pool and represents a specific role, function, or department within the participant of the pool	

Table 9.4 Swimlanes

Artifacts

Artifacts are used to extend the basic notation and provide extra context for specific modelling situations. Three of these are pre-defined but there are much more possibilities.

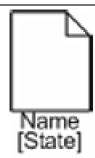
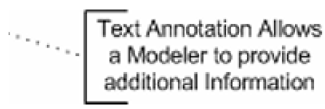
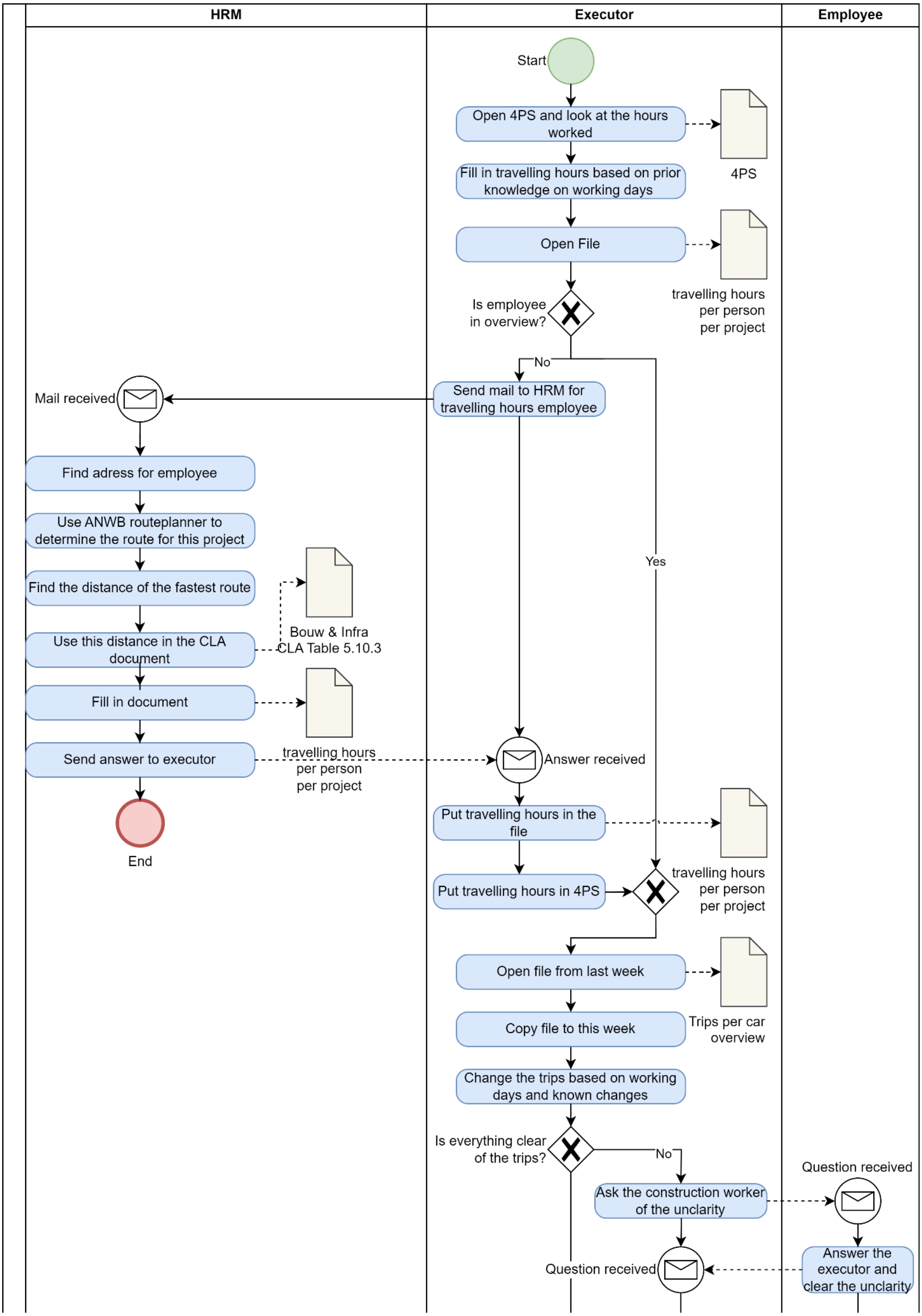
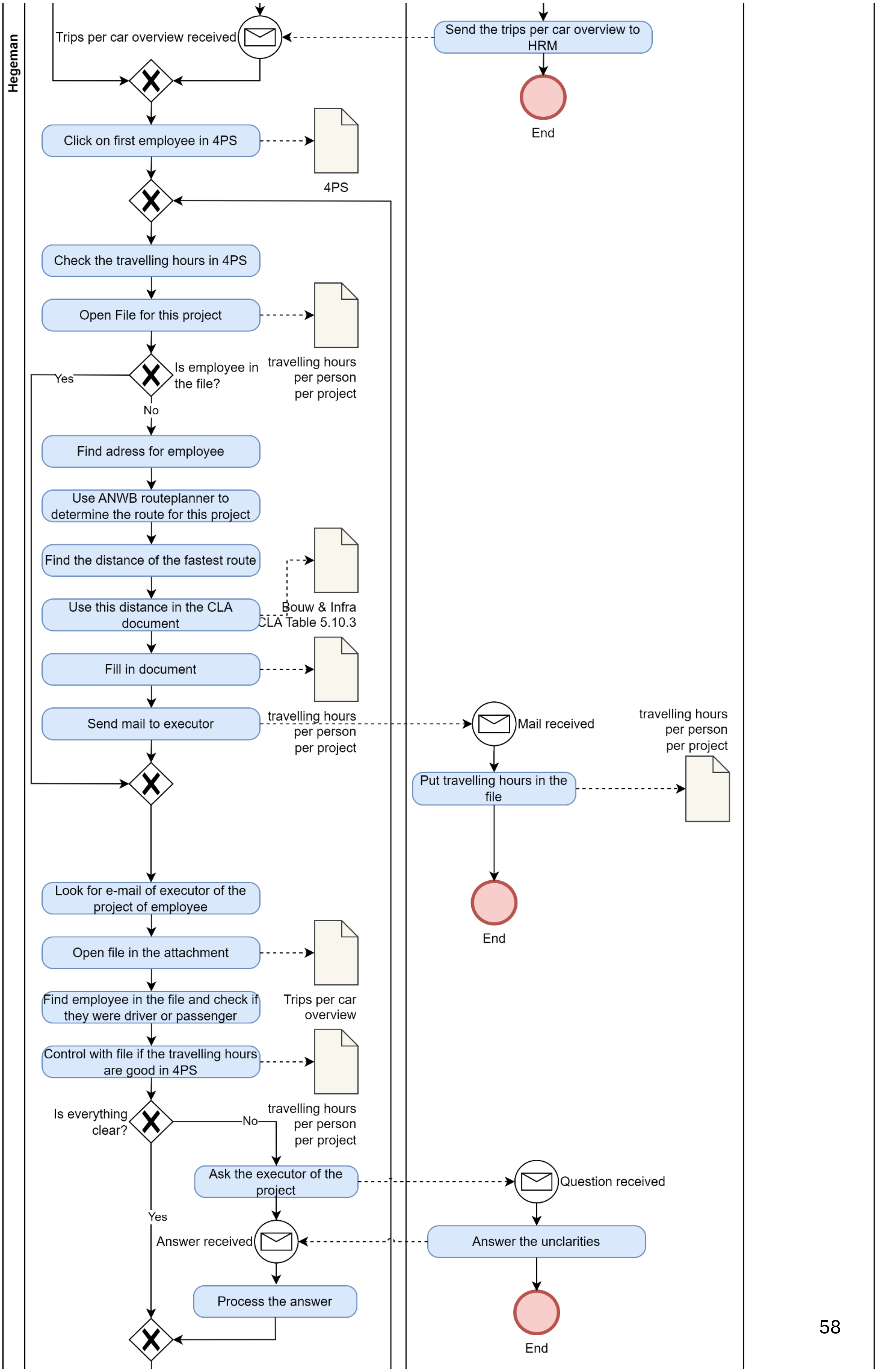
Object	**Explanation**	**Picture**
Data object	It is a mechanism to show how data is required by activities. The connection is always made by associations.	
Group	It is marked by a rounded corner rectangle with a dashed line. The grouping is used for documentation or analysis, but it is not influencing the sequence flow.	
Annotation	This is used by the creator of the BPMN to give more information to the reader.	

