Yard Management Improvements in the Outbound Logistics Department at PepsiCo Veurne

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Preface:

This thesis was written as my Bachelor thesis to obtain my Bachelor's degree in Industrial Engineering and Management at the University of Twente. This is the result of 5 years of studying in my home country Egypt and the Netherlands. Although my thesis period was a strange one because of COVID, I am still grateful that I got an opportunity to conduct an on-sight research in the Outbound Logistics department in PepsiCo, Belgium. First of all, I would like to thank Wim Geuens, Harold Notkamp, and Jesse Dirks for easing the process of getting my assignment. Then I would like to thank my work manager and supervisor Sven van Aerschot for the constant feedback and advice that lead me to the right track. Moreover, I would like to thank Bram van Neck for his critical feedback on my progress at the company which helped conduct my research.

In addition, I would like to thank my team that made life way better at work, Wouter, Christoph, Nico, Marie, and Jan.

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Finally, I would like to thank all people who helped me get through this adventure whether personally or professionally. My study colleagues, friends, and family. Thank you all for supporting me. Mom, tell dad he is not the only engineer now! I finally made it!

I hope you enjoy reading through my thesis!

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Management Summary

PepsiCo is an international food and beverage company that produces all over the world and supplies products to consumers for daily usage. One of the biggest snacks producing factories that PepsiCo owns is located in Veurne, Belgium (“VSF”). According to managers’ claims, they experienced a problem with managing their yard efficiently and effectively and for this reason, the research topic was introduced. The factory consists of two ‘sub-factories’, VSF1 and VSF2 representing the old and new parts of the factory respectively. These are considered separate factories as they produce different products using different ways of working, but they share the same yard. Both suffer from the consequences of yard congestion, which leads to further problems such as path blockage in their loading areas, leading to production stoppage. This directed the team to the following central research question:

How can yard management at PepsiCo Veurne be improved so as to better align the supply chain processes? In particular, how can KPIs be monitored and the number of loaders adapted so as to prevent blockage of loading docks leading to production stoppage?

To answer this research question, the study started by exploring the current Way of Working (WoW) by conducting interviews with stakeholders and employees involved in the process. The approach to finding solutions was by doing literature studies checking for similar topics previously researched, and by developing a simulation model. Personal observations had a great impact in understanding the process, hence, finding logical improvements to the process. Interviews were also conducted to understand different points of view about problems in the current way of working while the literature search was used as an exploration tool to find different approaches followed to solve similar problems.

This thesis presents three tools that are used together to find suitable dynamic solutions to the experienced problem: (i) a yard template, (ii) a KPI board, and (iii) a simulation study experimenting with the real-life situation.

An important observation during the research was that KPIs are scattered over different software systems. Hence, we needed to create a KPI dashboard measuring the performance of the loading and production processes by collecting, analyzing, and storing data in one location. The yard template was also an important tool to develop as it eliminates one of the core problems “lacking yard visibility”. This enables visualization of the parking contents on a certain date, storing historical data, and analysis using KPIs. To examine the truck movements shown in the yard template in a real-life, dynamic perspective, we developed a simulation model. This simulation requires inputs and assumptions which were modelled using historical data extracted from the KPI board. Data were represented as distribution functions and assumptions were made based on test statistics during the analysis phases.

By following the approach of using the three tools in parallel, we enable an easier and more effective decision-making support system. To summarize, the three tools entail the following:

i. The *yard template* is developed to solve the core problem of lacking yard visibility where the template enables the users to:
   - Visualize parking contents
   - Save time and effort of employees
   - Format input data consistently
   - Print overview of loaded trailers parked at the yard
   - Measure truck KPIs
   - Comment on transporters’ performance

ii. The *KPI board* is developed to avoid data scattering by collecting all production and loading data in one file to:
   - Collect, store and analyze data
   - Visualize loading and production data trends and patterns
   - Choose different timeframes to test data trends and patterns
   - Conduct analysis to find transporter ratio in parking on a certain date

iii. The *simulation study* is modelled to test the interventions and scenarios and their effect on the output data to:
   - Show the relation between the number of loaders and the number of stacked pallets in the loading area showing the optimal solution.
   - Test for different scenarios
     - Scenario 1: current production

        - Scenario 2: production increases by 10%
        - Scenario 3: production increases by 20%
    - Apply Interventions
        - Intervention 0: the current way of working
        - Intervention 1: increase the number of loaders currently filling trucks in both parts of the factory.
            - Sub-intervention 1: increase the number of loaders by one in VSF1.
            - Sub-intervention 2: increase the number of loaders by two in VSF1.
            - Sub-intervention 3: increase the number of loaders by one in VSF2.
            - Sub-intervention 4: increase the number of loaders by two in VSF2.
        - Intervention 2: changing VSF1 to live-loading (i.e., loading a truck upon arrival) only to see the effect on the waiting time and number of pallets on loading docks. (Other factors kept constant)
    - Show if congestion occurs
    - Act as the representing model of the real-life in the study

Scenario 1 showing the current production levels is calculated using historical data being represented in probability distributions. Scenarios 2 and 3 were calculated by adding 10% and 20% to the current production distributions already found from the analysis. As for the interventions, they show the changes to be applied in the simulation model by increasing the number of loaders for each part of the factory. They also test for visualizing the effect of changing the way of loading in VSF1 to live-loading on the waiting time and number of pallets stacked on the docks.

Figure 1 shows the number of stacked pallets in the loading area. The results show that in the null scenario, no pallets are stacked, which indicates that the company has to consider some deficiencies and hidden problems such as low productivity of loaders in the current WoW as this is not the case in real-life. For the simulation results, we found - as expected - similar waiting times in the null scenario and the 10% more production scenario as there is no congestion. In the 20% more production scenario, waiting times are not reliable due to having a missing link so the results were omitted from the analysis.

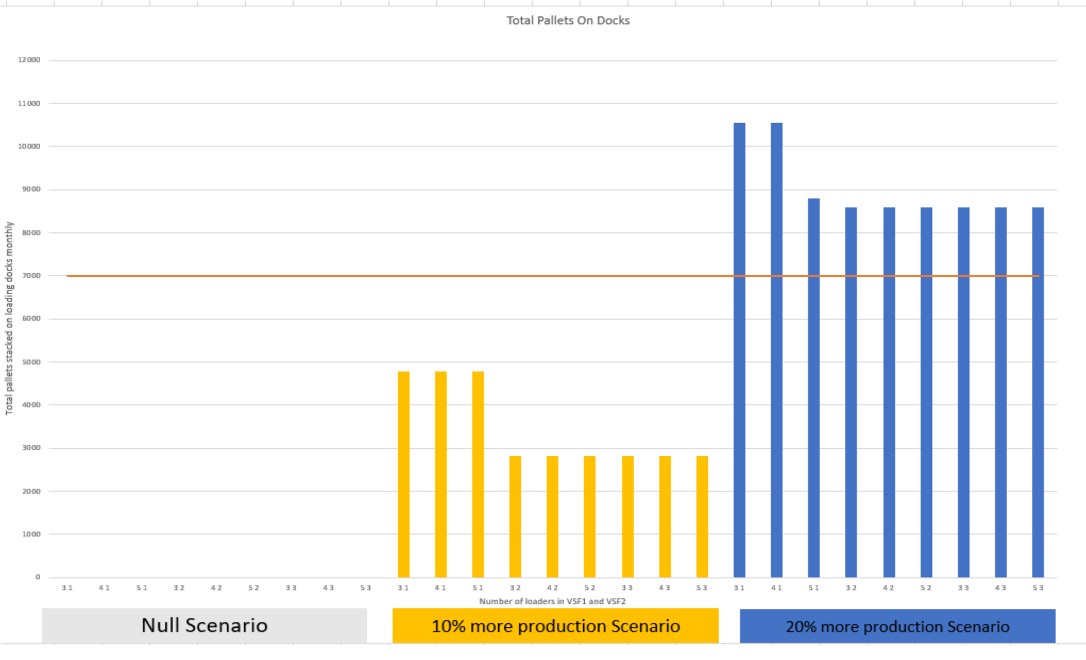

Figure 1: Total pallets on Loading Docks Simulation Results

Stacked pallets start to accumulate when production levels are increased by 10% and 20%, however, they can be reduced by either requesting more trucks to be filled or by moving them to warehouses. Stakeholders asked for applying the interventions 10% and 20% more production. Both interventions had different roles where 10% was used to measure whether the capacity of trucks is used to the maximum while 20% was used to test if blockage would occur due to pallet accumulation in the loading area. In VSF2, it appears that using one loader only in any of the scenarios results in the appearance of pallets in the loading area which means that one loader is incapable of fulfilling the number of requested truckloads. If PepsiCo aims for growth potential, adding one more loader to VSF2 to fill more trucks will reduce the waiting time and smoothen the flow.

Recommendations for PepsiCo:

Based on the findings of this research and evaluating the effectiveness of solutions, we recommend:

- Decision Support System

The decision support system is the bigger tool combining the KPI board and yard template to achieve effective and reliable results so they must work alongside.

  - Keep yard template running and up to date as it:
    - Helps visualize the contents of the parking space
    - Reduces the efforts and wasted time of employees
  - Keep KPI board running and up to date as it:
    - Analyzes data and spots problems statistically
- Change type of loading in VSF1 to live-loading only, as it:
  - Induces less waiting time leading to a higher number of trucks leaving the system
  - Improves rotational movement consequently when the waiting time is reduced
  - Allows more truck requests reducing the number of pallets stacked in the loading area

Recommendations for future research:

For future related studies, we have some recommendations to guide the new researchers in a path that can improve this research's findings. We recommend doing:

- Case Study
  - Doing a case study about costs of hiring a new loader
  - Possibility of increasing production levels by 10%
  - Availability of trucks in PepsiCo and know the possibility of requesting more
  - Automating the loading docks
- Improvements
  - Automate KPI board to save time and human error chances
  - Automate yard template by introducing barcode systems or by adding sensors on the parking

Use simulation model while changing the input distributions testing for an optimal number of loaders and strategies.

Contents

List of Figures

List of Tables

Glossary:

Term	Definition	Introduced on page
Loader	The employee responsible for moving pallets from conveyor belt to loading area and also filling in trucks.	Page 5
VSF (Veurne Snack Foods)	Name of PepsiCo plant in Veurne, Belgium	Page 5
All-rounder	The employee responsible for processing drivers, printing shipment documents, deciding on loading references, helping to move trucks across the parking, and helping in moving pallets around the factory.	Page 7
Shuttle Driver	The employee who moves trailers across the parking space, moves trailers to nearby warehouses, and is responsible for moving pallets from reject to quarantine designated area.	Page 7

List of Abbreviations:

- BU: Business Unit
- FIFO: First In First Out
- KPI: Key Performance Indicator
- MUs: Moving Units
- WoW: Way of working
- YMS: Yard Management Software

1. Introduction

This chapter introduces my research to obtain the Industrial Engineering and Management Bachelor's degree at the University of Twente. During the graduating phase of the program, I performed research at PepsiCo, looking into Yard Management. This chapter consists of several different sections where section 1.1 gives a brief about PepsiCo, then section 1.2 includes my motivation for the research. The research goal is then explained in section 1.3. Afterwards sections 1.4 and 1.5 briefly describe the methodology approach followed then the research and knowledge questions respectively. The research approach is then explained in section 1.6. followed by explaining the research scope in section 1.7. Then the deliverables are identified in section 1.8 while the report outline of the rest of the chapters will be found in section 1.9.

1.1. Introduction PepsiCo

PepsiCo is a public American food and beverage company that is considered one of the largest in the world. It took the name in 1965 after a merger between Pepsi-Cola and Frito-Lay to become PepsiCo. The company's main headquarters are based in New York while there are other headquarters in Europe and the Middle East. PepsiCo produces different products shipping to around 200 countries all over the world. They have been in the European market for more than 80 years now selling soft and energy drinks, chips, snacks, juice, and Quaker cereals.

The factory where this research took place is located in Belgium. It is called Veurne Snacks Foods and it supplies products to many countries like Belgium, The Netherlands, The United Kingdom, Germany, and France. The factory produces around 9500 tons per year which is considered a mass production volume.

1.2. Research Motivation

PepsiCo is currently facing some problems with one of their factories in Belgium producing chips and snacks, so they have formulated a research team to suggest some recommendations and fix the current issues that take place. This team consists of 3 persons including 1 student from the University of Twente conducting the bachelor thesis and also helping in the process of finding solutions to existing problems. The other two are full-time employees currently investigating the situation and working on a bigger research project. This problem that is currently faced by PepsiCo would require thorough and deep analysis, searching for improvements, and applying some enhancements.

As PepsiCo in Veurne produces massive quantities supplying to many European countries (such as Belgium, The Netherlands, The United Kingdom, Germany, and France), the outbound logistics department aims to have a smoothly running process leading to continuous production flow. This seems to be a simple goal to attain, but dealing with the number of pallets and trucks to suffice the demands of the countries shows many problems including congestions of pallets and trucks. To reduce the chances of congestion taking place in the parking and the loading area stacking pallets, faster loading and pickup of trailers are required. PepsiCo and transporters benefit from optimizing the way of working to have faster loads so that arriving drivers do not need to wait for a long time for pickup, hence the rotational movement is smoother.

The problem can be visualized in the yard management which lies under the Outbound Logistics department showing inefficiency at the end of the supply chain. Hence this research will be conducted at the outbound office of PepsiCo, Veurne, and will be presented to both the company and as a bachelor thesis to the University of Twente.

1.3. Research Goal

The goal of this research is to provide some improvements and recommendations to apply in the WoW in the factory's yard. I aim to provide the company with several tools that can help visualize the actual performance and smoothen the work process. This research focused on the Yard management which belongs to the Outbound logistics department of PepsiCo and it contributes to the bigger goal of the company "Having continuous smooth production flow". Working towards this end goal, some tools emphasize the required improvement points to be considered and help give better insights into the situation. On the other hand, this is a broad goal that cannot be reached by only the yard management approach, but every action has an impact on solving problems. There are several approaches towards reaching this goal and they cover different aspects that could be related in one way or another. One of these approaches is improving the company's yard management as for the current situation it creates congestions leading to production stoppage and this is the total opposite of the desired goal. We as a team are working in parallel on different researches where all should contribute leading to the same result: PepsiCo's main goal. The main focus of this paper would be on Yard Management, but this topic alone would not be sufficient to reach the goal. Therefore, more research should be conducted after solving the most problematic function in the process flow.

1.4. Methodology

For my Bachelor thesis, I have used the Managerial Problem-Solving Methods (MPSM) by Hans Heerkens(2017). This was a systematic approach that we used since the first year. I have chosen to use this method as it is supported by the University of Twente and because of the structured WoW throughout finding the problems and researching to find solutions. This method includes a formulation of alternative solutions while in my research I am aiming to change the WoW to avoid the problems we faced. Moreover, I also used the research cycle explained in the book Business research methods by Cooper& Schindler (2014) to search for the missing knowledge during the process. At first, some literature studies were conducted to understand how this type of problem can be approached and what are efficient tools to be used in solving these kinds of problems. Afterwards, some analysis about the findings took place and I started finding the most suitable solutions that fit in my situation. Then the solutions were brought to action and evaluated later on based on the performance.

1.5. Research and Knowledge Questions

In this subsection, the research questions and knowledge questions are explained. These questions are used to understand the scope of this research and help identify the aspects that require consideration to facilitate the research. Answers to these questions would be the structures' of the research approach followed and also showing solutions to the current problems.

1.5.1. Research Question

- *How can yard management at PepsiCo Veurne be improved so as to better align the supply chain processes? In particular, how can KPIs be monitored to prevent blockage of loading docks leading to production stoppage?*

This is the main question formulated to understand the problem I aim to solve during my research. Based on the problem analysis and the purpose of this research, the main research question was formulated to cover the whole scope. This question is a broad and general one and that is why some knowledge questions were also formulated. Due to having a general research question the knowledge questions which act as the skeleton of finding information during the research are required to ensure covering the whole scope by filling in the knowledge gaps. The scope of this research revolved around 3 points where the team needs to improve the yard visibility, transform big scattered data to critical KPIs to measure performance, and find the relation between loaders and the number of pallets stacked in the loading area.

1.5.2. Knowledge Problems and research subjects

Defining the problem (Stage 1)

1. What are the primary processes?
2. How is the current performance assessed?
3. What KPIs are currently in place?
4. Which processes result in the greatest negative impact on the process flow?

Formulating the approach (Stage 2)

5. Which analysis tools can be used throughout the research?
6. What is an adequate theoretical framework approach to follow in this research?
7. What are the data-gathering methods used?

Analyzing the problem (Stage 3)

8. Who are the people involved and stakeholders?
9. To which extent should the process details be included?
10. What are the root causes behind the problem?

Stage 4,5,6 and 7

11. What alternative solutions are promising?
12. What are their pros and cons?
13. Which are the most effective solutions and recommendations?
14. How will the validity of results be evaluated?

1.6. Research Approach

The research approach that I followed is trying to answer the research and knowledge questions. Those questions were formulated to try to cover all aspects in this research's scope while dividing the whole process into smaller tasks to facilitate the problem-solving approach.

Stage 1 questions were formulated to understand and define the problem that took place. These questions are answered by interviewing the current employees and managers and by observing the process flow. To know which KPIs were in place, data collection and analysis techniques were required. Fortunately, the company kept a record of all historical data which made the process easier. Whenever a set of data was needed, extraction of this data was the only required task with no need for data measuring. The data was scattered through different software systems for which I decided to collect the essential KPIs in one place.

As for stage 2, these questions were solved by referring to the methodology I intended to use. This was to help structure the WoW throughout the whole research, then this approach was validated through discussions with the company's external supervisor.

Stage 3, Analyzing the problem, was one of the complex parts of the research as the understanding of every aspect of the process was crucial to be able to tackle the correct problems. The stakeholder and root cause analysis were time-consuming tasks that needed thorough discussions and interviews. The discussions were first conducted with my team and after that, I start to interview employees responsible for certain roles(stakeholders).

For the rest of the stages mentioned above, the questions were answered by first conducting a literature search to check for similar research previously conducted. Then after finding more information about the topic, discussions, and evaluation of the findings took place during the weekly team meetings.

1.7. Scope

The scope of this research is to be presented to the Outbound Logistics department of PepsiCo, Veurne. This is a factory that sells goods to Netherlands, Germany, France, and Belgium While PepsiCo introduces the main project aiming for having continuous production without any stoppages, this research is required to improve the performance of the outbound logistics process by improving yard management and yard visibility. So, this research could be a foundation for other future projects regarding the main objective of the company. As shown in the problem cluster (see figure 4 below), several problems are leading to the main problem that PepsiCo currently faces. However, I would not be concerned with all those problems due to having limited time to conduct my research. For that reason, we have chosen to focus on yard management improvements as it is one of the vital causes of the deficiency in performance.

1.8. Deliverables

Deliverables of this research would be a process flowchart explaining the process we currently experience (this flowchart can be seen in section 2.5), a KPI board including gathered data with visualizations of charts, a standardized WoW on the KPI board, an overview template of the parking space and Simulation model screenshots with results.

The flowchart is to help readers understand how the process works and the decisions we have to make. For the KPI board, it is a tool that is used to gather data and conduct some analysis by visualizing charts. As for the simulation, this is to experiment with changes that need to take place on PepsiCo's parking space and WoW. Finally, the yard template is used to help visualize the parking overview with the current standing trailers.

1.9. Report Outline

In Chapter 2, the current situation of the company is described showing the WoW throughout the process. Afterwards, in Chapter 3, findings in the literature search are presented and their relationship with my research are explained. Then in chapter 4, yard visibility solutions are presented with different options to consider. This is followed by choosing one of the solutions to apply in the current situation. A KPI board is presented after the chosen solution while showing its importance in data collection and storage. Chapter 5 is about a simulation study conducted in this research to run experiments testing conditions. This chapter includes an explanation of the modelling phase, the assumptions made, the interventions, and also screenshots of the experiments. Screenshots would include graphs and data numbers that were found throughout the simulating process. Finally, Chapter 6 includes the conclusions and recommendations presented to the company based on the findings of this research. Each chapter includes a brief chapter summary at the end to show the key topics of this chapter.

P.S. all data numbers shown in this report are multiplied by factor X for confidentiality purposes.

2. As-Is situation

In the previous chapter, we introduced the research topic while asking some questions (research and knowledge questions) to be answered separately in the following chapters. In this chapter, we try to answer the knowledge questions classified in Stage 1 of the book Managerial Problem-Solving Methods (MPSM) by Hans Heerkens(2017), and these are:

1. What are the primary processes?
2. How is the current performance assessed?
3. What KPIs are currently in place?
4. Which processes result in the greatest negative impact on the process flow?
5. Which analysis tools can be used throughout the research?
6. What are the root causes behind the problem?

These questions were formulated to understand how is the WoW in the Outbound logistics department running while also keeping track of the performance levels. This was done by answering some questions regarding the process flow and the performance measurement.

In section 2.1 the process flow is explained while mentioning the way tasks are performed, then section 2.2 includes the loading of trucks as PepsiCo loads trailers in different ways. Afterwards, section 2.3 refers to the software systems used by the company. Section 2.4 shows the bottlenecks experienced by the company which caused inefficiency in the system. After this, the whole process is explained referring to the process flowchart diagram in section 2.5. The problem identification can be found in section 2.6 with a problem cluster figure identifying the main problems, core problems, and possible causes. Then this is followed by a chapter summary in section 2.7.

2.1. Process flow and way of working

The process flow and way of working are created to solve question 1, *What are the primary processes?*. We started by asking some questions and conducting analysis to figure out the whole flow and find the problems behind it. For now, there are two separate parts of the factory that produce different products. These two parts are labeled as the old and the new part (VSF1 and VSF2), where VSF2 has more advanced technology and an improved WoW. VSF is the name of PepsiCo's factory in Belgium.

VSF1 part consists of complete production lines with several flavoring machines then several packaging machines (palletizers) that lead to 16 loading docks at the end. While the VSF2 part also consists of complete production lines and ends at 5 loading docks which are processed by one loader per shift. The 16 loading docks for VSF1 include 3 automatic loading docks for which a loader (Employee responsible for moving pallets from conveyor belt to loading area and also filling in trucks) is unneeded and 13 docks which were processed by 3 loaders per shift. The automatic loading dock includes a conveyor belt used to fill in the trailers automatically and directly from the palletizer. It works with special trailers which have a moving base carpet that can go back and forth.

The two parts of the factory share an on-site parking space consisting of 46 parking slots. These 46 slots have no structure to show where trucks can park and there is a lack of visibility in knowing where the standing trailers are currently parked. So drivers arrive, choose an empty slot that interests them and they park their empty truck in that space. Then they move to one of the two Outbound logistics offices according to their loading reference then the processing and loading of the driver take place. The above description regarding the Outbound process outline is visualized in a graphical representation in the illustrated *Figure 2*.

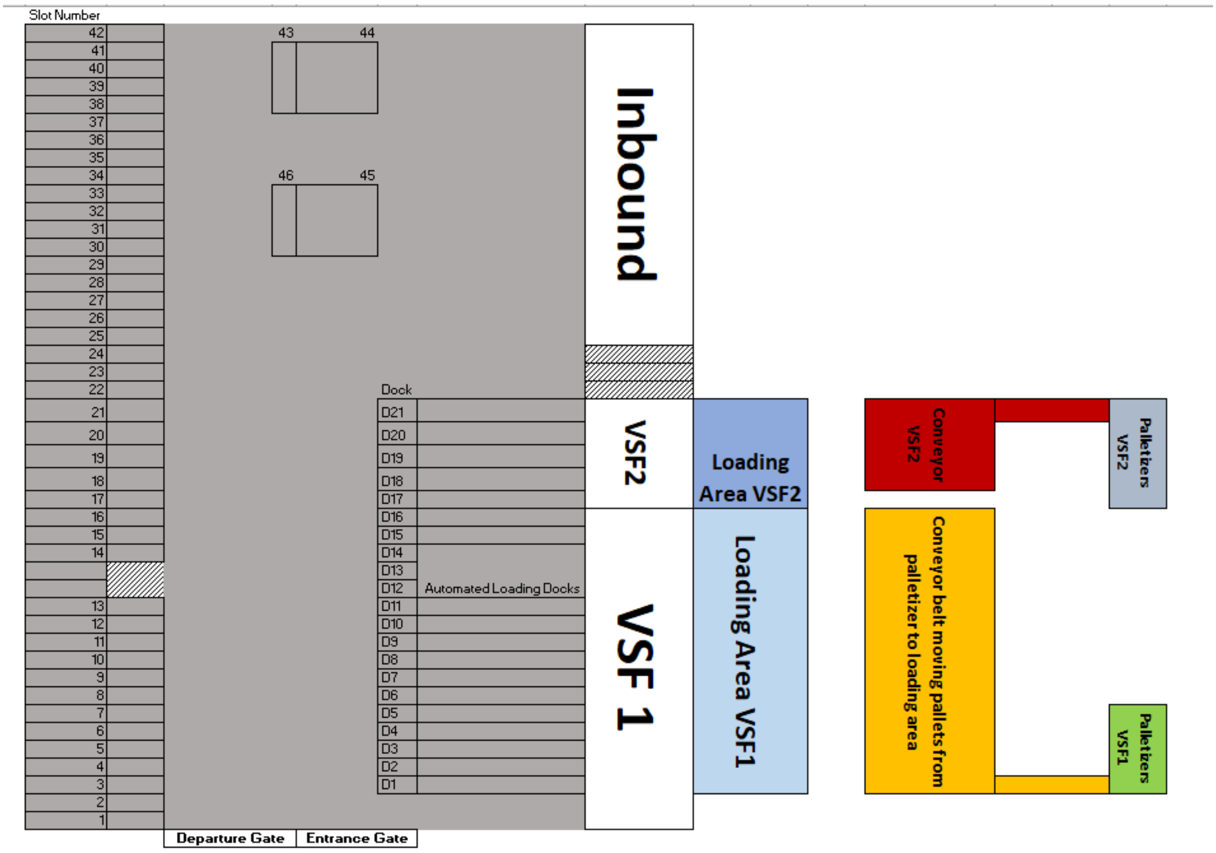

Figure 2:Visualization of Outbound Factory Plan

Both parts of the factory produce different products, VSF1 produces snacks and chips products, while VSF2 produces Doritos products, so the two departments were not viable to merge into one big part. Production is a part that would not get much of our attention, but the production machines and palletizers are continuously producing pallets that might lead to problems in the current situation. Finished goods need to be stored in the loading area as the company acquires a small on-site warehouse. The reason behind storing finished goods in the loading area is explained in the loading subsection.

The planning department sets the production plan for each country and sends the weekly plan to Production and Outbound departments. The production department is responsible for running the machines to process the product while they are also responsible together with the Quality department to provide finished ready-to-load pallets to the Outbound department. Outbound managers are responsible to convert the planning numbers into several requested trucks that can occupy the production batches. They send an overview planning request to the transport company and wait for their reply with the number of trucks available to send along with a planning schedule that includes the date and time of arrival.

2.2. Loading of Trucks

In this sub-section, the ways of loading trucks are explained showing the difference between the two types. This sub-section also plays an important role in providing an answer to question 1.

PepsiCo follows two different approaches of loading the trucks, “pre-loading” and “live loading”. Pre-loading is a contract currently in place with transporters. That simply requires leaving behind some empty standing trailers on the parking space so that PepsiCo can produce anytime for a certain order and fill in a trailer that would be placed back on the parking space after loading. This full trailer stays in the parking space until a new driver from the same company arrives also to pick up a pre-loaded trailer. The detailed explanation is visualized starting at label 12 in the process flowchart (Figure 3). The circle shown in the figure shows the start of a process and this is the automatic palletizer providing finished goods in pallets. As there is a distinction between VSF1 and VSF2 then the decisions of shipments are also different. VSF 1 palletizers require a decision by all-rounders (Employee responsible for processing drivers, printing shipment documents, deciding on loading references, helping to move trucks across the parking, and helping in moving pallets around the factory) on which shipment reference gets loaded, while if the products are VSF 2 palletizers require a decision by the loader to load pallets into an empty trailer. Then after the decision here comes a new trigger to the process at label 14 and this is if empty trailers are present. This would be a yes if there are empty trailers parked in the yard. When the answer to this trigger is yes, the loader carries pallets from conveyor belts (exit from palletizer) to fill in empty trailers parked across the loading docks. If the answer is a no then the loader should carry pallets from the conveyor belt and stack them in the loading area until a trailer is available for filling.

As for live-loading, this required a driver's arrival at the company with an empty trailer to be filled upon arrival. The driver is asked to stay in the parking space until the order is ready to pick up and a loading dock is available. Normally, products are ready according to the planning, but if a driver arrives earlier than the schedule they have to wait until products are ready. As previously stated, the company owns a small on-site warehouse that is not capable of keeping up with the massive production of pallets so the company mainly depends on pre-loading. We have an available nearby warehouse that is capable of acquiring more stock levels, but there are some restrictions in moving pallets to the other location due to the availability of shuttle drivers (The employee who moves trailers across the parking space, moves trailers to nearby warehouses, and is responsible for moving pallets from the reject area to quarantine designated area.) and legal restrictions to get on the road transporting products. We also try to keep everything on-site to prevent the double work of moving it to the warehouse then back from there to the plant for the filling.

Drivers follow a certain route upon their arrival holding an empty trailer till they leave the plant with a full trailer. They arrive at the security check where they are required to fill in some details to be allowed into the parking space, then they search for an empty slot to park their trailer. Afterwards, they enter into the Outbound logistics office so that they can be processed. Choosing the correct Outbound office depends on the order they are picking up so if the reference shows that it is a Doritos reference they go to the VSF2 Outbound office, while if it is chips or snacks reference they arrive at the VSF1 office. It sometimes happens that drivers arrive at the wrong office, but then the employees redirect them to the correct place. The processing of a pre-loaded truck is that a driver detaches the empty trailer brought and goes back to the parking space looking for the previously filled trailer(by trailer number) to attach it and leave the factory. As for live-loading, the Outbound employee checks if the driver arrives according to schedule, the product is ready and stored in the loading area. Then a check is made that an empty loading dock is available where they can park until their trailer gets filled up and they can leave the factory afterwards. Pre-loading trailers are usually moved by shuttle drivers from the parking space to the loading docks when the production is ready. This movement process was based on a request by the all-rounder in VSF1 or the loader in VSF2, but it was a random process as we kept no record of the trailers' data. The driver arrives to pick up the order, but the employee does not know where is it currently parked (in which slot), so the driver has to look for it by themselves which sometimes leads to human error picking up the wrong trailer.

2.3. Software systems used

In this sub-section, we try to answer questions 2 and 3 *How is the current performance assessed? What KPIs are currently in place?* By analyzing the approaches used by the company to gather data. In PepsiCo, it was hard to analyze datasets as the company used different mutually exclusive software systems for different parts of the factory.

At the start of this research, data were calculated and stored in different software systems where the company stored production and loading data. Production data was stored in two different software systems named Colos Warehouse Management and CSMS. CSMS was used to store VSF1 data and Colos, which is more advanced software, was used for VSF2 data. As for the loading data, this consisted of two data types, planning of trucks and loading of trucks. The planning of trucks was made by the Outbound logistics manager according to production plans sent by the Planning department and saved in software named GTMS. GTMS will not take a part in this research, but the data held in this software is the key data to all other software systems. Employees export data from GTMS to save it in Excel worksheets saved on Microsoft Teams. These worksheets are separated for VSF1 and VSF2, and these are used since the planning is added in GTMS until the truck leaves the system loaded. The loading data consists of some details like date and time of loading, data and time of pickup, and remarks. The worksheet includes hundreds of records as it is also used as a database for historical truck data, but no KPIs were in place due to inconsistency in formatting and data errors. The data scatter, use of different software systems, and separation of planning in different worksheets made it hard for Outbound Logistics managers to analyze and take concrete decisions in managing the yard structure.

2.4. Bottlenecks

Bottlenecks are the points that cause problems in systems. They cause deficiencies in systems and slow down processes while they can also lead to termination of the process. In this sub-section, we focus on identifying the bottlenecks in PepsiCo by solving the question *Which processes result in the greatest negative impact on the process flow?.* To solve this question, reliable data was needed in the data analysis approach to find out the deviations between expectations and real-life performances. According to managers' insights and preliminary data analysis, many bottlenecks were identified and those included: Long waiting times of trailers on parking space, human error in picking up standing trailers, stacking a huge number of pallets in the loading area, limited warehouse space, and most importantly the congestions experienced in the parking area.

Firstly, the long waiting times of trailers were due to the fact that PepsiCo had no visibility over their parking so for example, sending an overview including the late pickups to the transporter was a hard task. This was the main concern that needed immediate action as they have a relatively limited parking space compared to the number of trailers requested daily. The lack of yard visibility caused most of the bottlenecks mentioned above, as PepsiCo has a small on-site warehouse so empty standing trailers were needed to stack the finished goods pallets until they are picked up. The human error in picking up trailers was also a problem arising from lack of yard visibility where drivers were responsible to find their trailer in the company's parking space. This randomness in the process caused errors and slowed down the flow which created congestions in the outbound logistics. As for the congestions occurring in the parking area, this was due to having a larger number of trucks than the capacity of the on-site parking area. These trucks can fit in the area if drivers arrive according to schedule, park in a structured way, and leave the trailers in the designated areas. These bottlenecks will be explained in more detail in the relevant sections based on the approach to eliminate them.

Identifying these bottlenecks and their effect on the process flow, we found out the negative impact occurs in the yard area. This means that most of the backlogs and congestions occur because the parking area is underperforming.

2.5. Whole Process and Flowchart Diagram

In the below figure (Figure 3) the process is explained by using a process flowchart diagram. This is a complex flowchart and for that reason, it has been labelled using numbers and each of those numbers is explained.

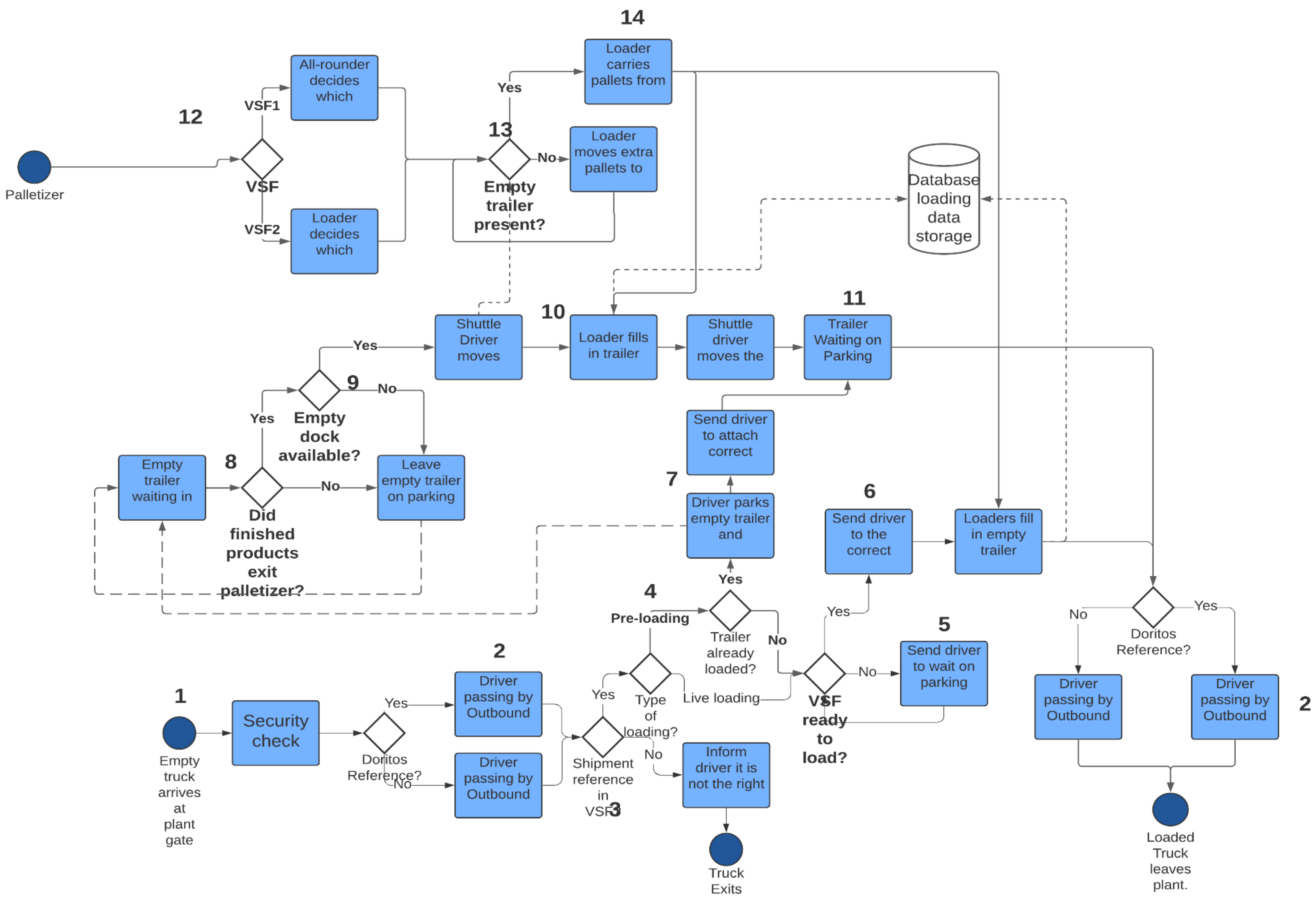

Figure 3:Outbound Logistics Process Flowchart

At label 1, a truck holding an empty trailer arrives at the factory security gate which requires passing through a security check. The following step, label 2, is a decision made based on the loading reference that the driver holds. If this reference is a Doritos reference then the driver passes by VSF2 outbound logistics office, while if it is not, then the driver needs to pass by VSF1 office. The process of passing by the office twice happens in two scenarios, one of them is dealing with inexperienced drivers that are new to the system or if the driver needs to live load. In both cases, the driver enters the office once upon arrival and once prior to leaving the factory. While the driver is in the office, the employee checks whether the reference belongs to VSF in any part of the factory (label 3). This check was to make sure that the trailers parked are in the correct location. If the answer to the question is “no” then the driver is informed that they came to the wrong location and exit the system. However, if the answer is “yes” then the employee processing the driver needs to check for the type of loading which depends on the transporter and the planning file.