Table 9.5 artifacts

9.3 Current process




Hegeman
Trips per car overview received
Send the trips per car overview to HRM
End
Click on first employee in 4PS
4PS
Check the travelling hours in 4PS
Open File for this project
travelling hours per person per project
Yes
Is employee in the file?
No
Find adress for employee
Use ANWB routeplanner to determine the route for this project
Find the distance of the fastest route
Use this distance in the CLA document
Bouw & Infra CLA Table 5.10.3
Fill in document
Send mail to executor
travelling hours per person per project
Mail received
travelling hours per person per project
Put travelling hours in the file
End
Look for e-mail of executor of the project of employee
Open file in the attachment
Trips per car overview
Find employee in the file and check if they were driver or passenger
Control with file if the travelling hours are good in 4PS
travelling hours per person per project
Is everything clear?
No
Ask the executor of the project
Question received
Yes
Answer received
Answer the unclarities
Process the answer
End

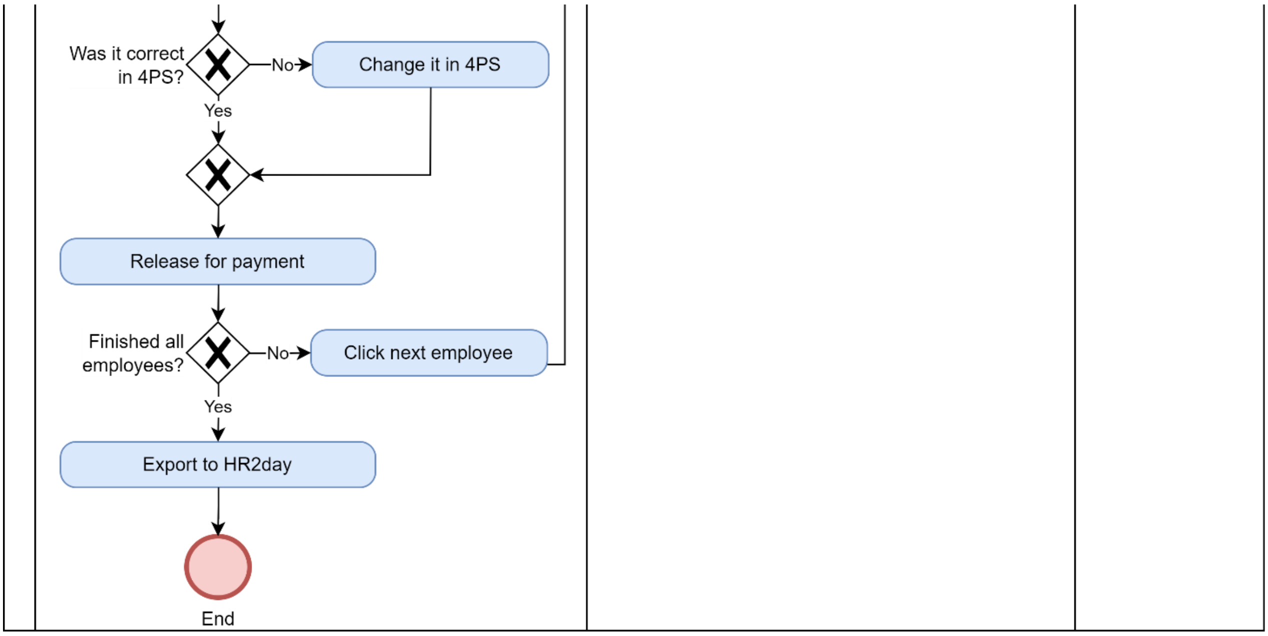
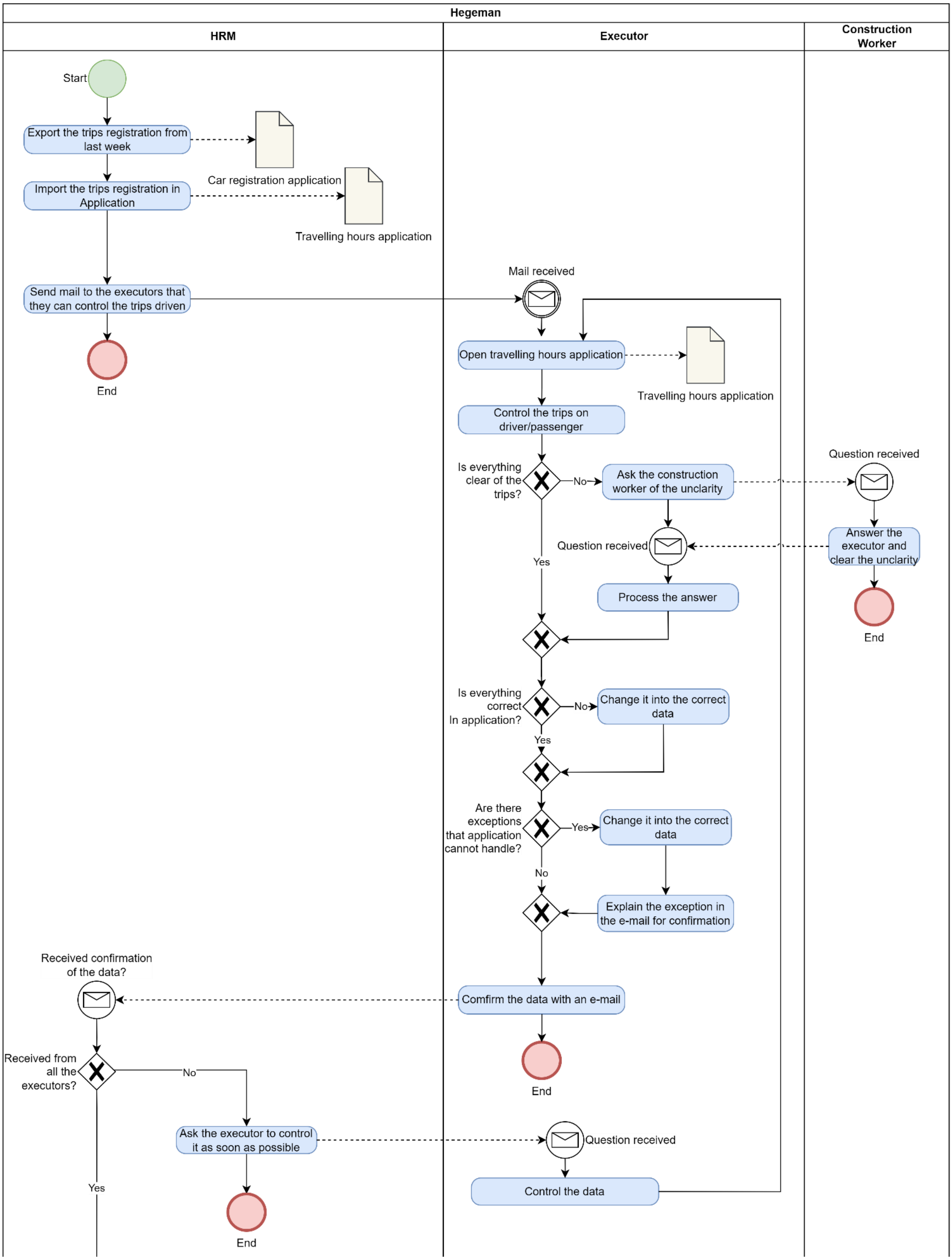


Figure 9.1 Swimming lanes current process.

9.4 Generic process



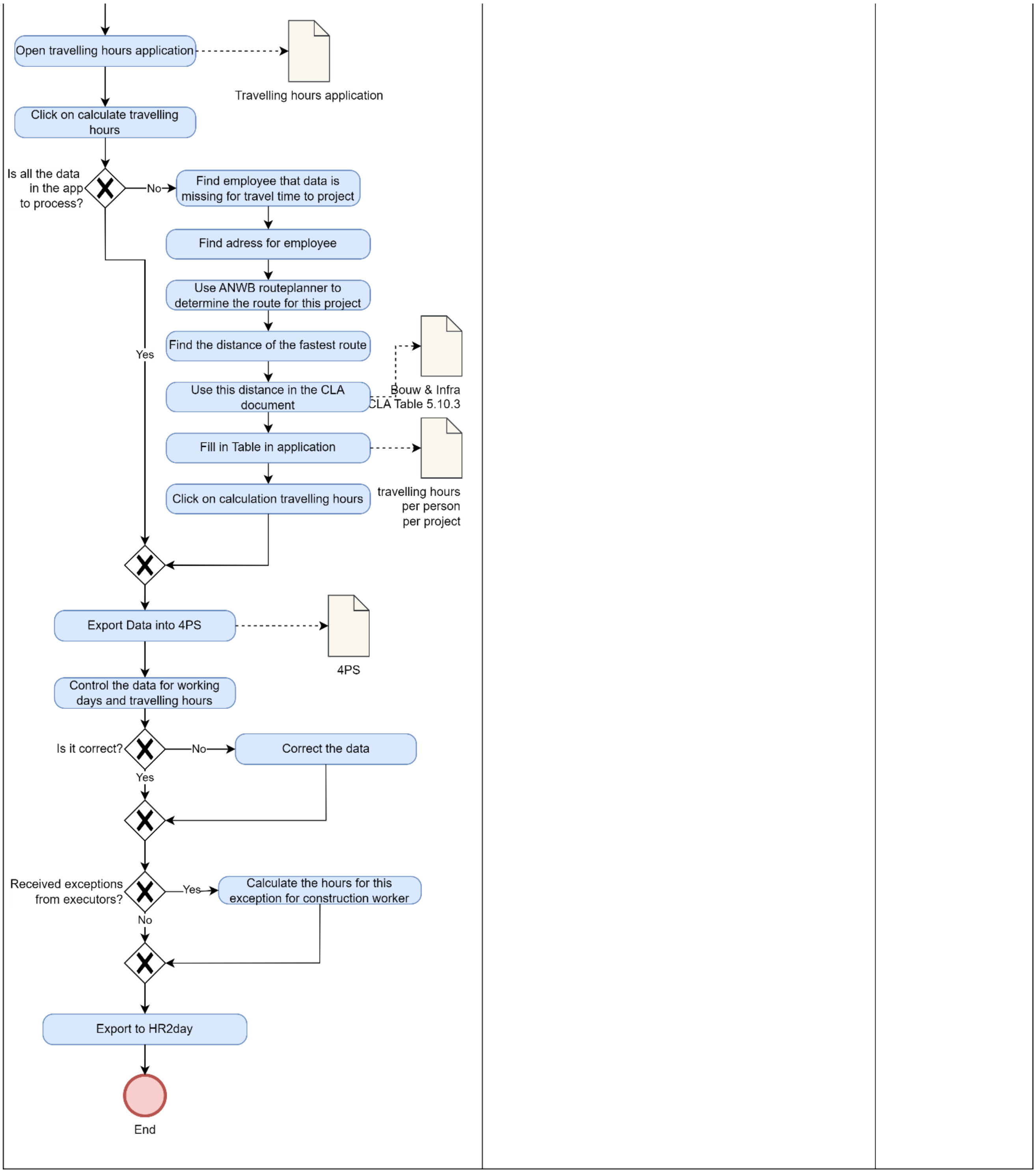


Figure 9.2 Swimming lanes new generic process.

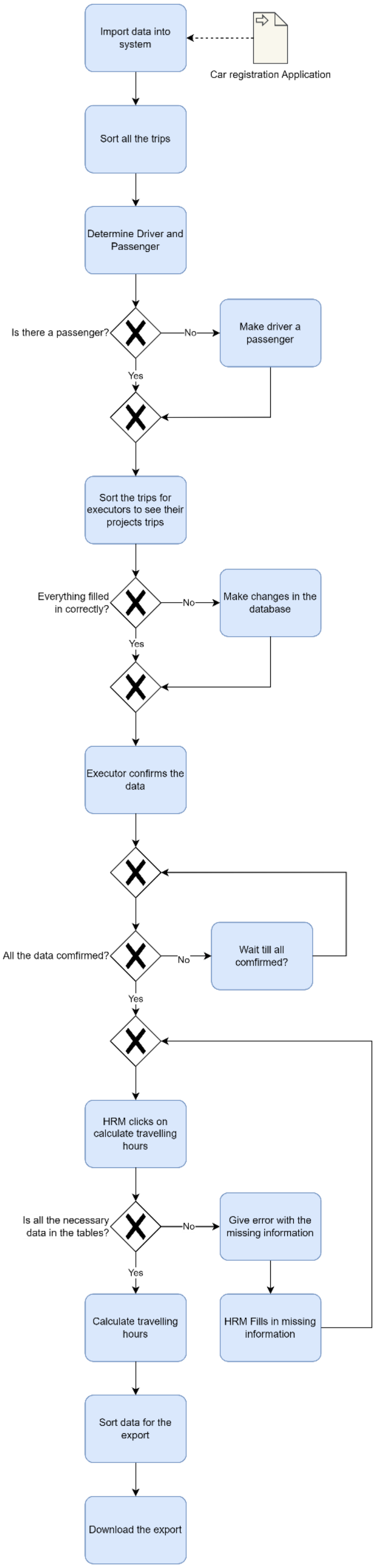


Figure 9.3 Generic tasks application.