Drivers arriving for live loading are labelled as label 5 in the flowchart. This stage includes a decision, made by the logistics employee responsible for processing the order, based on the readiness of VSF to load the trailer. If VSF is not ready then the driver is asked to wait on the parking space, but if it is ready then the driver is asked to park on a certain dock where loaders can start the filling process. After the loading is complete the driver has to return to the office one more time to sign the documents and leave the factory shipping the order. On the other hand, if the type of loading is pre-loading another decision needs to be made at label 4. This decision concerns having an empty standing trailer loaded prior to the driver’s arrival. When these trailers have not been loaded upon the pickup driver’s arrival, then the filling process is dealt with as if it is a live loading order where the driver has to follow the same path through labels 3 and 5. If the trailer was loaded then the driver is asked to park the empty trailer on one of the parking slots and sign the documents, then they are directed to know the trailer number that holds their order (label 6). After they detach the empty trailer, attach the full trailer and sign the documents, they leave the system.

The process of moving trailers across the parking or to the loading docks is triggered at label 8 in this flow diagram. This retrieves information from the stage where drivers detach the empty trailers leaving them in the parking area (label 8). An empty trailer already standing on the parking space stays parked until two questions are answered as yes, and those are: Did the palletizer produce the finished goods, and Is there an empty dock available? When those two questions are yes, managers, all-rounders, or loaders ask the shuttle drivers to bring an empty trailer from the parking space to the loading docks to prevent stacking of pallets in the loading area by filling in the truck(This requires information flow between label 9 and label 13). After the shuttle driver brings the trailer, the loader starts filling in the empty trailer, and then when the order is filled, the trailer is moved again by shuttle drivers to be parked in the parking area. This full trailer waits in the parking area until a new driver from the same transport firm arrives to pick it up. This is shown in the diagram at label 11 then after it is picked up the driver leaves the system without re-entering the outbound office.

2.6. Problem Identification

After finding the process that causes the highest negative impact we now have to identify the analysis tools to be used in this research and find the root causes of the problem. To be able to do such an analysis we asked the questions *Which analysis tools can be used throughout the research?, and What are the root causes behind the problem?.* These questions were acting as indicators guiding us throughout the research process. According to PepsiCo, some assumptions and intuition have been conducted around facing a problem in Yard Management. They intuited that there was a visible underperformance from the parking management. This caused congestion in the parking area where it was not able to handle the number of required trailers to keep up with the production pace. This intuition was based on the fact that we can see a huge number of pallets stored in the loading area. One of the main reasons that we store pallets in the loading area is that we have a small on-site warehouse to occupy the pallets. Not only stacked pallets in the loading area but also, the number of empty standing trailers on the parking is insufficient to pre-fill trailers with products and store them on the parking. These finished goods stored in the loading area can be reduced by managing the parking in a more efficient way which would allow requests for more trucks. This is not the main problem behind the company's research, but this is one of the most important topics to consider and try to solve. The company aims to produce without stoppages, but the stacking of pallets would block passages and consequently stop production. Being a part of the supply chain is a responsibility as the performance of the department affects the whole chain. For this reason, we are trying to fix the problems currently taking place at Outbound logistics to prevent arising problems with different departments.

To identify all possible causes to the main problem, we have used Root Cause Analysis(RCA) and its tools to formulate a problem cluster showing the root causes and core problems. By following these steps as shown in the problem cluster in Figure 4, we have identified the root causes to be lacking yard visibility and having an unstructured yard plan.

The problem that started the whole research process was an insight from an engineer that the company is not performing with a maximum capacity to continuously produce. This maximum capacity was never reached because there is not enough space to store the produced pallets. Conducting some research and thorough analysis we have found out some possible causes to this problem, then another main problem popped out and this was *Poor Yard Management.* This problem is one of the most affecting causes contributing to the problem. Hence, solving this main problem can be highly effective towards continuous production.

For the current situation, PepsiCo pre-loads trailers to save space on the inner side of the loading docks, and then shuttle drivers move those filled trailers onto the parking space. If we do not have enough trailers on the parking space, then we stack the pallets exiting the palletizers on the loading area which has a limited space relative to the production scale. This continuing production while empty trailers are absent would lead to blockage of the path for loaders which would require production stoppage. So, implementing a solution to manage the yard in an effective way would help structure the fleet of trailers on the parking space with faster pickups by the transporter which makes the availability of empty trailers more frequent. By having these trailers available then we can ensure the reduction of stacked finished-goods pallets on the loading area of the factory.

From that point in time, this task was assigned to me, formulating a research, measuring and storing data, analyzing and finding solutions so that we can achieve PepsiCo's main goal of continuously producing. I would be more concerned with Yard Management than continuous production, but this is because the current Yard Management is one of the obstacles facing smooth production.

Nowadays, trailer data can be found in individual manual templates. These templates are scattered where an employee must get on the parking site, check for locations, and visualize whether trailers are full and the data is not stored in a software system. As for the production data, the factory is divided into two sections, each working with a separate software so it is hard to track the performance through a digital report. These data were stored for future reference but were not used as KPIs in the outbound department. However, to find a solution to the current situation, KPIs must be measured and visualized by all employees in the department to find the underperforming tasks hence, structuring approaches to find solutions and trying to prevent the causes of the drops.

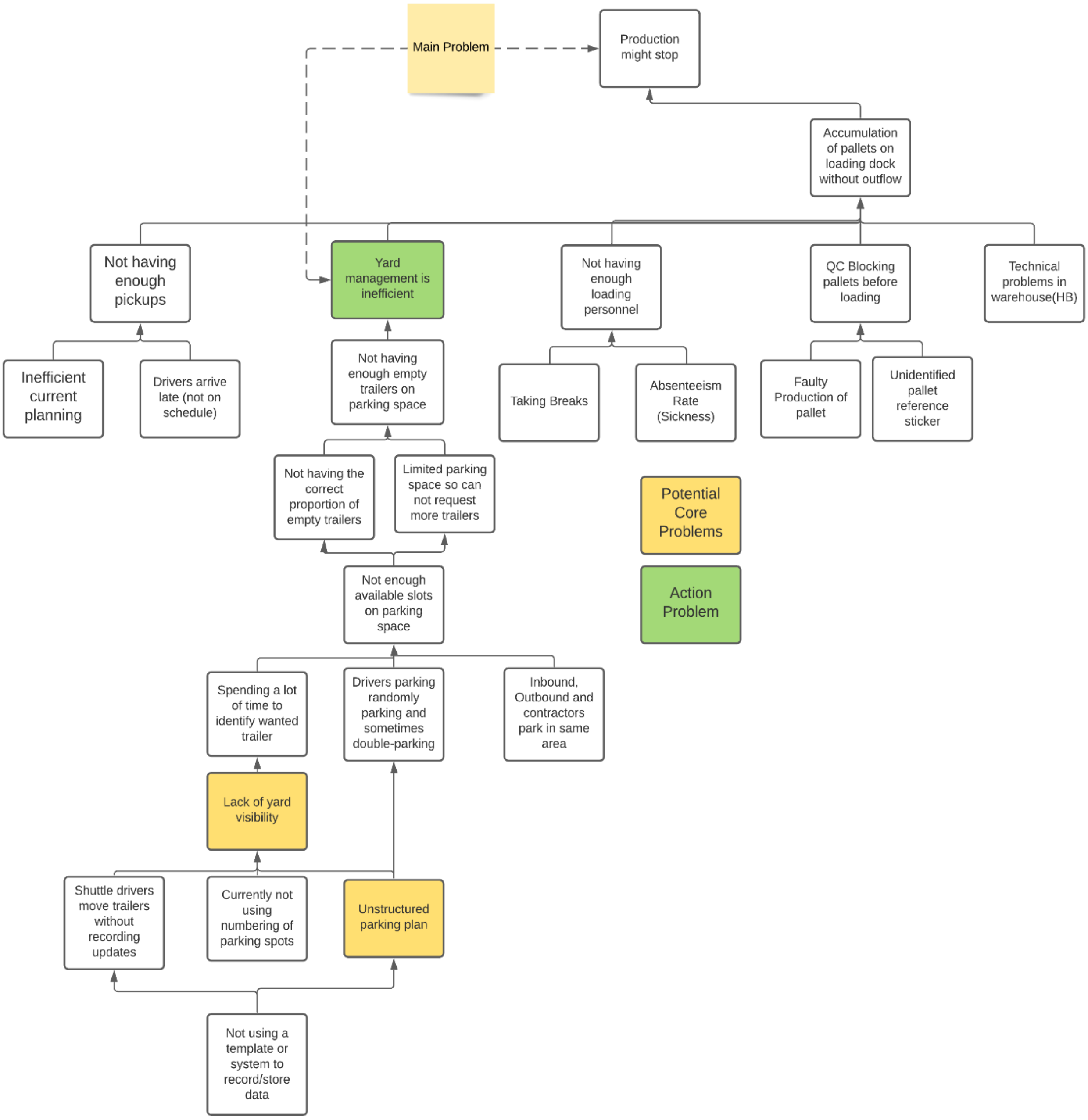

Figure 4:Problem Cluster

2.7. Chapter Summary

At the end of this chapter, an explanation of the process flow and the WoW that PepsiCo followed at the beginning of this research is included. Moreover, there was a detailed description of the different types of loadings while showing the software systems used to store the loading and production data. The software systems also explained why the data is hard to use in the analysis. The bottlenecks experienced in the process were mentioned with a brief explanation of the reasons behind considering them as bottlenecks. Also, the whole process was explained with an illustration of the whole flow in a process flowchart. This diagram was labelled in numbers so that the explanation is referred to the diagram easily. After understanding the current WoW and grabbing an insight on the whole process, the problem is identified with the help of a problem cluster presenting the main, action, and core problems.

In the As-Is chapter, the following questions were asked and by analyzing the situation to understand the main points of this study, answers were found making a positive impact on the process flow. The questions and answers were as follows:

What are the primary processes?

- Production
- Packaging (Palletizing)
- Loading
- Moving to Warehouse
- Processing Drivers

How is the current performance assessed?

- Performance was assessed based on experience and some data extracted from software systems. The performance was measured on a general basis which was not effective enough on such a scale.

What KPIs are currently in place?

- KPIs are not easily accessible so no KPIs were set in action

Which processes result in the greatest negative impact on the process flow?

- Yard Management

Which analysis tools can be used throughout the research?

- RCA
- Problem Cluster
- Logistics Process Flowchart

What are the root causes behind the problem?

- Lack of Yard Visibility
- Unstructured Yard Plan

3. Literature Search

In the previous chapter, we discussed the way of working that PepsiCo uses before adding any improvements, also the bottlenecks accompanied by this way of working. Now in this chapter, we will discuss different approaches followed by different authors in a literature search to solve a similar problem experienced by other researchers. To stay in scope and avoid distractions while searching through massive databases, the main question was formulated and this was *What is an adequate theoretical framework approach to follow in this research?*

To solve this question, some options are to be discussed trying to find the most viable solution in this situation. According to the bottlenecks of data scattering and yard problems we decided to narrow down the search to measuring the current performance, visualizing the flow, tools to increase yard visibility, and simulation. These were found to be the most important options as we need to try to understand why the flow is considered inefficient and try to solve the problems that we currently experience.

3.1. Measuring Current Performance:

In this subsection, the importance of measuring performance according to the theory found is discussed. All tasks conducted require performance measurement in order to specify the actual level of performance throughout the processes. There are currently many methods to do so, but they would differ based on the type of process flow and the variables which need to be measured. For that reason, we have chosen the concepts that will be used as evaluation of the articles throughout the literature study process to be: identifying the logistics processes and key performance indicators. Those two concepts help visualize how things work and also understand the flow of products through the supply chain while identifying the bottlenecks that the process faces. In the chosen articles, there were different methods to visualize the logistics processes and to choose KPIs. Analyzing these papers with different concepts required sacrificing some of the concepts that were less effective than others. So, we used a mix-and-match strategy to find a suitable way to visualize the process and identify variables that suit this research that can be easily formulated.

For the logistics processes, a conceptual flowchart was drawn showing the Outbound process. This flowchart then helped in understanding the needed indicators to measure so that the occurring problems are easier to identify. From the article by (Gerrits,2016), I understood how to formulate a logical flowchart when a simulation model needs to be designed. It is simply constructed by following the steps of the process as if you are teaching a baby how to walk, so it has to be basic, informative, and logical. That is because this flowchart is converted into a programming language used later on by inserting it into a computer to simulate our model. After we have conducted the flowchart it was now easier to expect the bottleneck locations, so we needed to identify the KPIs that can validate our assumptions. This chart helped with choosing or developing KPIs that would measure the actual performance precisely.

Managers start thinking of improvements and adaptations to the system whenever they can access the actual performance shown by the KPIs chosen. The improvements and adaptations are part of the decision-making processes that might be easier by following the so-called Decision Support System. “Decision Support Systems (DSS) in Supply Chains, for several purposes, including: testing alternative scenarios, prediction, understanding the behavior of complex systems, determining certain performance measures, or simply to animate the logistic flows, allowing to discover new knowledge from raw data.”(Dias, et al., 2019) This quote from Dias identifies the importance of understanding the current situation by identifying logistics processes and measuring the performance (including KPI formulation). This is needed to identify the bottlenecks in a particular process allowing an easier generation of solutions.

This helped in the research when a logistics flow chart was drawn followed by formulating a KPI board in which we can store the required performance measures to validate the claim of managers that the company is underperforming on the yard.

3.2. Visualizing the Flow

The logistics process flowchart is a tool that is used to help understand the process currently in place. It includes different shapes and features that help identify start events, processes, decisions, and end events. It should be a copy of the real-life WoW so if an engineer gets to see the chart they would be able to visualize how the process runs. This includes the product flow and information flow. An example of this process flowchart was discussed in Figure 3 in a previous section. It is also used alongside data acquired to pinpoint the problem and the location where it takes place. This would help managers and employees act according to this problem by introducing improvements that can change the performance.

In this research, we have created a flowchart showing the Outbound processes which shows the flow of a product from the stage it was palletized until it leaves the factory. This means it had passed through the loading docks and certainly the yard where we encounter the problems. After that, we used the flowchart along a KPI board to find the underperformance and our team figured out that the major problem took place in the yard especially with the WoW as we sometimes do double-work. This flowchart did not help solve the problem, but it now clarified where it is, why it takes place according to data, and what could be the possible solutions to fix this issue. Nearly all the articles mentioned in this chapter had constructed process flowcharts by the authors showing what their WoW looks like. However, some of them were poorly constructed, but it was still easy to classify the different tasks.

In the below figure (Figure 5) from the article "Simulation-based approaches for processes improvement of a sugar mill yard management system" (Kusoncom et al., 2018), the process flowchart is visualized showing the start points of each flow, the decisions made, and the flow of a process. This was explained by supply chain standard shapes that are easy to comprehend by engineers checking the model. This played a great role in helping during the construction phase of the model in this research.

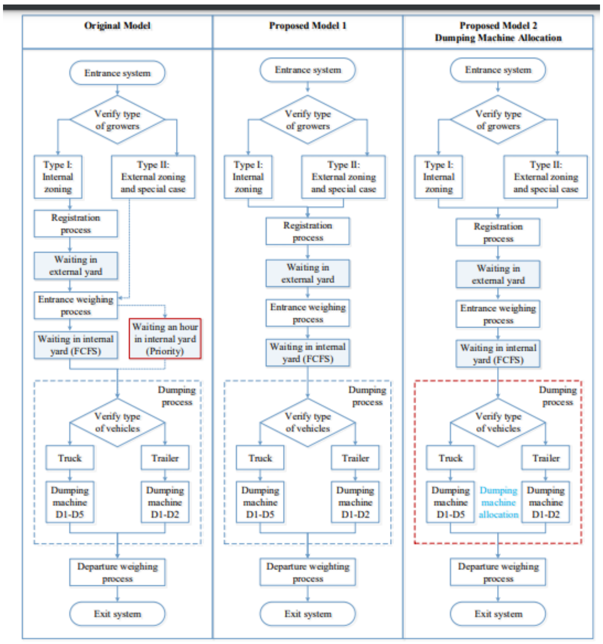

Figure 5:Logistics Process Flowchart Retrieved from: https://www.thaiscience.info/Journals/Article/EASR/10991120.pdf

3.3. Tools to Increase Yard Visibility

Zhen et al. (2016) identified the importance of reducing transportation costs. This was through creating a template that helped in planning and creating a schedule while keeping in mind the constraints of size and traffic congestion. Based on this article and one of the core problems mentioned before, we comprehended that we face the same problem as we have nearly no structure in the parking area. This also acted along with lacking yard visibility in creating the problem. For that reason, we grabbed an insight from their piece of work in creating a template that would help show where do the trailers stand on the parking, hence taking decisions would be easier for managers and employees.