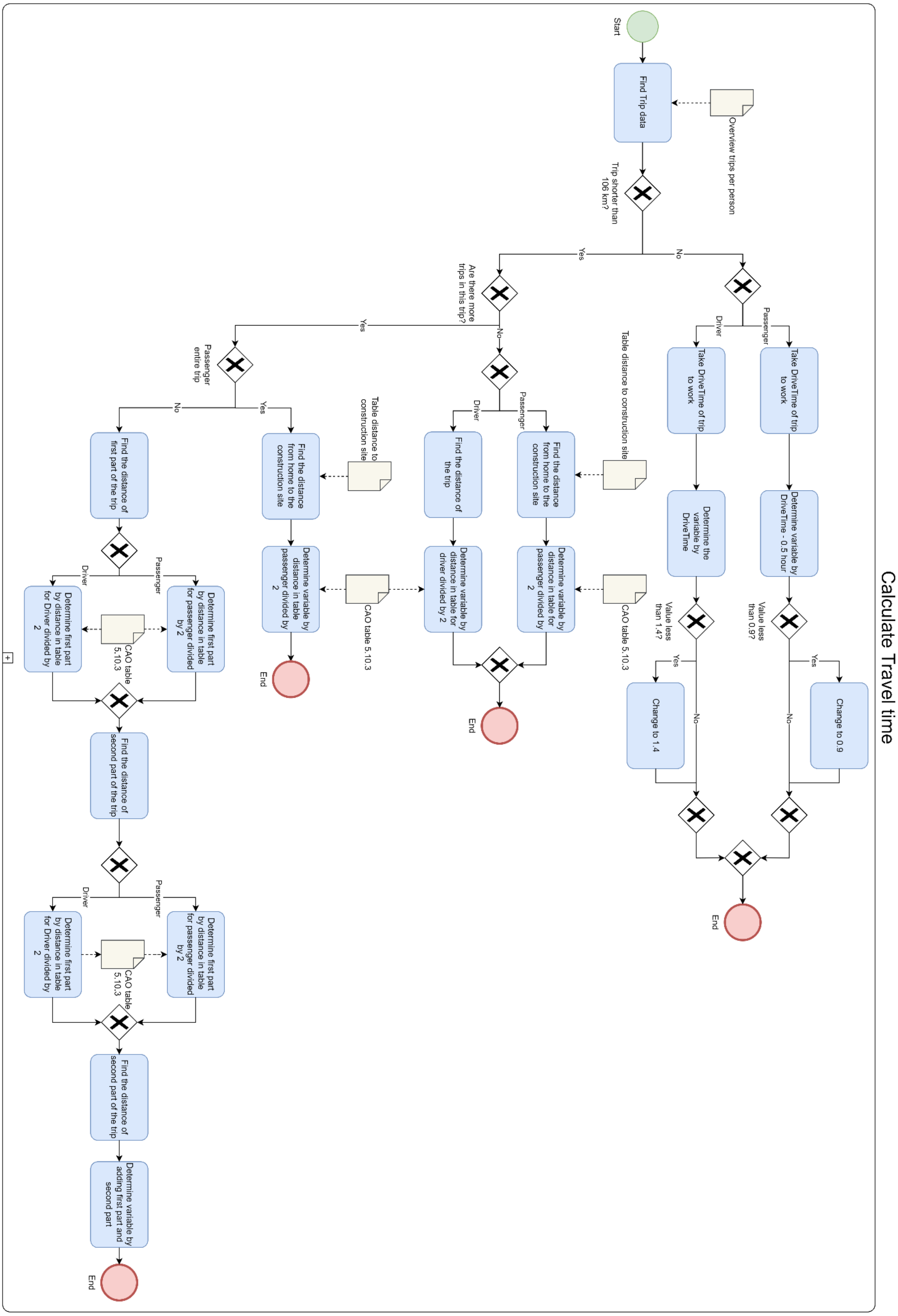


Figure 9.4 Subprocess calculate travel time generic.

9.5 Process for Hegeman

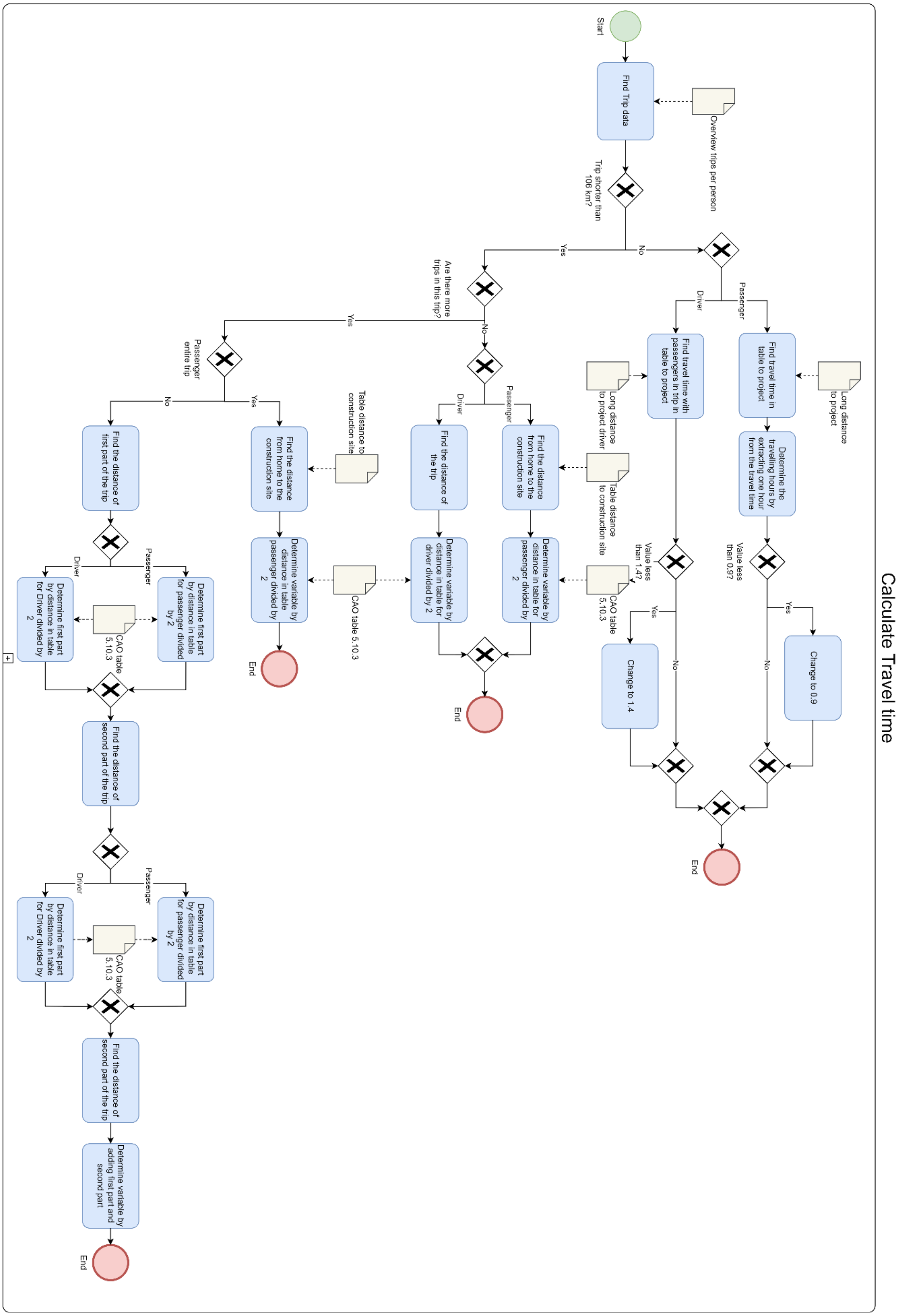


Figure 9.5 Subprocess calculate travel time for Hegeman.

9.6 Transforming the data in detail

Creating the Driven Trips

The Trip entity contains tag data for each person. Each time an individual uses their tag in a car, it creates a separate entry. It is crucial for further filtering to create complete driven trips, where the connections between passengers and drivers are established.

To achieve this, all trips are scanned, and when license plates match during overlapping times, they are grouped together to form a driven trip. This process ensures that each driven trip correctly reflects who was in the vehicle during that time.

Steps involved:

1. Scan Trips: Review all trip entries to identify potential groupings.
2. Match License Plates: Check for matching license plates within overlapping time periods.
3. Group Trips: Combine entries with matching license plates and overlapping times into a single driven trip.

Determining Role (driver or passenger)

Now that the driven trips are created, it is possible to determine the role of everyone in the trip. This involves establishing a start time for each trip by identifying who was the first to enter the vehicle. The person who entered the car first is assigned the role of the driver, and the rest are designated as passengers.

Additionally, a check is performed to see if there is more than one person in the trip. If there is only one individual, that person is automatically assigned the role of passenger, as the payment for travel hours is based on the role of a passenger.

Steps involved:

1. Establish Start Time: Identify the first person to enter the car for each trip.
2. Assign Roles: The first person is designated as the driver, and others as passengers.
3. Single Person Check: If only one person is in the trip, they are automatically assigned as a passenger.

Linking to projects

Trips must also be linked to projects. This is important not only for billing, which is done per project, but also for calculations. For instance, a project marked as prone to traffic congestion requires different calculations than one that is not.

To establish this link, the project address is compared with the trip start address or trip finish address of individuals in the trip. If there is a match, the trip is linked to the corresponding project. In some cases, this direct match may not occur, which will be explained below in the processing carpool trips section.

Steps involved:

1. Compare Addresses: Match the project address with the trip start or trip finish addresses.
2. Link Projects: If a match is found, link the trip to the corresponding project.
3. Manage Exceptions: Address cases where direct matches are not found, detailed in the processing carpool trips section.

Processing Carpool Trips

When carpooling is used, there will first be a trip to a carpool location, followed by a transfer to another vehicle that goes to the project site. Two key elements are important here: ensuring that trips are linked appropriately and that trips not directly heading to a project are still associated with that project.

To link these trips, a transfer time of one hour between trips is considered. If a person switches to another car within one hour, the trips are linked. For the linked trip, if the subsequent trip is associated with a project, the carpool trip also receives this project linkage. This is crucial because the carpool trip must be paid as if it starts from the project.

Steps Involved:

1. Identify Transfers: Check for car transfers within a one-hour window.
2. Link Trips: Group trips that involve a transfer within one hour.
3. Project Linkage: Ensure the carpool trip inherits the project linkage from the connected trip.

Creating to work and from work trips.

For the calculations, as explained in Sections 5.1.4 and 5.2, it is necessary to differentiate between trips to and from work for separate calculations, as scenarios may vary.

To add this distinction to the trips, the start and end addresses are examined. If the end address of the trip is the project address, it is marked as a "To Work" trip. If the start address of the trip is the project address, it is marked as a "From Work" trip. For carpool trips, the linked trips are checked against these criteria, and the linked trips are then marked accordingly.

Steps Involved:

1. Identify Trip Direction: Determine if the trip is heading to work or coming from work based on the trip start and finish addresses.
2. Create To Work Trips: Label trips ending at the project address as "To Work".
3. Create From Work Trips: Label trips starting from the project address as "From Work".
4. Carpool Trips: For linked carpool trips, check if any trip in the group meets the criteria and label all linked trips accordingly.

9.7 Calculations for the tool in detail

Carpooling Dynamics

For this calculation, it is first checked if the employee is an executor, as they are paid according to a different calculation and must be filtered out here. Next, it is determined whether the employee was a passenger for the entire trip. If so, they are paid according to the passenger transport scenario as a passenger. which will be explained later.

If the employee was a driver for any part or all the trip, the distances travelled as a driver and as a passenger are summed. This total is then looked up in the CAO Table 5.1 for each role, and the corresponding values are summed. This sum represents the travel time that the employee is paid for this trip.

Steps Involved:

1. Filter Executors: Identify and filter out trips made by executors.
2. Determine Role: Check if the employee was a passenger for the entire trip.
3. Calculate Solo Driver Commute: If the employee was a passenger for the entire trip, apply the solo driver commute calculation.
4. Sum Distances: If the employee was a driver for any part of the trip, sum the distances travelled as a driver and as a passenger.
5. Lookup in CAO Table 5.1: Use the summed distances to find the corresponding values in the CAO Table 5.1 for each role.
6. Sum Values: Add the values from the CAO Table 5.1 to determine the total travel time the employee is paid for.

When there is only one trip for the "To Work" or "From Work" trip, the calculation enters the sub flow "Calculate Without Carpool." Here, the executor trips are filtered first.

Executor Commute

For executors, the calculation begins by checking whether the project is prone to traffic congestion. If the project is not prone to traffic congestion, the executor receives no travel hours, and the flow ends with a value of 0. If the project is prone to traffic congestion, the executor receives half of the travel time as a passenger to the project.

The next step involves consulting the DistanceToProject list to find the distance to the project. This distance is then used to look up the corresponding value in the CAOTable5.1 as a passenger. The resulting value is halved to determine the payable travel hours for the executor.

Steps Involved:

1. Check Project for Traffic Congestion: Identify if the project is prone to traffic congestion.
2. End Flow if No Congestion: If not prone to traffic congestion, end the flow with a value of 0.
3. Consult DistanceToProject List: Find the distance to the project.
4. Lookup in CAOTable5.1: Use the distance to find the corresponding value as a passenger.
5. Calculate Payable Hours: Halve the decimal value from the CAOTable5.1 to determine the travel time the executor is paid for.

After filtering by executor, the next scenario is "the trip exceeds the distance table." Here, a decision is made when the distance of the trip is greater than 105 km, which directs you to this scenario.

Trip exceeds distance table.

When dealing with long-distance commutes, there are two different flows: one for passengers and one for drivers. The passenger flow is simple, while the driver flow is more complex.

For the passenger commute, the LongDistanceToCSPassenger table is used. HRM inputs a time value for someone traveling as a passenger. This time is used as the travel time.

For the driver commute, the LongDistanceDriver table is linked to the LongDistancePassenger table. This table provides a value for driving to the project when certain passengers are present. The LongDistancePassenger table is consulted to verify the passengers present for a specific travel time to a project. The driven trip is compared with the table, and if all passengers and the number of passengers match, the value is used.

Minimum values apply for this scenario: 1.8 hours as a passenger and 2.8 hours as a driver. These values are for the total time for the entire day. Since the trips to and from work are averaged later, the tables with the times must be based on the combined trips. If the minimum time is not met, it should be adjusted to the minimum according to the CLA.

Steps Involved:

1. Passenger commute:
    a. Consult LongDistanceToCSPassenger Table: Use the time value input by HRM as the travel time for passengers.
2. Driver Commute:
    a. Consult LongDistanceDriver Table: Use the linked LongDistancePassenger table to find the travel time based on the passengers present.
    b. Compare Driven Trip: Ensure all passengers and the number of passengers match the table to use the value.
3. Apply minimum values:
    a. Check Minimum Travel Time: Ensure the travel time meets the minimum values (1.8 hours for passengers, 2.8 hours for drivers).
    b. Adjust if Necessary: If the minimum time is not met, adjust to the minimum.