The article written by Ouhaman et al. (2021) is related to this research subject as they have the same problem of lacking management with the stacking on their yard. They have made a yard planning template that needs to be planned by the employee responsible. "The yard planner is in charge of finding the best storage configuration according to the yard layout while taking into consideration the state of each hangar."(Ouhaman et al., 2021) This is different from my situation as they deal with containers that require storage in a hangar, but in my research, we deal with standing trailers that need to be empty to use for storage purposes. We use the empty trailers to store the produced products as we have a small storage area until the transporter picks them up. An interesting fact that made this paper related to our topic was that they aimed to have continuous production without stoppage, but due to the lack of management, some blockage took place which is the same case in this research.

We also have the same problem in PepsiCo's case which makes the followed approach by different authors feasible in our situation.

3.4. Simulation

A simulation is an "experimentation with a simplified imitation of an operations system as it progresses through time, for the purpose of better understanding and/or improving that system" (Robinson, 2014). In a simulation model, we aim to program randomness and uncertainty. This needs data and probability distributions to provide an accurate estimate of the real-life situation. A simulation model can alter between adding constraints, experimenting with results, and changing performance variables to visualize the expected outcome if this was to be applied in real-life. Simulation usage is now more common by organizations as it is easy to adapt based on one's conditions, it operates in a risk-free environment and it saves money and time for the organization. It saves time as adapting the previously built simulation model by changing variables currently in place, is way easier than spending time to create a new model from scratch. Another reason that simulation became so common is the fact that it requires fewer assumptions and simplifications than building other types of models such as Markov or Integer-Linear Programming models. As PepsiCo experiences a lot of uncertainty in the arrival of trucks and production of pallets, a simulation model is needed to test the possible changes. These changes are hard to model in a queuing model due to uncertainty and randomness. To have an accurate model, distributions for the random data were essential so that the input data to the model are accurately representing the real-life situation. This required large datasets that can be analyzed and then inserted into the model. As we already have mass databases carrying historical data that can be translated into patterns and trends that act as inputs to the model, conducting a simulation in my research would be a helpful tool. In the article "Simulation of an automotive supply chain using big data" it was obvious that collecting huge datasets can be a setback to a simulation model while if the processing of data runs in an organized structured process, this would lead to better results. So after choosing the KPIs based on the process flowchart and storing them in the KPI board it was time for the processing. We have followed the approach that was used in the article to learn how is processing done and the found solution was by using Excel functions and the data analysis tool pack. The case where the authors wrote about in the article is close to what I am currently experiencing as “Bosch” the company mentioned in the article “Simulation of an automotive supply chain using big data”(Vieiraa et al., 2019) used to have “Big Data” while also at PepsiCo as a multinational we keep track of all data generated so we also have to deal with big data. To deal with these data as an input to the simulation model it was clearly hard to obtain trends, but it was easier to test for statistical distributions. Afterwards, a simulation model needs to be designed for which I found an interesting figure in the article about simulation by Kusoncom et al.(2018) This figure was used to show the step-by-step process of modelling a simulation.

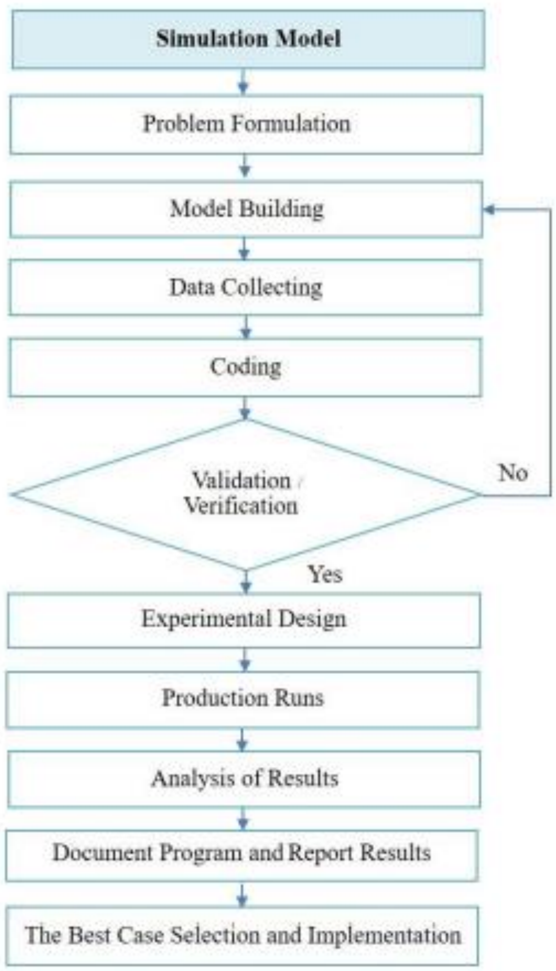

Figure 6:Steps to follow in modelling a simulation, Retrieved from https://www.thaiscience.info/Journals/Article/EASR/10991120.pdf

This figure shows how important the problem formulation is before building a draft of the model which would then be improved through an iterative process of validating the model and the planned versus expected outcomes. I am currently following this approach and keeping it as a reference through the process of my simulation building.

The above-mentioned article by Kusoncom revolved around a simulation study that was conducted on the sugar-producing industry. It might seem to be unrelated, but it is relevant to my research as they both do not have enough space to occupy the trucks entering the system. Also, both research studies are in the food industry as this company produces sugar and PepsiCo produces snacks and chips that cannot be stored for a long time. A simulation study would be conducted in my research to add a strategy in allocating trucks to parking spaces to reduce the waiting times. Reducing the waiting times would help provide more rotation of trailers so that more parking slots can be available to accommodate more trailers.

3.5. Chapter Summary

In this chapter about literature search, the current performance measurement was discussed and explained while showing the importance of having tools to facilitate this process. It also included the approaches to visualize the process flows and focused on the logistics process flowchart. The question asked throughout this chapter was *What is an adequate theoretical framework approach to follow in this research?* This was used to guide the researcher and his team throughout the search process in different databases. Moreover, the chapter included tools used to increase yard visibility and the benefits of creating a template. Finally, it included a brief description of Simulation, showing the importance of modelling the real-life in such a model to experiment changes. The steps followed to model the problem were also discussed being accompanied by a diagram showing these steps. According to the findings of this literature study, we decided to present a template, a KPI board, and a simulation model. These were found to be the important tools that can help solve such a problem according to previous similar research.

4. Yard Visibility Solutions

After finishing the problem description, analysis, and literature search in the previous chapters, we discuss the possible solutions to increase yard visibility. We found the bottlenecks in our process and analyzed the used approaches by other researchers in some literature searches to solve similar problems. We have been conducting a team meeting on a weekly basis where we used to discuss the findings and analyze the feasibility of these solutions in our case. To reach the desired target of having continuous production without stoppages by following the approach of tackling core problems, we started finding solutions to eliminate the lack of yard visibility problem. In this chapter the following questions will be asked and answered showing the findings of the research throughout the whole chapter:

8. *What are the data-gathering methods used?*
9. *Who are the people involved and stakeholders?*
10. *To which extent should the process details be included?*
11. *What alternative solutions are promising?*
12. *What are their pros and cons?*
13. *Which are the most effective solutions and recommendations?*
14. *How will the validity of results be evaluated?*

In section 4.1, possible solutions for yard visibility are mentioned while also evaluating them. Then in section 4.2 the chosen solution "Parking Overview Template" is explained while identifying the steps through the construction process. Afterwards, section 4.3 shows the KPI board used to measure and illustrate the collected data. The findings and evaluations made by PepsiCo are then shown in section 4.4. Then the chapter summary is found in section 4.5.

4.1. Possible Solutions for Yard Visibility

In this subsection, the possible solutions that are feasible in our situation are discussed showing the different options, showing their pros and cons, and also identifying the most effective solutions. To solve the yard visibility problem, we had to consider many options that contribute to eliminating the core problem showing some improvements. Comparing the WoW with reality brings up the question *What alternative solutions are promising?* This question is considered an important one as the current WoW shows poor performance which requires a change in a step or applying improvements. Searching for alternative solutions having a positive effect on the WoW, we found that two solutions are feasible in PepsiCo's situation. One of those was buying a known software that can be implemented into PepsiCo's system to increase visibility over the parking area. This software is being used by PepsiCo in the United States which made it more convenient to consider buying this specific software as it was clear that PepsiCo already has a linkage with this provider. Another solution was to create a template that we develop in order to do the essential functions already present in the software system. Due to time constraints, it was not an optimal solution to create a template then compare it to the software features. So, we made a draft of the Excel template on paper showing the features that would be included in the template, the interface for users, ways to enter data, and connections between datasheets. This was used to be able to evaluate the solutions based on certain criteria which ensures the feasibility in PepsiCo's situation, hence, choosing a solution. This evaluation was a crucial step before developing and implementing solutions as the development is a time-consuming task. For this reason, the question *What are their pros and cons?* was presented to make the evaluation easier to process. A table was created including the evaluating criteria sorted based on the importance to the stakeholders. This table had an evaluating scale of 1 being the worst and 5 being the best while 3 acts as the median. Then this weighted scoring is calculated based on the importance and the score achieved for each solution.

Criterion	Yard Management Software	Yard Template	Weight
Cost	1	5	40%
Time required to implement	2	5	20%
Live-support	5	1	15%
Confidentiality	1	5	10%
User-friendliness	5	4	10%
Communication with Transporters	5	3	5%
Total Weighted Score	2.4**	4.2**	100%

Table 1:Criteria to evaluate possible solutions

These criteria were chosen based on the stakeholders' preferences and they are sorted in the table based on their importance. First of all, Cost is the criterion that compares the required costs to obtain these solutions. It is shown in the above table that this criterion is the most important being weighted as 40% of the importance to the company. This was due to the fact that the company has some budget constraints, so comparing the buying and running costs were important. This was not used alone as other factors were also important in the choosing process. Looking into Cost which is the most important, the company needs to pay an initial investment for buying the Yard Management Software (YMS), buying compatible devices to run the software, one-time training fees, and a so-called monthly subscription. The training fees would be paid once to train all the employees that will use this software and the monthly subscription would be the running cost including updates, license, etc. As for the Excel yard template, it was a free-of-charge solution as the company already has a business subscription to the Microsoft license. There would not be any training fees as the researcher is the developer of the template and showing the work by providing the job aid is more than enough as a training session.

The second criterion to be considered is the time required for implementation. The more time needed to implement the system, the lower the score obtained in the evaluation. So as the YMS needs 6 weeks of preparation before implementing the software into the system and the yard template requires time for the development of all essential features which is lower than the 6 weeks' time period, the evaluation score is higher in the Yard Template than the YMS's score. Moreover, live support is a vital feature that is worth acquiring in the solution to be implemented. YMS has 24/7 live support for the software so it scores 5 while the template would not have any live support as soon as this research is done and the template is working so it scores 1. The support for the template would be given by Excel experienced employees who use the template, but there is no support from a developer.

Confidentiality is another important aspect for PepsiCo, as the company has high security for its data. Buying software requires providing the third party with company data to be able to model software that suits their needs. After conducting a meeting with one of the developers of this software, some points were highlighted such as transporters can have access to this system. This was considered a pro and a con because the transporter would be able to see the trailers left in the company's parking, but they would have more access to PepsiCo's data. As this was a topic of discussion within our team, YMS scored 1 for this criterion as the company did not welcome the idea of sharing data. As for the template, it scored 5 for this criterion since this was modelled in PepsiCo premises without sharing data with any external parties. The template can hold historical data records about the yard, so it is easily accessible if needed. It was a huge advantage to build a template that can run the same essential features as YMS without sharing information.

User-friendliness was also an important aspect to consider while choosing between the two proposed solutions. It was evaluated based on several features that are classified as features facilitating the job. These features included: visualizing an overview of the parking, ease of updating the overview, visualizing also nearby warehouses that PepsiCo use to park full trailers, and training needed for employees to use the chosen solution. YMS was an extremely user-friendly software where every action is one mouse click away. It appeared as if it was a kids' game, however, thorough training was needed to introduce the new WoW in implementing this software. This training was long and expensive so it was considered a con in this case. Still, YMS scored 5 in the evaluation criteria for the user-friendliness criterion. On the other hand, the template scored 4 for this criterion as it showed a clear overview of the parking and the nearby warehouse. It also needed minor training to the employees, just to introduce the new WoW. However, YMS was better for users as it is developed by experts aiming to ease employees' work process. So in this criterion, YMS scored a better score than the template.

As for communicating with transport firms, it was an important criterion, but the least important during the evaluation process. YMS can automatically send emails, overviews, and reports to transporters if the company requests this feature during the development phase. It also provides alerts to the transporter if a trailer had waited for too long in the parking area so that they can pick it up. As for the template, it had no direct communication between PepsiCo and the transport firm, but it still prints the overview sheet. This overview sheet used to be the employee's task by searching in the planning file for full trailers that have not been picked up and copying them into an email to be sent to the transport firm. The template helps print this overview by clicking a button that runs a macro to print this overview saving time and effort for employees and managers.

After presenting both solutions and the advantages of each, a new question is worth answering and this is *Which are the most effective solutions and recommendations?* Based on the evaluation and due to budget constraints at the present time, the excel template was considered to be a more suitable solution in this research. This conclusion was met by calculating the weighted score for each solution finding that the Excel template scores 4.2 and YMS scores 2.4. As the template scores a higher weighted score and provides the essential features needed by PepsiCo, then the rest of the non-essential luxurious features could be proposed later on in future research.

4.2. Parking Overview Template:

To face one of the core problems we already experience, we tried improving the yard visibility to reduce its impact on the rest of the problems. This means that we need to have an overview by keeping track of the currently standing trailers on the parking space. There were many options to consider, as mentioned in the previous section. When the visibility topic was first brought, we started by checking the WoW currently in place, and then acted accordingly. For the previous situation, there was randomness on the parking where drivers drop the empty trailers in one of the empty slots, then employees and shuttle drivers at the company need to spend a lot of time searching for this empty trailer to conduct pre-loading later. This was a time-consuming task to do as they have to go on the parking space knocking on trailers to know if they were filled then they would move it to the loading docks if found empty. To save time and effort for the shuttle drivers and employees we had to take an action by introducing a yard template that would be used in the Outbound office. This template was chosen over the software as any paid subscription at the company required approvals which needs time and we wanted an immediate solution to be in action. It scored a higher weighted total while also, the essentialities we aim for in the new WoW are doable features in the template then all the luxuries of the software are not needed at that time which made the choosing process easier.

This template was considered an important tool as it had some advantages to facilitate the Outbound process in VSF. It would provide the company with the following:

- Visibility over parking contents
- Reduction in wasted time by employees and shuttle drivers
- Overview report creation
- KPI analysis

The following features are attained by adding some formulas and macros to do the required job. The visibility of the parking increases as the trucks already standing in the parking area are now monitored. The wasted time is reduced as the employees and shuttle drivers know where do the trailers stand, the contents filled into it, and the destination of this truck altogether in one template. The wasted time is also reduced as the employees and managers can create an overview report by clicking a button in the template while in the current WoW, the employees need to do a manual search for loaded but still present trailers. Moreover, the template provides a KPI analysis, showing the trailers' on-time arrival, lateness and adherence. By using these KPIs we could start commenting on low performance by transporters trying to seek a better rotational movement by sticking to a time plan.

After developing the template, a minor change has been imposed on the current WoW which appeared to have an effect on saving wasted time. This change was that security personnel asked drivers to remember the slot number where they dropped off their empty trailer and inform this number to the employee processing their order-picking. They also informed drivers that they should not detach their trailers unless they are asked to as they may be asked to replace their trailers' location in the parking. After the drivers park the empty trailer, they enter the Outbound logistics office where the employee should be informed of the slot number. The employee updates the template accordingly so that the trailer would appear in the parking overview sheet. This would help ease the processing of drivers as now the employee only needs to look at a screen and inform the drivers with important information. This information consists of the exact location of the trailer, the trailer number, and if it has finished loading.

The template consists of 5 worksheets, each of those is used for a different function than the other, but they are all related and linked using functions and macros. Firstly, we have the Input sheet which is used to fill in details of unplanned trucks arriving at the factory. This sheet fills in the details: Trailer Number, Transporter, Date, Hour, Slot Number, Reference, VSF Reference, and if it is Empty. This uses the macro shown in Appendix A i) to save the data in the corresponding cell in the planning sheet "Incomingtrailers". This sheet includes all essential data about empty trucks that are not included in the planning. The input sheet is illustrated in Figure 8 placed by the end of this section.

Then the planning sheet "Pendelplan" consists of the stored data of trucks that were present and those we still expect according to planning. This sheet includes more details about trucks such as the date and time of loading, the date and time of pickup, and the planned date and time of arrival. It was used as the database of truck information where all referenced data were extracted from the "Pendelplan" sheet. The "Parking" sheet is the main worksheet for which we constructed this file. The main reason for its existence was to have an overview of the parking. It shows the layout of the on-site parking and nearby warehouses that also include space to park some trucks. We mainly use the parking spaces in the warehouses to park loaded trailers waiting for pickup so that we can free more space on the on-site parking space. It uses VLOOKUP functions to fill in the blanks by matching the slot number in this sheet by the slot number in the “Pendelplan” and the “Incomingtrailers” sheets to return the Transporter, the trailer number, and if the trailer is empty. This overview plan shows the exact locations of trailers on the parking space which makes it easier for employees and shuttle drivers to guide drivers to an empty loading dock, identify the empty trailers and also tell drivers where to park. The Overview Button that can be seen in the below figure (Figure 7), uses a macro to print the so-called Truck Overview into the “Overview” sheet. This overview is a record of all trucks that have been loaded on the parking space and are not yet picked up by the transporter. So the employee now does not need to look through the “Pendelplan” to find out those trucks, but it uses a macro so that if the truck is not empty, but still stands in the parking area, it should be printed in the other sheet and now the employee only has to copy those records into an email and send it to the transporter. The macro can be found in Appendix A ii).

Another improvement point recognized with implementing the template into the system is that human error caused by drivers is easily reduced. At first, they used to go search themselves for the required trailer, but now they are being directed to the slot number where they exist. This helps the employee keep track of the parking space as they now manage the drivers’ behaviors in the parking space. This was another improvement point in the WoW of the parking space.

It had been a struggle at first, but we made a training session for the users of the template identifying the change of roles of employees. This was also documented in a presentation named “The Job Aid” which helped remind employees of their new roles and tasks. By time drivers got used to how we will be doing this process further on. The security personnel had helped in this process of change by asking the drivers to remember the slot number, informing them that now we only use one office to process drivers, and also telling them not to detach their trailers unless they are told otherwise.

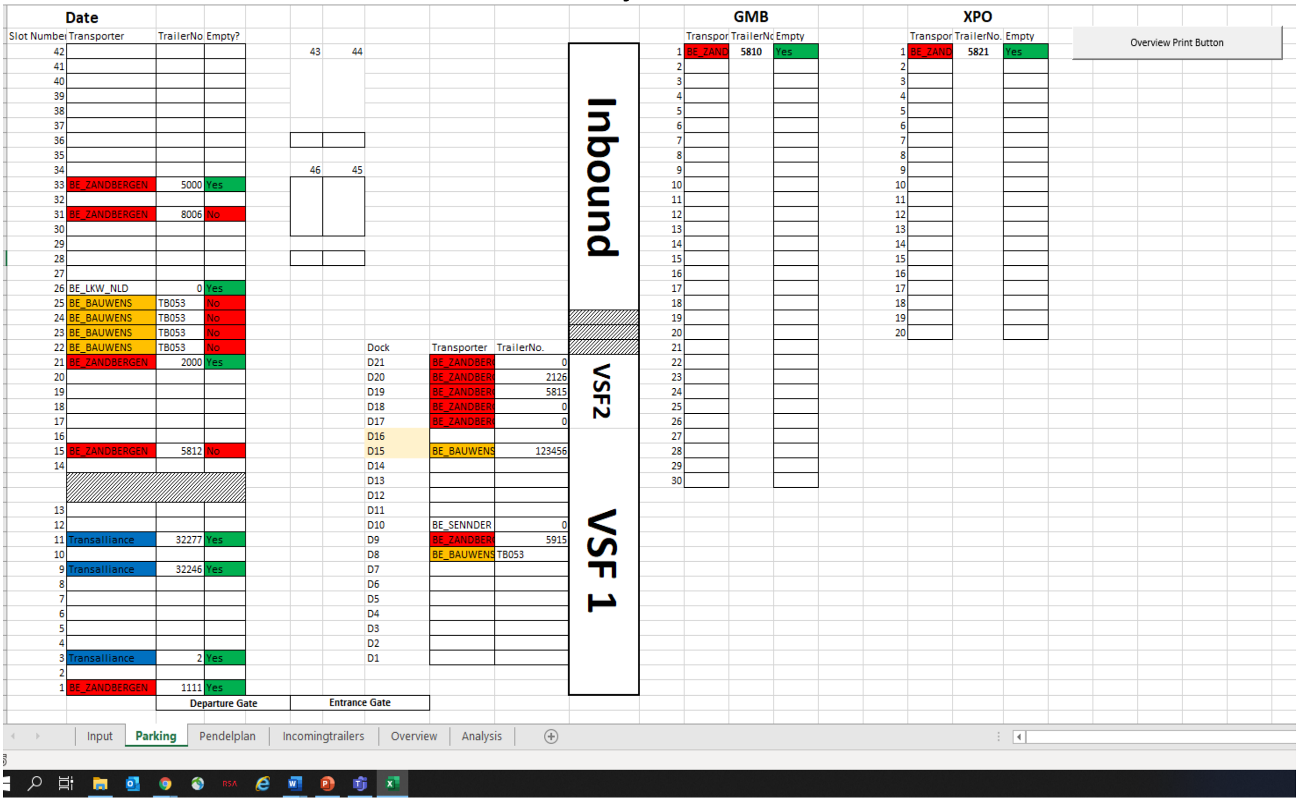

Figure 7:Yard Overview Template showing trailer information

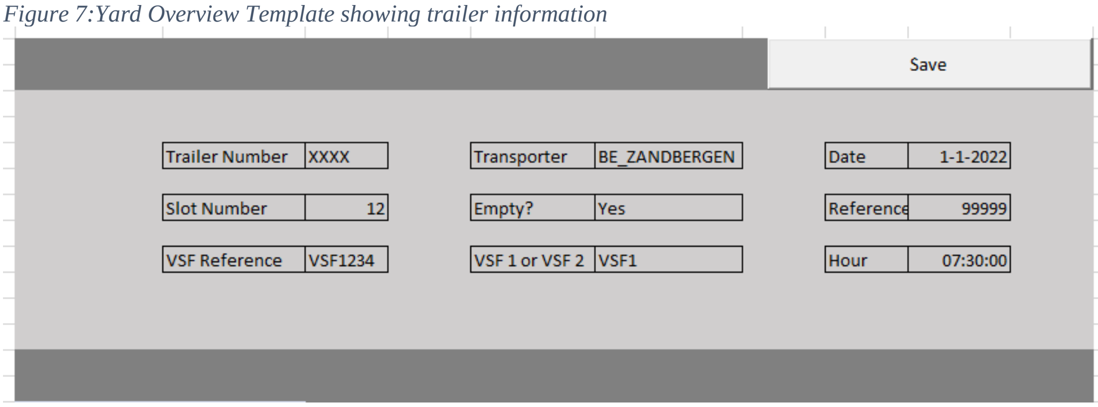

Figure 8:Input Sheet to register trucks

4.3. KPI Board

After creating a template tool to be used for data storing, visualizing, and analyzing, we figured out the importance of gathering the production and loading data into one file that can easily be used to store, visualize and analyze data. Here comes the question: *What are the data-gathering methods used?* For the previous situations, the KPIs were not calculated on a daily basis, they were measured, but stored in different locations causing data scattering. That's when we realized that using all this data can show a variety of information. One of the team always stated "Data speaks for itself", and by this statement, our team started planning on an adequate approach to collect this data. To validate the hypotheses made by employees and managers, actual performance measurement is required. For this reason, we created an Excel-based KPI board to keep a record of data from all over the system which should be collected in the same location.

The KPI excel file is used to keep a record of data from VSF1 and VSF2 on a detailed daily basis (based on shift and business unit), daily sums, weekly sums, monthly sums, and yearly sums. Unfortunately, due to the limited time of the research, there was no data in yearly sums as the data collected was for October, November, December, and January. Tracking the collected data was important as data trends and patterns over time were needed throughout the problem analysis. These trends were plotted by the means of charts and graphs to help in visualization. Data collected was extracted from software systems and recorded in the KPI board consecutively for each KPI (Key Performance Indicator).

The KPIs included in this board were categorized into two categories: Performance and People KPIs. The performance KPIs are KPIs used to measure the data related to the performance of machines while comparing the planning sent by another department to the actuals that appear to take place. These KPIs consisted of:

- Number of pallets planned to produce

Number of pallets planned to be produced on a certain date.

- Number of pallets actually produced

Number of pallets produced on a certain date.

- Planned Adherence (Planned vs Actual)

(Number of Actual produced pallets - number of planned pallets to produce)/number of planned pallets.

- Number of pallets on loading docks

Number of pallets stacked in the loading area by the start of each shift.

- Number of Requested Trucks (Ordered from transporter)

Number of trucks ordered from transporter according to planning.

- Number of Planned Trucks(Planned in timing and date)

Number of trucks accepted by the transporter and received planning for.

- Number of Loaded Trucks

Number of trucks filled per shift.

- Inflow Warehouse

Number of pallets entering the warehouse.

- Outflow Warehouse

Number of pallets taken out of the warehouse.

- Planned Carton boxes to produce

Number of product cartons planned to be produced.

- Actual Cartons produced

Number of product cartons produced

- Difference between planned and actual

The actual number of carton boxes produced - the number of planned cartons to produce.

As for the People KPIs, those were used to measure some performance indicators in relation to the number of employees present in the shift. The data for the two parts of the factory were combined as the outbound logistics performance affects the shared parking space. The two parts of the factory also use the same personnel so data combination was essential to get accurate data. The People KPIs consisted of:

- Planned Production Combined (VSF1 and VSF2)

Number of pallets planned to be produced on a certain date for the two parts of the factory combined.

- Actual Production Combined (VSF1 and VSF2)

Number of pallets produced on a certain date in the two parts of the factory combined.

- Hours of employees

Number of hours employees combined spend on a certain date working. (Could be more than 24 hours and this means that more than 1 employee was present)

- Planned production per hour

(Planned Production Combined)/ Hours of employees

- Actual production per hour

(Actual Production Combined)/ Hours of employees

For the performance KPIs, there was a differentiation in some of the variables between different parts of the factory. In VSF1 all the KPIs mentioned above are recorded, however, VSF2 variables did not record Inflow warehouse, Outflow warehouse, Number of pallets on loading docks, Planned Carton boxes to produce, Actual cartons produced, and the difference between planned and actual. These KPIs were measured for each BU (Business Unit) that the factory supplies to. Sums of these Bu records were also calculated so that the visualization of performance shows the whole factory's performance per shift.

VSF 1												
	11	12	13	14	15	16	17	18	19	20	21	22
	45	45	45	45	46	46	46	46	46	46	46	47
	11	11	11	11	11	11	11	11	11	11	11	11
KPIs	11-nov	12-nov	13-nov	14-nov	15-nov	16-nov	17-nov	18-nov	19-nov	20-nov	21-nov	22-nov
No. of planned production	0	270	1154	1197	2432	2531	3045	2463	2230	538	852	2302
No. of actual production	0	133	1252	1150	1966	2472	2862	2149	2094	541	1146	2155
Percentage Difference(Actual vs Planned)	#DIV/0!	-50,74%	8,49%	-3,93%	-19,16%	-2,33%	-6,01%	-12,75%	-6,10%	0,56%	34,51%	-6,39%
Number of pallets on loading dock	0	0	0	441	381	422	181	536	254	0	0	644
Requested Trucks	0	4	12	12	58	55	43	50	57	0	25	42
Planned Trucks	0	4	0	0	13	5	2	9	12	0	9	10
Loaded Trucks	0	0	0	0	54	43	40	41	47	6	0	0
Inflow Warehouse	0	4	206	495	214	88	554	307	344	44	131	373
Outflow Warehouse	0	95	86	229	365	514	152	294	351	274	262	173
VSF 2												
KPIs	11-nov	12-nov	13-nov	14-nov	15-nov	16-nov	17-nov	18-nov	19-nov	20-nov	21-nov	22-nov
No. of planned production	0	214	936	965	627	869	653	734	325	870	477	588
No. of actual production	0	0	774	885	645	839	520	726	277	873	560	546
Percentage Difference (Actual vs Planned)	#DIV/0!	-100,00%	-17,31%	-8,29%	2,87%	-3,45%	-20,37%	-1,09%	-14,77%	0,34%	17,40%	-7,14%
Requested Trucks	0	0	32	25	23	23	20	27	16	30	15	19
Planned Trucks	0	0	0	0	22	22	18	26	12	0	0	15
Loaded Trucks	0	0	23	34	21	26	18	27	9	28	20	18
People KPIs												
Planned VSF Combined	0	484	2090	2162	3059	3400	3698	3197	2555	1408	1329	2890
Actual VSF Combined	0	133	2026	2035	2611	3311	3382	2875	2371	1414	1706	2701
Hours Employees	0,00	51,31	69,66	62,33	117,28	153,93	139,27	153,93	131,94	58,66	51,33	146,60
Planned/Hour	0,00	9,43	30,00	34,69	26,08	22,09	26,55	20,77	19,36	24,00	25,89	19,71
Actual/Hour	0,00	2,59	29,08	32,65	22,26	21,51	24,28	18,68	17,97	24,11	33,24	18,42

Figure 9:Daily Sums Overview sheet

The data were extracted manually from the software systems used by PepsiCo and recorded into this KPI board. This dataset is shown in Figure 9 above consisting of the BU Sums for the 3 daily shifts combined.

This dataset seemed impossible to evaluate, so visualization of those variables in charts was considered an essential feature while developing this dashboard. For that reason, some interactive charts have been inserted while data alters according to the BU chosen from a dropdown list. When the BU was changed, the data used to plot the graphs also changed. Then illustrations appeared to be scattered and hard to identify trends so some filters were used alongside the graphs to figure out more accurate and smooth trends. In order to compare historical and present trends, two separate sheets were created; one of those is plotting the planned against the actual production and the other one is plotting the requested against planned and loaded trucks. Then filters were applied in these comparisons to remove unnecessary dates and only plot chosen dates testing for patterns.

The trend charts were used for graphical visualization of data, but the actual comparisons were done using descriptive statistics. The analysis included mean, median, range, and standard deviation. Those were the needed values to use in finding a confidence interval for PepsiCo's performance based on historical data. The confidence interval was to ensure that whenever performance changes, the company is prepared and ready for adapting according to that change. For example, if the production of pallets increased without having sufficient trucks in the parking area then process termination might take place. So having a confidence interval to know the range of possible change would help managers in the decision-making process. During the research, our team was not concerned about the production, but more about trucks.

The trends and patterns are illustrated in charts where planned vs actual production is shown in Figure 10 while the number of requested vs loaded trucks is shown in figure 11 below. For now, we focused on managing the yard effectively and in future research, more analysis will be conducted to find a 95% confidence interval of the number of requested trucks. This would ensure having a sufficient amount of trucks in the parking space so that production capacity might be increased. We focused on finding an optimal number of trucks to be requested so that the change in production is never more than the loading capacity.

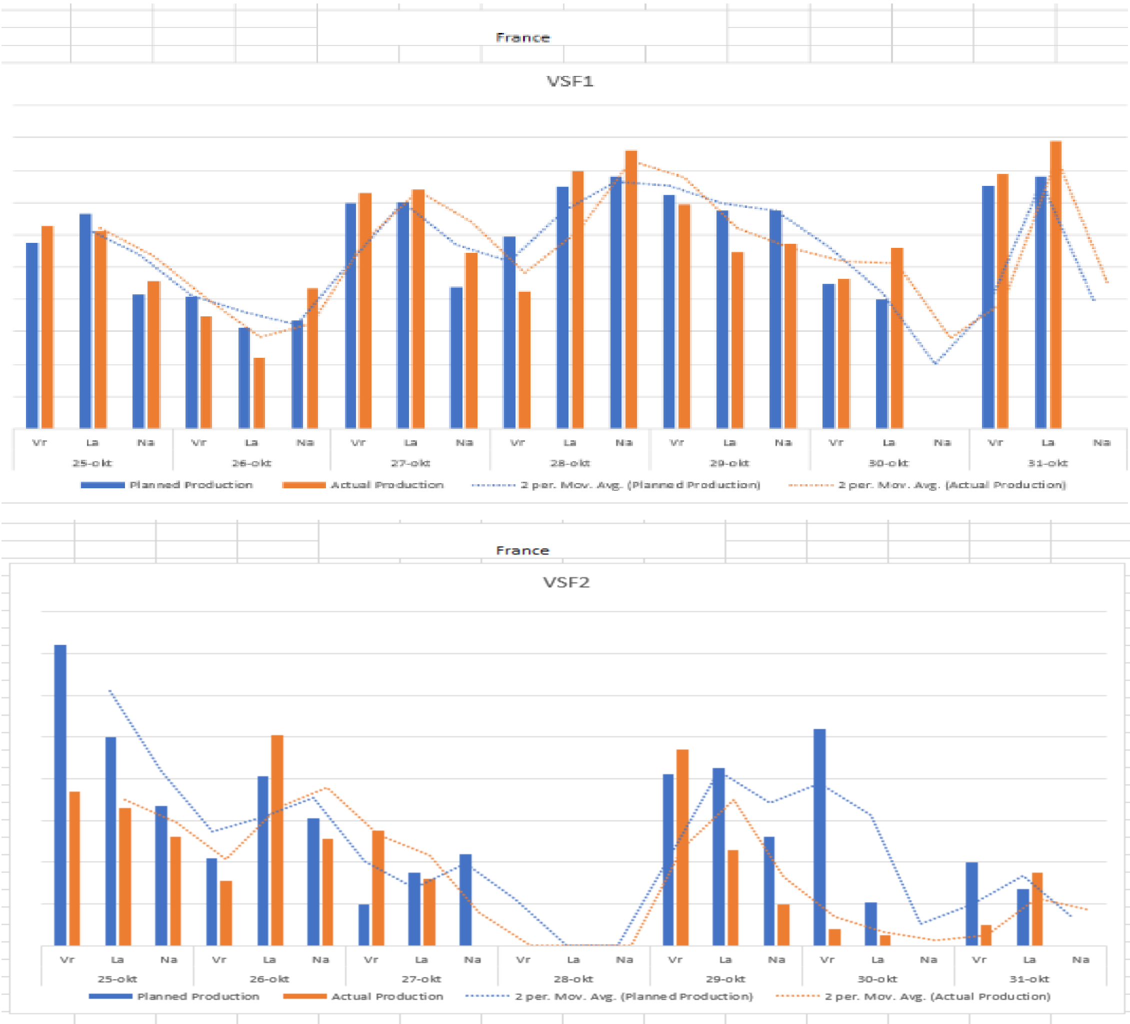

Figure 10:Planned vs Actual Production per shift

Managers visualizing these graphs comprehend that some problems are taking place on a certain date. For that reason, they start acting by conducting some data analyses on the plotting data for the chart. Some deviations visualized in charts are planned changes, while others are just consequences of occurring problems. For example in Figure 10, VSF2 production seemed to be zero, however, the production planning was also zero so this was not a malfunction in the process. On the other hand, as shown in Figure 11, there are big differences between the requested and loaded trucks during the morning shift on the 25th of October. This difference shows that there is a problem as the number of requested trucks is much higher than the number of loaded trucks. Managers at this point need to check for the number of pickups planned for this shift, the number of trucks loaded and kept in parking and the number of pallets moved to the warehouses to know why this problem is taking place. The problem analysis takes place using descriptive analysis, but for locating the problem the data trends and charts are used.