The last scenario for the calculation per trip is the passenger transport. This occurs when someone has been assigned the role of driver or passenger in a trip less than 106 km.

Passenger transport

When an employee is a driver, the distance of the trip is entered into the CAOTable5.1, and the value for the driver is taken as the travel time. For passengers, the DistanceToConstructionSite table is consulted, and the distance is entered into the CAOTable5.1. The value for the passenger is taken for this distance, representing the travel time.

Steps Involved:

1. Driver Commute:
    a. Enter Distance: Input the distance of the trip into the CAOTable5.1.
    b. Lookup Driver Value: Use the value for the driver from the CAOTable5.1 as the travel time.
2. Passenger Commute:
    a. Consult DistanceToConstructionSite Table: Find the distance to the construction site.
    b. Enter Distance: Input the distance into the CAOTable5.1.
    c. Lookup Passenger Value: Use the value for the passenger from the CAOTable5.1 as the travel time.

After all these calculations per trip are done, the trips to and from work are added together and averaged to get the correct travel time per day. Then, one more scenario follows:

Project is prone to traffic congestion.

This scenario applies when HRM and the working council designate a project as prone to traffic congestion. In practice, this means that construction workers are allowed to leave fifteen minutes earlier to avoid traffic jams. They are paid for these fifteen minutes, but not for the travel hours, to avoid double compensation. Therefore, fifteen minutes must be subtracted from the travel hours. Steps Involved:

1. Check Project Attribute: Check if the project has the boolean "prone to traffic congestion" set to yes in the project entity.
2. Adjust Travel Time: If the project is prone to traffic congestion, subtract 0.25 hours from the daily travel time.
3. Finalize Calculation: The resulting value is the adjusted travel time for the day.

9.8 Process comparison

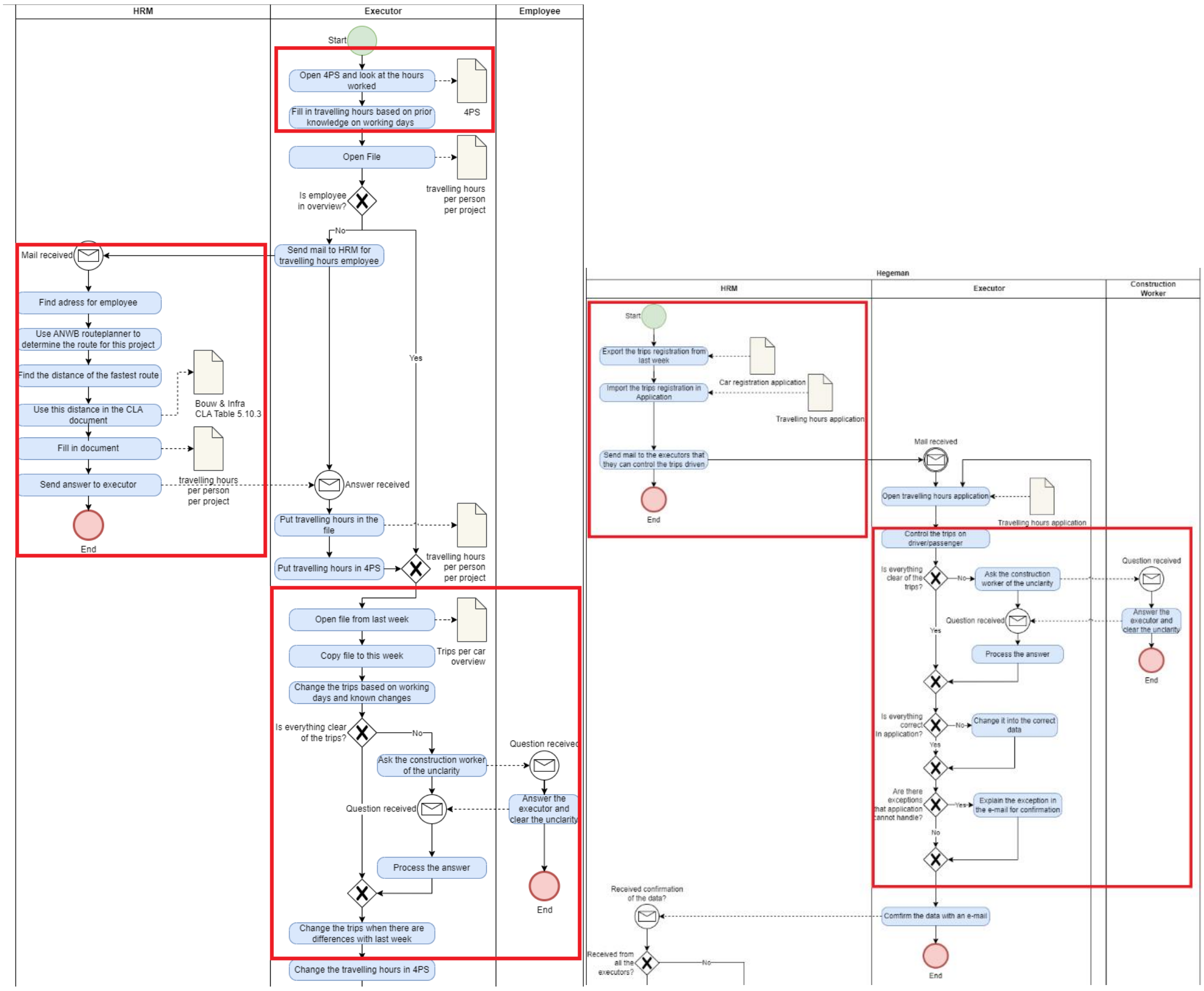


Figure 9.6 Old situation vs the new situation for the data integration (Red are the activities involved)

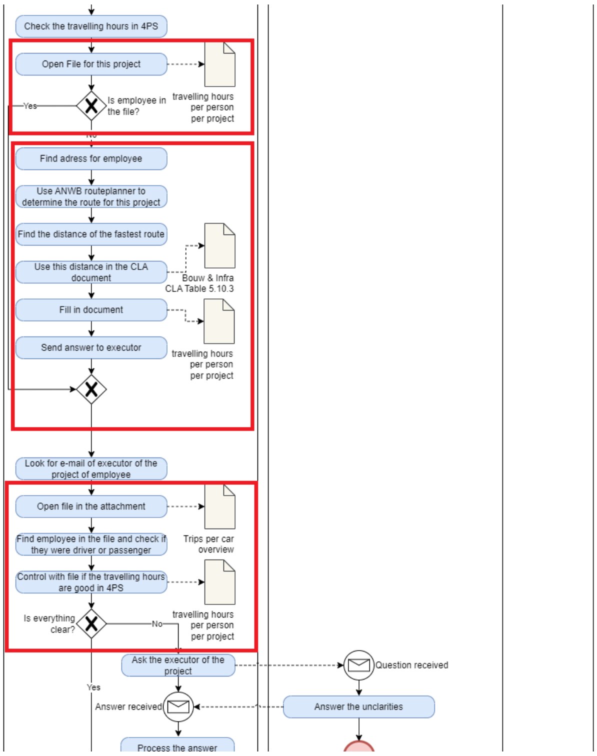


Figure 9.7 Steps in the current process which change with overview pages.

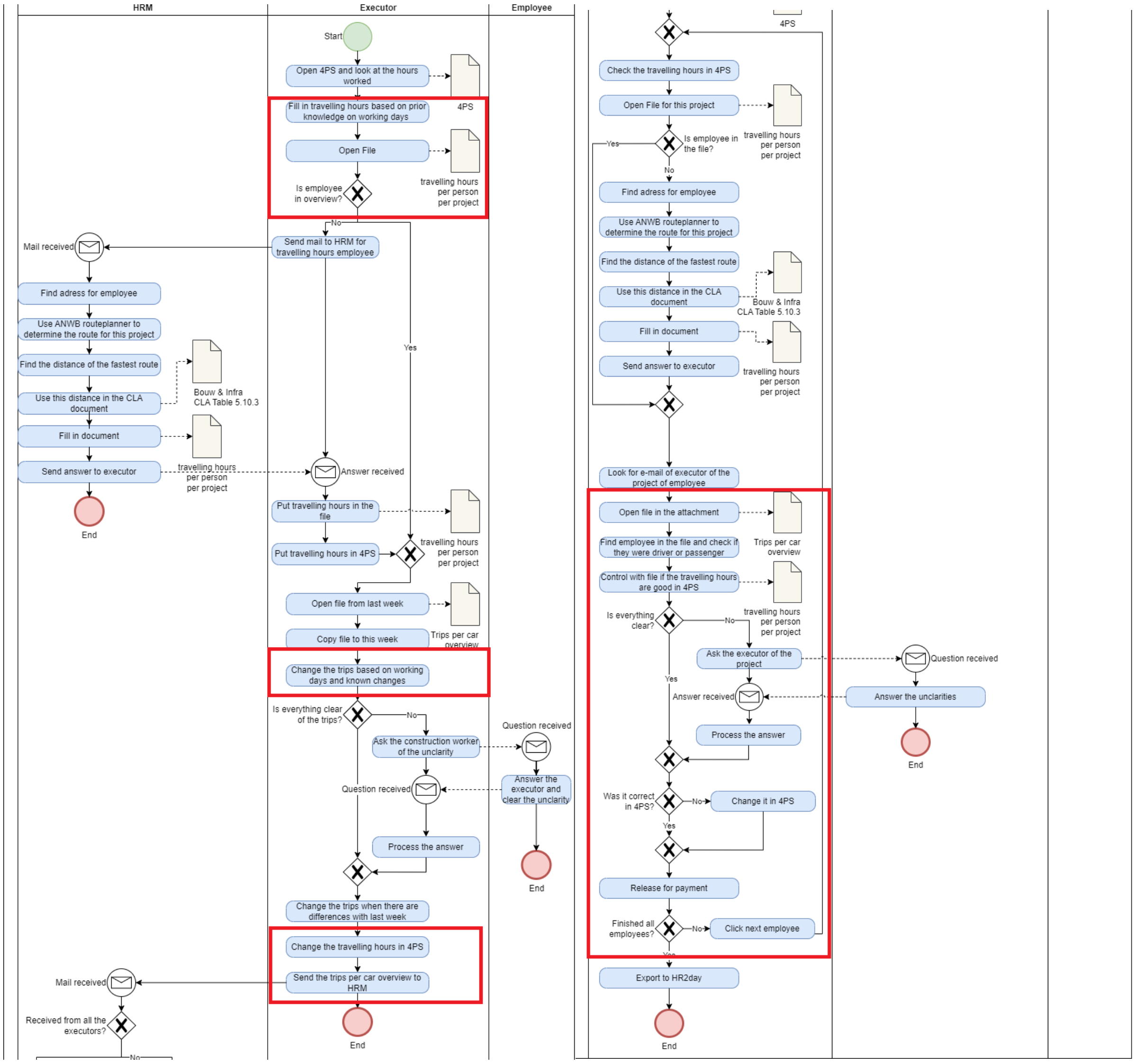


Figure 9.8 Calculation steps in current process.

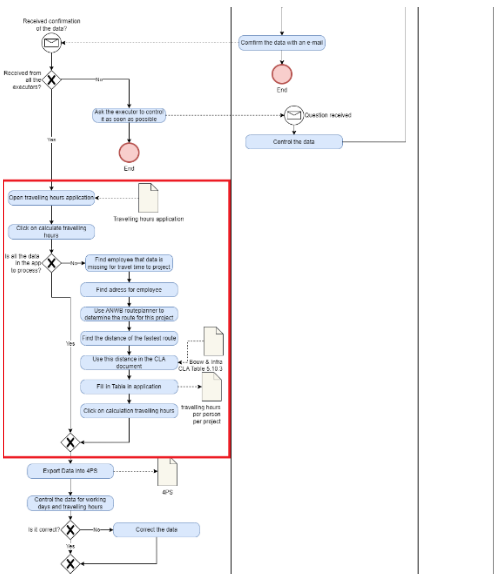


Figure 9.9 Calculation steps in new process.