Data can be used to compare different weeks together by using filters on datasets. For example, these filters can be showing only Mondays, only mornings, or comparing a full week with another week. This depends on the managers' decisions and the approach they follow to tackle problems taking place.

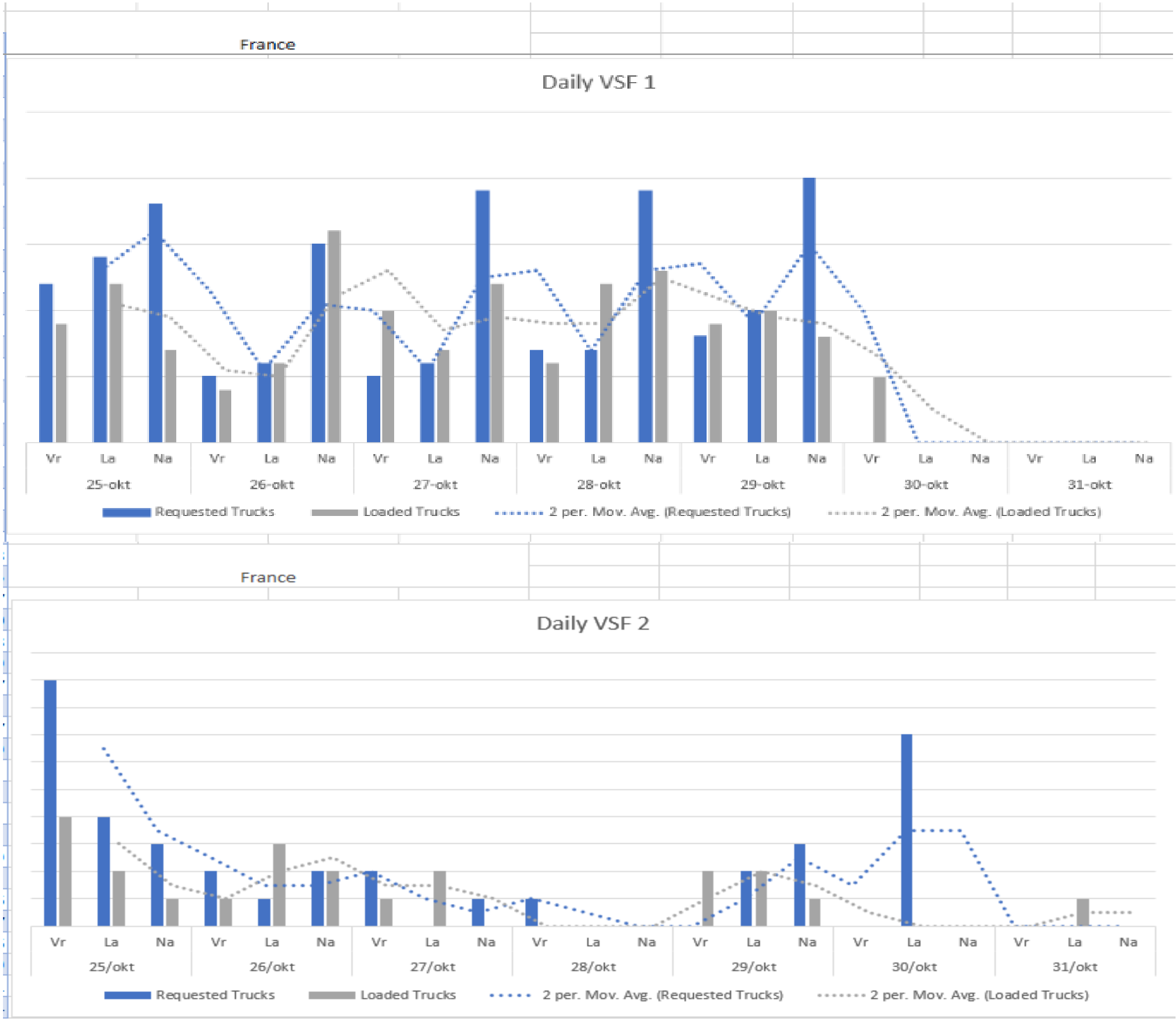

Figure 11:Requested vs Loaded Trucks per shift

4.4. Company feedback about yard template and KPI board

After choosing the yard template as the optimal solution over the YMS and explaining how it works, here comes the question: *How will the validity of results be evaluated?* This question needs an answer showing whether the desired effect takes place after implementation or if any improvements need to be done. In this section, the findings of PepsiCo managers about the yard template will be discussed. PepsiCo implemented the yard template into its system. There were some findings of the effect of implementing it to the WoW. One of these findings was that if a user misses a slot then the KPI analysis is messed showing some error messages. This was sometimes due to human error in the filling process, or missing planning data.

Moreover, an important finding was mentioned stating that an eliminated column from the old WoW seems to be crucial in this template. This column represents the present trucks by inserting a "ja" in the cell record to see if trailers are still parked. These two findings are important to consider as the wasted times by employees are still high when they have to search for a truck or calculate the KPIs manually.

Acting upon this feedback, the researcher had fixed the following issues regarding the template and it turns out to be an effective tool for the present time. PepsiCo seems to be appreciating this tool as it is an effective free tool that was developed in 3 weeks and was ready to implement in the system.

As for the KPI board, this was an effective tool used on a daily basis to check for data trends and patterns. It was showing the important KPIs to consider when problems arise helping to exactly spot the deficiency. They had some critical feedback when it was still under development trying to clarify their needs from this board. After it was developed only minor changes were needed and it turns out to be an effective tool.

4.5. Chapter Summary

This chapter included a brief recall of the problem mentioned earlier in the report. It shows the possible solutions that our team had considered while solving the yard management problem. These solutions were building a template that facilitates visualizing the parking area and the other solution was buying software developed by a company named Yard Management Solutions. The evaluation criteria shown in Table 1 resulted in choosing the yard template. This solution was then explained in more detail while supplementing the description with screenshots of the developed solution. Then for measuring performance in the company, a KPI board was created and it was mentioned showing its importance and the way to use it. The questions asked in the first section of this chapter are answered through the text and briefly bulletized below:

- *What are the data-gathering methods used?*
  - There were no data-gathering methods collecting data in one location, but KPIs were measured leaving some historical data.
- *Who are the people involved and stakeholders?*
  - PepsiCo employees and Managers
- *To which extent should the process details be included?*
  - This was a question asked to the stakeholders where we identified the criteria to evaluate solutions and KPIs crucial to use in solving this problem.
- *What alternative solutions are promising?*
  - YMS is a promising solution, but the Excel template was chosen for scoring a higher weighted total score.
- *What are their pros and cons?*
  - Pros of the YMS do not mean cons in the other tool and vice versa.
  - Yard Template seemed to score higher in:
    - Cost
    - Time required to implement
    - Confidentiality
  - YMS scored higher in:
    - Live-support
    - User-friendliness

        - Communication with transporters
- *Which are the most effective solutions and recommendations?*
    - The most effective solutions are using the provided tools in the decision-making system. The KPI board includes many historical and present data, while the yard template increases yard visibility and stores data. (P.S. Yard template scored 4.2 while YMS scored 2.4 in the total weighted score)
- *How will the validity of results be evaluated?*
    - The Excel yard template was validated by testing the functions using historical data and by receiving feedback from users on the effectiveness of the tool.
    - The KPI board did not need validation as long as data is inserted in the correct corresponding cell.

5. Simulation

In the previous chapters we were discussing the yard visibility solutions and data gathering methods, but the WoW previously in PepsiCo was never measured to find the maximum capacity. After holding data and doing some data screening, a simulation model is to be modelled to test whether the factory uses the maximum capacity or not and if there is growth potential. In this chapter, the approach followed to build a simulation model would be explained. The following question needs to be addressed in this chapter for its importance. *How will the validity of results be evaluated?* Scenarios and interventions intended to explore influences of the changes during the simulation are discussed in section 5.1. The modelling phase (including assumptions, variables to be measured, and inputs) is explained in section 5.2, then a screenshot of the model explaining the Methods and flow in the simulation is shown in section 5.3. Afterwards, experiments to be conducted with variable changes are explained, and also the results are shown using graphs and data numbers in section 5.4. The model validation technique is described in section 5.5. Finally, section 5.6 includes the chapter summary.

5.1. Scenarios and Interventions

In this simulation, we intend to explore the influence of the changes that can be applied in a real-life situation. In PepsiCo, Veurne, some changes can be applied while most importantly keeping the number of pallets on loading docks as low as possible. As for changes, it is customary to speak of scenarios and interventions. *Scenarios* may be states of nature, trends, etc. For example, production (of a certain product) may be increased due to growth in demand or due to company strategy. Per scenario, *interventions* are designed by the researcher so as to cope with these scenarios, for example, to facilitate the outflow of pallets from the factory by adapting the WoW on the yard. As the company aims to have a continuous smooth flow of production, the interventions made in the model are reflecting the possible changes that might take place in the future of the company.

We distinguish the following scenarios:

- Scenario 1: current production
- Scenario 2: production increases by 10%
- Scenario 3: production increases by 20%

We distinguish the following interventions:

- Intervention 0: the current way of working
- Intervention 1: increase the number of loaders currently filling trucks in both parts of the factory.
    - Sub-intervention 1: increase the number of loaders by one in VSF1.
    - Sub-intervention 2: increase the number of loaders by two in VSF1.
    - Sub-intervention 3: increase the number of loaders by one in VSF2.
    - Sub-intervention 4: increase the number of loaders by two in VSF2.
- Intervention 2: changing VSF1 to live-loading only to see the effect on the waiting time and number of pallets on loading docks. (Other factors kept constant)

The above-mentioned interventions and scenarios will result in 27 different experiments showing different cases. Then one more experiment is tested and this is changing VSF1 in the null scenario to live-loading only which results in a total of 28 different experiments. While the scenarios were identified by the stakeholders to test if the factory works with the intended productivity levels, the interventions identified by the researcher were to measure the amount of pallets stacked in the loading area. This was needed to check if the stacked pallets cause path or dock blockage in any of these scenarios. The results of these experiments are discussed in more detail later on in section 5.4. The change of the loading approach in VSF1 to live-loading was experimented only while applying the null scenario inputs (3 loaders in VSF1,1 loader in VSF2 and no increase in production levels) to analyze the output results as requested by the stakeholders. The scenarios during this study are the null scenario which is the normal model with no interventions, the 10% scenario which is a growth potential by 10% in the production of the company, and the 20% scenario which is also a growth scenario. During each of those scenarios, the interventions in increasing the number of loaders are applied to find an optimal solution in modifying the way of working. The analysis of results is based on the charts resulting from the experiments and comparisons in an excel file. The results of these interventions and scenarios are explained in the subsection "Results" in section 5.4 below.

5.2. Modelling Phase

The modelling phase is a preparation phase done before implementing the simulation logic into a software system. This phase includes assumptions, variables to be measured, and inputs to the model. In the following subsections, all details regarding the modelling phase are explained showing the importance of including it in the model.

Assumptions

To simplify the model while showing the real-life situation we make some assumptions. Those assumptions were used to reduce the uncertainty and randomness in the process. One of those was that all arriving empty trailers require a full truckload of 33 pallets. This differs in the real-life situation where some orders require full truckloads, others are half truckloads and some other trucks move a couple of pallets only. Based on the assumption of full truckloads, another assumption was derived and this was that all trailers have the same characteristics. So they require the same size of space to park and the same number of loaders to load pallets into the trailer. Moreover, some transporters are focused on pre-loading in the real life, but if PepsiCo does not hold enough empty standing trailers the loading type is changed to live-loading. This was avoided while modelling the simulation when we assumed that transporters stick to the time plan and consequently the type of loading. Requested trucks usually arrive on time, but sometimes they can deviate from the expected arrival time due to external factors. Those factors are excluded in the model and we assume a First In First Out processing(FIFO). This is the queue strategy that PepsiCo currently uses with processing trucks bearing in mind that trucks should arrive on schedule. Some trucks are planned for the afternoon shifts and they arrive in the morning shift, so they have to wait until earlier planned trucks are processed. As we exclude external factors from the model, we also assume that trucks will arrive in an order to be processed following the FIFO strategy.

For simplicity and for having most distributions close to normality, then an assumption that all distribution functions inserted into the simulation would follow a normal distribution with different means and standard deviations. Descriptive statistical analysis in Excel was conducted on each dataset and this is shown in Appendix B i).

Variables to be measured

Some variables were considered crucial throughout this research and those were to be measured by experimenting in the simulation model. This was to visualize the effect of changes in the current WoW on the variables to be measured. First of all, the most important variables to be measured as outputs were the number of pallets currently stacked in the loading area and the average waiting time per truck. These two variables were considered crucial as there is a direct relation between them and the congestions or blockages. The stacked pallets can cause many problems such as path blockage leading to production stoppage. So for this reason, this number is considered crucial and we try to reduce it as much as possible. The company tries to keep both variables as low as possible as when the number of pallets stacked is low, a smoother flow is ensured on the inner side of the factory due to having more space for loaders to move or stack pallets. As for the reduced waiting times per truck, this causes a smoother rotational movement of trucks in the parking area allowing the company to request more trucks. In order to measure the number of stacked pallets in the loading area, we measure the number of pallets produced "nPalletsVSF1" and "nPalletsVSF2". This was a counter that incremented by 1 whenever palletizers released a pallet to the conveyor belts. Each of the two variables had a different incrementor and palletizer to differentiate between the two parts of the factory. Then the number of trucks departed, representing the exit of trucks, was measured also by using an increment which adds 1 whenever a truck leaves the system.

Due to some technical difficulties experienced while modelling the simulation, the number of pallets stacked on the loading docks was calculated manually. In the simulation model, these variables are included being named "NoPalletsOnVSF1Dock" and "NoPalletsVSF2Dock" and they are measured by calculating the difference between the number of pallets produced and the number of pallets picked up by trailers. Each truck carries 33 pallets so the number of pallets left in the loading area equals the number of pallets produced minus 33* trucks that left the system.

The technical difficulties caused a reduction in the reliability of waiting times results. This was due to an assumption that pallets are always available while it is not the case in real life. Trucks now spend time according to the distribution function of loaders only without waiting for 33 pallets to fill it in and this made waiting time results unreliable.

On the other hand, the average waiting time is still considered an important variable that needs to be measured and kept as low as possible. Staying for a long period might cause congestion in the parking and reduce the ability to order more empty trailers for continuous production. Ordering more trucks means that production levels are viable to an increase and consequently fewer pallets will be stacked in the loading area. To do this, we made some analysis to check for the validity of results from this simulation model and we found out that we can still rely on these results as long as no congestion takes place.

"AvgWaitingTime" is the variable created in the simulation model using some data records stored in a database file. It calculates an average to the idle waiting time of truck records using the formula: (Departure time- Time of arrival in the system -processing time). The AvgWaitingTime is the time when trucks wait in queue or are left standing in the parking area waiting for pickup while the processing time is the spent time by trucks parking across docks to be filled up. Moreover, the number of trailers currently in the yard "NumberOfTrailersOnYard" is calculated by subtracting the number of trucks that left the system from the number of trucks that entered the system. "NumberOfTrucksEntered" and "NumberOfTrucksDeparted" represent the arrival and exit of trucks in the system which use incrementors that add 1 to the variable when trucks arrive or leave the system. These variables are important to keep track of trucks present in the system, helping to analyze the growth possibility and showing the number of available slots. This variable represents the empty slots in the parking area and is measured by subtracting the number of trailers on the yard from 46 slots which are the total on-site slots.

Inputs

To represent reality in the simulation model, the input variables consisting of distribution functions, constants, and frequencies, are considered the most crucial variables. Some analyses using historical data were conducted finding out that the data trends can be plotted in graphs. For this reason, the number of pallets produced and the truck arrival distributions were inputs to the model as distribution functions.

Each part of the factory was separated as the production lines and the loaders are split in real-life so to have an accurate measurement, the data should not be combined. For example, loaders in VSF have different experiences, so the processing time of trucks is a distribution function rather than being a constant. They spend different processing times, where more experienced loaders take less time to finish the job than the less experienced loaders. VSF1 uses 3 loaders to complete the filling of trucks while VSF2 uses 1 loader. These constants represent the number of loading personnel that the company assigns in shifts to do the loaders' jobs.

To show the frequency of transporter arrival, the truck arrivals per transporter were calculated as a ratio of the total trucks requested per day. After finding the ratio, all trucks arriving per day were combined to conduct some data analysis to find a distribution function. More detailed data about analysis and input data functions are shown in Appendix C.

The Capacity of parking slots consisting of 46 parking slots is considered a constant that represents the on-site parking. The input to the model excluded the external parking spaces (Warehouse parking also used) acquired by PepsiCo for simplification. These slots had an effect in reducing the congestion in the on-site parking so it was considered in the analysis and validity of results attained from experiments. The number of loading docks is also a constant that had an impact on the model design. The docks consist of 21 on-site docks being used to fill in trailers. For simplification of the model, 3 of the docks are used for automatic loading that requires no loader. These are not used for all the truck loadings so they are excluded in the model design phase. The left 18 docks are split into 13 docks for VSF1 and 5 docks for VSF2. To show these docks in the model, the VSF1 part had a parallelproc (processor) with a dimension of 3. Having 3 loaders assigned for each shift by PepsiCo means that 3 trucks can be processed in parallel at the same time and for this reason, the dimension was set to 3. In VSF2, one loader is hired for each shift so the processor was a singleproc, which means that only one truck can be processed at a time. To represent all docks available a buffer (waiting area) is inserted next to each processor with the capacity of 10 for VSF1 and 4 for VSF2. These numbers add up with processors to represent the 13 and 5 docks from real life. These buffers are added so trucks can park against the loading docks if they are close to the loading timeframe.

5.3. Model

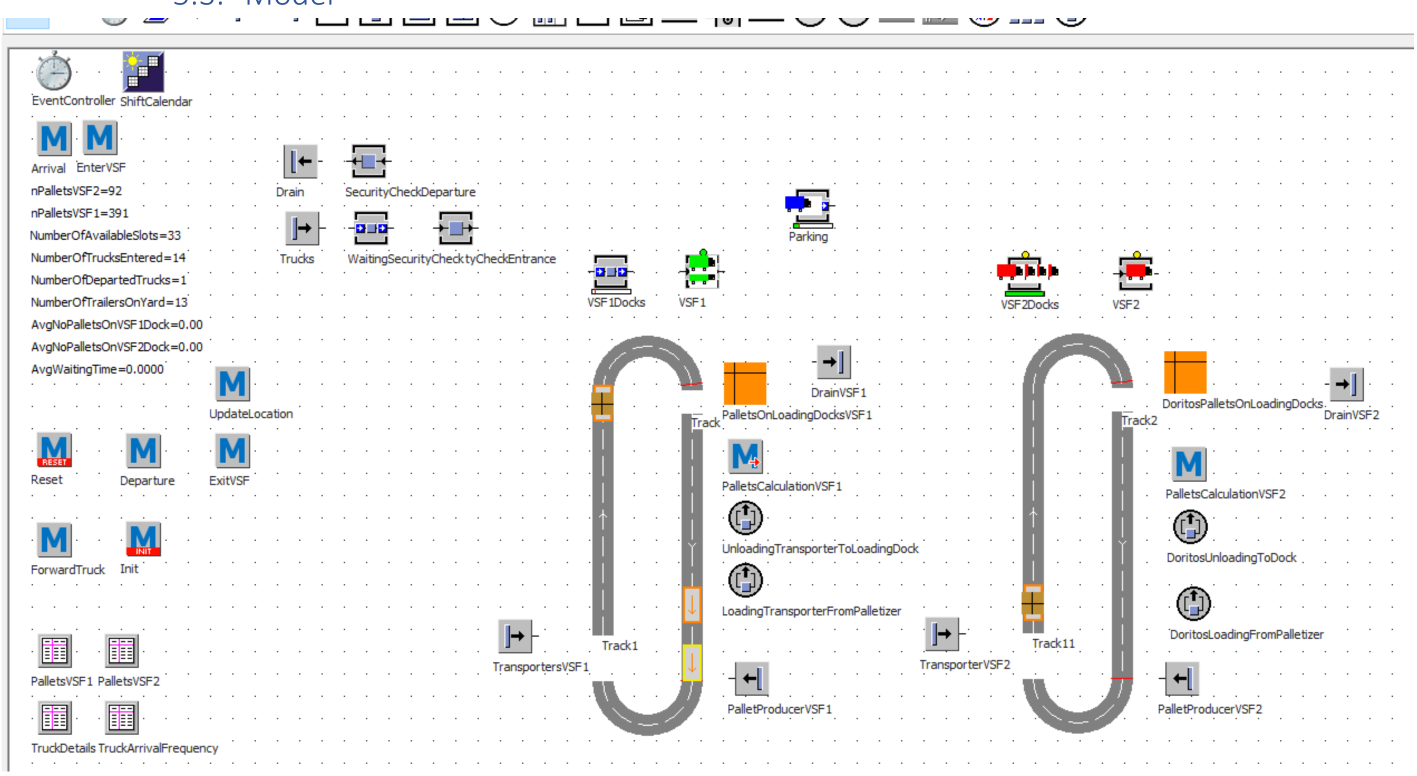

Figure 12:Simulation Model

In this subsection, the simulation flow is shown in Figure 12 which starts at the source named “Trucks”. The model’s start event. Then trucks move to the waiting area for the security check and this represents the waiting queue for entering the parking area. In the parking space, a decision is made and this is allocating MUs (Moving Units) to the correct transport firm shipping PepsiCo’s products. These are differentiated between VSF1 and VSF2 to be able to assign the trucks to the correct following step in the model. If the MU is a VSF1 category of MUs then it moves to “VSF1Docks” and consequently to “VSF1” which represents the processors for this part of the factory. Otherwise, the truck is moved to “VSF2Docks” and also to VSF2 which represents the processor in the newer part of the factory. After processing is complete, the truck is either moved directly to the departure or is moved back to the parking space. As explained previously in the loading sub-section, there is a differentiation between live-loading and pre-loading. So, the live-loading just exits the system where the truck is moved to “SecurityCheckDeparture” while if it is pre-loading it is moved back to “Parking”. It stays in the parking occupying some space until a new driver of the same transporter arrives for this truck to exit the system.

Methods

Methods are the objects inserted in the simulation model where controls are programmed. These controls allow other objects to be executed during the simulation run. For each model created by a developer, methods are the tool used to build their own programs by inserting keywords, assignments, and control structures all in one method. The methods included in this simulation model are classified into two categories, data storing and updating methods, and flow regulators. The data storing and updating methods are used to keep track of data storing it into databases (TableFile). This data is then used for reports and charts to visualize results resulting from the running of the simulation. As for the flow regulators, these are used to move parts in the simulation copying the real-life situation. They include a coded language that helps make decisions about moving or keeping a mobile part and if it is moved then what should the next step be.

5.4. Experiments

After presenting the important variables, input data, and the flow of the model, experiments to test the number of loaders needed based on optimal Output data were the next step to follow. Experiments are some interventions applied into the simulation model where inputs are varied to observe the effect they have on the Outputs. These are used in this model to change the number of loaders (changing dimensions of processors) to see the impact on the number of pallets stacked in the loading area and the average waiting time per truck. Changing the number of pallets produced is also a variable that can be experimented with, to know the maximum capacity that the current number of loaders and requested trucks can handle. All those experiments are accompanied by the percentage of productivity for a certain time period to grab an insight into the optimal efficiency of stages.

Results

After implementing the changes in variables and scenarios for each intervention, we gathered some results showing optimality by applying certain changes in real life. In Figure 13, the 28 results achieved from applying the interventions and scenarios are shown. Data were analyzed in an excel file to find a relation between the changes and to find the effect of interventions on outputs. The results shown are close to each other as these numbers represent averages of 5 observations for each intervention and scenario. The inputs were shown as "Loaders VSF1" and "Loaders VSF2", and they represent different numbers of loaders during experiment runs. It can be visualized that for each scenario, all combinations of interventions were applied. For example, in the null situation, we tested having 3 loaders in VSF1 while altering VSF2 loaders to 1,2 and 3 but also testing the opposite by fixing VSF2 and altering VSF1 between 3, 4, and 5 loaders. This was to apply the interventions of adding one loader and adding two loaders. These results show the interventions and scenarios applied to the simulation model. The first row of results in Figure 13 (marked with a green label) shows the current WoW without an increase in production levels. This WoW consists of pre-loading of some trucks in VSF1 and pre-loading to all trucks in VSF2 which are processed by 3 loaders and 1 loader respectively. This was then followed by the trucks departed VSF1 and trucks departed VSF2 which show the number of trucks that exit the processors. Exiting the processor in the simulation model means that these trucks are loaded, but may still be in the system waiting in the parking. Afterwards, the pallets calculation is shown in the columns "Pallets VSF1" and "Pallets VSF2". These represent the number of pallets produced during the simulation run. The average waiting time per truck which is an important factor to consider while doing this research is shown in the following column. After the waiting time, come the pallets on Dock VSF1 and VSF2. This represents the total number of pallets resulting from the difference between produced pallets and picked-up pallets stacked in the loading area. We accept having those numbers as negatives due to the fact that during the study we assumed that all trucks are full loads while in real-life some trucks pick up fewer pallets than the full truckload. This makes the number of pallets produced a little lower than the outflow in the simulation model. However, the deficit in the number of pallets causing the negative values is already compensated from the warehouse stocks. This is represented in the final 2 columns in Figure 13. While implementing the scenarios of having more production levels, we visualized an increase in the number of pallets in the loading area. So to reduce these numbers as much as possible to avoid congestions, the yellow highlighted columns named “Requested trucks to unload docks” and “Requested trucks to unload docks per day” were added. These two columns show calculated results that would show managers the increase in production while trying to keep the stacked pallets as low as possible so more trucks are needed.

As stated earlier the average waiting times are the times that the truck stays idle in the

	Loaders VSF1	Loaders VSF2	Trucks Departed VSF1	Trucks Departed VSF2	pallets VSF1	pallets VSF2	Avg waiting time per truck	Pallets on Dock VSF1	Pallets on Dock VSF2	Total On Docks	Requested Trucks to unload docks	Requested Trucks to unload docks per day	Inflow	outflow
Null Situation	3	1	1397,8	441,4	42353,2	15323,2	3:24:22.9229	-3774,2	757	0	0	0	7000	9000
	4	1	1397,8	441,4	43200	15324,2	3:24:26.5400	-2927,4	758	0	0	0		
	5	1	1397,8	441,4	43200	15324,2	3:24:56.0862	-2927,4	758	0	0	0		
	3	2	1421,4	477,2	43200	15324,2	1:18:38.8522	-3706,2	-423,4	0	0	0		
	4	2	1421,4	477,2	43200	15324,2	1:18:39.0722	-3706,2	-423,4	0	0	0		
	5	2	1421,4	477,2	43200	15324,2	1:18:39.0990	-3706,2	-423,4	0	0	0		
	3	3	1421,4	477,4	43200	15324,2	1:19:35.7523	-3706,2	-430	0	0	0		
	4	3	1421,4	477,4	43200	15324,2	1:19:35.9723	-3706,2	-430	0	0	0		
	5	3	1421,4	477,4	43200	15324,2	1:19:35.9992	-3706,2	-430	0	0	0		
10% more production	3	1	1397,8	441,4	46602,2	16873,8	3:24:22.9229	474,8	2307,6	4782,4	144,9212121	4,830707071	7000	9000
	4	1	1397,8	441,4	46602,2	16873,8	3:24:26.5400	474,8	2307,6	4782,4	144,9212121	4,830707071		
	5	1	1397,8	441,4	46602,2	16873,8	3:24:56.0862	474,8	2307,6	4782,4	144,9212121	4,830707071		
	3	2	1421,4	477,2	46602,2	16873,8	1:18:38.8522	-304	1126,2	2822,2	85,52121212	2,850707071		
	4	2	1421,4	477,2	46602,2	16873,8	1:18:39.0722	-304	1126,2	2822,2	85,52121212	2,850707071		
	5	2	1421,4	477,4	46602,2	16873,8	1:18:39.0990	-304	1119,6	2815,6	85,32121212	2,844040404		
	3	3	1421,4	477,4	46602,2	16873,8	1:19:35.7523	-304	1119,6	2815,6	85,32121212	2,844040404		
	4	3	1421,4	477,4	46602,2	16873,8	1:19:35.9723	-304	1119,6	2815,6	85,32121212	2,844040404		
	5	3	1421,4	477,4	46602,2	16873,8	1:19:35.9992	-304	1119,6	2815,6	85,32121212	2,844040404		
20% more production	3	1	1397,8	441,4	50833,4	18405,8	3:24:22.9229	4706	3839,6	10546	319,5636364	10,65212121	7000	9000
	4	1	1397,8	441,4	50833,4	18405,8	3:24:26.5400	4706	3839,6	10546	319,5636364	10,65212121		
	5	1	1429	463	50833,4	18405,8	3:24:56.0862	3676,4	3126,8	8803,2	266,7636364	8,892121212		
	3	2	1421,4	477,2	50833,4	18405,8	1:18:38.8522	3927,2	2658,2	8585,4	260,1636364	8,672121212		
	4	2	1421,4	477,2	50833,4	18405,8	1:18:39.0722	3927,2	2658,2	8585,4	260,1636364	8,672121212		
	5	2	1421,4	477,2	50833,4	18405,8	1:18:39.0990	3927,2	2658,2	8585,4	260,1636364	8,672121212		
	3	3	1421,4	477,4	50833,4	18405,8	1:19:35.7523	3927,2	2651,6	8578,8	259,9636364	8,665454545		
	4	3	1421,4	477,4	50833,4	18405,8	1:19:35.9723	3927,2	2651,6	8578,8	259,9636364	8,665454545		
	5	3	1421,4	477,4	50833,4	18405,8	1:19:35.9992	3927,2	2651,6	8578,8	259,9636364	8,665454545		
VSF1 live-loading only	3	1	1417	457,6	42353,2	15324	1:32:40.9906	-4407,8	223,2	0	0	0		

Figure 13: Results of Simulation Experiments

system. It seemed to be untrue to have similar results for different experiments, but these values were as expected in a situation of smooth flow without congestions. We decided to focus more on the number of stacked pallets in the null scenario and the 10% more production scenario. Data shown in Figure 13 are considered reliable as the number of stacked pallets would not reach the maximum capacity of the loading area and consequently, blockage would not take place as shown in Figure 14. The results seem to be similar as the number of requested trucks is not increased and due to pre-loading, the trucks have to wait for the arrival of another truck to leave the system. The processing time will not vary much as the loaders fill in trucks according to a normal distribution. However, the link between processing time in the model and the production speed and availability of pallets was missing due to a technical error in the simulation model. If the loading speed (processing time) is slower than the production speed then pallets start accumulating in the loading area which would lead to congestions and dock blockage. If this occurs, the dock blockage would lead to truck congestions in the parking space as the empty trailers cannot be filled. As long as there is no congestion in the loading area, loaders will take nearly the same time to fill in trucks. Whenever congestion and blockage start taking place, the trucks are expected to spend more time. However, in the simulation model, this scenario is just explained as a technical error. So the results in the 20% more production scenario are not considered reliable due to blockage of the loading area and loaders would not be able to fill in trucks. Being uncertain about the reliability of results and for acquiring plenty of slots to park trailers made us exclude the average waiting times from the results and focus on the number of pallets stacked in the loading area. For this reason, we decided to omit the average waiting time from our analysis and result figures.

After collecting all the results in the excel file shown in Figure 13, we chose the optimal scenarios based on the evaluation of the number of loaders completing the job, the average waiting time (for null scenario and 10% more production scenario only), and the total number of pallets on loading docks. These optimal solutions are shown in Table 2 below. For the null scenario, the optimal value was chosen because the reduction in the average waiting time is an obvious improvement when we consider the rotational congestion. It was chosen as other solutions would be wasting money and effort to hire more people while this will cause low productivity of loaders. It is seen in Figure 13 that when we had 3 loaders in VSF2 still the average waiting time increased compared to having 2 loaders. This means that productivity levels of loaders are lower as more loaders process the same number of arriving trucks. This would not be the case when more trucks are requested so pre-loaded trucks would spend less time waiting in the parking after being loaded. As for the 10% more production scenario, the number of pallets stacked on the loading docks along with the average waiting time was considered, and keeping it as low as possible is obtained by hiring one more loader in VSF2 which means having 3 loaders for VSF1 and 2 for VSF2.

Scenario	Loaders VSF1	Loaders VSF2	Trucks Departed VSF1	Trucks Departed VSF2	Pallets VSF1	Pallets VSF2	Avg. Waiting Time	Total On Docks	Extra Requested Trucks to unload docks daily	(Outflow -Inflow)
Current WoW	3	1	1397.8	441.4	42353.2	15323.2	3:24:22.9229	0	0	2000
Null	3	2	1421.4	477.2	43200	15324.2	1:18:38.8522	0	0	2000
10%	3	2	1421.4	477.2	46602.2	16873.8	1:18:38.8522	2822.2	2.850707071	2000
20%	3	2	1421.4	477.4	50833.4	18405.8	1:18:38.8522	8585.4	8.67212	2000
VSF1 to live-loading	3	1	1417	457.6	42353.2	15324	1:32:40.9906	0	0	2000

Table 2: Optimal Results of Simulation

The results show that the optimal value in the null scenario is obtained by adding one more loader without changing the number of arriving trucks. To remove the number of pallets on the docks, the company needs to hire 1 more loader than the current WoW in VSF2. Not only hiring one more loader but also, requesting 2.85 more trucks per day for the 10% growth scenario and 8.67 more trucks per day for the 20% growth scenario. These extra trucks are to be requested so that the loading docks are empty without stacking any finished goods pallets. For example in the 10% scenario, the total pallets on docks after trucks departed is 2822.2 and as the company aims to have zero pallets on the loading docks, then 2.85 more trucks per day should be requested to reach this goal. As shown in Figure 13, results show that there is a difference when we compare between having 3 loaders in VSF1 and 2 loaders in VSF2 with having 3 loaders in VSF1 and 1 in VSF2. This difference is obvious in calculating the average waiting time of trucks in the parking space. Increasing one loader reduces the average waiting time by nearly 1.5 hours per truck.

To compare all results, bar charts for the “Total pallets on Docks” are plotted to see the differences between scenarios and interventions. In Figure 14, the null scenario is illustrated where we can visualize that there are no pallets stacked on the loading docks for the different interventions. The 10% and 20% more production scenarios show that increasing the production levels while altering the number of loaders will result in the stacking of more pallets in the loading area. This showed that if production will be increased in the future, then more trucks need to be requested to equalize the difference between the null situation and the production level increase scenarios. In this figure, there is a horizontal orange line that represents the maximum capacity of stacked pallets in the loading area. This was used to check whether blockage would occur with the accumulation of pallets not being picked up. In the 10% more production scenario, blockage would not occur if the company does not request more trucks. However, to smoothen the process, the loading area should be nearly empty to allow loaders free space to move and stack pallets temporarily while loading trucks. This means that if the company applies 10% more production, they need to request more trucks to reduce this accumulation back to zero levels. As for the 20% more production scenario, the bars are higher than the maximum capacity and this means that blockage would occur in the loading area. The blockage would lead to different problems such as production stoppage, loaders unable to move, and trucks parking without being loaded. So to avoid this problem, production must not be increased by 20% until a future study is made by the stakeholders’ to request more trucks that can reduce the accumulation of pallets. As the ordering of trucks study includes movement of pallets to warehouses, demand planning, and production levels, production growth scenarios are not considered as the study is incomplete. This was due to having a limited time and a wide scope of this study so the stakeholders asked for indicators to know if the loading area would be blocked by then. Simulation results analysis revealed some areas of improvement that can have a significant impact on the WoW.

The waiting times were showing partially reliable results. The results showed that increasing loaders in VSF1 does not impact the average waiting times which means that loaders are present but idle due to the low number of requested trucks respective to the loaders’ capacity. On the other hand, it shows that increasing the number of loaders in VSF2 reduces the waiting time massively allowing the factory to request more trucks or to have a smoother flow without congestions.

By adjusting the number of loaders, the method of loading, and the number of requested trucks, waiting times might be minimized. As we got partially reliable data and received approvals to use more space acquired by PepsiCo, we decided to focus on the number of pallets being stacked in the loading area while ignoring the waiting times. After receiving the approval, we can move the filled trucks to the nearby warehouses and reduce congestion taking place in the parking. By following this approach, more trucks can be requested per day which allows an increase in production levels while keeping our goal of having an empty loading area possible to achieve. Moreover, the wasted time of trucks staying idle in the 46 on-site slots that PepsiCo has will be reduced. As stated earlier, the request for more trucks is a wide scoped project so we would ignore testing these results in this research, but two columns are added in Figure 13 to show the number of trucks required to unload docks returning the number of stacked pallets to zero.

The graph in Figure 14 shows that adding one loader to VSF1 (the old section of the factory) has no significant influence on results, whereas adding one loader to VSF2 (the new part of the factory) decreases the number of stacked pallets by nearly half. This demonstrates that in the current mode of functioning, there are not enough trucks to load the rest of the pallets so even when more loaders are added they affect the productivity of loaders by dividing the loads on more loaders. In the null scenario, the graph shows that there are no stacked pallets in the loading area. This means that the number of requested trucks is greater than or equal to the production levels. So if the number of requested trucks is greater than the required to carry the pallets, the company either cancels some trucks or compensates for the difference of pallets from warehouses. This is slightly affected in the simulation model by assuming that all arriving trucks are full truckloads of 33 pallets which can deviate sometimes in real life.

Stakeholders asked for a check whether the truck capacity has been used to its maximum capacity for the 10% while the 20% scenario was used to test for route blockage. We discovered that increasing production by 10% would require three or four additional trucks each day to return the number of stacked pallets to zero. The findings of the 20% scenario revealed that while the number of pallets placed on the docks per day would not cause congestion if no action is taken to move those pallets either by filling in additional required vehicles or by sending them to the warehouse, the accumulation of pallets would cause path blockage.

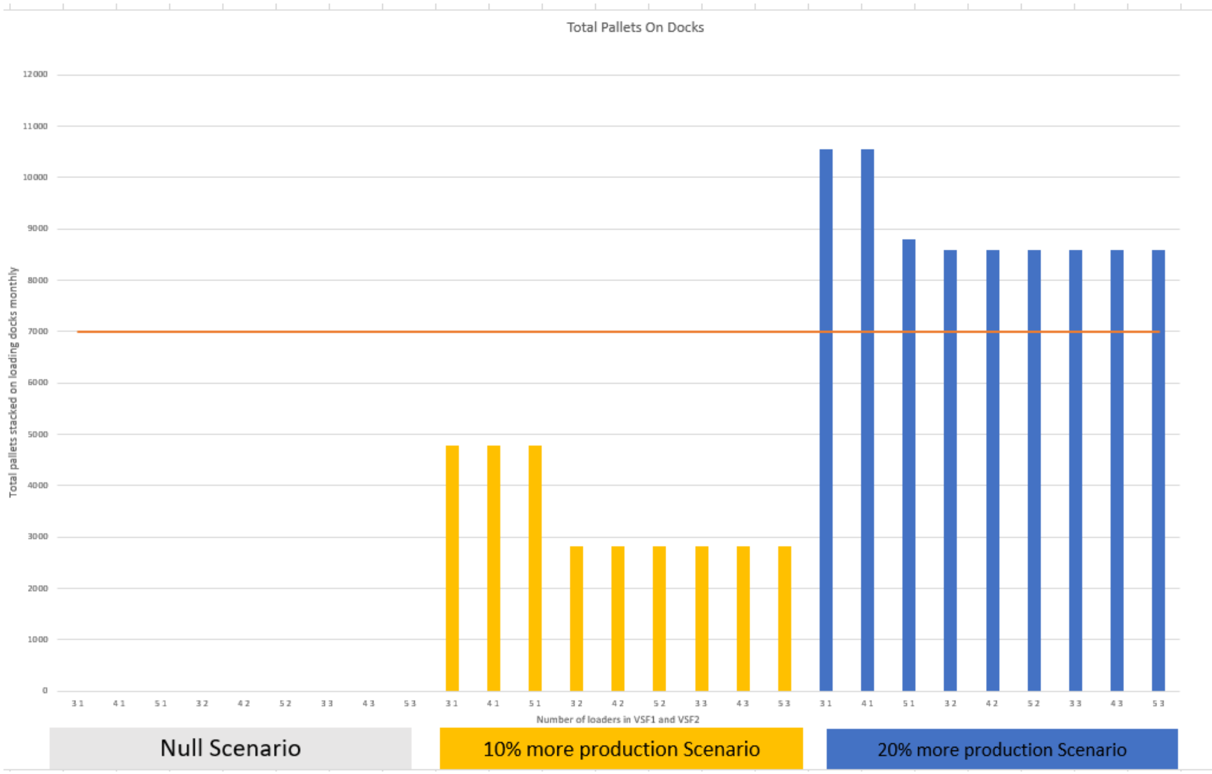

Figure 14:Total Pallets on Docks Results of Simulation Study

From the above figure, it was obvious that there are deficiencies and covered-up issues in the WoW that PepsiCo's administration needs to consider. This is because pallets appear to be zero in the model while in real life some pallets are stacked due to the idealism of the simulation. For example, low efficiency of loaders and unavailability of shuttle drivers to bring empty trailers over the docks. The pallets stacked within the loading area show up when we consider the 10% and 20% more production scenarios. These pallets can be decreased by asking for more trucks or moving these pallets to warehouses.

The main finding from the simulation results showed that in case the company has no potential of growing production levels, a new loader is not needed. However, a major change shall take place and this is changing the loading strategy to live-loading in VSF1. This change also shows a major reduction in the average waiting time of trucks, so to reduce the congestion without adding loaders this change should be applied.

5.5. Chapter Summary

In this chapter an explanation of the approach followed to formulate the simulation model was included Also the question *How will the validity of results be evaluated?* was answered by testing for the reliability and validity of inputs during modelling to make sure that outputs are also reliable. The interventions and scenarios applied to the model to test for different situations and changes that can be applied in real life are also shown. Moreover, assumptions, inputs, and variables to be measured (Outputs) are shown; these are used to find the optimal change that is worth implementing. The model built is also shown with an explanation of the flow showing the whole process. Finally, the results and key findings are mentioned and illustrated in figures showing the optimal results found.

6. Conclusion and Recommendations:

In this final chapter, let us discuss our conclusions and recommendations. Recommendations are split into two parts: recommendations for PepsiCo and recommendations for future research.

Conclusions:

Going through the long process of trying to find solutions to the big problem of managing the yard inefficiently and ineffectively, we found out that minor changes can sometimes show a great impact. For example, visualizing the yard and keeping track of performance measurement indicators. The main goal that PepsiCo is trying to reach consists of continuous production without stoppages or congestions. To achieve this goal we formulated the research question:

How can yard management at PepsiCo Veurne be improved so as to better align the supply chain processes? In particular, how can KPIs be monitored and the number of loaders adapted so as to prevent blockage of loading docks leading to production stoppage?

This research question states that KPIs need to be monitored and analyzed to adapt the number of loaders so that congestion can be avoided. For this reason, we developed tools acting as dynamic solutions to provide advice according to the faced problem helping stakeholders' decision-making. After conducting the root cause analysis, the core problem faced was dealing with inefficient yard management and its sub-causes were lacking yard visibility and unstructured yard plan. Before developing and creating the solution tools, some knowledge questions were created and answered to understand the scope of the research while keeping in mind the stakeholders' preferences about the approach to solve these problems.

To solve the core problem, we developed three tools: i) a KPI Board, ii) a Yard Template, iii) a Simulation Model. The KPI board is used to collect, store and analyze data while also enabling the visualization of performance data on charts. The yard template is used to enable users (managers and employees) to visualize the parking contents, monitor loading and truck KPIs, and store historical loading data. As for the simulation study, it was used to test for the effect of interventions, for each scenario, on the number of stacked pallets and the average waiting times. The interventions represented the changes to be applied while scenarios represented the growth potential of PepsiCo. Stakeholders had asked for a study testing for certain scenarios in the simulation study and these were: 10% more production and 20% more production scenarios.

The results of these studies showed that the KPI board is considered the most important change implemented in the WoW as data speaks for itself. Whenever data is gathered and stored, it is easier to analyze and find data trends and patterns. The KPI board was used to collect and visualize data for different time intervals (shifts, daily, weekly, monthly) and on data charts. Data was also used as input distribution functions to the simulation study so that reality is modelled in this simulation.

The results of the simulation are reliable in two cases which are the null and 10% more production scenario. They were considered reliable if no congestions take place while having finished goods always available. As this is not the case in real life, we decided to omit the average waiting time calculations due to congestion. According to this, it was obvious that input data extracted from the real-life performance is not mirrored in the simulation model as there are no blockages in the model. PepsiCo is now alerted that they have some hidden problems regarding the productivity levels of employees and for that reason, congestion occurs in reality but is not represented in the model. The 20% more production scenario shows congestion and dock blockages, so unless the company aims for expansions, this scenario is impossible to implement.

The main findings from the simulation study shown in chapter 5 were i) adding one more loader to the new part of the factory will reduce the number of stacked pallets in the loading area, ii) changing the type of loading in the old part of the factory to live-load only will reduce the average waiting time. PepsiCo will benefit from both findings as they are now able to request more trucks per day to load stacked finished goods. To avoid congestion in the parking area while changing the number of requested trucks, the yard template is considered an important tool to use. This tool increases the yard visibility by showing the parking contents and reduces the wasted idle time and unnecessary effort.

Through conducting this research, we learned that solutions need not be closely related to the problem to show an effect. In our case, the problem was having intermittent production with frequent blockages taking place. Following the logic, the problem leading to this seems to be planning or production problems, while it turned out to be problems regarding yard management.

Recommendations for PepsiCo:

Based on the findings of this research and evaluating the effectiveness of solutions, we recommend:

- Decision Support System

The decision support system is the bigger tool combining the KPI board and Yard template to achieve effective and reliable results so they must work aside. Hence, we recommend:

  - Keep Yard Template running and up to date as it:
    - Helps visualize the contents of the parking space
    - Reduces the efforts and wasted time of employees
  - Keep KPI board running and up to date as it:
    - Analyzes data and spots problems statistically
- Change type of loading in VSF1 to live-loading only, as it:
  - Induces less waiting time leading to a higher number of trucks leaving the system
  - Improves rotational movement consequently when the waiting time is reduced
  - Allows more truck requests reducing the number of pallets stacked in the loading area

Recommendations for future research:

For future related studies, we have some recommendations to guide the new researchers in a path that can improve this research's findings. We recommend doing:

- Case Study
  - Doing a case study about costs of hiring a new loader
  - Possibility of increasing production levels by 10%
  - Availability of trucks in PepsiCo and know the possibility of requesting more
- Improvements
  - Automate KPI board to save time and human error chances
  - Automate Yard Template by introducing barcode systems or by adding sensors on the parking

Use simulation model while changing the input distributions testing for an optimal number of loaders and strategies.

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Appendices:

Appendix A:

i)

```
Private Sub CommandButton1_Click()
'Create and set variables for the Parking Structure & Parking Log
Dim PSt As Worksheet, POverview As Worksheet, PendelPlan As Worksheet

Set PSt = Sheet1
Set POverview = Sheet3
Set Incomingtrailers = Sheet6


'Create and set variables for each cell in the Parking Structure sheet
Dim TrailerNr As Range, Transporter As Range, DateOfData As Range, SlotNr As Range, Blank As Range, Reference As Range, VSFReference As Range, VSF1orVSF2 As Range, Hour As Range

Set TrailerNr = PSt.Range("D8")
Set Transporter = PSt.Range("G8")
Set DateOfData = PSt.Range("J8")
Set Hour = PSt.Range("J12")
Set SlotNr = PSt.Range("D10")
Set Blank = PSt.Range("G10")
Set Reference = PSt.Range("J10")
Set VSFReference = PSt.Range("D12")
Set VSF1orVSF2 = PSt.Range("G12")



'If no "TrailerNr" has been entered, exit Macro
If TrailerNr = "" Then
MsgBox "Trailer Number can't be an empty cell"
Exit Sub
End If

'If no "Transporter" has been entered, exit Macro
If Transporter = "" Then
MsgBox "Transporter can't be an empty cell"
Exit Sub
End If

'If no "SlotNr" has been entered, exit Macro
If SlotNr = "" Then
MsgBox "Slot Number can't be an empty cell"
Exit Sub
End If

'If no "DateOfData" has been entered, exit Macro
If DateOfData = "" Then
MsgBox "Date can't be an empty cell"
Exit Sub
End If

'If no "Blank" has been entered, exit Macro
If Blank = "" Then
MsgBox "Empty? can't be an empty cell"
Exit Sub
End If

'Create a variable for paste cell in Incomingtrailers worksheet
```

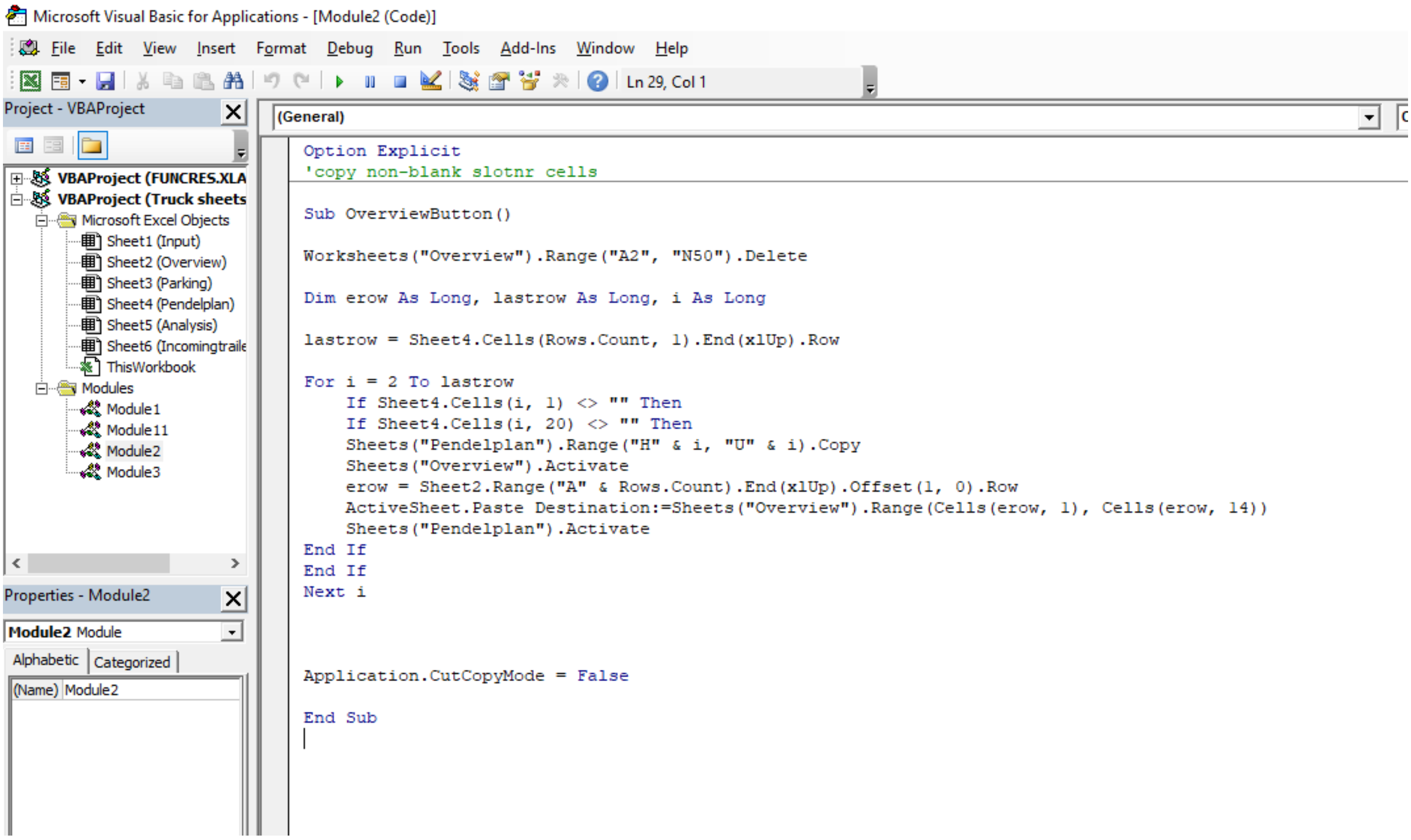
```
Dim DestinationCell As Range
If Incomingtrailers.Range("H3") = "" Then 'If H3 is empty
    Set DestinationCell = Incomingtrailers.Range("H3") 'Then destination cell is H2
Else
    Set DestinationCell = Incomingtrailers.Range("H1").End(xlDown).Offset(1, 0) 'Otherwise the next empty row
End If

'Copy and Paste data from Parking Structure to PendelPlan
DateOfData.Copy DestinationCell
Transporter.Copy DestinationCell.Offset(0, 1)
Hour.Copy DestinationCell.Offset(0, -1)
TrailerNr.Copy DestinationCell.Offset(0, 10)
SlotNr.Copy DestinationCell.Offset(0, -7)
Blank.Copy DestinationCell.Offset(0, 11)
Reference.Copy DestinationCell.Offset(0, 4)
VSFReference.Copy DestinationCell.Offset(0, 5)
VSF1orVSF2.Copy DestinationCell.Offset(0, 6)
'Clear the contents in the Parking Structure Worksheet

Transporter.ClearContents
TrailerNr.ClearContents
SlotNr.ClearContents
Blank.ClearContents
Reference.ClearContents
VSFReference.ClearContents
VSF1orVSF2.ClearContents

End Sub
```

ii)




```
Option Explicit
'copy non-blank slotnr cells

Sub OverviewButton()

Worksheets("Overview").Range("A2", "N50").Delete

Dim erow As Long, lastrow As Long, i As Long

lastrow = Sheet4.Cells(Rows.Count, 1).End(xlUp).Row

For i = 2 To lastrow
    If Sheet4.Cells(i, 1) <> "" Then
    If Sheet4.Cells(i, 20) <> "" Then
    Sheets("Pendelplan").Range("H" & i, "U" & i).Copy
    Sheets("Overview").Activate
    erow = Sheet2.Range("A" & Rows.Count).End(xlUp).Offset(1, 0).Row
    ActiveSheet.Paste Destination:=Sheets("Overview").Range(Cells(erow, 1), Cells(erow, 14))
    Sheets("Pendelplan").Activate
End If
End If
Next i


Application.CutCopyMode = False

End Sub
```

Appendix B:

Appendix B and C were removed for confidentiality.